Drivers of Zoonoses Spillover in Nepal:

Community Priorities

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Declaration by student

I, Anna Durrance-Bagale, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis. This work has not been submitted previously for an academic qualification.

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Abstract

Background

Emerging zoonotic diseases represent a growing global threat, particularly for countries with constrained infrastructure and resources. There is a lack of qualitative research to understand community awareness, priorities, perceptions and practices around zoonotic risk, and how these are shaped by socio-cultural contexts, in Nepal. This study aimed to address these knowledge gaps by examining the implications for community engagement and co-production of community-level mitigatory strategies through a One Health approach in Nepal.

Methods

This qualitative multimethod study used critical realist methodology, incorporating semi-structured individual and group interviews, photovoice, and unstructured observations with community members, and semi-structured interviews with policymakers and human and animal health-workers. I used thematic analysis informed by critical realism to analyse the data. Examination of issues surrounding zoonotic disease, awareness, and behaviours with communities, health experts, and policymakers, enabled a critical analysis of what people described and how this related to behaviours.

Findings

Major themes on potential drivers of zoonotic disease and community knowledge of risk factors and prevention were: (i) disease awareness; and (ii) beliefs and behaviours. Participants were aware of diseases that might affect them, their family, or livelihood. Disease information usually spread informally between friend and family networks rather than through official channels. Use of traditional medicine was widespread, with discussion around whether this was an out-dated practice, and some describing this as pragmatic, since traditional healers are often more accessible and affordable than health facilities. Bushmeat consumption was something 'others' do, although some noted bushmeat could be medicinal and others discussed 'clean' and 'dirty' rodents. Hygiene practices were described as necessary to remove dirt but seldom linked explicitly to illness prevention.

Major themes on community engagement and co-production of mitigatory activities were: (i) existing mitigatory practices; (ii) cultural factors; (iii) experience of community programmes; and (iv) community priorities and co-production. Community participants, despite strong opinions and desire to participate in disease control interventions, reported minimal or no attempts by intervention providers to engage them in design, implementation, evaluation, or accountability. Most had no experience of awareness programmes. Participants highlighted the importance of working in 'local' languages, respecting religious and cultural realities, relating initiatives to lived experience, and including community leadership.

Through discussions with policymakers and healthcare practitioners, I aimed to identify how an effective One Health approach could realistically be operationalised in Nepal. Participants discussed themes such as One Health as a concept and opportunity; policy and politics; financing; and catalysts to raising awareness; power relations and multi-sectoral collaboration; community engagement; and collaboration with international partners; and lack of data and research on zoonotic disease that could inform a One Health control programme in Nepal. The government was perceived as generally supportive, endorsing a One Health plan with the incorporation of technical working groups involving relevant sectors. Participants recognised that healthcare in general is underfunded, with little data on zoonotic disease, resulting in a lack of awareness at governmental levels of the importance of the issues. Many participants were positive about the potential for the One Health strategy in Nepal. Similar barriers and enablers to progress were discussed by representatives of both human and animal health sectors, which suggests that there is a space for mutual understanding that could feed into a workable and effective method of implementing a One Health approach in Nepal.

Conclusion

This PhD contributes to a small body of literature on community priorities, zoonotic disease threats, and One Health perspectives on working most effectively with(in) communities to address these threats. The findings illustrate the significance of acknowledging the multi-dimensional religious, cultural, educational, financial and social contexts in which people live, and how these influence their beliefs, needs and priorities. Implications from this PhD include the importance of promoting trust in communities through inclusion of prominent community members (community health volunteers, traditional medicine practitioners, women's group leaders); the use of local languages; the acceptability of different media for interventions (theatre, drama); and the need to be realistic and pragmatic about available resources, to manage the expectations of community members. I have demonstrated the utility of both critical realism and participatory approaches (photovoice) in this type of research. Taken together, this PhD provides and develops insights to inform the design and implementation of research and interventions addressing drivers of zoonotic disease risk in conjunction with, and tailored to, communities in Nepal.

Contents

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'They disturbed the silent spaces where secrets dwelled in peace with the dreams of the dead, where forgotten diseases lived in calm quarantined contentment. And when the diseases were dislodged they too began to roam about looking for beings that would give their agitation a new home.'

Ben Okri, 1993

Definitions

Term	Definition
Axiology	'The influence of values on knowledge that is acquired and how it is acquired' [1]
Bushmeat	'Raw or minimally processed meat from wild animals' [2]
Co-production	A process during which potential or actual end-users (such as members of a community) work together with service providers (healthcare professionals, policymakers, academics) to produce knowledge and interventions that are useful, workable, and (cost-)effective
Community	'The residents of settlements where health research is conducted, potential study participants, all other residents in the immediate locality' [3]
Community engagement	'The process of working collaboratively with and through groups of people affiliated by geographic proximity, special interest, or similar situations to address issues affecting the well-being of those people' [4]
Critical realism	'A branch of philosophy that distinguishes between the 'real' world and the 'observable' world. The 'real' cannot be observed and exists independently from human perceptions, theories, and constructions. The world as we know and understand it is constructed from our perspectives and experiences, through what is 'observable'' [5]
Epistemology	'Understanding of the nature of knowledge, the 'getting to know' process, the relationship between the person who seeks to know and the knowledge they construct' [1]
One Health	'An integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent' [6]
Ontology	'One's understanding of the nature of reality and what can be known about that reality' [1]
Positionality	'Our understanding of ourselves, of who we are and what we bring to our research' [7]
Qualitative research	'Seeks to answer questions about the 'what', 'how' or 'why' of a phenomenon, rather than questions about 'how many' or 'how much'' [8]
Reflexivity	'Questioning and challenging of one's own thoughts and beliefs. As such, reflexivity is a process that we engage in throughout our research from conception through to dissemination' [7]
Social science	'The study of people: as individuals, communities and societies; their behaviours and interactions with each other and with their built, technological and natural environments' [9]
Spillover	Process in which an infectious agent is transmitted into a novel host species [10]
Subjectivism	'An epistemological position that says that we cannot simply observe the world and produce knowledge. Instead, knowledge production is theory-dependent' [11]
Theory-dependent knowledge production	'Knowledge production is influenced by the theories that a researcher adopts' [11]
Zoonosis	Disease or infection that is naturally transmissible from vertebrate animals to humans [12]

Chapter 1: Introduction

(Re)-emerging zoonotic diseases, those that are naturally transmissible from animals to humans [12], represent an increasing threat to health globally, but particularly in low-income countries that may lack the infrastructure, finances and political will to address them effectively [13]. Around 75% of new or emerging infectious diseases that have affected humans in the 21st century are of zoonotic origin, with many of these emerging from wildlife reservoirs [14-16], highlighting the threat that these pathogens pose globally [13]. Anthropogenic drivers of zoonotic disease emergence include rapid population growth, urbanisation, habitat encroachment, fragmented landscapes, proximity of humans to animals [10, 15, 17, 18], and consumption of bushmeat (raw or minimally processed meat from wild animals, including rodents) [2, 19, 20], further complicated by under-resourced and inaccessible healthcare provision [10, 15, 21-24]. In resource-poor settings, spillover events (when an infectious agent is transmitted into a novel host species [10]) are likely to be under-reported as healthcare staff have little access to diagnostics, government-recommended disease prevention measures are not widely followed, and surveillance mechanisms are either poor or non-existent [25, 26]. The COVID-19 pandemic demonstrated the potential of zoonotic diseases to cause serious health and economic issues and threaten livelihoods around the world [14, 27]. Examining the human-animal interfaces that may permit the emergence of disease and potential cross-species transmission is essential to preventing spread of zoonotic disease [18, 27, 28], and identifying potential mitigatory mechanisms to address this.

The threat posed by zoonotic diseases is especially pertinent in countries such as Nepal, those classified as 'least developed' by the United Nations [29], and therefore least likely to have the financial and personnel resources to be able to cope with such a threat. There are many factors increasing the risk of, and vulnerability to, disease outbreaks in Nepal, and understanding and working within local cultures, beliefs, and practices is essential to understanding how these factors may affect risk of exposure to emerging zoonotic diseases [30-34]. However, there is little research on this topic focusing on Nepal. This study aimed to fill this gap, working with participants to identify potential drivers of zoonotic disease risk and community-based mitigation approaches in Nepal.

In this introductory chapter, I discuss the study setting, the importance of One Health and what social science can contribute to this approach, why co-production is key to effective research and interventions, and why a qualitative approach to this study was particularly valuable. Finally, I state my research aim and objectives, and summarise the structure of the thesis.

1.1 Study setting

A range of socio-economic, environmental and other contextual factors converge in Nepal, increasing the risk of, and vulnerability to, disease outbreaks. These factors include poverty and poorly resourced health systems, rapid population growth, increasing urbanisation, variable literacy, economic vulnerability, consumption of bushmeat, and anthropogenic encroachment on wildlife habitat associated with agriculture and other land use changes [15, 35].

Nepal is categorised as a lower-middle income economy by the World Bank, with a gross national income per capita of US$1,086-4,255 [36]. This differs from the United Nations description of Nepal as a least developed country as the latter takes into account other factors (such as the presence of structural impediments to development), rather than simply financial parameters. In 2019, Nepal spent 4.45% of gross domestic product on healthcare, averaging US$53 per capita [37]. In 2023 the Nepali government cut the already-insufficient healthcare budget by 17% to 5.9% of the total government budget for the next fiscal year [38].

Many people in rural and urban areas of Nepal are subsistence or backyard farmers, living in very close proximity to their livestock and poultry. Over 80% of Nepalis are engaged in some form of agriculture, with one of the highest livestock-to-human ratios in Asia (5.8 livestock per household), increasing the risk of zoonotic disease transmission [39]. This is especially true in rural and agricultural areas, where the interface between wildlife reservoirs and domesticated livestock may present additional opportunities for pathogen transmission [25, 40]. One potential factor in zoonotic risk in Nepal is consumption of bushmeat. Rats are hunted and eaten in some communities (e.g., the Musahar community in the east of the country) while bats are eaten by members of the Chepang, Newar and Tamang communities, especially during festivals [41]. With an under-resourced healthcare system, there is little scope for Nepal to develop advanced surveillance systems to identify potential infectious disease threats, and there is little research detailing burden from these diseases in the country.

Healthcare services are basic and much of the Nepali population has little to no access to qualified healthcare providers, particularly in remote and rural regions: 41% of rural communities have no access to a health post, and 80% do not have access to a public hospital within 30 minutes of their home by public transport [42]. This lack of access to healthcare provision means that communities are unlikely to report potential spillover events, and this, coupled with lack of government-approved prevention measures and poorly functioning or non-existent surveillance mechanisms means that the presence of disease may be unrecorded [25, 26].

1.1.1 Epidemiology and burden of zoonotic disease in Nepal

The zoonotic disease landscape in Nepal is poorly understood, although leptospirosis (rodents as primary reservoir) and rabies (dogs as primary reservoir, bats also recognised) are serious long-standing public health issues throughout the Indian subcontinent. The chains of infection for rabies and leptospirosis make clear the potential for these diseases to cause illness and concomitant financial distress in Nepal. Rabies can be transmitted from community (feral) dogs to people and their livestock, while rodents are a key zoonotic reservoir for leptospirosis, which are ubiquitous in rural and urban areas of Nepal. Nipah virus, an emerging pathogen with a case fatality rate of 70% in humans, is spread by fruit bats, and has been responsible for outbreaks among humans in neighbouring India and Bangladesh following several spillover events [43, 44]. In September 2023 there was an outbreak of Nipah virus disease in Kerala, India, with two confirmed fatalities [45], demonstrating the threat of this disease. Nipah is included on a list of the ten highest-priority pathogens by the World Health Organization [46].

Between 20,000 and 40,000 animal bites are reported annually in Nepal, 90% from dogs [47]. Anti-rabies vaccinations are requested by 150 people every day at the main infectious disease hospital in Kathmandu [48]. Although dogs pose the main rabies threat to humans, in 2019 there was a reported death from rabies after a bite from a rabid bat (personal communication, Dr Sher Bahadur Pun). This, and Nipah, may become of concern in the future as large colonies of fruit bats are present in the heavily populated Kathmandu valley and eastern areas of Nepal. Rodents represent a low risk for rabies transmission but as they live in close proximity to humans and often bite, post-exposure prophylaxis is recommended after rodent-human contact [49].

Global incidence of leptospirosis is unknown, with an estimated prevalence of 10 cases per 100,000 population affected in tropical climates [50]. Leptospirosis is not included in routine surveillance or the early warning and reporting system in Nepal, but incidence is presumed to be under-reported due to a lack of appropriate diagnostic facilities and symptoms that are difficult to differentiate from those of other common diseases [50]. This disease poses a serious health threat in rural areas of Nepal, where subsistence farmers are in close contact with livestock and rat urine in paddy fields and water sources. One study examining clinical determinants of leptospirosis in Nepal found that working in paddy fields (odds ratio 1.3, 95% confidence interval 1.11-1.72) and owning goats (odds ratio 1.3, 95% confidence interval 1.05-1.66) significantly increased risk of humans contracting leptospirosis by 1.3 times compared with people not doing either of these practices [51]. Diagnosis of leptospirosis can be difficult: in a study of 36 patients diagnosed with enteric fever at a Kathmandu hospital, 18 tested positive for leptospirosis, which had not been included as part of the initial differential diagnosis [52]. A 2016 study examining the prevalence of infection with leptospirosis in patients who had been hospitalised with suspected Japanese encephalitis infection found that prevalence was significantly higher in the Terai region (plains along the Indian border [53% (222/416

samples]) and the mountain region [45% (188/416)] than in the Himalayan region of the country [1% (6/416)] [53].

1.1.2 Zoonotic disease governance in Nepal

Although zoonotic diseases likely place a huge and potentially increasing socio-economic burden on Nepal, little research has been done and there are few policies in place to address this issue [54]. Nepal has three tiers of government – federal, state and local – which, coupled with a weak regulatory capacity, make policy formulation and implementation complex [54]. Nepal has a Zoonotic and Other Communicable Disease Control Section, under the Ministry of Health and Population, while the independent (and externally funded) National Zoonoses and Food Hygiene Research Centre, in Kathmandu, acts as a research arm of the Ministry of Health. Six zoonoses (i.e., taeniasis/cysticercosis/neurocysticercosis, hydatidosis, brucellosis, toxoplasmosis, avian influenza, leptospirosis) have been identified as priority zoonotic diseases with epidemic potential, although few data are available on incidence or prevalence of these [55]. In December 2022 Nepal voluntarily underwent the World Health Organization (WHO)'s joint external evaluation of international health regulation core capacities (known as the JEE), which discussed how the human and animal health sectors had come together to work on constructing a new list of the ten priority zoonotic diseases of greatest public health concern (influenza, rabies, coronavirus, leptospirosis, brucellosis, salmonellosis, leishmaniasis, zoonotic tuberculosis, cestode and toxoplasmosis) in Nepal, and to facilitate implementation of a One Health approach in the country [39]. The authors of the report found that, although Nepal has made a clear start on attempting to deal with zoonotic disease threats, mechanisms to action initiatives around these still need to be designed and implemented [39].

Research on zoonotic disease is generally lacking in Nepal, in particular qualitative work that does not attempt to quantify risk but instead focuses on elucidating, through discussion with people, the particular context or shared meanings that affect their understandings of these diseases and their causes. Considering these knowledge gaps, this study aimed to characterise the key contextual factors and mechanisms driving behaviours around, and awareness (or otherwise) of, risk factors, prevention and treatment of zoonotic diseases in selected communities in Nepal.

1.2 What is social science?

Social science can be defined as 'the study of people: as individuals, communities and societies; their behaviours and interactions with each other and with their built, technological and natural environments' [9]. Social science allows us, to an extent, to analyse and interpret the relationships between individuals, communities, governments, and businesses, and use this analysis to predict the behaviours in which these relationships may result, for example, armed conflicts, man vs. nature, and the climate emergency [56]. Comprehension of these relationships and behaviours may lead to the ability to influence or change

outcomes, so we can use social science to analyse data, predict events, and try to prevent or encourage these.

In this project I used a qualitative social science methodology, informed by critical realism, involving interviews, focus group discussions, photovoice, and unstructured observations (see Chapter 2), and working with people from six communities in Nepal, to identify which factors might affect the potential for spillover of zoonotic disease into human populations in Nepal, and how this spillover could potentially be prevented. This included discussions on whether communities see evidence of animals in their homes and surroundings, how they perceive these animals, how aware they are of dangers posed by these animals, and what they do to protect themselves from potential disease risk.

1.3 What is One Health?

Calvin Schwabe introduced the concept of 'One Medicine' in 1976, following the 19th century work of Rudolf Virchow, who suggested that human and non-human animal medicine should be linked as disease processes were similar in both groups [57]. With the addition of an environmental or ecosystem perspective, One Medicine developed into One Health, which has a more holistic focus: human, animal and environment sectors, working together to understand the risks of, respond to, and attempt to control (re)emerging disease [57, 58]. More recently, the One Health concept has expanded further, following the formation in 2021 of the One Health High-Level Expert Panel (OHHLEP) by the Food and Agriculture Organization (FAO), the World Organization for Animal Health (WOAH), the United Nations Environment Programme (UNEP), and the WHO [6]. The definition has recently been made more inclusive, with One Health now posited as: 'an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent' [6]. The related paradigms of eco-health and planetary health have also developed over recent years: the former focuses on ecocentric rather than anthropocentric issues, whereas planetary health centres on the importance of environmental and ecosystem health [6]. In this thesis I used the wider One Health concept as this was more relevant to the research questions I was posing. The concept of One Health with respect to this PhD project is discussed in greater detail in Chapters 6 and 7 of this thesis.

The recognition of the complexity of the relationship between the human, animal and environmental sectors [58], and the concomitant need for an integrated One Health approach is a step forward, but One Health research is still largely compartmentalised, and the need for a stronger social science approach to One Health that takes into account contextual factors, although sometimes discussed, has not often been put into practice [24, 30-32, 59-62].

1.4 The need for a qualitative social science approach to One Health

Social science research allows us to focus on the people who may be most vulnerable to a potential zoonotic disease outbreak in Nepal, working with them to identify their priorities and what would 'work' for them in terms of how they can protect themselves from disease risk [30-34]. Shifting from seeing risk as a simple behavioural issue (e.g., not washing hands), and trying to identify what factors may influence behaviours (e.g., religious beliefs, cultural norms) is crucial [28]. Seeing how community members perceive threats, what kinds of mitigatory practices they may already have in place (and if not, why not) through dialogue with the people in question demonstrates respect for them and their views and values, while allowing a more sensitive and nuanced interpretation, and may increase the potential success of any kind of initiative aimed at preventing or mitigating disease risk in these contexts [6, 31]. Osborne and colleagues argue for the inclusion in disease response teams of social scientists, who can be involved in describing the context of affected communities (to aid in community engagement), communicating findings, and formulating policy recommendations [63]. The combination of social science and One Health is exemplified by existing platforms such as the One Health Social Sciences Initiative, which states that social science approaches, taking into account cultural, economic, linguistic, and demographic aspects, are necessary to delineate and address the causes of disease and poor health outcomes, and to work toward equitable health [64]. SoNAR-Global, a network involving 11 African, Asian and European institutions, is aimed at fostering collaborations between social scientists working on antimicrobial resistance and infectious disease threats globally [65].

Social science research can be quantitative or qualitative, or sometimes both. In simple terms, qualitative research 'seeks to answer questions about the 'what', 'how' or 'why' of a phenomenon, rather than questions about 'how many' or 'how much'' [8], aiming to understand and explore rather than quantify. A qualitative approach using interviews, focus groups and photovoice was ideal for my PhD, as I wanted to talk to community members about their opinions and beliefs, and through this attempt to define what cultural and contextual norms or ideas might be informing their behaviours, with regard to zoonotic disease risk. Qualitative research can also take into account reflexivity and positivity (discussed in Chapter 2), recognising that this research is by necessity subjective, as it is produced by a human being with their own beliefs, upbringing, gender, age, education etc, and that these factors will inevitably influence how they perceive and understand their research data. By identifying why people behave as they do, qualitative research findings can contribute to policy and practice, and implications of this are discussed in more detail in Chapter 7.

The need for a One Health approach to zoonotic disease is clear, as it involves human, animal and environmental drivers. I would argue that approaches usually taken to addressing issues around zoonotic disease risk ignore cultural, social and religious drivers, among others. Qualitative research is an important component of the success of One Health research: without an understanding of how different groups and cultures may perceive health, and taking into account power relations and other aspects that may affect how

people produce meaning, any knowledge produced may be inadequate (or even useless or harmful) in terms of pushing forward initiatives aimed at improving public health outcomes [6, 31]. Social science is sometimes seen as a 'weak' or 'soft' way of producing knowledge, especially when involving qualitative rather than quantitative data, so findings are therefore downgraded and may be perceived as irrelevant or biased [66].

Social science is often used as a medium for delivering existing knowledge and awareness [31], rather than contributing to knowledge generation or expertise. This naively presumes that the only reason people do not behave in ways that appear sensible, e.g. washing hands before eating, or using gloves while transplanting paddy, is because they are unaware of how this makes them vulnerable to pathogens. This means that disease risk is often framed as communities not being aware of, or not understanding, the concept of disease risk. In the literature review conducted for this PhD (Chapter 3), I found that the most frequently discussed potential driver of zoonotic disease risk in the Indian subcontinent was lack of awareness in communities, with little discussion of other drivers that may have influenced behaviour [28]. This simplistic focus on awareness as the main driver ignored the fact that, even when people were aware of risk factors for disease and potential routes of transmission, their behaviour did not change [28, 40]. This suggests that more complex, implicit and unspoken processes underlie behaviours that may appear to others to be irrational [1]. Working with(in) communities, placing behaviours and drivers that may facilitate disease transmission or increase risk into context, considering cultural and religious beliefs, including those around the status of animals and livestock, and how people make sense of transmission and risk, is crucial to understanding and decreasing risk of spread of zoonotic disease [30-33]. This may be especially true for underserved populations, for example, people who have low literacy, or those living in informal settlements with little access to healthcare [34, 67-69].

This unsophisticated understanding leaves a huge gap that must be explored for any approach to be effective. Communities should be engaged as active partners in research and programming, rather than treated as passive recipients of knowledge constructed by others. Social, economic, religious and cultural drivers that people experience must be identified and examined, along with how these affect their relationships with other people and with their animals. How these drivers affect their ability to participate in practices that will result in better (or worse) health outcomes needs to be researched [31]. Qualitative research, involving discussions with community members on these contextual factors, is highly appropriate to achieve these aims.

1.4.1 Social science in action: H5N1 in Thailand

The need for a social science approach to One Health was neatly illustrated in research involving disease spread after an outbreak of H5N1 in Thailand, which found that taking into account the socio-ecological context of a potential outbreak, how animals contracted the disease, and how humans may have been

exposed, was key to understanding the disease ecology, and, therefore, any likely impact on human populations [70, 71]. For example, the researchers found that contextual factors such as the number of fighting cocks used in cock fights (a culturally important practice in the region) influenced the spread of the disease, as did the traditional rice-duck farming system, in which free-ranging ducks were able to feed in paddy fields, and shed virus into these fields. This work informed a restructuring of the relevant duck farming system to reduce risk of disease transmission to humans [71].

1.4.2 Qualitative research in action: Ebola in Africa

Focusing on culture and how this interacts with ecology and biology to influence human behaviour is key to controlling or preventing outbreaks such as Ebola: understanding how people explain outbreaks, taking into account their context and local beliefs and practices, as well as demonstrating respect for local cultures and developing trust within them [60]. Barry Hewlett worked with communities, interviewing them to understand their 'model' or explanation of illness: why it happens, who is responsible, and what people do to prevent (or encourage) it. Before this, teams had been helicoptered in with little to no awareness of how local communities viewed the outbreak, and their perceptions of what might be causing it. For example, women were more likely to die because they were primary caregivers and responsible for washing the bodies of people who had died from Ebola. They were stigmatised more than men and so were perhaps less likely to admit to being ill, which would have increased the likelihood of them spreading any infection. This lack of contextual understanding meant that the outbreak team missed opportunities to use community knowledge and practices to help control the outbreak [60].

The utility of this type of understanding has also been demonstrated for other facets of Ebola, where comprehension of relationships between bushmeat hunting, community perceptions of risk, changes in land use and expansion of human habitations, and the link between these and disease emergence, has led to a more effective policy to prevent infection [24, 72]. For example, LeBreton and colleagues found that only certain activities around bushmeat were perceived as risky, whereas all activities were in fact as likely to transmit disease as others [72], while Wolfe *et al* state that how humans and wildlife interact, and how humans perceive these interactions, is central to understanding behaviour and how it contributes to risk of pathogen emergence [24].

Qualitative social science researchers, alongside communities, can contribute to conceptualisation of One Health approaches by examining issues such as power relations and resource allocations [31], along with factors such as social status, cultural beliefs, religion, gender, and education. This is especially important in remote or resource-constrained communities, who are unlikely to ever have been asked about their priorities, their ideas, and their practices [59], all of which are central to any explanation of behaviours that may, on the surface, appear confusing or counter-productive. In addition, these communities are likely to be

at highest risk of spillover of zoonoses, as a result of living in under-resourced areas with little access to healthcare, increased contact with livestock and wildlife, and lack of support from government or civil society [32].

Lack of insight into why people behave as they do is likely to mean that approaches focused solely on behaviour change or regulation will fail, as they ignore the cultural, historical, social and economic factors and meanings that cause the behaviours in the first place [61]. Involving communities in a way that ensures they can participate and contribute as much as possible is important, which is why I used photovoice during this PhD. As Catley and colleagues state, 'participatory' approaches should involve communities defining and prioritising issues in their own context, and developing solutions to these issues [73]. Social science theory, in this case, critical realism, can help to unpick the subjective understandings, assumptions and meanings that people hold, and contribute to working toward a more holistic view of potential initiatives [74, 75]. In this research I used traditional qualitative methods (interviews, focus group discussions and observations) coupled with a method that is not used as frequently (photovoice) but that I judged might allow participants, especially those who were less literate or less used to discussing their opinions, to relax and potentially enjoy the process. This depth of engagement with community members, particularly those who took part in the photovoice component, allowed me to talk through with them and unpick factors that might be driving certain behaviours.

1.5 The need for community engagement and co-production in research and interventions

For the purposes of this study, I define community broadly, following the lead of Adhikari and colleagues, as including 'the residents of settlements where health research is conducted, potential study participants, all other residents in the immediate locality' [3]. I define community engagement as 'the process of working collaboratively with and through groups of people affiliated by geographic proximity, special interest, or similar situations to address issues affecting the well-being of those people' [4]. Community engagement has a range of aims, including respecting communities, building trust and social relationships, providing appropriate benefits (during research projects, avoiding exploitation of participants and protecting them from potential harms), and supporting a clear and fair consent process (particularly important when participants may have low literacy or be from otherwise disadvantaged populations) [3, 76]. While some community engagement is focused on empowerment and increasing autonomy (ethical good practice), other types of engagement are focused on achieving outcomes from the research in question (instrumental, e.g., increasing retention in studies) [3, 76]. Engagement can be as superficial as simply informing communities of health issues (e.g., awareness programmes), through participatory visual methods such as photovoice [77,

78], to more in-depth initiatives like co-production of research projects with community members, asking for their priorities and reflections at all stages [3].

Co-production is a process whereby researchers work with community members to achieve outcomes that are relevant and meaningful to them in their context. However, there is discussion over what the definition of co-production actually is, with Oliver and colleagues [79] discussing four types of co-production, including i) substantive, where co-production increases the quality of the research, ii) instrumental, where it makes research more effective, placing outcomes in the relevant context, iii) normative, where co-production is seen to be more ethical and 'fair', and iv) political, where it is related to increasing ownership, empowerment and inclusion, making research less exclusive and not only done by 'elites' [79-87]. For the purposes of this thesis co-production is defined as a process during which potential or actual end-users (such as members of a community) work together with service providers (healthcare professionals, policymakers, academics) to produce knowledge and interventions that are useful, workable, and (cost-)effective. This type of working may help to increase trust, empowerment and ownership among communities that may otherwise be marginalised [67, 88]. In addition, interventions may be more effective if communities have been actively involved in planning solutions so that they are culturally and contextually sensitive [67, 68, 88]. Community views on what is likely to work may be more realistic as they are working within what they have, rather than an ideal-world scenario. Recommending an expensive or time-consuming 'solution' to an issue if people can afford neither the time nor the expense of these potential solutions will be ineffectual [89]. Additionally, co-production in healthcare aims at ensuring that communities have at least some control over the design and implementation of any initiative or piece of research that is directly related to their situation, allows them ownership of the process and the outcome, and, at least in theory, allows them to hold health providers accountable [69, 90]. Many issues must be kept in mind while doing this type of work, including the power relations within and across communities [88], involving people who are respected within the community, which may be groups as diverse as local politicians, female community health volunteers, and traditional healers, and recognising that participants and researchers are likely to be from very different backgrounds and hold very different assumptions, including the perceived utility of a co-produced project. I discuss the significance of inclusion of these groups with reference to my findings in detail in Chapter 7.

The purpose of this PhD, rather than co-producing a piece of research with communities, was to identify, through discussion with the people involved, what might make this process effective in the future. Due to the time and financial restraints of this project, embedding within one of the communities who participated was not feasible, but I aimed to lay the groundwork for such a project in the future.

1.6 Research aim and objectives

I aimed to identify potential anthropogenic drivers of zoonotic disease risk and community-based mitigation approaches in Nepal, through collaborative discussions with people in affected communities, healthcare practitioners, and policymakers, and to examine how any community-level mitigatory factors were, or could be, implemented. Research on these issues is lacking in Nepal, particularly qualitative studies focusing on the views and experiences of affected people during the development and implementation of any intervention or research.

Objectives were to:

1. identify potential anthropogenic drivers of zoonotic disease risk (Chapter 3 and Chapter 4).
2. explore community perceptions and knowledge of risk factors, prevention, and treatment for common zoonotic diseases in selected rural and urban sites in Nepal (Chapter 4).
3. identify existing and potential mitigatory activities, including barriers and enablers to the effective implementation of these activities (Chapter 5).
4. identify, in collaboration with community members, policymakers, and human and animal healthcare personnel, what might foster community engagement and co-production of pilot One Health projects focused on mitigation in Nepal (Chapter 5 and Chapter 6).

1.7 Thesis structure

Chapter 1 introduces my research, the study setting, and concepts relevant to qualitative social science, co-production and One Health. I conclude with the aim and objectives of my research.

Chapter 2 provides detailed methodology, including the philosophical foundations of the research, the methods I used, my positionality and reflexivity, and ethics processes.

Chapter 3 provides a scoping review I conducted to inform my PhD research [28] and published in August 2021 in the journal One Health. In it, I summarise the available literature on potential anthropogenic drivers of zoonotic disease risk in the Indian subcontinent. I chose to include research on the subcontinent as a whole as literature focused on Nepal is sparse (only 9% of articles included discussed findings from Nepal) and using a broader geographical area was much more informative, especially as many of the countries included have similar cultures and religions and findings were, at least to an extent, applicable to Nepal. I describe the findings in terms of diseases covered, mitigatory practices used by communities, and discuss how improving the understanding of risk perceptions in communities would help in co-designing interventions that are specific to the context and therefore likely to be relevant to communities.

Chapter 4 is an exploration of community perspectives on zoonotic disease in Nepal, disease awareness and how beliefs and behaviours might affect potential spread of these diseases, using through interviews with all participants, and photographs taken by selected participants. This chapter addresses Objective 1, to identify potential anthropogenic drivers of zoonotic disease risk in communities in Nepal, and Objective 2, to examine community perceptions and knowledge of risk factors, prevention, and treatment for common zoonotic diseases in these selected communities.

Chapter 5 complements Chapter 4, and focuses on potential avenues for co-production of responses to zoonotic disease threats within the Nepali communities included in this study. This chapter is again informed by interviews with all participants, and the photographs taken by selected participants. This chapter addresses Objective 3, to identify existing and potential mitigatory activities that around zoonotic disease in selected communities, including barriers and enablers to the effective implementation of these activities, and Objective 4, to work with community members, policymakers, and human and animal healthcare personnel to identify what would foster community engagement and co-production of mitigatory activities in Nepal.

Chapter 6 focuses on perspectives on the multi-sectoral One Health approach in Nepal, informed by interviews with healthcare practitioners and policymakers. This chapter provides an understanding of the current policy landscape around zoonotic disease in Nepal, and explores the perceptions of policymakers and healthcare practitioners on this topic, identifying opportunities and challenges to operationalising a coherent One Health approach in conjunction with community members in Nepal. This chapter addresses Objective 4.

Chapter 7 discusses the implications of my findings for community co-production of interventions to address zoonotic disease threats in Nepal. Using findings discussed in Chapters 4, 5 and 6, I develop a conceptual framework, demonstrating why contextual factors are so important to the future of research into, and interventions focused on, zoonotic disease in Nepal. Implications for future research, including limitations of the current project, and my reflections on my PhD journey as a whole are included here. I close the chapter with overall conclusions drawn from the entire project.

Chapter 2: Methodology

2.1 Study design

I chose a qualitative (interpretivist) multimethod study design, underpinned by critical realist philosophy, and recognising contextual nuances of Nepal's socio-cultural landscape. This pragmatic approach, using different methods (i.e., interviews, focus groups, photovoice and unstructured observations) fit my topic and research question because it allowed me to work with participants to clarify what they thought about the topic and why they acted as they did and, for those participants who took part in the photovoice component, to actually show me what was important to them using photography.

2.2 Philosophical foundation

2.2.1 Ontology (Realist)

Ontology is how we understand the world; Haigh and colleagues define it as 'one's understanding of the nature of reality and what can be known about that reality' [1]. For the purpose of this project, my ontological position was realism: the world exists independently of me and everyone involved in this project.

2.2.2 Epistemology (Subjectivist)

Epistemology is how we know what we think we know, and how who we are affects our knowledge production. Again, as Haigh and colleagues define it, epistemology is about 'understanding of the nature of knowledge, the 'getting to know' process, the relationship between the person who seeks to know and the knowledge they construct' [1]. For the purpose of this project, my epistemological position was subjectivism: we observe the world, but the conclusions we draw from this observation may not necessarily be correct. Our observations are theory-dependent, i.e., we cannot observe objectively – instead, we bring our beliefs, perceptions and understandings into everything we do. I discuss this concept of reflexivity further in Chapter 7.

2.2.3 Axiology (Participatory)

Axiology is how our values influence our interpretation and how we acquire knowledge. Projects taking a critical stance focus on improving conditions for marginalised or oppressed groups and working toward emancipation. For realism, this is largely done by clarifying how mechanisms may be changed to increase beneficial, or suspend harmful, effects [1]. In this study the axiology was participatory, in that people in communities were asked to discuss their views, opinions and priorities, sometimes involving inherent cultural or religious beliefs, and trying to relate these priorities to actionable and useful outcomes. This participatory axiology can inform policy and programming, e.g., co-production or co-design of research and interventions, as it acknowledges that inequitable and marginalising outcomes can result from both individual and systemic

factors [91]. Working with community members to examine how their beliefs and opinions affect their situation is central to addressing these factors.

2.2.4 Macro-theory (Critical realism)

The combination of a realist ontology and a subjective epistemology results in an overarching critical realist perspective: the world exists independently, and production of knowledge is theory-dependent and can therefore be fallible. In this project I used a critical realist lens as a tool for analysing social issues and developing potential solutions to these issues [1, 75, 92, 93]. Critical realism has been used to examine issues as diverse as women's experiences of agricultural policy on farms in Canada [92] and the relationship between human rights and social determinants of health [1]. Taking a critical realist perspective can help to interrogate the complexity that surrounds the world by examining the 'observable' world – what we can see, what people tell us, how we understand issues – and the 'real' world – what may actually be driving behaviours [92]. This stance helps the researcher maintain a pragmatic but critical engagement with participants' understandings of reality, rather than simply interpreting what participants are saying [94].

Critical realism was conceived in the 1970s by the philosopher and sociologist Roy Bhaskar as a rejection of the dominant theories of the time, positivism and constructivism. Positivism underpins most medical and epidemiological research [95], and does not engage with what cannot be measured, leading to a simplified approach to public health issues [96]. Positivists suggest that the only valid knowledge comes from experiencing events, and that information from these experiences forms the source of all knowledge. Constructivists conceive of all knowledge as constructed by humans to explain phenomena and events. Against this, critical realists posit that human knowledge is only part of a 'deeper and vaster reality' [92], and that we cannot reduce everything to our understanding and knowledge of reality. The real world exists independently of our perceptions and the constructions we build around these [75, 95]. We can understand the world only if we understand the structures or processes (e.g., culture, language, power relations) that generate events. These processes are independent of the events they generate: even when we are not observing the processes, they exist, and so can be empirically identified [75, 92, 95, 97, 98].

Critical realists deny that we can have an objective, definite understanding of the world, as all understanding is influenced by social and cultural contexts, and beliefs, emotions and values are part of our subjective reality [99]. This means that we have to interpret everything, and this obviously is affected by our positionality and reflexivity, our mental states when conducting and analysing our work, and also those of participants. Everyone has their own perspective, and this perspective is part of their world, and must be considered in any analysis. However, this is not denying that there is a reality, just that our understanding of this reality is limited and incomplete, and our understanding of the world influences our beliefs, culture and personal perspective [75, 100]. Relationships between social and cultural influences and how we understand our

reality are not accessible to us – they are perceived through the phenomena and experiences that they generate, e.g., our behaviour in a given situation [100]. And these behaviours and perspectives are as real as any other, 'concrete' phenomena and should be treated as such [75]. Critical realists argue that 'mental' phenomena (e.g., beliefs, thoughts, perspectives) are involved in the causal processes that produce social phenomena and behaviours, and so are central to any attempt to explain events and actions. These perspectives and situations causally interact with each other [75]. Therefore, a critical realist perspective allows a clearer understanding of the connections between a person's perspective and their situation.

Critical realists believe that reality consists of three domains: (i) empirical: events that have been or could be experienced; (ii) actual: events that have been caused by the causal mechanisms; and (iii) real: structures, entities or organisations that have properties that allow them to activate mechanisms that affect other structures or organisations (causal mechanisms). These entities can be physical or non-physical (e.g., power relations). To identify the properties of entities and structures, we can ask: what are the preconditions for this entity to exist? Can A exist without B? What does this entity have that allows it to do certain things? [1].

The findings of my literature review (Chapter 3) suggest that, despite knowing what officials advise, people often do not behave in expected ways, even when official advice is available and communities are aware of the mechanisms of disease transmission [28]. For example, following an outbreak of Nipah virus in Bangladesh, easily comprehensible messages about the dangers of consuming raw date palm sap were disseminated by the Government, including 'do not drink raw sap' and 'avoid drinking raw sap', but behaviours in outbreak-affected communities continued unchanged [101]. In Sri Lanka, a clear understanding of transmission of leptospirosis was not associated with taking preventive measures to avoid contracting the disease by students working in paddy fields [102]. This suggests that simple measures attempting to raise awareness do not change behaviour effectively and that there are other, less obvious factors or processes underlying behaviour.

I use critical realist theory to unpick the 'observable' world – what we can see, what people tell us, how we understand issues – and the 'real' world – what is actually driving behaviour [92]. By discussing relevant issues around zoonotic disease, awareness and behaviours with members of different rural and urban communities, and with human and animal health professionals and policymakers, I was able to build a picture of what people understand (observable) and how this relates to how they do, or do not, behave (the 'real' world). I examined why, for example, people do not follow hygiene protocols when working with animals or drink raw palm sap when they are aware that this will potentially make them ill. The common-sense belief is that people will behave in a way that protects them from illness. However, the literature review and anecdotal evidence indicates that this is not the case. Taking a critical realist viewpoint means recognising that actions can be a

result of beliefs and views (why we act in a particular way) AND structural properties that may constrain, encourage or otherwise influence our behaviours [96].

Taking a critical realist stance allowed me to work with participants to understand what they think needs to be done to achieve their goals (and what these goals might be), and how this can be done, taking into account their beliefs and their context and how these inform their actions. Positionality and reflexivity are central to any analysis informed by critical realism, as I discuss later in this chapter and in Chapter 7.

2.2.5 Theoretical framework

Fundamental Cause Theory, first described by Link and Phelan in 1995, states the importance of contextualisation of identified risk factors for illness, with a focus on social factors such as socio-economic status and social support (e.g., access to resources) as 'fundamental causes' of disease [103, 104]. These fundamental causes are important because they are part of a wider constellation of factors that drive mechanisms that cause illness, although they are not the only causal mechanisms. Link and Phelan argue that individual risk factors need to be put in context to identify why people are at risk of disease risk. If we do not do this, we ignore the many dynamic processes that work on these factors to produce disease risk [103, 104]. If we understand why people are unable to avoid certain risk factors, for example drinking polluted water as this is the only water available, or living with commensal rodents as it is impossible to effectively remove them, we can understand why people are necessarily exposed to risk, and work with them to discover what mitigations can be implemented. Without understanding the processes and risk factors that put people at risk, efforts to change behaviours will focus on the individual rather than their context and how these interact, and therefore likely be too simplistic and ineffective [103, 104]. These factors will include an individual's beliefs and perceptions, but by centring these in the appropriate context, we can learn more about how to decrease risk. Link and Phelan suggest that policymakers should ensure that all interventions aimed at changing behaviour should consider why people are at risk of risk. This will ensure that relevant, contextual factors are addressed by the intervention, rather than simply focusing on the individual's behaviours [103, 104].

This theory is useful as a starting point, but focuses more on the contextualisation of social and socio-economic factors, rather than more subtle, less concrete factors such as individual perceptions, power relations, religious and cultural beliefs [103, 104]. While these factors are evidently important, my PhD develops this further by involving participants in identifying what processes lead to increased risk of exposure, and, through analysis of their discussions and photographs and incorporating other, less concrete factors into the theory, potentially make it more applicable and relevant to communities, particularly in resource-constrained contexts. The framework I developed is presented in Chapter 7.

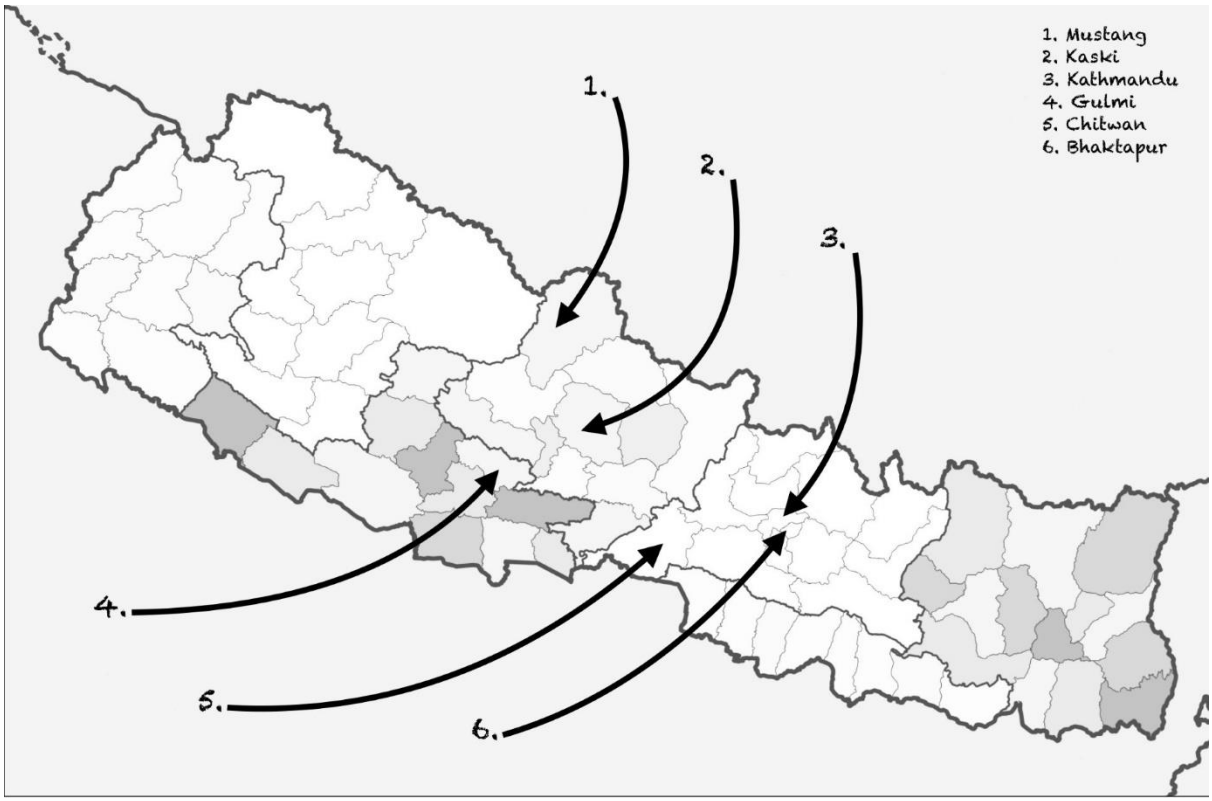
2.3 Research question

My overarching research question was: "what are potential drivers of risk of zoonotic disease in communities in Nepal, what mitigatory factors are in place (and why), and how could any community-level mitigatory factors be implemented, using a One Health approach?" Findings from the scoping review (Chapter 3) helped to inform and direct the research question and the project as a whole. As discussed in Chapter 1, Nepal is classified as a 'least developed' country, is under-resourced both financially and in terms of personnel, and is vulnerable to an outbreak of zoonotic disease for many reasons including lack of surveillance, lack of a properly functioning healthcare system, and general lack of awareness of disease risk at governmental level. Coupled with the lack of research and available data on the incidence and prevalence of zoonotic disease in Nepal (see Chapter 3 and Chapter 6), it was an ideal choice for this type of project.

2.4 Study sites

I collected data in six community sites (Figure 1), representing rural and urban districts in two of the most heavily populated provinces in Nepal, including districts in mountainous areas (Mustang) and the Terai region (lowland – Chitwan). These sites were selected after discussion with colleagues and my external supervisor in Nepal, Professor Nanda Bahadur Singh, Vice-Chancellor of Mid-Western University. One site was an informal settlement in Kathmandu. Communities living in these settlements in Kathmandu are at risk of rabies and rodent-borne disease - they live in close proximity to refuse and open sewers and have no access to hygienic latrines or clean water sources. Community dogs are ubiquitous at these sites. To earn an income, community members often collect recyclables, which may be polluted with animal excreta, from local houses and streets.

Figure 1: Map of Nepali districts included in research



2.5 Participant sampling and recruitment

I used a combination of typical sampling and snowballing. Typical sampling is a type of purposive sampling that is often used in qualitative studies that are designed to explore concepts, as it allows researchers to describe typical cases. I used typical sampling to select participants who were likely to generate appropriate data to help answer the research questions. As with most sampling used in qualitative research, typical sampling does not allow generalisability of findings, but allows identification of usual experiences in a particular setting [105, 106]. Snowballing is used frequently in qualitative research: initial 'seed' contacts are identified through searches of relevant documents and websites and invited to take part. These participants are then asked to provide names of others who might have interesting experiences or opinions to share, and who might be interested in taking part in the study. Snowballing is useful when the researcher needs to demonstrate to potential participants that they are trustworthy, and so being referred by a colleague or contact may help gain their trust and make them more willing to participate in the research [107].

I selected six districts (two in the Kathmandu valley) after discussion with Nepali colleagues on feasibility and the potential presence of information-rich cases in various areas, and enrolled adult participants including, as far as possible, people of different ages and genders. We aimed to conduct six to eight individual, semi-structured interviews and one focus group discussion (FGD) of six to 10 participants from each community per site. This initial estimated sample size was realistic and judged sufficient for a qualitative study using purposive sampling, which is often used to identify information-rich cases in a cross-section of the

population, but was flexible and open to adjustment during the study [105, 106, 108]. In each district selected for the study, we contacted a healthcare worker (if available) and asked them to suggest people to contact in each community. For instance, we wanted to talk to people who might have had some relevant experiences (e.g., might have been bitten by a dog, or who kept livestock), or people who were relatively prominent in the community (e.g., leader of a women's group). If we could not contact a healthcare worker, we instead tried to identify a prominent member of the community (e.g., teacher or member of a community group) and asked them to suggest participants. We met the suggested people, explained the aims of the study, and interviewed them if they were willing to participate. We asked each participant to identify another potential participant until approximately six to eight individuals and one discussion group had been recruited per community, or until sufficient numbers per community had been reached, attempting to include participants of different ages and genders.

I recruited 20 national and subnational policymakers and implementers for semi-structured interviews, using a mixture of purposive sampling and snowballing. This sample size was realistic for this study and was designed to provide a range of opinions and viewpoints. I generated a seed list of Nepali human or animal healthcare professionals and national or regional policymakers, who asked colleagues in Nepal to nominate potential participants from appropriate organisations in the country. All were contacted by email, with two refusing due to time constraints and three not responding. At the end of their interview participants were asked to nominate others who might have useful experiences or viewpoints to discuss. All participants were interviewed in their home, place of work or a local café, as they judged appropriate, and to allow confidentiality and privacy, as far as possible.

These sampling and recruitment strategies were appropriate for a critical realist approach as we aimed to gain an understanding of how people in the sites were affected by their context and the meanings and understandings they had for the topics in which we were interested [75].

2.6 Data collection methods

This multimethod study incorporated semi-structured interviews, FGDs, photovoice and unstructured observations with community members, and semi-structured interviews with health-workers, veterinarians, and policymakers.

Data were collected between April and July 2022. Both interviewers had post-graduate training in social science research and interview methods. All sessions were audio-recorded on a Dictaphone with a smartphone as back-up in case of any technological issues, with the permission of the participant(s). If participants did not agree to be recorded I took comprehensive notes during the session and wrote these up immediately after the session.

Data collection methods were appropriate to a critical realist analysis, particularly the combination of interviews/FGDs and observations, as this allowed a measure of triangulation and deeper understanding of participants' (possibly implicit) perspectives rather than relying on one approach from which to draw explicit (and possibly erroneous) conclusions [75]. Triangulation involves combining several different methods to study the same phenomenon: if a similar conclusion or idea can be drawn from each method, this suggests that the conclusion is likely to be valid. Participant behaviours (e.g., laughing) may have added nuance to the interpretation of their words, particularly when discussing sensitive issues, as was sometimes the case in this study, and these were noted down during the sessions.

2.6.1 Semi-structured interviews

Justification

Semi-structured interviews are frequently used in qualitative research as they permit the researcher and the participant some flexibility during their discussion but also allow focus on issues that either consider are key to the desired outcomes of the research [109, 110]. This type of interview has been defined as designed to obtain 'descriptions of the life world of the interviewee in order to interpret the meaning of the described phenomena' [110]. Individual, semi-structured interviews were appropriate for this PhD as I was able to use a topic guide I prepared before the start of the fieldwork during the interviews, but this format also allowed me to prompt participants when I judged that they might have opinions or views or data of interest to additionally contribute to our discussion. If participants had anything they wanted to contribute that was not covered by the topic guide they were able to introduce topics at any point during the interview.

Tool development

The topic guide for community participants covered human-animal contact, biosecurity and food hygiene, environmental changes, health issues, and disease awareness, including any experience with awareness programmes. The topic guide for policymakers and healthcare practitioners covered participants' relevant experience, views on community awareness, and comprehension of governmental policy on zoonotic and infectious diseases. I was also interested in their experiences of what is being done to engage communities in policy development and implementation in Nepal. Topic guides are presented in Appendix 1.

Development of the topic guides for the semi-structured interviews and group discussions was informed by the literature review (Chapter 3), wider reading around the issues of zoonotic disease, my understanding of critical realism, and discussion with colleagues. I revised topic guides iteratively as needed. Colleagues in Nepal reviewed topic guides for relevance and socio-cultural appropriateness before interviews began.

Conduct

Interviews lasted approximately 30 minutes and were conducted in Nepali or English as chosen by the participant. Community interviews were run by me and Hari, with Hari translating participant responses. Interviews were audio-recorded using a Dictaphone, with the exception of three interviews in the informal settlement for which participants did not give permission to be recorded. All of the healthcare professional and policymaker interviews were conducted by me alone, in English. I conducted seven of the healthcare professional and policymaker interviews remotely using Zoom software (Zoom Video Communications Inc, San Jose). With permission, these interviews were audio-recorded with automatic transcription enabled. I reviewed and corrected the transcripts against the recording immediately after the interview.

Interviews usually took place in the participant's home, office or a café. If participants did not feel comfortable with one of these venues, for whatever reason, we went somewhere they agreed to be interviewed.

2.6.2 Focus group discussions

Justification

Focus group discussions usually consist of approximately six to 10 participants and the researcher as moderator, sometimes with a second researcher as a note-taker and/or observer [111]. Focus groups are perceived as more flexible and dynamic in comparison with semi-structured, individual interviews [109, 110]. They allow participants to have a more natural discussion between themselves, with the researcher either participating and directing the conversation to topics in which they are most interested, or withdrawing as far as possible to allow the discussants to direct the discussion [109, 110]. This means that ideas and concepts that are not on the topic guide can be introduced into the discussion, and this can be a fruitful research method, allowing participants to justify their opinions on relevant subjects.

Tool development

The topic guide for the FGDs covered the same topics as that for the individual, semi-structured interviews.

Conduct

Discussions lasted around 45-60 minutes and were conducted in Nepali by me and Hari, with Hari translating during the discussion. The FGD in Bhaktapur was conducted in a mixture of Nepali and Newari at participants' request: all participants were fluent in both languages. All FGDs were audio-recorded. Focus groups took place in the home of one of the participants, in a café, or in a quiet space outside, as appropriate and chosen by the group members.

2.6.3 Photovoice

Justification

Photovoice is a participatory research method that can be used with communities as a collaborative approach to data collection [112]. Participants take photographs and discuss the significance of these images for them in their particular context and situation [77]. A systematic literature review of studies using this method suggested that it can enhance understanding of community experiences, beliefs, behaviours and priorities [78, 113] and may be particularly useful in marginalised communities where people may be less familiar with traditional methods of enquiry such as interviews [114]. This is also true for participants who are less literate or less confident talking to people they do not know or necessarily trust [115, 116]. Participants can produce a physical image of their viewpoint, as something concrete from their reality, without relying on words alone [112]. Participants can be identified as such rather than as subjects of the research, which means the whole process may be perceived as more of a collaboration than an investigation [114]. This collaboration is central to a critical realist understanding, as it allows the participants to physically show us their beliefs, practices, and traditions, and their multiple roles, as, for example, community member, mother, member of women's group, farmer, business owner, and disposer of dead animals. Photovoice is an ideal tool to use with critical realism as it allows participants to demonstrate how they make sense of their world: what is (non-)significant for them and what they would like to know to allow them to have agency over their situation and the world around them [114].

Conduct

At the end of their interview, I asked participants who had engaged well with the interview and were enthusiastic to participate to use a simple digital camera to take photographs that illustrated their perceptions, feelings and beliefs around zoonotic disease risk in their community. They were then asked to describe why they had taken these images. As some participants had poor literacy, or may have felt intimidated about voicing their opinion, asking them to use photographs to illustrate their views may have encouraged them to talk and provided an additional rich source of valid, reliable data [117]. All photographs are presented with explanatory text in Appendix 2.

2.6.4 Unstructured observations

Justification

Taking notes of unstructured observations on any context, content or concept that appeared potentially significant or interesting that occurred during interviews or FGDs, e.g., how participants interacted with animals around them, or if they laughed or appeared uncomfortable while discussing certain topics, can provide insight into contextual factors and how these may relate to topics being discussed, or actions being taken (for example, photographing certain objects or situations) [118].

Conduct

During the semi-structured interviews and FGDs I made brief written observations on the 'three Cs' [118]: context, content, or concept. Every evening I wrote down any ideas, reflections and observations I had on the interviews or FGDs, or how people had responded during photovoice.

2.7 Data management

Recordings in Nepali were transcribed directly into English from audio recordings by a Nepali healthcare professional who was fluent in both languages and familiar with public health and infectious disease. Two of the first transcriptions were reviewed and back-translated by a second native Nepali speaker to ensure that the transcription accurately reflected the recording. I transcribed all interviews that were run in English. Terms used by participants for animal diseases were cross-checked with a Nepali veterinarian fluent in English to ensure that they represented the correct disease as far as possible, and to check for any nuance related to these diseases that might not have been obvious to the translator [119].

Interview and FGD transcripts were imported into NVivo software (QSR International Pty Ltd, Version 12, 2018) for data management.

I gave photographs taken by participants an identifying code and wrote a simple textual description. This description was imported into NVivo with the accompanying explanatory text from the participant who took the photograph.

The unstructured observation notes were imported into NVivo and used to generate a thicker, richer description of the phenomena being discussed. Thick description uses data from different sources to contextualise events and behaviour and aid in their interpretation [120].

2.8 Data analysis

2.8.1 Critical realist approach

As described above, critical realism posits that certain 'generative mechanisms' necessarily exist for us to experience events. These mechanisms are 'intransitive' (existing whether or not we detect them), 'transfactual' (they are not transitory, they are enduring), and govern events [121, 122]. These mechanisms are complex and can be cultural, physical, psychological, biological, socio-economic or normative, or a combination of these [123]. One of these mechanisms could be, for example, the effect of social structures, which imply power relations and different influences (e.g., the relationship between a community member and a traditional healer) and help to explain a phenomenon (e.g., in a focus group, why a person may stop talking when an elder opens their mouth to comment). However, mechanisms are influenced and constrained by context, with a particular context potentially altering an outcome by affecting the

mechanisms that produce it [124]. This underlines the importance of understanding the specific context in which research is done, for example, cultural and religious factors relevant to the place or people, as outcomes are contingent on the effects these factors have on mechanisms [125]. It also must be kept in mind that context is often not a tangible, stable 'thing' or event, but can be aspects that influence interactions (e.g., power relations and social status) and therefore processes and outcomes [126, 127].

2.8.2 Reflexive thematic analysis

Reflexive thematic analysis is a 'subjective situated engagement with data' [128]. During this analytical process the researcher interrogates what, how and why they are doing what they do, and how this affects their research and analysis. The generation of knowledge is subjective, not objective, and this subjectivity is a resource to be drawn on during the analysis. What effects do we have on the output? How do people react to us during the fieldwork? This has to be considered during the analysis.

Braun and Clarke discuss the ten core assumptions of reflexive thematic analysis, which include that the researcher is the primary tool for this type of analysis, and that codes and themes are generated by the researcher (they do not 'emerge' as is so often stated) – this is an active rather than passive process. Codes build into themes, which are patterns that share an idea, concept or meaning [128]. Effective analysis involves both a deep immersion into the material (in this case, interview and FGD transcripts, photovoice descriptions and notes, and unstructured observations), as well as time away from the data, allowing thoughts and ideas to coalesce [128]. I achieved this by performing an initial analysis on the data and then writing other sections of the thesis, before returning to the data and re-considering my codes and themes.

Codes are the result of the process of coding the data, locating interesting concepts, meanings or ideas associated with sentences or smaller fragments of text (or photographs, or observations, in this case) [128]. Themes are generated from these codes. This is a long and iterative process, and data can be (and usually are) coded to different themes, rather than a singular theme. This increases the richness of the data and allows identification of informative patterns. Codes contain one facet of a concept, whereas themes contain many facets of an overarching concept [128].

Inductive coding, rather than deductive, involves coding data without using a pre-existing structure [129], while taking into account the beliefs and background of the researcher who is responsible for coding the data. In practice, this meant that, although I took the dataset as the starting point for the analysis, I remained cognisant of my presence during the process, and my position with respect to the data, and how this may have affected my analysis. Therefore, the inductive orientation which I (and any other researcher) took could not be 'pure', as I was positioned in relation to the data, and was working with a topic guide during the interviews, and this inevitably affected my perceptions and understandings of the data [128].

Reflexive thematic analysis was discussed with regard to its use by One Health researchers by Hennessey and Barnett, two academics of veterinary epidemiology, in 2023 [130]. The authors acknowledge the importance of ontological and epistemological positioning and the specific theory that the researcher is using, combined with reflexivity (see section below). However, despite an exponential increase in the number of animal health-focused One Health papers using thematic analysis since 2007, they found that papers were not explicit about the theories that informed their work and analysis [130]. They argue that as data do not exist independently of theoretical positioning, findings from these papers are potentially not as useful as a form of knowledge creation as they could be. They recognise that many One Health researchers will have had little to no exposure to social science concepts, and are working with a set of 'taken-for-granted knowledges' that they have never examined critically. Instead of this concrete way of thinking, Hennessey and Barnett identify the key issue as the need to recognise that data only exist as a response to questions that researchers ask, the methods used to extricate these data, and researcher positionality [130].

2.8.3 Critical realism and reflexive thematic analysis

Examining the data through a critical realist lens involved placing the data from interviews, FGDs, photographs and observations in context, and considering how this context may affect interpretation by the participants and the interviewer. This process examines context and causal mechanisms: what are the necessary contextual factors that produce or cause the empirical event or understanding that participants are discussing? What type of context makes these events or ways of understanding possible? What type of context might prevent an event or an understanding (e.g., socio-cultural factors, financial factors, educational factors)? By deconstructing what people were saying or doing, I began to build a clearer, richer and more informative description of a likely explanation of what is actually happening, and why [122, 131, 132]. Thematic analysis, although outlining steps that should be taken during the analysis, is not linear or rigid, and allows the researcher to return to earlier steps in an iterative process, to gain the most from the data [74, 128].

I reviewed and coded all transcripts, explanations of photographs, and observation notes in NVivo, using reflexive thematic analysis though a critical realist lens to generate themes and sub-themes from the data. Traditionally, reflexive thematic analysis involves six steps: (i) data familiarisation; (ii) generating initial codes; (iii) generating themes; (iv) reviewing potential themes; (v) defining/naming themes; and (vi) synthesising findings and writing up [128, 129, 133]. Fryer describes a five-step critical realist approach to thematic analysis, that, in the main, mirrors these six steps: (i) develop a research question, (ii) become familiar with the data, (iii) apply, develop and review codes, (iv) develop and review themes (from codes), (v) generate conclusions and reports (or findings) [74]. This allows for the development of causal explanations (such as, as I shall discuss throughout this thesis, beliefs and opinions) for experiences and events. Part of developing

the codes (step 3) involves checking that these are descriptively valid (do the codes we have used accurately describe the data?) and interpretatively valid (do the concepts embodied in the codes accurately reflect the data?). Again, this is an iterative process, as sometimes codes may be amended, or data may be moved from one code to another [134]. Developing and reviewing themes (step 4) is related to causal explanations: these causal mechanisms result in the events and experiences that participants discuss during their interviews, or show us through their photography. Data, codes and themes (the latter two generated from reflexive thematic analysis) correspond to experiences, events and causes that are an integral concept of critical realism. The data are the transcripts, unstructured observations and photographs (experiences) generated during the fieldwork; the codes are descriptions of these experiences (events); and the themes are the mechanisms that we can postulate as causing the experiences and events [74]. To give an example from Chapter 4 of this thesis: data = transcripts, observations and photographs; codes = experience of disease, perceptions of rabies, livestock and disease, and sources of information; and themes = disease awareness, and beliefs and behaviours. The reviewing part of step 4 means questioning the validity of our themes and causal explanations: for example, do they make intrinsic sense? Are they appropriate? Have they been discussed in earlier research? Do participants use these explanations themselves? [134].

Coding the interviews, FGDs, photovoice and observations involved familiarisation, spending time with the four types of data and identifying any initial, overarching themes: looking for common patterns in the data, e.g., issues that may have been mentioned, discussed or represented by more than one participant. This is an iterative process, as themes can be added or modified while the data are being read and analysed. Once I had generated initial codes I examined how (and whether) these codes formed coherent themes. This process involved placing the findings in context and examining how context may have affected interpretation by both the participants and me as the interviewer. I then began to reason further about why the data appeared the way they did [9]. During this process the researcher examines context and causal mechanisms, e.g., why people do not wash their hands after helping a cow give birth, or do not avoid drinking raw palm sap. What are the necessary contextual factors that produce the empirical thing observed? What type of context (e.g., power relations, lack of finances) makes these actions (or non-actions) possible? What different explanations can we suggest for phenomena we have observed [135]?

Bringing critical realism and reflexive thematic analysis together, an analysis informed by critical realism considers the interplay of social and cultural beliefs and the material world, and how this interplay might affect participants' sense-making of their reality. Critical realism allows researchers to capture lived experiences in that particular moment, but understand that these experiences are situated in a particular context [128]. We must also remember that communities are not one homogenous, coherent mass with shared beliefs and values, they are a collection of individuals. Power relations are always going to be in play, with people benefitting from some events or processes, and others not. Using these two approaches together

allowed me to access participants' interpretation and account of their reality, rather than a decontextualised, objective 'truth', which critical realists would argue does not, and cannot, exist [99].

Doing thematic analysis with a critical realist approach means that we are aiming to say something about causation, which it is often assumed that qualitative research cannot do [74]. Attempting to unpick why (or why not) communities use certain mitigatory activities that may reduce the risk of zoonotic disease, I aimed to describe or explain some of these causative factors. This is linked to our participatory axiology – asking communities to participate, without trying to understand these factors, could potentially be read as unethical and exploitative: simply trying to mine participants for information, rather than for something that could be useful for the community members taking part in the research.

2.9 Positionality and reflexivity

2.9.1 Positionality

Positionality is how we understand ourselves: who we are and how that might affect or shape our research. Reflexivity is a process where we are mindful of, and continually question and challenge, our beliefs and responses to what others are telling us, during all stages of the research project, from beginning to end [7]. Producing research and knowledge, interpreting findings and writing these findings up into a coherent form, is never neutral but always includes values and judgements and assumptions, whether implicit or explicit [8, 136]. It is important that researchers consider the potential impact of their beliefs, biases, experiences and emotions during the life of the research project [137], particularly if they are writing up their findings and conclusions from the perspective of their own, 'foreign gaze' [138].

As a relatively privileged, white, educated English woman I was different from the participants in this project. Despite having a relatively good knowledge of Nepali culture, and having lived and worked in Nepal intermittently since 2006, I was aware that I brought my own cultural values, preconceptions, and assumptions into planning, conducting, analysing and writing up the research. Being an objective observer is impossible, as the researcher, with their social, political and educational values, their motivations and hopes, is part of the context during the work. This must be kept in mind while analysing findings and developing conclusions [8]. As a member of LSHTM staff I was able to access the School's Decolonising the Curriculum toolkit, and actively participated in the associated online fora, discussing aspects of my work with colleagues and reflecting on their feedback. This helped me focus as I worked through all stages of the project.

While planning the study I discussed the methodology with Professor Singh and other Nepali colleagues, including an infectious disease specialist at Sukraraj Tropical and Infectious Disease Hospital in Kathmandu. The PhD proposal was reviewed by Professor Singh and two of my Nepali colleagues, who provided important

feedback, particularly on cultural and (potentially) political aspects of what I wanted to research, which they judged appropriate and likely to help meet the objectives of the project. I was careful during interviews to not make my views on politics in Nepal evident. I did not want to be perceived as blaming the country's government for not having enough resources to optimally address relevant issues. Resources in Nepal have by necessity to be spread thinly and I tried hard to keep that in mind during interviews, while analysing data, and when writing up findings.

During the interviews and FGDs I expected my obvious outsider status to affect some of the interactions with participants, in both positive and negative ways. Most participants in the six communities had little to no experience of interacting with, and may have been suspicious of, foreigners or strangers in their community. People who live in Western cultures are used to being interviewed and asked about their opinions but this cannot be assumed of others [109]. These interviews were the first time most of the community participants had been asked their views and experiences on any issue, by anyone, and they may have felt uncomfortable being open about what could have been an emotive or politically charged topic. Some were confused about why I had travelled to Nepal to ask their opinions and discuss issues with them that they did not even perceive to be issues. Many participants took time to really understand why I was doing what I was doing – why fly halfway across the world, and spend money doing so, to ask them about how they interacted with their livestock, or how they dealt with rodents in their house? In many ways their questions made more sense to them than mine did.

Being an 'outsider' does have advantages: 'insiders' (i.e., people who are part of the community involved in the research) may be too close and their personal experience may affect their expectations or the way they interact with the participants [139]. Talking to me may have helped them feel more confident about doing so. However, participants may have felt that they 'needed' to tell me what they thought I wanted to hear. On the other hand, as I am obviously different to participants, they may have found it easier to discuss issues openly with me.

When they heard my name during the introduction to the research project and the consent procedures, participants were usually surprised, as the second part of my surname is Nepali (my first husband was Nepali). This suggested that I was not such an outsider as they may have originally thought, and was a good way of breaking the ice as participants then began to ask questions about me and my background, and, if they were from the same (kshatriya) caste or region as my ex-husband, they often asked questions about his family and upbringing. In these cases it was a two-way exchange of information rather than participants answering questions with no reciprocity. Participants appeared to enjoy the process as it, possibly, made them feel that I was giving something (personal details) in exchange for their knowledge and experiences. Many times we

finished an interview, turned off the Dictaphone, and people offered us tea and snacks and wanted to continue what had become a social event.

Having Hari, a Nepali man, present during the interviews may have encouraged some participants to talk, particularly as some men may have felt more comfortable discussing issues with another man, who may have appeared more familiar and, perhaps, more credible to them. Hari is from a rural area of the west of the country and has extensive experience of running qualitative interviews with different groups in Nepal. During the fieldwork he was effective at making participants feel comfortable and encouraging them to talk. I can speak conversational Nepali and so I was able to discuss some issues with participants directly. My, albeit basic, language ability appeared to allow some participants to open up and discuss their views, and most addressed me directly during the interviews.

2.9.2 Reflexivity

During fieldwork I kept a reflexive journal and I return to reflexivity at the end of the Discussion in Chapter 7.

2.10 Ethical considerations

2.10.1 Ethical approval

The Nepal Health Research Council (ref: 2193) and London School of Hygiene & Tropical Medicine Observational Research Ethics Committee (ref: 26507) provided ethics approval for the study.

2.10.2 Potential harms and benefits

This was an observational rather than interventional study, involving procedures including taking consent, running interviews and group discussions, and accompanying participants as they took photographs. None of these procedures should have caused discomfort to the participants but they were encouraged to discuss anything that made them uncomfortable with me or Hari, and were reminded that they could stop participating at any point. There was no physical risk to any of the participants but there may have been issues with them trusting outsiders who they had not previously met. If participants did not wish to discuss various aspects of the topic guide these were omitted. If participants did not wish to take photographs they did not have to do so.

This research involved people living in rural or urban areas with little access to healthcare, and who may have had low literacy, especially the participants living in the informal settlement in Kathmandu. These participants were understandably slightly reticent about giving consent and having their responses recorded. Of the four interviews we ran in the informal settlement, three were not recorded, at participant request. Instead Hari did simultaneous translation and I took notes and made observations during the interviews.

It was evident that many participants actively enjoyed participating in the research, particularly those who were asked to take photographs. Many participants told us that this was the first opportunity they had had to discuss issues like this, and, in fact, to discuss any issues at all with someone external to their community. This could be perceived as a benefit to participants.

2.10.3 Informed consent

The informed consent form and information sheet were translated into Nepali from simple, clear English by a Nepali healthcare professional. These documents were then back-translated into English and checked by me to ensure that the sense had not changed. The information sheet and consent form, and the study as a whole, were explained to potential participants before any other study procedure took place. If they agreed to participate, participants were asked to sign a consent form or give verbal consent confirming that they had read the study information sheet. The consent of illiterate participants was witnessed by a person unrelated to the study team and selected by the participant, after thorough explanation of the relevant documents. Participants were given a copy of the information sheet to keep.

2.10.4 Privacy and confidentiality

It was made very clear to potential community participants that their responses would only by heard by me and Hari (in individual interviews), or the other participants in FGDs. All policymaker and healthcare professional interviews were run by me alone. I informed participants that if I quoted from their interview these quotes were included using a code rather than initials. If participants did not want their words quoted they were able to request this (although none did so). No identifying information (names, exact locations or dates of interviews) is included in any of the thesis chapters. We asked each participant if they were clear on all the above before they signed the informed consent form.

Photographs taken by participants were not labelled with their name. People who participated in the photovoice part of the fieldwork were asked to try and avoid taking photographs of people, unless these were key to their ideas. Any photos in which people were identifiable without their consent were to be deleted immediately at the site. People who agreed to be photographed were to be asked to sign or thumbprint a specific photography participant consent form. In practice, no participant photographed a person during the study.

All recordings and photographs were assigned an alphanumeric code for confidentiality. Signed informed consent forms were scanned and shredded. Electronic data were password-protected and only accessible to the study team.

During the fieldwork individual data files (audio recordings/photographs) were password-protected and stored on my password-protected laptop and on a password-protected external hard-drive. At the end of each day files were uploaded to the LSHTM secure server. All equipment was locked in a safe where possible (e.g., in hotels). At the end of the project, data were stored on the LSHTM secure server, in line with LSHTM standard operating procedures, and I deleted all data from my laptop and external hard-drive.

2.10.5 Covid-19 protocol

As a result of the COVID-19 pandemic, I was aware that some participants may have felt uncomfortable about taking part in case of infection and so we took supplies of masks and hand sanitiser with us and offered these to participants. However, although COVID-19 was frequently mentioned as a relevant topic by participants during the fieldwork, none of them requested masks or sanitiser. The pandemic also meant that I had to take a 9-month interruption of studies as I was unable to travel to Nepal for fieldwork during this period.

Chapter 3: Drivers of zoonotic disease risk in the Indian subcontinent: a scoping review

3.1 Chapter introduction

This chapter presents the scoping review I did to inform the PhD. The review focused on literature around the potential anthropogenic drivers of zoonotic disease risk in the Indian subcontinent. I included 80 sources that reported relevant findings, with most reporting research from India (39%) or Bangladesh (31%), and 9% of sources focused on Nepal. People generally did not seek post-exposure prophylaxis for rabies even when vaccination programmes were available and they understood that rabies was fatal, instead often relying on traditional medicines. Similarly, people did not take precautions to protect themselves from leptospirosis infection, even when they were aware of the link with rice cultivation. Nipah was correlated with presence of bats near human habitation. Official information on diseases, modes of transmission and prevention was lacking, or shared informally between friends, relatives, and neighbours. Behaviour did not correspond to disease knowledge. The review identified various human behaviours which may drive zoonotic disease risk in the region. I found that awareness of risk was not sufficient to successfully change behaviours that put people potentially at risk of zoonotic disease. I concluded that further research, using interdisciplinary and participatory methods, would improve understanding of risks and risk perceptions and thus help in co-designing context-specific, relevant interventions.

This paper was published open access in the peer-reviewed journal One Health in August 2021 (https://doi.org/10.1016/j.onehlt.2021.100310) [28]. I assert my right to include this paper in this thesis: as per Elsevier's copyright policy, authors have the right to 'use and share their works for scholarly purposes (with full acknowledgement of the original article): include in a thesis or dissertation' (https://www.elsevier.com/en-gb/about/policies-and-standards/copyright).

3.2 Research paper

The research paper cover sheet is presented below, followed by the paper.

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed <u>for each</u> research paper included within a thesis.

<u>SECTION A – Student Details</u>

Student ID Number	1408190	**Title**	Ms
First Name(s)	Anna		
Surname/Family Name	Durrance-Bagale		
Thesis Title	Drivers of zoonoses spillover in Nepal: Community priorities		
Primary Supervisor	Associate Professor Natasha Howard		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

<u>SECTION B – Paper already published</u>

Where was the work published?	One Health		
When was the work published?	14 August 2021		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	Not applicable		
Have you retained the copyright for the work?*	**Yes**	Was the work subject to academic peer review?	**Yes**

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Where is the work intended to be published?	
Please list the paper's authors in the intended authorship order:	
Stage of publication	Choose an item.

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I performed the data collection and analysis, and wrote the first draft of the paper. I incorporated other authors' comments, submitted to the journal, dealt with peer-reviewer comments and proof-read the final version.

SECTION E

Student Signature	[redacted]
Date	26/03/2024

Supervisor Signature	[redacted]
Date	26/03/2024

Drivers of zoonotic disease risk in the Indian subcontinent: a scoping review

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Abstract

Literature on potential anthropogenic drivers of zoonotic disease risk in the Indian subcontinent is sparse. We conducted a scoping review to identify primary sources, published 2000-2020, to clarify what research exists and on which areas future research should focus. We summarised findings thematically by disease.

Of 80 sources included, 78 (98%) were original research articles and two were conference abstracts. Study designs and methods were not always clearly described, but 74 (93%) were quantitative (including one randomised trial), five (6%) were mixed-methods, and one was qualitative. Most sources reported research from India (39%) or Bangladesh (31%), followed by Pakistan (9%), Nepal (9%), Bhutan and Sri Lanka (6% each). Topically, most focused on rabies (18; 23%), Nipah virus (16; 20%) or leptospirosis (11; 14%), while 12 (15%) did not focus on a disease but instead on knowledge in communities. People generally did not seek post-exposure prophylaxis for rabies even when vaccination programmes were available and they understood that rabies was fatal, instead often relying on traditional medicines. Similarly, people did not take precautions to protect themselves from leptospirosis infection, even when they were aware of the link with rice cultivation. Nipah was correlated with presence of bats near human habitation. Official information on diseases, modes of transmission and prevention was lacking, or shared informally between friends, relatives, and neighbours. Behaviour did not correspond to disease knowledge.

This review identifies various human behaviours which may drive zoonotic disease risk in the Indian subcontinent. Increasing community knowledge and awareness alone is unlikely to be sufficient to successfully change these behaviours. Further research, using interdisciplinary and participatory methods, would improve understanding of risks and risk perceptions and thus help in co-designing context-specific, relevant interventions.

Keywords: Zoonoses, zoonotic disease, Indian subcontinent, leptospirosis, rabies, Nipah virus

Introduction

Emerging zoonotic diseases represent a growing threat to global health, particularly in countries that may lack the finances and infrastructure to address them effectively [13]. Globally, over 60% of human infectious diseases are caused by pathogens shared with wild or domestic animals [15, 140]. Investigating the human-animal interface is essential to understanding the emergence of zoonotic diseases and possible prevention mechanisms [18]. Concentrated small mammal densities, different species living in close proximity, and anthropogenic encroachment on habitats that disturb existing ecosystems all affect the dynamics of emerging zoonotic disease [10, 141]. Synanthropic rodents are associated with fragmented and human-dominated landscapes, increasing the likelihood of zoonotic spillover [17].

Threats posed by zoonotic diseases are global but especially pertinent in low-income countries, where a range of socio-economic, environmental and other contextual factors often converge to increase risks of, and vulnerability to, disease outbreaks. These factors include fragile and poorly resourced health systems, rapid population growth, increased urbanisation, variable literacy, economic vulnerability, consumption of bushmeat (raw or minimally processed meat from wild animals [2]), and anthropogenic encroachment on wildlife habitat associated with agriculture and other land use changes [10, 15, 21-24]. In addition, spillover events are likely to be under-reported in resource-poor settings as communities have little access to healthcare and diagnostics, government-recommended disease prevention measures are not widely followed, and surveillance mechanisms are either poor or non-existent [25, 26].

Working within existing cultural beliefs and practices is essential to reducing incidence of emerging zoonotic diseases, including leptospirosis (i.e. rodents as primary reservoir, but many other host animals potentially involved), rabies (i.e. dogs as primary reservoir, bats also recognised), and Nipah virus (NiV; i.e. fruit bats as primary reservoir). Leptospirosis and rabies are serious issues throughout the subcontinent while NiV, with a case fatality rate of 70%, is present in India and Bangladesh [43, 44, 50] and one of the ten highest-priority pathogens globally [142]. A recent study found that risk of zoonotic disease spread was increased in tropical areas, including the Indian subcontinent, that are undergoing changes in land use related to agriculture, and with high wildlife biodiversity [22].

This review aimed to synthesise existing evidence on anthropogenic, behavioural and environmental drivers of zoonotic disease risk in the Indian subcontinent. Objectives were to: (i) summarise the scope (i.e., extent and nature) of the literature focused on this geographical area; (ii) synthesise major anthropogenic and environmental drivers of zoonotic disease risk; and (iii) identify key areas for further research.

Methods

Study design

We conducted a scoping review, adapting Arksey and O'Malley's classic six-stage scoping framework with later revisions [143-146]. Scoping reviews are preferable to a systematic review when the existing literature has not been reviewed comprehensively or 'exhibits a complex or heterogeneous nature not amenable to a more precise systematic review' [146].

Stage 1: Defining the research question

Our primary research question was: 'Which environmental, cultural, and behavioural factors may drive potential zoonotic disease spillover in the Indian subcontinent?' The review included all primary research related to factors that may drive risk of zoonotic disease in the chosen geographical area. Our working definitions are presented in Table 1.

Table 1. Working definitions

Anthropogenic	Anthropogenic effects, processes, objects, or materials are those that are derived from human activities, as opposed to those occurring in natural environments without human influences [147]
Behavioural	The way in which one acts or conducts oneself [148]
Cultural	Shared patterns of behaviours, interactions, cognitive constructs, and understanding that are learned by socialisation [149]
Driver	Any natural or human-induced factor that directly or indirectly causes a change [150]
Environmental	The conditions in which a person, animal or plant lives or operates or in which an activity takes place [151]
Indian subcontinent	Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka (https://en.wikipedia.org/wiki/Indian_subcontinent)
Spillover	Process in which an infectious agent is transmitted into a novel host species [10]
Zoonotic disease	Disease passed from a vertebrate non-human animal to a human (https://www.who.int/news-room/fact-sheets/detail/zoonoses)

Stage 2: Identifying relevant studies

First, we searched six electronic databases systematically (Global Health, Global Index Medicus, MEDLINE, EMBASE, PsycINFO and Web of Science) to ensure comprehensiveness. We used relevant terms and related terminology for the topic, adapted to the subject headings for each database as applicable. For example, Box 1 shows the MEDLINE search. Second, we hand-searched reference lists of all eligible papers purposively. Third, we asked stakeholders to identify any additional sources (Stage 6).

Box 1. MEDLINE search strategy

1 (Zoono* or reservoir* or "animal-to-human" or "human-to-animal" or "animal-human" or "human-animal").mp
2 Zoonoses/
3 1 or 2
4 (spillover* or outbreak* or emerging or emergence or emergent or emerged or reemerging or re-emerging or re-emergent or reemergent or re-emergence or interfac* or interaction* or contact* or exposure*).mp
5 Disease outbreaks/
6 communicable diseases, emerging/
7 4 or 5 or 6
8 (Bangladesh or Bhutan or India or Maldives or Nepal or Pakistan or Sri Lanka or Indian subcontinent).mp
9 exp Bangladesh/ or Bhutan/ or India/ or Maldives/ or Nepal/ or Pakistan/ or Sri Lanka/ or Indian subcontinent/
10 8 or 9
11 3 and 7 and 10
12 11
13 limit 12 to yr="2000 -Current"

Stage 3: Selecting studies

We established eligibility criteria iteratively, with initial criteria based on the research question and geographical area. Studies had to meet all criteria to be included. Documents in English and French were included as most relevant, as other publishing languages (e.g., Chinese, German) are not typically associated with such research on the Indian subcontinent. We included studies from 2000 to September 2020 (the search date) to keep the number of studies identified manageable and of contemporary relevance. All study designs, interventions and participants were included as applicable. As there is little research on this area, drivers and risk factors did not need to be a primary objective of the study but primary data on environmental, behavioural, or cultural factors in the context of zoonotic risk had to be presented for the paper to be eligible for inclusion. Studies that did not include human participants were included if they discussed pertinent data (for example, if they included information about bat roosting sites and the proximity of such sites to human habitation, or potential effects of different factors on disease risk for human populations). Studies that focused solely on wildlife sampling without discussing potential effects on human populations and habitations were not included. All authors agreed final inclusion criteria: primary research articles published since 2000 in English or French, which focused on the Indian subcontinent and examined behavioural, cultural or environmental factors, defined in Table 1, in the context of zoonotic disease risk.

Documents were imported into EndNote (Version X9; Clarivate Analytics), where duplicates were removed. The remaining documents were imported into Covidence systematic review software (Veritas Health Innovation, Australia) where titles and abstracts were first screened to assess potential relevance. Articles included at this stage then underwent full-text screening against eligibility criteria. Finally, reference lists of

all eligible articles were iteratively checked for any additional documents to assess for eligibility, resulting in the total number included (Figure 1).

Stage 4: Charting data

Information was extracted from included sources into an Excel spreadsheet with the following headings: (i) source identifiers: i.e., lead author, publication year; (ii) source characteristics: i.e., country, disease focus, study discipline, primary objective, study design, study population; and (iii) key findings in relation to drivers of zoonotic risk.

Stage 5: Collating, analysing and reporting results

Documents were summarised by publication year, country, and disease focus. Extracted data on evidence and findings across studies were then analysed thematically using deductive and inductive coding as described by Braun and Clarke [129].

Stage 6: Consulting stakeholders

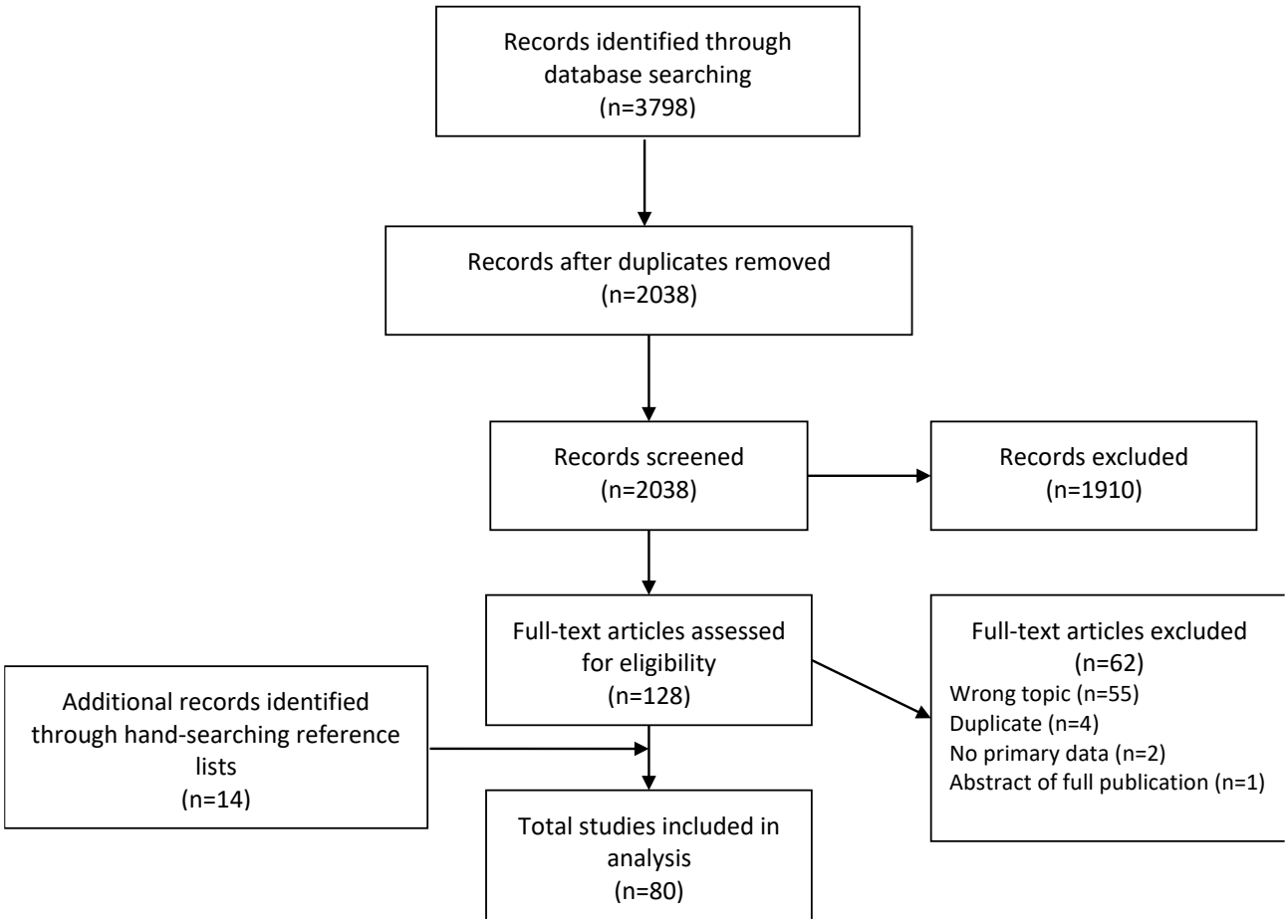
We contacted three zoonosis experts from the region to obtain their feedback on our initial findings and any suggestions for additional studies that might meet eligibility criteria. Two provided feedback, stating our findings made sense in terms of regional context but neither suggested additional studies for inclusion.

Results

Extent, nature, and distribution of literature

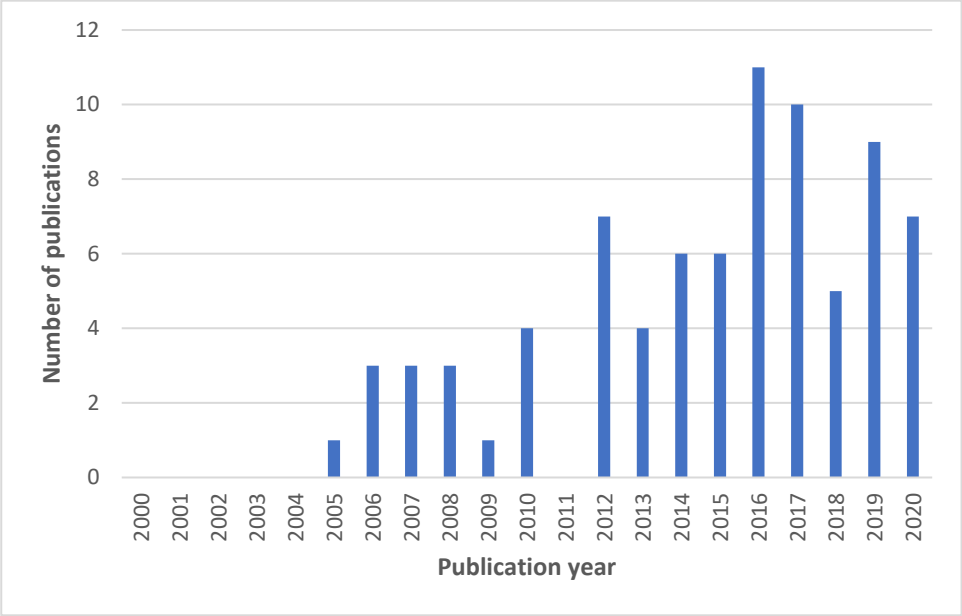
The database search retrieved 2,038 unique records after removal of duplicates, of which 66 met the eligibility criteria. A further 14 sources were identified through hand-searching the reference lists, while no additional sources were identified through stakeholder consultation, giving a total of 80 included articles (Figure 1).

Figure 1. PRISMA diagram



No eligible sources were published between 2000 and 2004, followed by an increase in the annual number of publications since 2005, with a peak in 2016 (Figure 2). More details of the sources included are presented in Table 2.

Figure 2. Number of sources by year of publication



With the exception of two conference abstracts, all sources were original peer-reviewed research articles. Study designs and methods were not always clearly described, but 74 (93%) were quantitative (including one randomised trial), five (6%) were mixed-methods, and one was qualitative. Quantitative studies were predominantly cross-sectional (50/74; 68%).

A few studies clearly described their sampling methods, while most provided minimal or no explanation. Fifty-three (66%) studies appeared to use convenience sampling although sampling methods were not clearly described in most sources.

Geographical distribution of sources was not even. Most reported research from India (31; 39%) or Bangladesh (25; 31%), followed by Pakistan (7; 9%), Nepal (7; 9%), Bhutan and Sri Lanka (5 [6%] each), and none from the Maldives. No sources reported multi-country results.

Topically, most focused on rabies (18; 23%), NiV (16; 20%) or leptospirosis (11; 14%), while 12 (15%) did not focus on a particular disease but instead on general zoonotic disease knowledge in communities. Study populations were predominantly the general public (approximately 40%), while 33% were in occupationally exposed populations, e.g., livestock farmers or bat harvesters. Sixteen (20%) sources included people with suspected or confirmed diseases of interest, e.g., NiV, rabies, leptospirosis and brucellosis. Seventeen (21%) sources examined risk factors for zoonotic disease as an explicit objective.

Findings by disease

Findings are summarised under rabies, NiV and leptospirosis - the most frequently researched diseases, and 'other diseases' as appropriate. Table 3 presents a summary of key drivers for, and factors associated with, zoonotic disease risk in this geographical area.

Rabies

Fifteen sources described behaviour related to rabies, particularly behaviour of people bitten by a potentially rabid animal. Ahmed and colleagues found people bitten by dogs in Pakistan did not seek post-exposure prophylaxis or vaccinate their domestic dogs even when aware of the existence of vaccination programmes. This was true despite 70% of participants knowing rabies was a vaccine-preventable disease and 75% understanding that it was fatal [152]. Similar responses were found in Bangladesh, with most participants (32%) not treating bite wounds before attending hospital for post-exposure prophylaxis, 22% applying antiseptic or water, 14% applying soap and water, and 15% applying products such as lime, soda, salt and kerosene oil [153]. Another study in Bangladesh also reported use of traditional treatments after dog bite [154], with 59% seeking treatment from healers before attending hospital and only 2% cleaning wounds properly with soap and water. In India, 64% of dog bite victims did nothing or adopted 'religious practices' to prevent rabies [155].

Fourteen sources described drivers of rabies related to lack of awareness and understanding of the disease, its causes and prevention. Communities often reported low awareness of rabies, in terms of preventing bites and behaviour following a bite or other contact with potentially infected animals [152, 153, 155-169]. Some sources discussed community beliefs and the use of traditional medicines as prevention or post-exposure prophylaxis [153]. Studies in India found some participants had heard about rabies, but knowledge of first-aid following a bite was poor, with application of chillies, turmeric or kerosene and visiting traditional healers recommended [157, 159, 161]. In two Pakistan studies, most participants stated there had been no rabies awareness campaign in their community [152], with similar findings in India [156, 159] and another study from Pakistan [162]. People reported getting their information from friends, family and neighbours, with women who had received no formal education likely to be less aware of the disease [156]. Other common sources of information included media and television [154, 161]. One study in Pakistan found that half of participants were informed about rabies by community elders or neighbours and only 1% learnt of the disease from an animal health official [162]. Brookes and colleagues found that 73% of participants in India received information on rabies from friends and neighbours, with few having been made aware by a public health official or at school (6%); none of the interviewees had heard rabies mentioned in the media or in a specific awareness campaign [156].

Although 93% of study participants in Pakistan knew dogs were the main transmitters of rabies, only 40% said they would visit hospital if bitten by a dog [162]. Brookes and colleagues found Indian farm workers who

learnt about rabies from a veterinarian were more likely than non-farm workers to use traditional prevention remedies [156]. A study of cattle owners in Bhutan found most who had heard of rabies had heard from a neighbour and only 22% had participated in animal health or rabies training [158]. In Bhutan, most community participants said they would report a suspected rabid dog to the authorities, although 50% of them admitted allowing their dogs to interact with feral dogs. Another study in Bhutan indicated most people had received rabies education from veterinarians and public health officials [163].

The role of human or animal rabies vaccination was not commonly understood. An Indian study found only 43% of participants were aware of a human vaccine while 57% stated vaccinating dogs would help prevent rabies [161]. In two other studies in India, 70-75% of participants believed rabies was curable [155, 160]. Knowledge of rabies symptoms in dogs was low among participants in a study in Bangladesh [153]. The main environmental driver of rabies, identified in three sources, was the presence of stray dogs in communities [153, 170].

Leptospirosis

Ten sources described behaviour relevant to leptospirosis. A cross-sectional study in Pakistan found people exposed to rice paddy water, e.g. through rice cultivation, had almost 7 times higher odds (p-value not calculated) of being seropositive for leptospirosis than those unexposed [171]. In India risk factors including working in mines, exposure to cattle, and open defecation were significantly associated with leptospirosis seropositivity [172]. A study in Sri Lanka identified residing on or working close to a farm and handling cattle as risks significantly associated with leptospirosis infection [173], while another, examining behaviour of secondary students, found only 18% involved in cultivating rice used gloves or boots while doing so and 13% bathed in stagnant water [102].

Two sources studied awareness of leptospirosis in Sri Lanka. Paddy field farmers were significantly more aware of leptospirosis than were other community members, as were people living in endemic areas. Most participants knew rats were a reservoir (94%), whereas only 3% knew cattle and buffalo could also act as reservoirs [174]. Sources of leptospirosis information mentioned by secondary schoolchildren living in a rural endemic area included television, school, newspapers, and educational programmes, with 50% having accurate knowledge of the disease [102].

Eleven sources examined environmental drivers of leptospirosis. Studies in India identified rat infestation of housing and proximity to water bodies as significant risks for leptospirosis [172, 175-178], while in Nepal associations were found between leptospirosis and contact with livestock [179]. Working in paddies was identified as a high-risk occupation by 90% of participants in Sri Lanka, and 58% were aware of water being the main mode of transmission [174]. Climatic conditions were significantly associated with risk of

leptospirosis in a study in Pakistan [180]. Seroprevalence was highest in humid sub-tropical climatic regions (51%), followed by semi-arid regions (44%) and lowest in hot and dry regions (28%).

Nipah virus

Ten sources described behaviour related to the risk of NiV, which is strongly associated with human-bat proximity and contact [181-190]. All sources mentioned bat contacts, with risk factors for NiV infection including proximity during bat breeding season [181], consuming raw or fermented date palm sap, and climbing trees in which bats were observed [101, 182-187, 191, 192]. In one Bangladesh outbreak, those infected with NiV had almost 5 times higher odds (adjusted odds ratio 4.91, 95% CI 3.16-7.65) of having consumed raw date palm sap than controls [183]. Another study found the odds ratio to be 7.9 (95% CI 1.6-38) [185]. One of 11 NiV deaths occurred in the son of a date palm sap collector, who reported hearing bats in his trees at night and having seen bat excrement in the sap collection pot. This collector had sent fresh sap to his relatives, two of whom died from encephalitis believed to be related to NiV infection, although this infection was not confirmed [185]. Bat hunting and feeding potentially contaminated dropped fruit to livestock were frequently reported behaviours in two studies in Bangladesh [193, 194]. Bats were eaten or used as medicine in rural communities [194] and 94% of households reported bats consuming fruit from trees on their property [193].

One source discussed insufficient awareness as a driver of disease risk in a NiV-endemic area in Bangladesh, finding that 50% of participants reported drinking raw sap, while only 5% were aware of NiV. However, participants who were aware of the possibility of infection from consuming raw palm sap were as likely drink it as those who were unaware (i.e., 69% versus 67%) [101].

Twelve sources, all from Bangladesh, discussed environmental drivers of NiV. A case-control study found NiV cases were associated with living close to trees used as bat roosts (odds ratio 40.1, 95% CI 3.9-416.7) or having bats near the house during the day (odds ratio 6.5, 95% CI 1.1-37.5) [182]. Living in areas near where bats were observed was cited as a potential driver in many papers [101, 182-187, 191, 192]. An outbreak investigation found villages affected by NiV were more likely to contain habitat suitable for *Pteropus* gigantus (odds ratio 2.6, 95% CI 1.2-5.8), considered the main transmitter for NiV infection, than unaffected villages [195]. Outbreaks in central and northwest Bangladesh occurred in villages with higher population densities and fragmented forests, suggesting human population density and encroachment on wildlife habitats can affect NiV spillover into humans [196]. Hegde and colleagues found that, after controlling for date palm sap consumption, age, and sex, NiV cases were significantly associated with nocturnal bats around homes in the month preceding illness [183]. Infrared photographs demonstrated that *Pteropus* bats visited date palm trees during sap collection to lick the sap [197]. Cortes and colleagues analysed data from 57 NiV spillover events

(2007-2013) and found that these were associated with low temperature and lack of rainfall, accounting for 36% of variation in the total number of spillover events each winter [198].

Other diseases

Eight sources described behavioural drivers related to transmission pathways of brucellosis, including consumption of raw milk [199-201], and lack of handwashing and general hygiene, especially when milking or birthing cattle [158, 199-203]. Occupational exposure was also discussed [204]. One source described behaviours related to avian influenza, including keeping poultry in the house [205, 206] and close contact with sick birds [207, 208]. A study on knowledge of campylobacteriosis in India demonstrated that no interviewees knew anything about the disease [209].

Other drivers included beliefs that visiting a shrine would help treat disease [199], lack of formal training on animal husbandry [210], and little awareness of disease transfer from animal to human [211-215] or animal to animal [216, 217]. Knowledge of disease was shared between relatives and friends rather than through formal routes [207, 218-220]. Illiterate or informally educated female smallholders had much less understanding of zoonotic disease risk than male smallholders in a study in Nepal [40]. Two sources discussed environmental drivers of Japanese encephalitis in Nepal, including proximity to water sources, poultry and pigs being raised coterminously, and the presence of wild birds close to the house [210, 221].

Structural issues included lack of vaccination or access to veterinary advice as risk factors related to anthrax [222]. These were also mentioned for Japanese encephalitis [210, 221], canine echinococcosis [223], brucellosis [201], hepatitis E [224] and zoonotic disease generally [206, 225].

Discussion

We aimed to synthesise existing evidence on potential drivers of zoonotic disease risk in the Indian subcontinent.

Scope of literature

For our first objective, summarising the scope of existing literature, we identified 80 sources describing primary research on potential drivers of zoonotic disease risk in this geographical area. Three diseases, rabies, NiV and leptospirosis, were most commonly researched, although disease drivers overlapped considerably. Descriptions of study designs and methods, including how populations were sampled, were often unclear. Sources were heterogeneous in terms of methods used and populations included, but some clear trends were evident, in terms of both geographical location of studies and diseases researched. Most studies focused on India and Bangladesh, with rabies, leptospirosis and NiV the most frequently researched diseases. Rabies is a fatal and widely known disease, whereas NiV and leptospirosis, which are both related to

occupational hazards such as raw palm sap harvesting and paddy planting, are potentially more likely to disproportionately affect rural communities with fewer resources rather than urbanised populations.

Major potential drivers

For our second objective, synthesising major potential drivers of zoonotic disease risk, the most recurrent was 'lack of awareness'. Information was usually shared informally between friends, relatives, and neighbours, with little available from official channels. Importantly, even when official information was available, and communities were aware of disease transmission, this was not reflected in behaviour change. For example, despite propagation of readily accessible messages about the dangers of consuming raw date palm sap by the Government of Bangladesh, including 'do not drink raw sap' and 'avoid drinking raw sap' outbreak-affected communities continued to do so [101].

Most authors did not engage critically with the issue of whether there is a need for awareness of modes of disease transmission for community behaviour change, or discuss why people may choose to not change their behaviours. One potential reason for the lack of association between awareness and behaviour change appears related to lack of access to expert knowledge on how to treat animals [167, 206, 211, 226]. Another reason may be the preference for traditional medicines. This lack of behaviour change could be related to cultural practices, or may relate primarily to structural issues such as community poverty and lack of access to healthcare providers and veterinarians. For example, much of the population of Nepal, one of the countries covered in this review, has little to no access to qualified healthcare providers, particularly in remote and rural regions: 41% of rural communities have no access to a health post, and 80% do not have access to a public hospital within 30 minutes of their home by public transport [42]. Many families are unable to afford veterinary care, even when it is available, and must treat their livestock themselves. Similarly, those bitten by potentially rabid animals may self-treat to avoid the expense and effort of visiting a medical practitioner.

In terms of other drivers identified in the review, the use of traditional medicines and particular food and drink are deeply ingrained cultural practices. For example, production and consumption of date palm sap has been part of community life in Bangladesh for generations [185]. Communities may be understandably resistant to changing these behaviours, both because they are likely to have been preserved for many years as culturally significant and because those recommending such changes (e.g., politicians, national and foreign experts) may not be perceived as legitimate, e.g., not trusted or respected within communities, highlighting the importance of producing solutions with communities [69]. In terms of seeking healthcare, many communities are poor and may necessarily prioritise food and shelter over attending healthcare centres, even if these are available. These underlying issues may partly drive why communities may appear to 'ignore' official advice, e.g., to stop consuming raw palm sap, or to visit healthcare providers after being bitten by an

animal, and add a layer of complexity to research. We need to take a critical perspective that can help to interrogate this complexity, elucidating what non-explicit processes underly observed behaviours, before we can claim to know what is actually driving behaviours [1]. A recent study that examined human-animal interactions and the spillover potential of coronavirus in China interviewed 1,585 people who were likely to have been exposed to bats or other wildlife, including workers at live animal markets, animal breeders, or people involved in the wildlife trade [26]. Li and colleagues found that, although the majority of the respondents were aware of zoonotic disease spread, and stated that they were concerned about possible disease emergence from animals sold at wet markets, they did little to protect themselves from potential exposure, e.g., washing hands or sourcing meat from supermarkets rather than wet markets [26]. Despite awareness of potential drivers of zoonotic disease spread, interviewees did not modify their behaviour to protect themselves from possible contamination. This supports our position that community attitudes to behaviours perceived as 'risky' by experts or people in higher-income countries, and what drives these, are likely to be complex and influenced by many factors that must be understood before any awareness or behaviour change interventions are initiated.

A recent study in communities at high risk of zoonotic disease in Uganda found that most people were not aware of zoonotic disease, and that although this was partly a failure of communication, other factors, e.g., consumption of (free) bushmeat, had to be taken into account. Authors suggested that interventions should involve sustainable solutions that do not impinge on communities' livelihoods, rather than just providing educational interventions [227]. However, solutions such as increasing domestic livestock production in resource-poor countries brings its own complications: disease control is often basic or non-existent in agricultural communities, and may encourage emergence of other pathogens [15].

The way forward and future research

National strategies are key to preventing future zoonotic outbreaks and protecting the health of communities [10]. However, designing strategies remains a complex issue due to lack of effective surveillance and the many socio-ecological factors that influence disease spread. A One Health approach, involving collaboration between human health, animal health and environmental sectors at all levels of government, is likely to be crucial for implementing effective surveillance, prevention and mitigation strategies. Such an approach was not widely discussed in the sources, but should involve medical professionals, veterinarians, and environmental specialists working with community members to foster a concerted grassroots approach to research and practice. Communities could be involved in pinpointing what is likely to work in their context, which could influence disease surveillance and reporting mechanisms, and enforcement of regulations. Policy and legislation need to be put into place, although these processes take much political will and effort and are predicated on consistent governance and co-production with communities to design effective and workable strategies. Encouraging this type of initiative may have become easier following the Covid-19 pandemic, as

policymakers and communities alike have been made aware of the importance of zoonotic disease transmission, and the potential ramifications of the spread of these diseases. Further research should focus on encouraging a coherent One Health response, working with and in communities to identify their priorities, their requirements, the barriers and enablers to effectively addressing risk factors around zoonotic disease, and how behaviour change initiatives could be supported by governmental and multilateral bodies.

Limitations

Several limitations should be considered. Only English and French sources were included, and although unlikely considering publishing trends favouring English since 2000, some relevant studies published in other languages may have been missed. For similar reasons, we may have missed some studies not indexed in the databases we searched. We did not critically appraise source quality as this was a scoping review designed to identify and synthesise the extent and nature of existing research, and was not a systematic review. The heterogeneity of the studies included in terms of methods, outcomes, populations and objectives precluded a comprehensive and useful quality appraisal. It was beyond the scope of this review to include studies solely focused on prevalence and dynamics of zoonotic agents within animal reservoir populations (e.g., wildlife sampling surveys). If these did not incorporate discussion of these factors with regard to effects on disease risk in human populations they were excluded.

Conclusions

Our review provided evidence from 80 primary research sources of behaviours and environmental factors that may drive zoonotic disease risk in the Indian subcontinent. Three diseases, rabies, NiV and leptospirosis, were the main focus of this research, although respective drivers overlapped considerably. Potential drivers included lack of awareness, cultural practices such as use of traditional medicines, and insufficient hygiene behaviours (e.g., hand-washing, use of protective clothing). We contend that behaviour change is essential to preventing spillover events from animals to humans. Future research should focus on working within communities to design context-specific interventions that are tailored and not generic. However, advocacy around the need for governments to invest time and financial resources into working with communities may be difficult, particularly when many outbreaks of zoonotic disease may not be reported or recognised as a key issue to be addressed.

Author contributions

All authors conceived the study and contributed to design. ADB conducted the search, analysed data with help of all authors, and drafted the manuscript. JWR, SRB and NH provided critical review. All authors agreed the version submitted.

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Declaration of interest

None declared.

Table 2. Sources included in the analysis

First author (year)	Country	Disease	Population	Type of study	Study design
Agampodi (2010)	Sri Lanka	Leptospirosis	General population	Knowledge and awareness	Cross-sectional study
Ahmed (2020)	Pakistan	Rabies	General population	KAP	Cross-sectional study
Alam (2020)	Bangladesh	Rabies	Dog bite victims	Knowledge	Cross-sectional study
Arif (2017)	Pakistan	Brucellosis	Dairy farmers	KAP	Cross-sectional study
Arunkumar (2019)	India	Nipah	Suspected cases	Outbreak investigation	Mixed-methods: interviews and laboratory data
Biswas (2015)	India	Non-specific	Farmers	Knowledge	Survey
Br (2019)	India	Non-specific	Bat harvesters	Risk mapping	Ecological study
Brookes (2019)	India	Rabies	Farmers	Outbreak investigation	Survey
Chakraborty (2016)	Bangladesh	Nipah	Cases and controls	Outbreak investigation	Mixed-methods: surveys and interviews
Chakraborty (2017)	Bangladesh	HPAI H5N1	Cases	Outbreak investigation	Mixed-methods: interviews and laboratory data
Chattopadhyay (2006)	India	Campylobacteriosis	General population	KAP	Cross-sectional study
Chinchwadkar (2020)	India	Non-specific	Female farmers	KAP	Cross-sectional study
Cortes (2018)	Bangladesh	Nipah	Not applicable	Outbreak investigation	Ecological study
Datta (2010)	India	HPAI H5N1	Rural population	KAP	Cross-sectional study
Deka (2020)	India	Brucellosis	Dairy farmers	KAP	Cross-sectional study
Dhakal (2012)	Nepal	Japanese encephalitis	Pig farmers	KAP	Cross-sectional study
Dhakal (2014)	Nepal	Japanese encephalitis	Pig farmers	KAP	Cross-sectional study
Ghosh (2016)	Bangladesh	Rabies	General population	KAP	Cross-sectional study
Gupta (2014)	India	Canine echinococcosis	General population	KAP	Cross-sectional study
Gurley (2017)	Bangladesh	Nipah	Cases and controls	Outbreak investigation	Case-control study
Hahn (2014)	Bangladesh	Nipah	Outbreak villages	Outbreak investigation	Ecological study
Hahn (2014b)	Bangladesh	Nipah	Outbreak villages	Outbreak investigation	Ecological study
Haider (2017)	Bangladesh	Hepatitis E	Pig handlers	Outbreak investigation	Case-control study
Haleem (2018)	Pakistan	Cystic echinococcosis	Livestock farmers	KAP	Cross-sectional study
Hegde (2016)	Bangladesh	Nipah	Cases and controls	Outbreak investigation	Case-control study
Herbert (2012)	India	Rabies	Slum dwellers	KAP	Cross-sectional study
Homaira (2010)	Bangladesh	Nipah	Cases and controls	Outbreak investigation	Case-control study
Hundal (2016)	India	Non-specific	Livestock farmers	KAP	Cross-sectional study
Ichhpujani (2006)	India	Rabies	General population	KAP	Cross-sectional study
Ichhpujani (2008)	India	Rabies	General population	KAP	Cross-sectional study

Islam (2013)	Bangladesh	Anthrax	Livestock farmers	Outbreak investigation	Mixed-methods: interviews and observation
Islam (2016)	Bangladesh	Nipah	Cases	Outbreak investigation	Case-control study
Kapoor (2019)	India	Rabies	Exposed	Knowledge	Cross-sectional study
Kelly (2018)	Nepal	Non-specific	Smallholders	KAP	Cross-sectional study
Khadayata (2020)	India	Non-specific	Livestock farmers	KAP	Cross-sectional study
Khan (2012)	Bangladesh	Nipah	Sap harvesters	Intervention study	Randomised controlled trial
Khan (2013)	Bangladesh	Nipah	Not applicable	Outbreak investigation	Ecological study
Khan (2017)	Pakistan	Leptospirosis	Occupational exposure	Risk mapping	Cross-sectional study
Khan (2019)	Pakistan	Rabies	General population	KAP	Cross-sectional study
Khattak (2016)	Pakistan	Tuberculosis	Livestock workers	KAP	Cross-sectional study
Kochar (2007)	India	Brucellosis	Cases of brucellosis	Epidemiological investigation	Observational study
Kothalawala (2018)	Sri Lanka	Brucellosis	Dairy farmers	KAP	Cross-sectional study
Luby (2006)	Bangladesh	Nipah	Cases	Outbreak investigation	Case-control study
Luby (2009)	Bangladesh	Nipah	Cases	Outbreak investigation	Ecological study
Madhusudhana (2015)	India	Leptospirosis	Cases	Outbreak investigation	Mixed-methods: interviews and laboratory data
Manandhar (2013)	Nepal	Avian influenza (H5N1)	General population	Awareness	Cross-sectional study
Mangalgi (2015)	India	Brucellosis	General population	Epidemiological investigation	Cross-sectional study
Mangalgi (2016)	India	Brucellosis	Occupational exposure	KAP	Cross-sectional study
Masali (2007)	India	Leptospirosis	General population	Epidemiological investigation	Cross-sectional study
Massei (2017)	Nepal	Non-specific	Dog owners	KAP	Cross-sectional study
Matibag (2007)	Sri Lanka	Rabies	General population	KAP	Cross-sectional study
Mohankumar (2015)	India	Rabies	Animal bite victims	KAP	Cross-sectional study
Montgomery (2008)	Bangladesh	Nipah	Cases	Outbreak investigation	Case-control study
Nahar (2015)	Bangladesh	Nipah	General population	KAP	Cross-sectional study
Openshaw (2016)	Bangladesh	Non-specific	General population	Risk mapping	Cross-sectional study
Openshaw (2017)	Bangladesh	Non-specific	General population	Risk mapping	Cross-sectional study
Parmar (2016)	India	Leptospirosis	Suspected cases	Epidemiological investigation	Cross-sectional study
Parveen (2016)	India	Leptospirosis	Mine workers	Epidemiological investigation	Cross-sectional study
Patel (2019)	India	Non-specific	Animal handlers	KAP	Cross-sectional study
Pathak (2014)	India	Brucellosis	Occupational exposure	Risk mapping	Serological study
Rahman (2012)	Bangladesh	Brucellosis	Occupational exposure	Risk mapping	Cross-sectional study
Rahman (2012b)	Bangladesh	Nipah	Cases	Outbreak investigation	Case-control study
Rajkumar (2016)	India	Non-specific	Livestock owners	KAP	Cross-sectional study
Regmi (2017)	Nepal	Leptospirosis	Febrile patients	Epidemiological investigation	Serological study
Rinchen (2019)	Bhutan	Rabies	Cattle owners	KAP	Cross-sectional study
Roess (2015)	Bangladesh	Non-specific	General population	KAP	Cross-sectional study
Sah (2017)	Nepal	Avian influenza	School children	KAP	Cross-sectional study

Samarakoon (2013)	Sri Lanka	Leptospirosis	School children	KAP	Cross-sectional study
Schonning (2019)	Sri Lanka	Leptospirosis	Cases and controls	Risk mapping	Case-control study
Singh (2005)	India	Rabies	Rural population	KAP	Cross-sectional study
Singh (2020)	India	Rabies	Rural population	KAP	Cross-sectional study
Sohail (2018)	Pakistan	Leptospirosis	General population	Risk mapping	Cross-sectional study
Sohan (2008)	India	Leptospirosis	Cases	Outbreak investigation	Ecological study
Sultana (2012)	Bangladesh	HPAI H5N1	Poultry farmers	KAP	Qualitative: interviews and observation
Tenzin (2010)	Bhutan	Rabies	Rabies exposed	Outbreak investigation	Ecological study
Tenzin (2012)	Bhutan	Rabies	General population	KAP	Cross-sectional study
Tenzin (2017)	Bhutan	Rabies	General population	KAP	Cross-sectional study
Thapa (2014)	Bhutan	Anthrax	General population	Outbreak investigation	Ecological study
Tiwari (2019)	India	Rabies	General population	KAP	Cross-sectional study
Yadav (2020)	India	Brucellosis	Dairy farmers	Risk mapping	Cross-sectional study

Table 3. Summary of key drivers for, and factors associated with, zoonotic disease risk

Disease	Number of studies	Driver		
		Behavioural/cultural	**Environmental**	**Other**
Rabies	18	Limited impact/lack of knowledge/awareness Incorrect wound care Do not seek medical care after bite Do not vaccinate dogs Limited hygienic behaviour after a bite Use of traditional medicine as prevention/cure Consuming meat from suspected rabid animals Contact with sick animals	Exposure to stray/'community' dogs Domestic dogs roam free	
Nipah virus	16	Limited impact/lack of knowledge/awareness Consuming raw/fermented date palm sap Consumption of dropped fruit Bat hunting Climbing trees	Contact with infected bat Exposure during harvesting time Low precipitation/low temperature Bat roosts near human habitation High human population density Fragmented forest Poor housing Seasonal patterns: winter and spring Proximity to bat feeding sites	Bat excreta found in pots used for fermenting sap
Leptospirosis	11	Limited impact/lack of knowledge/awareness Rice cultivation practices Consumption of contaminated food and water Contact with animals Exposure to cattle Open defecation Use stagnant water to bathe Do not use boots or gloves in paddy field Walking barefoot	Exposure to paddy field Domestic rat infestation High density of rat population Heavy rain Salinity of soil and water logging Proximity to water bodies Exposure to contaminated/stagnant/flood water Living in rural area Exposure to rodents Living in close proximity to livestock	Occupational exposure: agricultural/forestry/fisheries
Non-specific	12	Limited impact/lack of knowledge/awareness Lack of hygienic behaviour Lack of hygiene around cattle birthing Bat harvesting Consumption of raw/unpasteurised animal products No contact with veterinarians Direct contact with animal waste Animals kept in home	No private water source/toilet Humans and animals share water sources	

Brucellosis	9	Limited impact/lack of knowledge/awareness Consumption of raw milk Lack of hygienic behaviour Handling of infected material Animal handlers Animals unvaccinated Self-medicate livestock	Share housing with livestock Overcrowded housing	Occupational exposure: dairy workers
Avian influenza	5	Limited impact/lack of knowledge/awareness Direct contact with infected poultry Poultry living in house Lack of hygienic behaviour Unhygienic carcass disposal		
Anthrax	2	Limited impact/lack of knowledge/awareness Consumption of meat from sick animals Lack of vaccination Unhygienic carcass disposal Contact with infected carcasses Animals fed with infected kitchen waste		Moribund animals killed to be eaten as dead animals cannot be eaten
Japanese encephalitis	2	Limited impact/lack of knowledge/awareness Lack of hygienic behaviour	Exposure to paddy field	
Canine/cystic echinococcosis	2	Limited impact/lack of knowledge/awareness Lack of hygienic behaviour Dogs fed raw offal Animals slaughtered in housing Self-medication		
Hepatitis E	1	Limited impact/lack of knowledge/awareness Pig farming Handling raw pork		
Campylobacteriosis	1	Limited impact/lack of knowledge/awareness		
Tuberculosis	1	Limited impact/lack of knowledge/awareness Lack of hygienic behaviour		

3.3 Chapter summary

This chapter described and analysed the findings from the scoping review on literature around the potential anthropogenic drivers of zoonotic disease risk in the Indian subcontinent. I focused on the subcontinent as a whole as literature focused on Nepal is sparse and using a broader geographical area was much more informative, especially as many of the countries included have similar cultures and religions and were therefore, at least to an extent, applicable to Nepal. I described the findings in terms of diseases covered, mitigatory practices used by communities, and discussed how improving the understanding of risk perceptions in communities would help in co-designing interventions that are specific to the context and therefore likely to be relevant to communities.

Chapter 4: Exploring community awareness and perspectives on zoonotic disease in Nepal: A critical realist analysis

4.1 Chapter introduction

This chapter addresses Objective 1, to identify potential anthropogenic drivers of zoonotic disease risk in communities in Nepal, and Objective 2, to examine community knowledge of risk factors, prevention, and treatment for common zoonotic diseases in these selected communities. In this chapter I present findings from the reflexive thematic analysis of the interviews with all participants, and the photographs taken by community members. The analysis generated two major themes: disease awareness (sub-themes: experience of disease; perceptions of rabies; livestock and disease; sources of information), and beliefs and behaviours (sub-themes: traditional medicine use; bushmeat consumption; hygiene practices). Participants were aware of diseases that they perceived might affect their family or livelihood (e.g., rabies, avian influenza) or that they had experienced themselves. This was especially true of rabies, with most participants able to discuss how the disease is transmitted, and actions that should be taken pre- and post-bite. Information on disease was usually spread informally, with little experience of formal programming. Use of traditional medicine was widespread, although there was some discussion around whether this was an anachronism, with some participants seeing this behaviour as pragmatic, as accessing traditional healers is often easier (and cheaper) than visiting health posts. Consumption of bushmeat was seen as something that 'others' do, although some participants stated that bushmeat could be medicinal, and others made the distinction between 'clean' and 'dirty' rodents. Hygiene practices were perceived as necessary to remove dirt, but this was not usually linked explicitly to illness. Working with(in) communities is essential to unpicking the complexities around behaviours that might increase disease risk, especially in communities that lack resources to mitigate these threats.

4.2 Research manuscript

The cover sheet is presented below, followed by the manuscript.

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed <u>for each</u> research paper included within a thesis.

<u>SECTION A – Student Details</u>

Student ID Number	1408190	**Title**	Ms
First Name(s)	Anna		
Surname/Family Name	Durrance-Bagale		
Thesis Title	Drivers of zoonoses spillover in Nepal: Community priorities		
Primary Supervisor	Associate Professor Natasha Howard		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

<u>SECTION B – Paper already published</u>

Where was the work published?			
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<u>SECTION C – Prepared for publication, but not yet published</u>

Where is the work intended to be published?	PLoS Global Public Health
Please list the paper's authors in the intended authorship order:	Anna Durrance-Bagale, Hari Basnet, Nanda Bahadur Singh, Steven R Belmain, James W Rudge, Natasha Howard
Stage of publication	**Not yet submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I performed the data collection and analysis, wrote the first draft of the paper, and incorporated other authors' comments into this final draft.

SECTION E

Student Signature	
Date	

Supervisor Signature	
Date	

Exploring community awareness and perspectives on zoonotic disease in Nepal: A critical realist analysis

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Keywords Awareness, community, infectious disease, Nepal, risk factors, zoonotic disease

ABSTRACT

Background

Qualitative research focused on community knowledge of zoonotic disease in Nepal is lacking. We aimed to characterise the contextual factors and mechanisms driving awareness of risk factors, prevention and treatment of zoonotic diseases in selected communities in Nepal.

Methodology

In this multimethod study grounded in critical realist theory, we interviewed 39 people in six communities, with another 34 in 5 focus groups. Ten participated in photovoice. Twenty healthcare professionals and policymakers were also interviewed, 14 representing human health and six representing animal health. We used reflexive thematic analysis informed by critical realism to interpret data.

Findings

We generated two major themes: disease awareness (sub-themes: experience of disease; perceptions of rabies; livestock and disease; sources of information), and beliefs and behaviours (sub-themes: traditional medicine use; bushmeat consumption; hygiene practices). Participants were aware of diseases that they perceived might affect their family or livelihood (e.g., rabies, bird flu) or that they had experienced themselves. This was especially true of rabies, with most participants able to discuss how the disease is transmitted, and actions that should be taken pre- and post-bite. Information on disease was usually spread informally. Use of traditional medicine was widespread, although there was discussion around whether this was an anachronism, with some participants seeing this behaviour as pragmatic, as accessing traditional healers is often easier (and cheaper) than visiting health posts. Consumption of bushmeat was seen as something 'others' did, although some suggested bushmeat could be medicinal and others distinguished between 'clean' and 'dirty' rodents. Hygiene practices were perceived as necessary to remove dirt, but this was seldom linked explicitly to illness.

Discussion

This study provides insights into the significance of acknowledging the multi-dimensional religious, cultural, educational, financial and social contexts in which people live, and how these influence their beliefs, needs, priorities and behaviours. Working with(in) communities is essential to unpicking the complexities around behaviours that might increase disease risk, especially in communities that lack resources to mitigate these threats.

INTRODUCTION

The COVID-19 pandemic highlighted the potential for diseases of zoonotic origin to cause serious health and economic issues and threaten livelihoods globally [14, 27]. Around 75% of new or emerging infectious diseases that have affected humans in the 21st century are zoonotic, with many of these emerging from wildlife reservoirs [14-16], highlighting the threat that these pathogens pose globally [13]. Anthropogenic drivers of zoonotic disease emergence include rapid population growth, urbanisation, habitat encroachment, fragmented landscapes, proximity of humans to animals [10, 17], and bushmeat consumption [19, 20], further complicated by under-resourced and inaccessible healthcare provision [10, 15, 21-24]. Examining the human-animal interfaces that facilitate this emergence and potential cross-species transmission is essential to preventing spread of zoonotic disease [18, 27, 28].

A range of environmental, socio-economic and other anthropogenic factors that may increase the risk of, and vulnerability to, zoonotic disease outbreaks converge in Nepal [15]. The country is categorised as a lower-middle income economy by the World Bank, with a gross national income per capita of US$1,086-4,255 [36]. In 2019, Nepal spent 4.45% of gross domestic product on healthcare, averaging US$53 per capita [37]. Many people in rural and urban areas of Nepal are subsistence or backyard farmers, raising livestock and poultry, increasing the risk of disease transmission. This is especially true in rural and agricultural areas, where the interface between wildlife reservoirs and domesticated livestock may present opportunities for pathogen transmission [25, 40].

Healthcare services in Nepal are basic and much of the population has little to no access to qualified healthcare providers, particularly in remote and rural regions: 41% of rural communities have no access to a health post, and 80% do not have access to a public hospital within 30 minutes of their home by public transport [42]. This lack of access to healthcare provision means that communities are unlikely to report potential spillover events, and this, coupled with lack of government-approved prevention measures and poorly functioning or non-existent surveillance mechanisms means that the presence of disease may be unrecorded [25, 26].

Zoonotic diseases are poorly understood in Nepal, although leptospirosis and rabies are serious long-standing public health issues throughout the Indian subcontinent. Nipah virus, an emerging pathogen with a case fatality rate of 70% in humans, is spread by fruit bats, and has been responsible for outbreaks among humans in neighbouring India and Bangladesh following several spillover events [43, 44]. Another potential driver of disease risk in Nepal is consumption of bushmeat. Rats are hunted and eaten in some communities (e.g., the Musahar community in the east of the country) while bats are eaten by members of the Chepang, Newar and Tamang communities, especially during festivals [41].

Between 20,000 and 40,000 animal bites are reported annually in Nepal, of which 90% are from dogs [47]. Although dogs pose the main rabies threat to humans, in 2019 there was a reported death from rabies after a bite from a rabid bat (personal communication, Dr Sher Bahadur Pun). This, and Nipah, may be of increasing concern as large colonies of fruit bats are present in the heavily populated Kathmandu valley and eastern areas of Nepal and human-bat contact due to habitat encroachment is likely.

Global incidence of leptospirosis is unknown, with an estimated prevalence of 10 cases per 100,000 population affected in tropical climates [50]. Leptospirosis is not included in routine surveillance or the early warning and reporting system in Nepal, but incidence is presumed to be under-reported due to a lack of appropriate diagnostic capacities and symptoms that are difficult to differentiate from those of other common diseases [50]. This disease likely poses a serious health threat in rural areas of Nepal, where subsistence farmers are in close contact with livestock and rat urine in paddy fields and water sources. Suggesting that leptospirosis is also an issue in urban areas, one study found that 18 of 36 patients diagnosed with enteric fever at a Kathmandu hospital were infected with the disease, which had not been included as part of the initial differential diagnosis [52].

Our recent review, focused on the Indian subcontinent, found that the most frequently discussed potential driver of zoonotic disease risk was lack of awareness in communities [28]. Information was often unavailable through official channels such as healthcare workers or health camps, but instead was shared through informal networks of neighbours, relatives and friends. Access to information and awareness of routes of disease transmission was not reflected in behaviours [28, 40]. This suggests that complex, non-explicit processes may underlie behaviours that appear, on the surface, to be irrational [1]. Critical realism is useful as a tool for analysing social issues, appropriate for working with marginalised communities and encouraging questioning of the accepted status quo [1, 92]. Critical realism has been used to examine issues as diverse as women's experiences of agricultural policy on farms in Canada [92] and the relationship between human rights and social determinants of health [1]. By discussing relevant issues around zoonotic disease, awareness and behaviours with community participants, we attempted to build a picture of what people understand (observable) and how this relates to how they do, or do not, behave (the 'real' world). Critical realism was thus an appropriate theory to work with in an attempt to identify and unpick these implicit processes [1]. Working with communities, exploring behaviours and drivers that may facilitate transmission in context with practices and cultural beliefs is crucial to comprehending and decreasing risk of new or re-emerging zoonotic disease spread [30, 33].

Research on zoonotic disease in general is lacking in Nepal, in particular work that does not attempt to quantify risk but instead focuses on elucidating what communities know about these diseases. Considering

these knowledge gaps, this study aimed to characterise the key contextual factors and mechanisms driving awareness of risk factors, prevention and treatment of zoonotic diseases in selected communities in Nepal.

METHODS

Study design

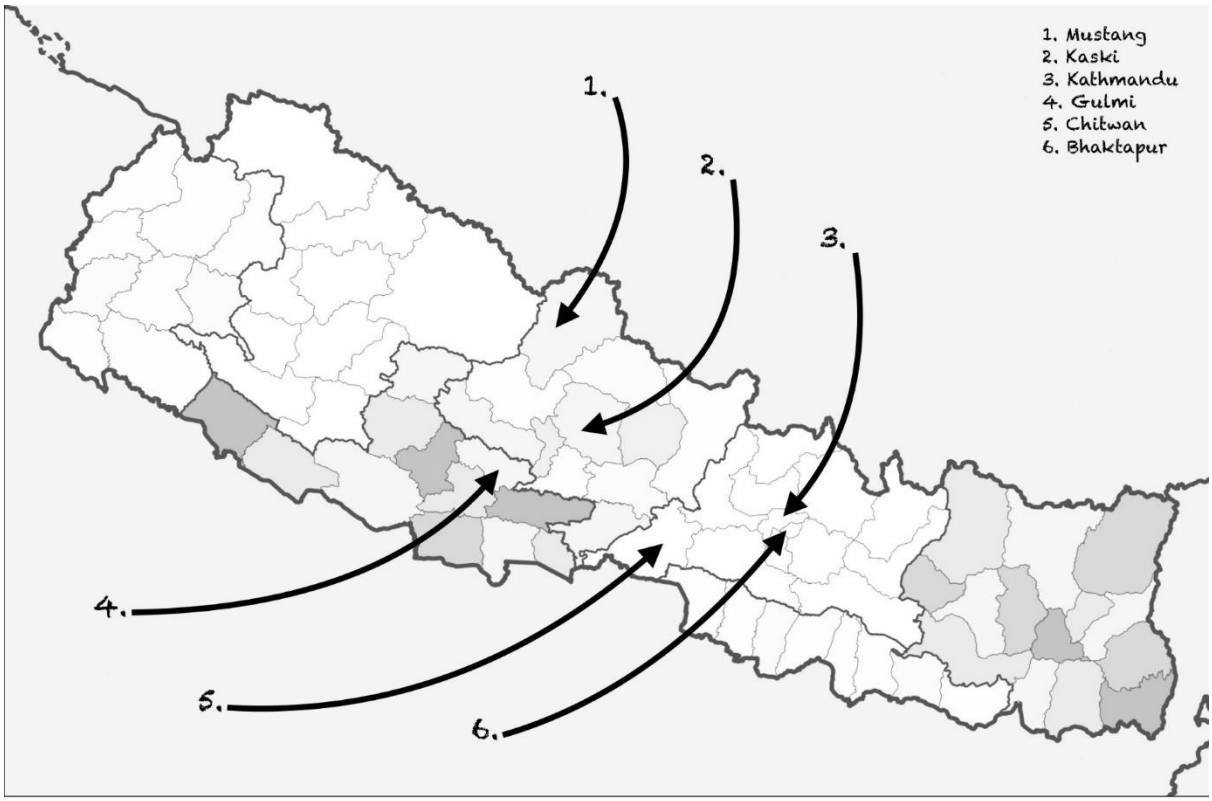
This was a qualitative multimethod study, drawing from interviews and focus group discussions (FGDs) with community members, health-workers, veterinarians, and policymakers, and photovoice with community members.

Our study was informed by critical realist theory, a philosophy of science that combines a realist ontology (the world exists independently of us) and a subjective epistemology (we can observe the world and draw conclusions, but these are fallible), and highlights the importance of an understanding of the specific context in which people live and work [1, 92, 126]. This context is not only a collection of tangible, explicit 'things' (e.g., rural/urban setting, financial situation) but also has dynamic and relational, and more implicit, properties (e.g., power, social status) [126]. This contextual understanding was supplemented by a participatory axiology, a value system that recognised the centrality of members of communities and their views, opinions and beliefs in addressing issues that affect them: in this case, risk of zoonotic disease spread. Critical realism allows a participatory axiology that can inform policy and programming, e.g., co-production or co-design of research and interventions, as it acknowledges that inequitable and marginalising outcomes can result from both individual and systemic factors [91]. Working with community members to examine how their beliefs and opinions affect their situation is central to removing, or working with, these factors.

Study sites

We selected six sites (two in the Kathmandu valley) after discussion with Nepali colleagues (Figure 1). An informal settlement in Kathmandu was selected as one of the sites (site 3). Sites 2, 3 and 6 were predominantly urban areas, while the other three were more rural and remote. Site 1 (Mustang) is a mountainous, sparsely populated area. Site 5 (Chitwan) is situated in a national park area in the lowland Terai region, bordering India, where many people earn a living from tourism centred on elephant riding and birding.

Figure 1. Map of sites



Participant sampling and recruitment

We used a combination of typical sampling (a type of purposive sampling, where participants are selected who may generate useful or interesting data) and snowballing, where participants recommend other potential participants. Typical sampling is often used in exploratory qualitative studies, as it allows researchers to describe typical cases. In this study, we used typical sampling to select participants who were likely to generate appropriate data to help answer the research questions. As with most sampling used in qualitative research, typical sampling does not allow us to generalise findings, but instead to identify usual experiences in a particular setting [105, 106]. We enrolled adult participants including, as far as possible, people of different ages and genders (Figure 1). We aimed to have six to eight individual interviews and run one FGD with six to 10 participants per site. This initial estimated sample size was judged sufficient to gain an understanding of the views, opinions and experiences of participants, but was open to adjustment during the study if this became necessary (e.g., if we were not collecting informative data) [105]. In each district selected for the study, we contacted a healthcare worker (if available) and asked them to suggest people to contact in each community. If we could not contact a healthcare worker, we instead identified a prominent member of the community, for example a teacher or member of a community group (e.g., a local women's group) and asked them to suggest participants. ADB and HB met the suggested people, explained the aims of the study, and interviewed them if they were willing to participate. We asked each participant to identify another potential participant until approximately six to eight individuals and one group had been recruited per community.

ADB generated a seed list of Nepali human or animal healthcare professionals and national or regional policymakers, and asked colleagues in Nepal to nominate potential interviewees from appropriate organisations in the country. All were contacted by email, with two refusing due to time constraints and three not responding. At the end of their interview participants were asked to nominate others who might have useful experiences or viewpoints to discuss.

These types of sampling and recruitment were appropriate to a critical realist approach as we aimed to gain an understanding of how people in the study sites were affected by their local context and the meanings and understandings they held for the topics in which we were interested [75].

Consent procedures

ADB explained the study to potential participants before any other study procedure took place. If they agreed to participate, they were asked to sign a consent form or give verbal consent confirming that they had read and understood the information sheet. Consent of illiterate participants was witnessed by a person unrelated to the study team and selected by the participant, after thorough explanation of the relevant documents. A separate consent form was provided for people who appeared in any photographs taken by participants. If consent was not provided, the image was to be immediately deleted. In practice, no participant photographed a person during the study.

Data collection

Data were collected between April and July 2022. Both interviewers had post-graduate training in social science research and interview methods. All participants were interviewed in their home, place of work or a local café, as they judged appropriate, and to allow confidentiality and privacy, as far as possible. All recordings and photographs were given an alphanumeric code to ensure confidentiality. Completed consent forms were scanned and shredded. Electronic data were password-protected and only accessible to the study team.

The methods chosen for data collection were appropriate to a critical realist analysis, particularly the combination of interviews/FGDs and unstructured observations, as this allowed a measure of triangulation and deeper understanding of participants' (possibly implicit) perspectives rather than relying on one approach from which to draw explicit (and possibly erroneous) conclusions [75]. Triangulation involves combining several different methods to study the same phenomenon: if a similar conclusion or idea can be drawn from each method, this suggests that the conclusion is likely to be valid. For example, participants may state one thing during an interview but their behaviour may suggest otherwise, particularly when discussing sensitive issues, as was sometimes the case in this study. For example, when participants discussed (and

denied eating) bushmeat, they sometimes laughed or blushed or looked uncomfortable, suggesting that they may have been unwilling to discuss their participation in this activity.

Interviews

Topic guide development was informed by findings from a literature review we previously published [28] and our understanding of the context. During the interviewing process additional topics raised by participants were discussed, as appropriate. The topic guide for community participants covered human-animal contact, biosecurity and food hygiene, environmental changes, health issues, and disease awareness, including any experience with awareness programmes. The topic guide for policymakers and practitioners covered participants' relevant experience, views on community awareness, and comprehension of governmental policy on zoonotic and infectious diseases.

Interviews lasted around 30 minutes and were conducted in English (by ADB) or Nepali (by HB and ADB) as per participant preference. Seven of the healthcare professional and policymaker interviews were conducted remotely by ADB using Zoom software (Zoom Video Communications Inc, San Jose) and audio-recorded with automatic transcription enabled. ADB reviewed and corrected the transcripts against the recording.

FGDs

The topic guide for the FGDs covered the same topics as that for the individual interviews. Discussions lasted around 45-60 minutes and were conducted in Nepali. One FGD was conducted in a mixture of Nepali and Newari at participants' request as all participants were fluent in both languages.

Unstructured observations

During the interviews and FGDs ADB noted brief observations on the 'three Cs' [118]: any context, content or concept that appeared potentially significant or interesting, e.g., how participants interacted with animals around them, or if they laughed or appeared uncomfortable while talking about certain topics. This type of unstructured observation can provide insight into contextual factors and how these may relate to topics being discussed, or actions being taken [118], if used as part of triangulation (described above).

Photovoice

At the end of their interview, participants who had engaged well and were enthusiastic about participating were asked to use a simple digital camera to take photographs that illustrated their perceptions, feelings and beliefs around zoonotic disease risk in their community. They were then asked to describe why they had taken these images.

Photovoice is a participatory research method that can be used as a collaborative approach to data collection [112]. Participants take photographs and discuss the significance of these images for them in their particular context and situation [77]. This method can enhance understanding of community experiences, beliefs, behaviours and priorities [78] and may be particularly useful in marginalised communities who are likely less familiar with traditional methods of enquiry [114]. Photovoice has been used in critical realist research, as it physically involves participants rather than them being simply subjects of the research. This type of collaboration is key to allowing participants to potentially demonstrate their beliefs, practices, and traditions, and their multiple roles, as, for example, community member, mother, member of women's group, farmer, business owner, and disposer of dead animals. Participants are able to demonstrate how they make sense of their world: what is (non-)significant for them and what they would like to know to allow them to have agency over their situation and the world around them [114].

Analysis

Recordings in Nepali were transcribed into English by a Nepali healthcare professional familiar with public health and infectious disease, and who was fluent in both languages. Two of the first transcriptions were reviewed and back-translated by a second native Nepali speaker to ensure that the transcription accurately reflected the recording. Interviews in English were transcribed by ADB. Names used by participants for animal diseases were cross-checked with a Nepali veterinarian fluent in English to ensure that they represented the correct disease as far as possible, and to check for any nuance related to these diseases that might not have been obvious to the translator [119].

Interview and FGD transcripts were imported into NVivo software (QSR International Pty Ltd, Version 12, 2018) for data management. Photographs were given an identifying code and simple textual description by ADB. This description was imported into NVivo with the accompanying explanatory text from the participant who took the photograph. Unstructured observation notes were imported into NVivo and used to generate a thicker, richer description of the phenomena being discussed. Thick description uses data from different sources to contextualise events and behaviour and aid in their interpretation [120].

ADB reviewed and coded all transcripts, explanations of photographs, and observation notes in NVivo, using reflexive thematic analysis through a critical realist lens to generate themes and sub-themes from the data. The analysis involved six steps: (i) data familiarisation; (ii) generating initial codes; (iii) generating themes; (iv) reviewing potential themes; (v) defining/naming themes; and (vi) synthesising findings [128, 133].

The analysis was influenced by the work of Fryer and Wiltshire, on critical realist approaches to thematic analysis [74, 134]. Fryer suggests five steps that allow for development of potential causal explanations for phenomena: (i) develop a research question; (ii) become familiar with the data; (iii) apply, develop and review

codes; (iv) develop and review themes (from codes); and (v) generate findings [74]. Developing and reviewing themes is related to causal explanations: these result in the events and experiences that participants discuss during their interviews, or may show us through their photography. Data, codes and themes (the latter two generated from reflexive thematic analysis) correspond to experiences, events and causes that are an integral concept of critical realism. The data are the transcripts, unstructured observations and photographs (experiences) generated during the fieldwork; the codes are descriptions of these experiences (events); and the themes are the mechanisms that we can postulate as causing the experiences and events [74]. While reviewing (step iv) we can question the validity of our themes and causal explanations: are they intrinsically sensible? Are they appropriate? Do participants use these explanations themselves? [134].

Critical realism has been posited as a popular theoretical positioning for reflexive thematic analysis [128], and acknowledges the centrality of the researcher in any interpretation of phenomena. Reflexive thematic analysis allows the interpretation of context-dependent, situated realities, rather than decontextualised truth: untangling how a participant's social and material circumstances affects how they understand the world [128]. Taking a critical realist approach to the data meant triangulating the sources (the data from interviews, FGDs, photographs and unstructured observations), to understand the reality of participants' lived experience, extrapolating from their words and, in some cases, images they took. This process enabled development of a clear narrative and analysis of the causal mechanisms and contextual factors that affected participants' perceptions and understandings.

Reflexivity

These interviews were often the first time many participants were asked about their views and experiences on similar issues by anyone, particularly an obvious outsider. This outsider status can have advantages, as 'insiders' (i.e., people who are part of the community involved in the research) may be too close and their personal experience may affect their expectations or the way they interact with participants [139].

ADB, a white, educated, English woman, brought her own cultural assumptions, preconceptions, and values to the research. Having lived and worked in Nepal for various periods since 2006, with an extensive network of contacts, she had some insight into, and understanding of, cultures and issues that are likely to be pertinent to Nepali communities. However, it is impossible to stand outside and observe objectively, as producing research and knowledge, interpreting findings and writing these findings up into a coherent form, is never neutral but always includes values, judgements and assumptions, whether implicit or explicit [8, 136]. Researchers must consider the potential impact of their beliefs, biases, experiences and emotions during the life of the research project [137], particularly if they are writing up their findings and conclusions from the perspective of their own, 'foreign gaze' [138]. This need to keep positionality in mind throughout the analytic process is one reason why critical realism was chosen as the theoretical approach to this study,

as this is an important facet of this type of analysis, recognising that the researcher's presence itself influences the findings.

Ethics

The Nepal Health Research Council (ref: 2193) and London School of Hygiene & Tropical Medicine Observational Research Ethics Committee (ref: 26507) provided ethics approval.

FINDINGS

Participant characteristics

Thirty-nine people (21 men, 18 women) from communities at six sites participated in semi-structured interviews. Thirty-four people (14 men, 20 women) participated in five FGDs at different sites (Table 1). Estimated ages are given as some participants were unable or unwilling to disclose their age. Photographs were taken by nine interviewees and one FGD participant across the six sites. This was judged to be a sufficient number to demonstrate the utility of photovoice as a method in this exploratory study, and does not imply saturation. Twenty Nepali healthcare professionals and policymakers were interviewed in English (Table 2): 14 representing human health (13 men, one woman) and six representing animal health (three men, three women). Location information is not included for these 20 participants to protect their anonymity.

Table 1. Community participant characteristics

Identifier	Gender	Estimated age	Language
Bhaktapur1	Female	45-50	Nepali
Bhaktapur2	Female	50-55	Nepali
Bhaktapur3	Male	35-40	Nepali
Bhaktapur4	Female	30-35	English
Chitwan1	Male	45-50	Nepali
Chitwan2	Male	70-75	Nepali
Chitwan3	Female	45-50	Nepali
Chitwan4	Male	40-45	English
Chitwan5	Male	35-40	Nepali
Chitwan6	Male	60-65	Nepali
Gulmi1	Female	65-70	Nepali
Gulmi2	Female	35-40	Nepali
Gulmi3	Female	55-60	Nepali
Gulmi4	Female	45-50	Nepali
Gulmi5	Male	60-65	Nepali
Gulmi6	Female	55-60	Nepali
Kathmandu1	Male	25-30	Nepali
Kathmandu2	Male	45-50	Nepali/English
Kathmandu3	Female	35-40	Nepali
Kathmandu4	Female	35-40	Nepali
Kathmandu5	Male	20-25	English
Mustang1	Female	45-50	Nepali
Mustang2	Female	40-45	Nepali
Mustang3	Male	20-25	Nepali
Mustang4	Male	40-45	Nepali
Mustang5	Female	35-40	Nepali
Mustang6	Male	40-45	Nepali
Mustang7	Male	45-50	Nepali
Pokhara1	Male	45-50	Nepali
Pokhara2	Male	20-25	Nepali
Pokhara3	Male	30-35	Nepali
Pokhara4	Female	50-55	Nepali
Pokhara5	Male	45-50	Nepali
Pokhara6	Female	50-55	Nepali
Pokhara7	Male	55-60	Nepali
Pokhara8	Male	55-60	Nepali
Pokhara9	Female	50-55	Nepali
Pokhara10	Female	35-40	Nepali
Pokhara11	Male	55-60	Nepali
Bhaktapur FGD	5 male, 4 female	20-70	Nepali/Newari
Chitwan FGD	1 male, 3 female	20-70	Nepali
Gulmi FGD	0 male, 9 female	20-70	Nepali
Mustang FGD	5 male, 1 female	20-70	Nepali
Pokhara FGD	3 male, 3 female	20-70	Nepali

Table 2. Healthcare professional participant characteristics

Identifier	Type	Gender	Interview
Health1	Infectious disease specialist	Male	In-person
Health2	Clinician/NGO	Male	In-person
Health3	Public health specialist	Male	In-person
Health4	Consultant for health NGOs/iNGOs	Male	In-person
Health5	Government/NGO	Female	In-person
Health6	Infectious disease specialist	Male	In-person
Health7	Government/clinician	Male	In-person
Health8	Consultant for health NGOs/iNGOs	Male	In-person
Health9	Government/infectious disease specialist	Male	In-person
Health10	Consultant for health NGOs/iNGOs	Male	Remote
Health11	Infectious disease specialist/academic	Male	Remote
Health12	Public health specialist	Male	Remote
Health13	Consultant for health NGOs/iNGOs	Male	Remote
Health14	Government/public health specialist	Male	Remote
Livestock1	Government/veterinarian	Male	In-person
Livestock2	Government/veterinarian	Male	In-person
Livestock3	Government/veterinarian	Female	In-person
Livestock4	Government/veterinarian	Male	In-person
Livestock5	Government/veterinarian	Female	Remote
Livestock6	Government/veterinarian	Female	Remote

iNGO: international non-governmental organisation; NGO: non-governmental organisation.

Thematic findings

Analysis of interview and FGD transcripts and the photographs generated two overarching themes: i) disease awareness and ii) beliefs and behaviours. While some ideas were explicitly discussed during interviews, others were implicit in what participants did not say, or how they said it. This was especially true during discussions of traditional medicine, use of which is prevalent throughout Nepal, and bushmeat consumption, which is common in some communities. For example, as discussed below, participants were often keen to dissociate themselves from the practice of bushmeat consumption, or visiting a traditional healer, but underlying these views was an awareness that these practices might be judged to be an out-dated practice (or worse) by the researchers, or by people in other communities.

Disease awareness

We identified four sub-themes of experience of disease, perceptions of rabies, livestock and disease, and sources of information. We found that participants were pragmatic: aware of diseases that they perceived might affect their family or livelihood (e.g., rabies, bird flu) or that they had experienced themselves. This was especially true of rabies, with most participants able to discuss how the disease is transmitted, and actions that should be taken pre- and post-bite. Information on disease was usually spread informally between networks of friends and family, with little experience of formal programming by official organisations.

Experience of disease

Disease awareness was related to experience: if participants were aware of zoonoses this was usually a result of caring for domesticated animals (buffalo, goat, poultry) or having contact with dogs or rodents:

> 'I knew that you don't have rabies from rodents, but then there could be other diseases related with its faeces. So plague and new things, but we have never experienced those things in our lifetime.' [Bhaktapur4]

Many participants kept pet dogs or were exposed to community dogs and knew about rabies. Most people knew that rabies was spread by dog bites and fatal, and many understood that vaccination was important. People keeping backyard poultry knew about bird flu:

> 'I am aware [of animal-human transmission]. The cows, buffalos and other animals have a disease called luto [*demodicidosis*]. If we touch that wound, we might be infected[…]I also was bitten by a dog and I got the vaccine, also the dog was well vaccinated just in case.' [Chitwan6]

> 'I know that dog bites can cause rabies for which rabies vaccine are provided. We are concerned about rabies so we do vaccinate our dog. We sometimes wash our hands after petting them.' [Mustang3]

One participant who had experienced a dog bite shared knowledge of rabies:

> 'The dogs had bitten me and I had taken medicine and vaccine. I still have the bite mark. Dogs can cause rabies and if the infected dogs bite an individual, we need to get vaccinated if the dogs die within 7 days.' [Gulmi2]

The perception of awareness being related to experience was seconded by a healthcare practitioner:

> 'If you talk about the communities like if there are some professionals or maybe some workers are engaging with the animals like meat handlers or poultry, poultry farm workers, and poultry farm owners and then maybe the fishermen, and also the mahouts, and some pig farmers, if you go to the communities where this kind of operational activity is going on, maybe you will find some awareness of that because they might be suffering from maybe foot and mouth disease, some skin disease in animals or tuberculosis sometimes, or avian influenza in birds.' [Health2]

One animal health professional described work he had done with communities experiencing avian influenza, where there was low-level awareness:

> ‘One of our questions is, are you aware about the diseases that have been transmitted to people and animal? They say yes, sometimes and most of them name like bird flu, but more than that, they don't know anything.’ [Livestock2]

One practitioner suggested that, although most community participants might deny any knowledge of specific zoonotic diseases, they have a more general understanding:

> ‘Most of the community don’t know about specific disease. But while talking about the symptoms, do you have these kinds of symptoms? do you have this problem?, they will definitely say, yes we have, and we can identify if it is a communicable disease. But they don’t know the disease by name.’ [Health12]

This was seconded by an animal health representative:

> ‘Since it's like after every monsoon, this type of problem, there might be people have some knowledge on that, but definitely as *leptospira* they don't have that.’ [Livestock2]

This was reflected by some participants, eager to say they were aware of the possibility of disease transmission from animals, but when probed were unable to be specific:

> ‘In general I know but being specific like this disease transmit from these animals, I don’t know.’ [Bhaktapur3]

> ‘I don’t know the name of disease but I just heard that disease can transmit from animals.’ [Gulmi1]

Some participants denied the knowledge they did have, even when this clearly informed their behaviours:

> ‘I don’t have much information but I have seen a man die about 20 years back in Gorkha when a mad dog bites human. I don’t know the name but the dogs who are salivating when they bite can kill humans and they themselves can die as well. Medication has also to be taken fast in order to prevent it[…]We vaccinate the dog so that they don’t spread the disease if they bite other people. People also ask if the dog is vaccinated in case the dog scratches them.’ [Pokhara8]

This was also apparent in an FGD, when a participant contradicted themselves:

> ‘We have no idea [about animal-human transmission]. I had heard that some diseases are transmitted by dogs such as luto [*demodicosis*].’ [Pokhara FGD]

Some participants were happy to acknowledge that, although denying any awareness, they knew enough to protect themselves and this was reflected in their behaviours:

> ‘Yes, from rat also disease is transmitted[…]I don’t know [which one] but we don’t eat the food that is touched by the rat.’ [Pokhara6]

> ‘I have no idea about the disease spread by animals but am aware that proper sanitation should be maintained while handling them. I don’t have any idea about that [rat-borne disease]. We just clean the rice and other grain properly before eating and ensure that it is stored properly.’ [Pokhara8]

Perceptions of rabies

There was general agreement among human and animal healthcare professionals that most people in Nepal are aware of rabies and routes of transmission, but are unwilling, or unable due to lack of time and money, to have rabies prophylaxis, or visit a health post to be vaccinated post-bite. This is despite the fact that rabies vaccination is free in Nepal:

> ‘I think people in the community level they are more aware about rabies. Because they know dogs are domestic animals, the people in Nepal, they usually have dogs, and they even know about bat. So, I think rabies is the most common zoonotic disease people have heard and also they know about the rabies vaccine, which is available through different public hospitals.’ [Health3]

Demonstrating that the COVID-19 pandemic has increased awareness, one of the informal settlement participants indirectly linked COVID-19 and rabies, stating that he became aware of the potential for zoonotic disease 2 years before the interview, during the pandemic. He displayed understanding of transmission risks, despite having no formal education:

> ‘I came to know this [animal-human transmission] just 2 years ago. And people are staying 2 metres far from each people because disease can even be transmitted from animals. So, there’s no doubt about transmission of disease from different animals like dogs and cats. It’s very compulsory to inject rabies vaccine after dog bite. From vaccinated dogs, diseases don’t get transmitted.’ [Kathmandu2]

As community dogs are frequently present in streets throughout the country, people are likely to be exposed to them and may have a better understanding of this disease and behaviours that can prevent the spread (or

what actions they should take after a bite). However, this is not always the case. In the informal settlement we visited in Kathmandu, we observed a 2-year-old child cuddling and kissing a community dog, which was drooling and covered in suppurating sores, as the mother sat watching and smiling. This suggests it is unlikely that mother or child had experienced negative effects of such behaviour, despite the omnipresence of these animals. Another interpretation could be that, as these dogs are everywhere, the mother had no way of preventing her child from touching the animal, and so she may have allowed this behaviour despite being aware of the potential seriousness of a bite, resigned to the fact that there was little she could do about it.

One animal healthcare participant told an illustrative story about how misconceptions around rabies can be fatal:

> 'I remember one story. It was in the [redacted] area, a very remote place, we had to walk for 2 hours down to the village. One man's niece had been bitten by a dog, and the uncle was so angry that he grabbed the dog and killed it but at that time the rabid dog bit him. Whenever every villager told him to get vaccinated, he just said 'how could that dog get rabies? I am so powerful, I won't get rabies.' His wife was telling us this[…]the uncle died.' [Livestock6]

Members of a FGD demonstrated perceptions that can exist around symptoms of rabies once a person is bitten:

> 'P1: They start to act like dogs.
> P2: I also heard that they give [birth to] babies like dogs.
> P3: My father-in-law was bitten by a dog and did not get vaccinated due to which he started salivating, also he would start barking and digging.' [Gulmi FGD]

Livestock and disease

Most participants stated that if animals look healthy, they are healthy. Some participants were unwilling to believe that they could catch diseases from animals, particularly as they are often in close contact with livestock, pet dogs, and synanthropic animals such as rodents and bats and have never experienced any concomitant illness:

> 'I don't have any idea [about animal-human transmission]. When we rear animals, they look healthy and we also have not been affected[…]Rats have been around us since a long time, we also see them in the field but we have never fallen sick. Do they really transmit disease?' [Gulmi3]

> '[Cattle] may transmit disease but I have reared them and they are healthy and I don't think they would transmit disease.' [Gulmi4]

One participant stated that they take as much care of their animals as they do their children:

> 'Maybe, it [animals] can transmit diseases but I have had no knowledge or information about it. I take care of all my animals as my child but have no idea of the disease it may cause.' [Pokhara3]

Sources of information

One of the disease awareness sub-themes focused on where participants acquired their information. Sources of information were usually informal (e.g., social media, discussions with friends or relatives) although some participants did mention more formal routes (e.g., government awareness campaigns, NGO drama programmes). Three of the informal settlement participants enthusiastically discussed a drama group who came to their settlement and staged a play focused on health promotion and water, sanitation and hygiene issues.

The COVID-19 pandemic had raised awareness of disease transmission:

> 'People did provide information [on COVID-19] but no programmes were conducted here. We usually listen to such information like washing our hand for 20 seconds in the TV and radio.' [Gulmi3]

> 'After the rise in COVID the use of social media has increased. We all got the awareness information about COVID through Facebook.' [Bhaktapur FGD]

This raising of awareness was underlined by one of the photovoice images, which was of a colony of fruit bats resting in trees in a widely used park in Bhaktapur, one of the major settlements in the Kathmandu valley. The participant who took this photograph stated that, before COVID-19, they would not have been aware of the potential for bats to affect humans but seeing these bats now in a public place, above their head, made them uncomfortable.

Photograph 1: Fruit bats resting in trees in a public park (Bhaktapur4)

This was discussed further by a healthcare professional:

> ‘They wouldn't be aware of many diseases, but they would be aware of like this bird flu, which makes the news, bigger news, that makes people fear, or bigger news that gets into the attention of the general public[…]Ministry of Health and Population, they also put out these notices through radio, newspaper and all those things about these diseases.’ [Health8]

One participant pointed out the importance of learning by experience, which was reflected in some participants’ experience with dog bites:

> ‘I have been hearing about animal-borne disease from TV, radio, friends and also have read in course book; however, I don’t give much more attention to such disease[…]I have been hearing such thing but have not such experience of animal disease. It’s said that you can learn best by experience so, due to lack of experience I don’t know more.’ [Pokhara10]

Underlining the point made above that awareness might be easier to spread if people or their animals are likely to be directly affected by a disease, one participant discussed an information campaign focused on keeping their livestock clean and healthy:

> ‘I have some idea as people come around to make us aware in every household, the municipality, to ask about the livestock and other information and also take names and make people aware of the disease they might cause as well as cleanliness and sanitation.’ [Chitwan5]

This was highlighted by a human health participant, who suggested that, during periods of elevated risk, people start listening:

> 'At the lay person level, at the farming level, just the normal population of Nepal, the awareness about these zoonotic diseases is quite low. And periodically we do get to hear about avian flu, swine flu, H5N1, when that happens people suddenly become aware.' [Health10]

However, as one healthcare participant pointed out, awareness is temporary and people forget once the initial outbreak or panic is over, so the question is how to ensure that this knowledge is retained:

> 'Awareness can be quite temporary[…]. Each year we have an avian influenza outbreak in chickens, so at that time some people decide not to buy…even if it's happening in some other province quite far away, sometimes people might have the tendency of not buying poultry items. But that is quite temporary. Even they can forget it after 1 week.' [Health5]

Beliefs and behaviours

The three sub-themes were traditional medicine use, bushmeat consumption, and hygiene practices. Use of traditional medicine was widespread, although there was some discussion around whether this was an outdated practice, with some participants seeing this behaviour as pragmatic, as accessing traditional healers is often easier (and cheaper) than visiting health posts. Consumption of bushmeat was seen as something that 'others' do, although some participants stated that bushmeat could be medicinal, and others dichotomising 'clean' and 'dirty' rodents. Hygiene practices were perceived as necessary to remove dirt, but this was not usually linked explicitly to illness.

Traditional medicine use

Many participants, male and female and of all ages, stated that, when ill, they would customarily use traditional medicine, and only consult an allopathic health professional if this did not work:

> 'Most people try home remedies to cure certain diseases as it is our practice. Then if it does not work, we take them to the health post.' [Mustang1]

> 'We have visited the traditional healers in the past when my children were small because it was believed they can heal them. In case that did not work we would take them to the hospital.' [Chitwan5]

Other participants discussed illness as being caused by spirits. If appeasing these spirits helps prevent or stop illness, allopathic medicine, which does not address this causation, will be ineffective:

> ‘People believe that there are certain spirits around the city and people sometimes get caught by them. The person then can suffer from stomach-ache or headache. And one you have made offering to these spirits it goes away.’ [Bhaktapur FGD]

> ‘P1: I have got bitten by dog. I went to a shaman [*dhami jhakri*]. I also took a ball of mud with me to show the bitten part. He then blew in it.
> P2: Also, if snake bites you there is a different type of stone they use for the wound.
> P3: These stones are still available but no one uses them as the shaman has already died[...]These stones suck all the poison.’ [Bhaktapur FGD]

Other participants suggested that visiting traditional healers was an outdated practice, dissociating themselves from older people and those in different, often rural, communities, and suggesting they are better educated and aware of modern medicine. Members of one FGD had an animated discussion about traditional healers and medicine, stating that, although older generations used to believe in traditional medicine, people now visit the doctor when ill and receive modern medical treatment. However, when probed, one participant explained that traditional medicines sometimes work better than allopathic treatment and so they still believe in their efficacy. Another participant discussed treatment of fractures, and that traditional medicines and mantras fix these better than allopathic treatments.

The urban-rural dichotomy was explicitly mentioned by one participant, with an implicit ‘othering’ of people in rural areas:

> ‘I have noticed that some people that do not get treated at the hospital get treated by the traditional healer. People do not believe these here but in the village a lot of people believe it. For example, some traditional healers take the poison from the wound of the snake bite with the help of mantras.’ [Pokhara FGD]

Echoing this othering, another participant made it clear to us during his interview that he identified as middle class and different from his neighbours; his family felt the need to ‘hide’ their visits to the healer from him, potentially a result of the perception of stigma attached to this practice:

> ‘I am against going to the traditional healers. But my family goes to them sometimes by hiding it from me. However, there are many people who believe in it.’ [Pokhara1]

Traditional medicines are also used to treat livestock in an attempt to avoid a time-consuming and potentially expensive (and futile) trip to the veterinarian:

> 'If the goat had loose motion, we feed them hot oil in the winter. If the goat does not pee, we feed the leaf of the eggplant. If the homemade treatment does not work, we take them to the vet.' [Gulmi2]

> 'People ask us to take them to the vet but to get there it takes 3 to 4 days. Till then the buffaloes may already be healthy or have died due to the sickness. There are no proper services here. We give them garlic clove, mustard seed and other weeds. Hemp plants are also used.' [Pokhara3]

One animal health professional discussed how (and why) communities would use traditional medicines in preference to allopathic treatments:

> 'Sometimes they also give local treatment, locally available medicines, they don't ask first[…]they just think like 'ok, if this happens, last time this medication worked.' It's traditional, herbal medicine. And then they use that one. And sometimes even when we go there and we say 'use this kind of medicine' they say 'no, this kind of herbal medicine works'[…]some farmers, because of their experience, they use herbal medication and if that does not work, it is severe, they then consult vets[…]people think there are lots of side-effects with modern medicines so they first choose the herbal medicines.' [Livestock3]

Most communities have a resident traditional healer and people may deem it unnecessary to travel to a healthcare post that may not be open, or will be unaffordable, when they have accessible healthcare in their area. Traditional medicines are cheaper and easier to obtain than allopathic versions as they are often made from herbs that grow in the local area:

> 'We want to know about the treatment as most of the people use herbs. Limited medicine is available so training on how to use such herbs could be given as not all the people can afford to buy the medicines.' [Mustang FGD]

Bushmeat consumption

Participants were asked whether they knew of any people who had experience of eating bushmeat, and what they knew about these practices. Few participants admitted to having tried bushmeat themselves, although many of them knew of communities in Nepal (not their own – another example of othering) that did this:

> ‘I ate a snake but I never eat rats[…]We don’t eat rats, we don’t eat bats also. But you know in Tharu community they eat rats [*laughing*].’ [Kathmandu5]

> ‘In some of the community, from Terai they eat bat, many Chepang community eat. Tharu community eat rats. Like that in this community they didn’t eat bats and rats.’ [Mustang7]

One participant reluctantly admitted to eating rat meat:

> ‘I have eaten a rabbit. Okay, because rabbits are staying in the forest, forest rabbit. Before 10 years, I stay in another part of Chitwan, there was other Tharu people that they kill the rat. And then they make a meat and I taste it one time. Okay, I taste once.’ [Chitwan4]

Another framed eating bushmeat as being an outdated practice, and something that people are embarrassed about:

> ‘No, we don’t [eat rats]. However, in earlier times people used to eat it as meat with wines and other. Still, very few of the population eat rats from field. Now they have stopped as people are educated and hesitate to eat them out of shyness as well.’ [Chitwan1]

Some participants judged bushmeat to be medicinal, or useful for disease prevention, although even in these cases participants were discussing the behaviour of ‘others’, and not their own or that of their community:

> ‘In the past we had heard the people did consume rat meats that they trap while harvesting rice in the paddy field. They believed that the mouse meat was medicinal.’ [Bhaktapur1]

> ‘People do eat rats and fox after finding it as it is believed to provide a lot of energy. People also traps rats in their house and eat it as well. People also believed that eating fox meat can cure or treat uric acid problems.’ [Gulmi2]

> ‘I have heard that people who suffer from piles eat mouse to treat it but I have not consumed it.’ [Pokhara3]

This issue was further clarified by a participant who is based in Kathmandu but spends time in a rural home. He explained the difference between ‘dirty’ and ‘clean’ rodents, focusing on the paddy harvest:

> ‘The Tharu people and still some people in my community love rats and eat rats. Because there are two kinds of rats, in my understanding. One rat that is available in the home and one rat that is available in the field[…]the one in the rice field, I think most of the people eat[…]the rats that are available in the cultivation field, they are a nicer one, cleaner, because they used to eat only rice that is produced in the field[…]they eat the clean rats but not the dirty ones.’ [Kathmandu5]

This was underscored by participants from other regions, who stated that field rats are ‘safe’ to eat (e.g., not likely to make the consumer ill):

> ‘As the rat in the field also eats grains so it is said that they are safe to eat.’ [Bhaktapur FGD]

This was reportedly even true of Tharu, who are perceived as traditional consumers of bushmeat by people outside this ethnic group:

> ‘These people [Tharu] do not eat the rats found inside the house but those rats which are found in the field by digging and trapping them. But no one eats rats in this area or this region.’ [Pokhara7]

Not eating rats was seen as a way of preventing disease by members of the Chitwan FGD, who stated that their ancestors used to eat rats and other bushmeat but stopped when they heard about ‘plague transmitted by such animals’.

The perceived dichotomy between ‘clean’ and ‘dirty’ rats was supported by an animal healthcare practitioner, who discussed rodent consumption at the end of the paddy harvest as a cultural event in the Nepali calendar:

> ‘Rat has many diseases. We have reports of leptospirosis in animals and in humans. So that might be a burden, but people they have a culture, they have a tradition that after they harvest the paddy, they keep on digging and digging to get the rats. They make the rat like a barbeque.’ [Livestock4]

Hygiene practices

Participants discussed various practices related to hygiene including food and water storage, and handwashing. Behaviours described tended to reflect beliefs around objects and animals being dirty rather than explicitly that lack of hygiene could spread disease. Many participants discussed the removal of rat faeces from, and thorough washing of, grain before cooking. One photovoice participant took a photograph of rat faeces mixed with grain in a container in their kitchen. When asked how they would deal with this situation, they said they would remove the faeces and then cook the grain.

Photograph 2: Rodent faeces in grain store (Pokhara7)

One participant said that they regularly ate food that had been contaminated by rats but that they had not experienced any ill effects:

> '[Rats] affects mostly all the crops. The mouse and the birds peck as well. We often eat rat-infected foods. I believe we don't get ill by it. I don't feel as if something's happened to us till now.' [Pokhara4]

However, other participants did suggest that consumption of food contaminated by rodents was likely to make them ill:

> 'We wash it properly before consuming it. My mother used to tell me that if we eat rat poop our stomach would bloat so we need to clean the food properly.' [Gulmi6]

> 'I usually close all the rat holes inside the house and cover all the food that we consume. We usually try to control it as the rats can cause another disease.' [Pokhara7]

Domestic pets were perceived to be clean and therefore hygiene practices were unnecessary:

> 'As he [pet dog] is domesticated, we do not wash our hand regularly.' [Bhaktapur1]

DISCUSSION

Key findings

In this study we used a critical realist perspective to examine perceptions of zoonotic disease in communities in Nepal, working with them to reach an in-depth understanding of this relatively neglected area of research. There was little difference in perceptions of and perspectives on zoonotic disease between male and female or urban and rural participants. This is perhaps unsurprising as this was a new subject for most participants, despite the fact that they are potentially at risk of zoonotic disease through exposure to synanthropic animals (e.g., rats and bats), consumption of livestock and bushmeat, hygiene practices, lack of awareness of transmission routes, and reliance on traditional medicine, compounded by a lack of accessible and affordable healthcare. Some behaviours were suggested as more likely to be performed by older people or in rural areas, but when younger or more urban participants were probed further they sometimes opened up and stated that in fact they had also, for instance, eaten bushmeat, or used traditional healing practices rather than visit an allopathic practitioner. This suggests a process of othering, where we differentiate ourselves from others who are situated as intrinsically different, possibly when participants felt uncomfortable about discussion of a behaviour that they judged to be out-dated or potentially harmful, and did not want to be associated with behaviours or practices [228]. This was clear in one interview, where the participant was keen to emphasise his membership in the middle class, and associated this with not using traditional healers, despite the fact that his family (and others in his community) did so.

Earlier research examining awareness and practices related to zoonotic disease in smallholder farmers in Nepal found that 40/89 (45%) of farmers were not aware of potential transmission from livestock to people. Any potential mitigatory practices (e.g., hygiene and vaccination) were not necessarily related to this awareness [40]. We found that, although most participants denied having knowledge of zoonotic diseases and potential transmission, they were often able to discuss symptoms and prevention mechanisms, such as vaccinating pet dogs, avoiding contact with community dogs, and removing rodent faeces from grain. This suggests that participants may have been implicitly reluctant to demonstrate their knowledge (or, as they may have perceived it, lack of knowledge) in front of an outsider or perceived experts [228]. Despite having knowledge about rabies transmission and prevention, they may have felt intimidated in this particular context, and so did not want to say the 'wrong thing', despite assurances that all opinions and views were interesting to us. Participants were able to discuss decisions they made that would protect their health (albeit sometimes indirectly), at the same time as claiming that they did not know that animals can transmit disease to them. All participants in the informal settlement – three of whom had low literacy – were aware of rabies, even if they were not always sure of the animals responsible for transmission. Two of them mentioned prophylactic vaccination of dogs as preventing spread of rabies (one had a pet dog). That rabies is better understood than other zoonotic disease may be a reflection of available funding for awareness campaigns, often run by the government in partnership with NGOs, who may also finance these. It could also be that participants are unable to avoid knowledge of rabies, when community dogs that may carry the disease are ever-present in their environment.

Rodent-human conflict (destruction of crops, clothing and property, concerns around infection and disease spread by rats) was mentioned frequently during the interviews, and most participant photographs featured either rat-mediated damage or attempts to mitigate the damage (e.g., home-made traps, covers for grain stores). Rodent consumption was discussed many times, although usually as an activity performed by 'others' rather than by the participant themselves or their community or ethnic group. The idea of 'clean' and 'dirty' rats, the former acceptable as food while the latter are not, possibly reflects an instinctive and unspoken avoidance of disease: not eating 'dirty' rats is adaptive and likely to benefit those people who behave in this way [229]. This is supported by findings from Viet Nam and Cambodia, where one study found that rodent consumers perceive rats as healthy, nutritious and disease-free [19]. Rodents that eat grain from the field, and not general waste and detritus from homes, are clean and therefore healthy and consumable. People are exposed to rat faeces and urine in their homes, and so associate 'these' rats with dirt (and, indirectly, with disease). Participants were (implicitly) aware that they should clean their grain because the rat faeces makes the food 'dirty' and that this is a bad thing, but they did not often explicitly discuss a link between dirt and illness or disease during interviews.

Participants sometimes evinced reluctance to discuss certain issues. For example, bushmeat was frequently mentioned, but usually as something that other communities did, or that was done in the past. This potential reluctance needs to be unpicked further. Adler and Adler, who have studied this phenomenon in depth, suggest that reluctance is a function of potential embarrassment at discussing topics perceived as sensitive [230]. This makes sense in terms of participants not wanting to talk about, or admit to, bushmeat consumption, or use of traditional medicine. The taboo around rodent consumption, reflected by participants' reluctance to discuss it in relation to themselves, means that it may be challenging to address or even discuss, as the first step will be encouraging people to admit that it happens (and that they may also have participated). Bushmeat consumption is an important tradition for some ethnic and cultural groups in Nepal and this free and easily accessible source of protein is likely to be useful for a resource-poor community of subsistence farmers. As such it may be difficult to persuade people that eating rats or bats is not necessarily a healthy practice, especially as rodent consumption is associated with celebrations such as the paddy harvesting season. Kurpiers and colleagues, in discussing the effects of bushmeat consumption on emerging infectious diseases, suggest that disease spillover can occur through indirect contact (e.g., through exposure to faeces or urine) or consumption. Discussing rodents specifically, they suggest that Mpox virus, leptospirosis, salmonella, Lassa fever, and Mokola virus, have all been linked with consumption of rodent bushmeat [231-233]. Huong et al discuss the relevance of the wildlife supply chain, bringing wild animals into restaurants for consumption, and state that this was a factor in the spread of COVID-19 within China and then to the wider world [19]. They found that positivity for coronavirus detection in field rats in Viet Nam increased along the supply chain: rats bought from traders were less likely to test positive than rats bought

from large markets, which were less likely to test positive than those served in restaurants [19]. These studies support the case that eating bushmeat, or butchering wild animals, is likely to have deleterious effects on health, and at different stages from capture to consumption.

There was a distinct dichotomy between 'us' (me and our community) and 'them' (others who eat bushmeat, or ancestors who did so in the past). We observed much laughter and shyness around this issue, suggesting that some participants may have tried bushmeat but did not want to admit to it as it is judged taboo and perpetrated by 'others' who are in some way different. As rodents and bats are an excellent and readily available source of protein, another possibility is that by denying that they ate bushmeat, participants were inferring that they were rich enough to buy meat or to rear animals to eat. To place this in context, the communities described as eating rodents are judged poor and badly educated, often with low literacy, by some groups in Nepali society, and so admitting to a behaviour that these communities perform would be tantamount to placing the speaker within that group (or at least having something in common with that group). Interestingly, one of the participants in the informal settlement in Kathmandu was of Tharu ethnicity, a group widely believed to eat bushmeat. This participant stated that while Tharu in the west of Nepal will eat rodent meat, those in the east (and by definition, she herself) would usually not, although during festivals they may do so. It is also possible that participants did not want to discuss the eating of wild animals as hunting and killing these animals (e.g., wild boar or deer in protected wildlife reserves) is illegal in Nepal and so they may not have wanted to admit to behaviours that they knew could get them into trouble.

In terms of traditional medicine, a belief in spirits who control health and sickness, as evinced by participants in the study who discussed visiting a *dhami jhakri* (shaman) to cure illness, means that people might be fatalistic about experiencing illness. Suggesting that they have agency over whether their behaviours affect the likelihood of becoming ill may be difficult. This relationship between belief in spirits and health has been investigated in Nepal in the context of tuberculosis [234], and perinatal mortality and morbidity [235]. Marahatta and colleagues found that, when sick, people with tuberculosis visited traditional healers in preference to allopathic practitioners, and this was related to their belief that their disease was a result of karma and so little could be done to address their health issue [234]. Similarly, Paudel *et al* suggest that perinatal deaths were attributed to karma, fate, destiny and the will of the gods, and as traditional healers are perceived as chosen by the gods, these are the people who must be consulted to prevent such deaths [235]. A study in Laos found that health-seeking behaviour by community members was influenced by their belief in the healing power of rituals, spirits and traditional healers, and that these have an important psychological and social significance [236]. These belief systems have implications for any method of raising awareness, especially as, in many contexts, attending a healthcare centre and being prescribed allopathic medicines will be more expensive than visiting a traditional healer and using ingredients that can be picked in the local area.

Some participants suggested that traditional healers were an anachronism, dissociating themselves from older people and those in different, often rural, communities, and suggesting they are better educated and aware of modern medicine. Members of one FGD had an animated discussion about traditional healers and medicine, stating that, although older generations used to believe in traditional medicine, people now visit the doctor when ill and receive modern medical treatment. However, when probed, one participant reluctantly explained that traditional medicines sometimes work better than allopathic treatment and so they still believe in their efficacy.

A study in Bangladesh found that 59% of people bitten by dogs visited traditional healers before going to hospital [154], and in India 64% of people who had a dog bite adopted 'religious practices' to prevent rabies, rather than attending an allopathic health professional [155]. The consistent mention of traditional medicine as the first option for treatment when people were sick suggests that these practitioners are generally prominent, trusted and respected, as well as being easily accessible. Working with these healers and other community leaders in a way that is sympathetic to cultural beliefs and existing practices may be an effective avenue to increasing awareness in communities [235]. This has been demonstrated in studies in Ethiopia, Ghana, Mexico, Bangladesh, Mozambique [237-241], and Nepal [242], where training of traditional healers on issues around transmission and prevention of HIV resulted in a significant improvement in healers' knowledge of these issues, facilitated provision of culturally acceptable education to local communities, and reduced the stigma around HIV/AIDS [242].

Implications

Our findings have some clear implications for policy and practice in Nepal. An understanding of community awareness, beliefs and behaviours, as told by communities themselves, is essential to work toward co-production of a contextually relevant intervention that will have resonance in the community [30]. As one of the human healthcare professionals stated, emphasising the importance of awareness, 'Just because people are not aware of something, it does not mean that they are not getting it' [Health5]. We need to work with(in) communities to ensure that potential routes to awareness reflect what people know, what they want to know, and what is feasible in their situation, to increase the likelihood of interventions and policies being effective for the people they are aimed at.

With the exception of one older participant, all participants stated that they wanted to know more about what actions they could take to avoid zoonotic disease. While we acknowledge that such responses may have been, at least to an extent, a result of participants wanting to be polite and respectful to the researchers, most participants appeared genuinely happy to be asked to take part, with many saying that they had never been asked for their opinions before. This was especially true of one participant who was asked to take

photographs and became so enthusiastic that he kept bringing out more drinks so that we would stay longer, and he could take more images. This suggests that there is an appetite for awareness programmes, particularly when people can take an active, participatory role in them, and this willingness to participate could be fostered by organisations.

Awareness was present to some degree despite a lack of formal educative programmes or campaigns run by local or federal government. Three participants living in the informal settlement talked enthusiastically about a drama session run by an NGO, which had obviously resonated with them, suggesting that this may be a good way to involve community members in programmes around hygiene or related issues, like zoonotic disease transmission. Participants enjoyed these sessions, particularly appreciating the fact that an organisation had spent time and resources coming to their settlement to run the awareness campaign. Events run inside the settlement, and therefore not requiring any financial outlay from the participants, who may not have the financial resources to attend clinics, may be especially useful. Visual theatre, rather than written notices, worked well in this situation as most settlement residents have low literacy: of the four participants, three had at most two years of schooling and stated that they were unable to read or write. This suggests that an effective awareness campaign might benefit from some interaction or role-playing, so participants can imagine what a dog bite feels like, and what kind of action they are able to take in this event. Drama and theatre have been demonstrated to promote community awareness, engagement, and empowerment in communities that are underserved and likely to have low literacy [243], as in the informal settlement. This could be a mechanism to make health education more inclusive and therefore more effective, both in informal settlements and in communities with little to no easy access (geographical or financial) to healthcare provision. Another potential avenue for raising awareness has been demonstrated by the PREDICT project, supported by the United States Agency for International Development and focused on detecting, preventing and controlling infectious disease risk in people and animals globally [244]. This project includes social scientists, who are tasked with identifying behaviours in communities at the human-animal-environment interface, which are judged high risk for virus emergence. Working with local leaders from various countries, the team produced a picture book with simple text, ‘Living safely with bats’, that illustrates the importance of bats to local ecosystems, their role as a potential disease vector, and how community members can live safely with these animals [245]. During community meetings, a local leader presents the book and discusses the images with the audience, creating awareness in a familiar space in which people are encouraged to ask questions and share their opinions [246].

Unlike the perceived difference between ‘clean’ and ‘dirty’ rats, there is no similar split between domestic pets and livestock. This may be related to the close relationship between people and their animals described above. Some participants appeared to take the issue of zoonotic disease personally – they take good care of their animals and so they would not be responsible for causing illness. These participants took obvious pride

in rearing their animals and looking after them, and may have felt that we were questioning their animal husbandry skills, although we worked hard to make it clear that we were in no way judging any of their practices. For many of the participants in rural areas, their livestock will be their livelihood and a huge investment. They may not want to consider the ramifications on their income of their animals becoming ill and dying, or their reputation in the village if their animals are believed to be causing illness, as well as having an emotional bond with their animals. Research suggests that members of poorer communities who raise livestock spend more money on the health of their animals than on their own health, particularly on therapy rather than prevention [247], so there is definitely space for more research to pinpoint what would encourage smallholders to learn about zoonotic disease, without perceiving this as a reflection on their animal husbandry skills.

As described above, many participants were reticent to discuss bushmeat consumption when it referred to their own practices rather than those of others. The taboo nature of bushmeat consumption may complicate interventions to address the practice, as identifying and then working with consumers will not be straightforward if they do not feel comfortable admitting (or even acknowledging) the practice. When we realised that people were not comfortable with discussing this issue, we used deflection, which involves deflecting attention from the participant, and instead discussing a topic in a more general way [230]. Instead of asking directly whether they themselves ate or had ever eaten bushmeat, we asked whether they had ever heard of any person or community in Nepal who practised this. This approach was effective, as participants often relaxed and then opened up about their personal experiences, with less evident discomfort. Ensuring that community members feel comfortable discussing these types of issues is the first step to addressing potentially significant consequences of these behaviours through appropriate mitigation strategies.

The unwillingness shown by some participants to think through the potential effects of zoonotic disease may be linked to fear, which was mentioned by one healthcare professional as a framing that might be an effective driver of awareness. However, fear can be counterproductive, and, instead of promoting healthy behaviours, may work against them. This was seen in the 2014-2016 Ebola outbreak in west Africa, where some fear-related behaviours increased risk of infection (e.g., hiding ill relatives or removing them from in-patient care, increased stigmatisation), when people were not clearly informed of the likely outcome of these behaviours (e.g., more people becoming infected) [248].

Limitations

Limitations of the study include that participants may not have felt able to discuss certain behaviours or practices that they perceived as sensitive or anachronistic (e.g., bushmeat consumption, use of traditional medicine), especially with an obvious outsider. However, as described above, we worked hard to deflect attention away from the fact that we were discussing this topic, and this did appear to work as people opened

up to us. Our study sample was necessarily focused on certain areas, and so people in other communities may hold different views, although we did find that opinions and practices were coherent across the different sites. Interviewing was new to most participants, who had never been asked their opinions on this (or any other) topic before, so they may have felt uncomfortable with the process. While interviewing we worked hard to build a rapport with participants, explaining what we were doing and why, and discussing how their experiences and thoughts were important for the study. Community interviews almost all involved simultaneous translation and some meaning may have been lost during this process. However, all recordings were transcribed verbatim and so transcripts included both the original Nepali vocabulary (translated into English) and the simultaneously translated English, so this loss was, as far as possible, limited. Shared demographics may act as a link between interviewer and participant [230] and the first author was obviously a different ethnicity to all participants; although, as discussed in the Reflexivity section above, during the planning, interviewing, analysis and writing stages she attempted to keep her positionality, assumptions, preconceptions, values and motivations for doing the research in mind, there is a limit to how much difference this might practically make. With these caveats, we believe this study contributes to the limited body of evidence on awareness and behaviours around zoonotic disease in selected Nepali communities.

Conclusion

This study demonstrated that a clear concept of how aware people in a community are, through talking directly to the people involved and comprehending contextual factors, is necessary to effectively working to address threats that exist in these contexts and environments. Our findings that bushmeat consumption and, in particular, use of traditional medicine are relatively common practices must be placed into context. If people eat bushmeat because it is an easily accessible form of protein that has traditionally been used to cure illness, and if traditional medicines are used because healers are trusted members of the community, and, again, more easily accessible than health posts, then these drivers must be taken into consideration in any attempt to understand a community's perspective on illness and what can be done to address these threats. Understanding how people perceive potential disease threats, and how their behaviours may influence these, is key to beginning to address these threats. Working with(in) communities and understanding the explicit and implicit contextual factors is essential to unpicking the complexities around behaviours that might inadvertently encourage the spread of diseases, especially in communities that lack resources to mitigate these threats.

4.3 Chapter summary

This chapter described and analysed community perspectives on zoonotic disease in Nepal, disease awareness and how beliefs and behaviours might affect potential spread of these diseases. Chapter 5 complements this chapter, focusing on potential avenues for co-production of responses to zoonotic disease threats within the Nepali communities included in this study.

Chapter 5: Exploring co-production of responses to zoonotic disease threats with(in) Nepali communities

5.1 Chapter introduction

This chapter addresses Objective 3, to identify existing and potential mitigatory activities around zoonotic disease in selected communities, including barriers and enablers to the effective implementation of these activities, and Objective 4, to work with community members, policymakers, and human and animal healthcare personnel to identify what would foster community engagement and co-production of mitigatory activities in Nepal. In this chapter I present findings from the analysis of the interviews with all participants, and the photographs taken by community members. The analysis generated four overarching themes: i) existing mitigatory practices, ii) cultural factors, iii) experience of community programmes, and iv) community priorities and co-production. We found that community participants, despite strong opinions and desire to participate in disease control interventions, had experienced little or no attempt by intervention organisers to engage them in design, implementation, evaluation, or accountability. Most had no experience of programmes at all. Participants highlighted the significance of working in 'local' languages, respecting religio-cultural realities, relating initiatives to lived experience, and ensuring that local leaders are involved. Meaningful co-production requires recognising communities – through legitimate leadership/representation - as the experts and equal partners who can 'work alongside' at all stages of any initiative.

5.2 Research manuscript

The cover sheet is presented below, followed by the manuscript.

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Please note that a cover sheet must be completed <u>for each</u> research paper included within a thesis.

<u>SECTION A – Student Details</u>

Student ID Number	1408190	**Title**	Ms
First Name(s)	Anna		
Surname/Family Name	Durrance-Bagale		
Thesis Title	Drivers of zoonoses spillover in Nepal: Community priorities		
Primary Supervisor	Associate Professor Natasha Howard		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

<u>SECTION B – Paper already published</u>

Where was the work published?			
When was the work published?			
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<u>SECTION C – Prepared for publication, but not yet published</u>

Where is the work intended to be published?	Social Science & Medicine: Qualitative Research in Health
Please list the paper's authors in the intended authorship order:	Anna Durrance-Bagale, Hari Basnet, Nanda Bahadur Singh, Steven R Belmain, James W Rudge, Natasha Howard
Stage of publication	**Not yet submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I performed the data collection and analysis, wrote the first draft of the paper, and incorporated other authors' comments into this final draft.

SECTION E

[redacted]

Student Signature	
Date	

Supervisor Signature	
Date	

Exploring co-production of responses to zoonotic disease threats with(in) Nepali communities

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Keywords Co-production, community engagement, infectious disease, mitigation, Nepal, One Health, zoonotic disease

ABSTRACT

Background

Co-production between researchers, service providers, and affected communities is an old concept renewed by current efforts to decolonise global health, reduce exploitative practices, and develop more sustainable, context-relevant interventions to address global health issues. Working for change with and within communities is central to healthcare improvement, but engaging with communities – what people know, feel, do, and what they would like to change – remains challenging for disease control professionals. Co-production aims to help ensure communities have some control over the design and implementation of any intervention, greater ownership of processes and outcomes, and, theoretically, some capacity to hold intervention providers to account.

Methodology

In this multimethod study with a critical realist lens we used interviews, focus groups and photovoice in communities across Nepal to identify how zoonotic diseases and their control are perceived and enacted: what people do, why, how this differed in the past and could be improved in future.

Findings

Thirty-nine people in six communities participated in interviews, with another 34 in 5 focus groups. Ten took photographs. Twenty healthcare professionals and policymakers were also interviewed: 14 representing human and six representing animal health. We generated four overarching themes: i) existing mitigatory practices, ii) cultural factors, iii) experience of community programmes, and iv) community priorities and co-production. Community participants, despite strong opinions and desire to participate in disease control interventions, had experienced little or no attempt by intervention organisers to engage them in design, implementation, evaluation, or accountability. Most had no experience of programmes at all. Participants highlighted the significance of working in 'local' languages, respecting religio-cultural realities, relating initiatives to lived experience, and ensuring that local leaders are involved.

Discussion

Meaningful co-production requires recognising communities – through legitimate leadership/representation - as the experts and equal partners who can 'work alongside' at all stages of any initiative. Implications from this research include the importance of promoting trust in communities through inclusion of prominent community members (community health volunteers, traditional medicine practitioners, women's group leaders); the use of local languages; the acceptability of different media for interventions (theatre, drama); and the need to be realistic and pragmatic about available resources, to manage the expectations of community members.

INTRODUCTION

Zoonotic diseases are a rapidly growing threat, epitomised by profound impacts of the COVID-19 pandemic on the health and economic status of populations globally [27]. With over 60% of infectious diseases in human caused by pathogens shared with domestic or wild animals [15, 16], sustainable, One Health approaches to communicable disease management are paramount. Zoonoses are a particular threat in under-resourced countries like Nepal where much of the population, especially in rural areas, may have little access to functioning health posts [42], and depend on livestock for their livelihood, which may facilitate close human-animal interactions that could present a disease risk [249, 250]. As a lower-middle income country with an annual spend of around US$53 per capita on healthcare [36, 37] there is little scope for Nepal to develop advanced surveillance systems to identify potential infectious disease threats, and there is little research detailing burden from these diseases in the country.

Finding cost-effective ways of trying to ensure that healthcare initiatives work is important, especially in resource-poor countries, where the most vulnerable people may not have the capacity (financial or otherwise) to implement interventions, and where, if sufficiently engaged, they themselves can play a role in delivery of health outcomes [63, 251]. This could include using existing resources such as health volunteers who are already part of a community. Putting local people at the centre of any programme initiation or implementation, asking them about their priorities, is crucial, as is considering issues such as cultural, social and religious norms and beliefs, ethics, inclusivity, and power relations, which may affect both a community's willingness to discuss and participate, and also the success of a programme [63, 67-69, 252]. Taking into account underserved populations, e.g., community members who have low literacy, or those living in informal settlements with less access to healthcare and frequent contact with synanthropic rodents or community dogs [34], is also important, to try and reach as many people as possible.

Initiatives are more likely to work if communities have been actively involved in planning solutions so that they are culturally and context-sensitive (what works 'here' may not work 'there') and been given the chance to discuss their actual situation rather than how this is perceived by outsiders [3, 89, 251, 252]. Additionally, their views on what is likely to work may be more realistic as they are working within what they have, rather than an ideal-world scenario. This was demonstrated clearly during the Ebola Virus Disease outbreak in west Africa in 2013-2016, where the response was, to an extent, shaped by the communities affected [253, 254]. Feasibility and recognition of what assets are available is central here: there is little point recommending an expensive or time-consuming 'solution' to an issue if people can afford neither the time nor the expense of these potential solutions [3, 89, 251, 252].

The value of knowledge depends on context. Examining why people behave as they do informs attempts to engage communities in co-production of both research and solutions [251]. Community engagement has a

two-fold purpose in healthcare provision: i) to improve the health of individuals and communities; and ii) to empower people, helping them achieve some control over this facet of their life [255]. Co-production in healthcare aims to ensure that communities have some control over the design and implementation of any intervention, gives them ownership of the process and the outcome, and should allow them to hold health providers to account [69, 90]. In 1969 Arnstein described an eight-rung 'ladder of citizen participation', which differentiates between an 'empty ritual of participation' and 'real' power [256]. This idea was further developed by Jennie Popay [257]. Community control is the most powerful type of community engagement, while informing and increasing awareness is seen as the least powerful. The main aims of community engagement are to enable communities to 'define their own needs and solutions', while supporting them to do so, to make services more responsive and effective [257]. Co-production, in the context of zoonotic disease specifically, has received relatively little attention, despite the fact that this process, among healthcare professional and policymaker stakeholders, has been demonstrated to allow identification of spillover routes, and may be central to disease control strategies [249]. Involving communities in this process would likely increase the efficacy of any intervention [251].

Risk factors that might increase potential for disease emergence in communities are often not clear, which means that designing appropriate mitigatory strategies is difficult [258]. This is why talking with communities about what they do, and why they do it (or why not) is key to constructing any effective initiative. Local people's knowledge and practices are likely to be an untapped source of information and they may well already implement methods and ways of avoiding the spread of illness, even if this is not clearly articulated. Research examining lessons from another zoonotic disease event, the Ebola epidemic in west Africa in 2014–2016, suggests that initiatives addressing disease risk must involve local communities and stakeholders to be effective. This active participation increases trust and helps ensure that solutions are relevant and context-sensitive [259]. In a recent scoping review on anthropogenic factors that may increase zoonotic disease risk in the Indian subcontinent, we concluded that simply promoting community knowledge and awareness will not result in behaviour change, and that working with and in communities, co-designing both research and implementation, is key to successful, relevant and context-specific interventions [28].

Through discussions and photovoice in communities and interviews with other stakeholders, we aimed to identify existing and potential mitigatory activities addressing zoonotic disease at community level, and to assess what would encourage co-production of activities to prevent potential transmission of zoonoses. Research on this issue is lacking in Nepal, particularly qualitative work focusing on the views and opinions of participants during the development and implementation process of any intervention.

METHODS

Study design

This was a multimethod study, incorporating interviews, focus group discussions (FGDs) and photovoice with community members, and interviews with health-workers, veterinarians, and policymakers.

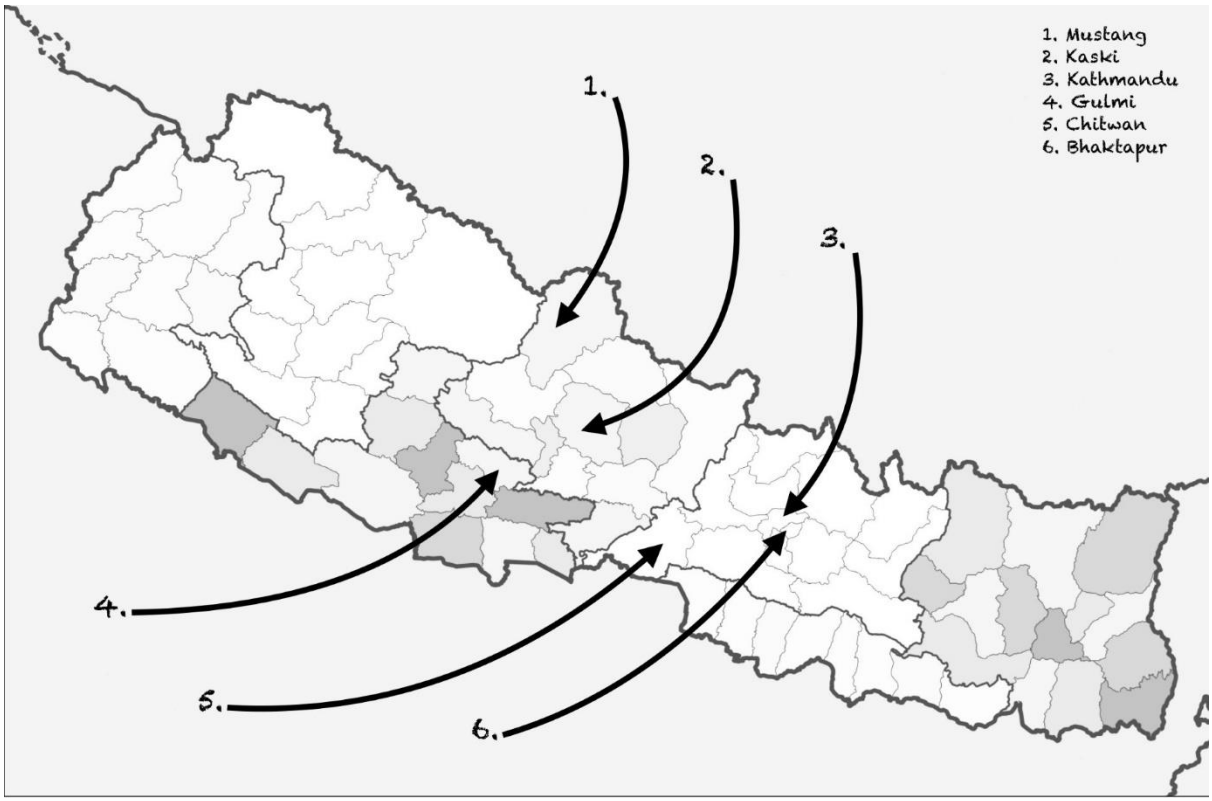
We used critical realist theory to inform our study: a philosophy of science combining a realist ontology (the world exists independently of us) and a subjective epistemology (we can observe the world and draw conclusions, but these are fallible), in which an understanding of the specific context in which people live and work is central [1, 92, 126]. Context is not just a collection of explicit aspects, such as rural/urban setting or financial situation, but also more implicit properties (e.g., power, social status) [126]. This was supplemented by a participatory axiology, which recognises the importance of community members and their views and experience in addressing issues that affect them: here, risk of zoonotic disease spread. This participatory axiology can inform policy and programming, e.g., co-production or co-design of research and interventions, as it recognises that marginalising outcomes can result from individual and systemic factors [91]. Involving members of communities in identifying and examining how their beliefs and opinions influence their situation is central to working with these factors.

Critical realism supports analysis of social issues and work toward potential solutions [1, 92]. Critical approaches are appropriate for working with marginalised populations and have been used to research a range of social issues [1, 92]. Realist perspectives allows examination of the physical, 'observable' world – what we see, what we are told, how we understand issues – and the 'real' world – what influences and drives behaviours [92]. With community participants, discussing issues relevant to them that may affect perceptions of, and behaviours around, zoonotic disease, we attempted to construct a picture of what they understand and how this relates to what they do.

Study sites

We selected six sites after discussion with Nepali colleagues (Figure 1). An informal settlement in Kathmandu was selected as one of the two sites in the Kathmandu valley. Three sites – Kaski (Pokhara), Kathmandu and Bhaktapur – are largely urban, while Mustang and Gulmi are rural and remote. Chitwan is a national park where many people earn a living from tourism focused on elephant riding and birding, while Mustang is mountainous and sparsely populated.

Figure 1. Map of sites



Participant sampling and recruitment

We used a combination of typical sampling and snowballing [105, 106], as discussed previously (Chapter 4). Briefly, we enrolled adult participants of different ages and genders (Figure 1), aiming for six to eight individual interviews and one FGD with six to 10 participants per site. This sample size was judged sufficient to develop an understanding of the views, opinions and experiences of participants, but could be adjusted as necessary (e.g., if we were not collecting informative data) [105]. In each district selected, we contacted a healthcare worker (if available) and asked them to suggest potential participants. If a healthcare worker was not available, we identified a prominent member of the community, for example a teacher or member of a community group (e.g., a local women's group) and asked them to suggest participants. ADB and HB met the potential participants and explained the aims of the study, and interviewed them if they were willing to participate. We asked each participant to identify another potential participant (snowballing) until approximately six to eight individuals and one group had been recruited per community.

ADB generated a seed list of Nepali human or animal healthcare professionals and national or regional policymakers, and asked Nepali colleagues to nominate potential interviewees from relevant organisations in the country. All were contacted by email: two refused due to time constraints and three did not respond. At the end of their interview participants were asked to nominate others who were likely to have useful experiences or viewpoints to discuss.

These types of sampling and recruitment were appropriate to a study with a critical realist approach, as we aimed to gain an understanding of how people in the study sites were affected by their local context and the meanings and understandings they held for the topics we discussed [75].

Consent procedures

ADB explained the study to potential participants before any other study procedure took place. If they agreed, participants were asked to sign a consent form or give verbal consent confirming that they had read and understood the study information sheet. Consent of illiterate participants was witnessed by someone selected by the participant and unrelated to the study team, after thorough explanation of the documents. A consent form was provided for people who appeared in any photographs taken by participants. If consent was not provided, the image was to be deleted. No participant photographed a person during the study.

Data collection

Data were collected between April and July 2022. Both interviewers had post-graduate training in social science research and interview methods. All participants were interviewed in their home, place of work or a local café, as they judged appropriate, and as far as possible to allow confidentiality and privacy. All recordings and photographs were given an alphanumeric code to ensure confidentiality. Completed consent forms were scanned and shredded. Electronic data were password-protected and only accessible to the study team.

Data collection methods were also appropriate to critical realist analysis, particularly the combination of interviews, FGDs and observations, which allowed some triangulation and deeper understanding of participants' (possibly implicit) perspectives rather than relying on one approach from which to draw explicit (and possibly erroneous) conclusions [75].

Interviews

Topic guide development was informed by findings from a literature review we previously published [28], and from our understanding of the relevant context. During the interviewing process additional topics raised by participants were discussed as appropriate.

The topic guide for community participants covered human-animal contact, biosecurity and food hygiene, environmental changes, health issues, and disease awareness, including any experience with awareness programmes. The topic guide for policymakers and practitioners covered participants' relevant experience, views on community awareness, and governmental policy on zoonotic and infectious diseases.

Interviews were approximately 30 minutes and were conducted in Nepali (by HB and ADB) or English (by ADB) as chosen by the participant. Seven of the healthcare professional and policymaker interviews were run remotely by ADB using Zoom software (Zoom Video Communications Inc, San Jose) and audio-recorded with automatic transcription enabled. ADB reviewed and corrected the transcripts against the recording.

FGDs

The topic guide for the FGDs covered the same areas as the individual interviews. Discussions lasted around 45-60 minutes and were conducted in Nepali. One FGD was conducted in both Nepali and Newari at participants' request: all participants were fluent in both languages.

Unstructured observations

During interviews and discussions ADB made brief written observations on the 'three Cs' [118]: any context, content or concept that was potentially significant or interesting, e.g., how participants interacted with animals around them, or if they laughed or appeared uncomfortable while discussing certain topics. These unstructured observations may allow an insight into contextual factors and how these may relate to topics being discussed, or actions being taken [118].

Photovoice

Selected community members who had engaged well during the interview were asked to use a simple digital camera to take photographs that illustrated their perceptions, feelings and beliefs around animal-associated infectious disease risk in their community. They were then asked to describe their reasons for taking these images.

Photovoice is a participatory research method that can be used in communities as an approach to data collection. Participants take photographs during interviews and then discuss the significance of these images for them in their particular context and situation [77]. A systematic literature review of studies using this method suggests that it can enhance understanding of community experiences, beliefs, behaviours and priorities [78] and can be especially useful in marginalised communities who may be less familiar with traditional methods of enquiry such as interviews [114]. This is also true for participants who are less literate or less confident talking to people they do not know or necessarily trust [115, 116]. Participants can produce a physical image of their viewpoint, as something concrete from their reality, without relying on words alone [112]. Participants can be identified as such rather than as subjects of the research, which means the whole process is more of a collaboration than an investigation [114]. This collaboration is central to a critical realist understanding, as it allows the participants to physically show us their beliefs, practices, and traditions, and their different roles, as, for example, community member, mother, member of women's group, farmer, business owner, and disposer of dead animals. Photovoice is an ideal tool to use with critical realism as it

allows participants to demonstrate how they make sense of their world: what is (non-)significant for them and what they would like to know to allow them to have agency over their situation and the world around them [114].

Analysis

Recordings in Nepali were transcribed into English by a Nepali public health professional. Two of the first transcriptions were back-translated and reviewed by another native Nepali speaker to ensure that the transcription accurately reflected the recording. Interviews in English were transcribed by ADB. Names used by participants for animal diseases were cross-checked with a Nepali veterinarian fluent in English to ensure that they represented the correct disease.

Interview and FGD transcripts were imported into NVivo software (QSR International Pty Ltd, Version 12, 2018) for data management. Each photograph was assigned a code and simple textual description by ADB. This was imported into NVivo with the accompanying explanatory text from the participant who took the photograph. Unstructured observation notes were imported into NVivo and used to generate a thicker, richer description of the phenomena being discussed. This allows data from different sources to be used to contextualise events and behaviour and aid in their interpretation [120].

ADB reviewed and coded all transcripts, photograph explanations, and observation notes in NVivo, using reflexive thematic analysis though a critical realist lens to generate themes and sub-themes from the data. The analysis involved six steps: (i) data familiarisation; (ii) generating initial codes; (iii) generating themes; (iv) reviewing potential themes; (v) defining/naming themes; and (vi) synthesising findings [128, 133].

The analysis was influenced by the work of Fryer and Wiltshire on critical realist qualitative analysis [74, 134]. Fryer suggests five steps to allow development of potential causal explanations for phenomena: (i) develop a research question; (ii) become familiar with the data; (iii) apply, develop and review codes; (iv) develop and review themes (from codes); and (v) generate findings [74]. Developing and reviewing themes is related to causal explanations: these result in the events and experiences that participants discuss during their interviews and photography. Data, codes and themes correspond to the experiences, events and causes that are an integral concept of critical realism. The data are the transcripts, unstructured observations and photographs (experiences) generated during the fieldwork; the codes are descriptions of these experiences (events); and the themes are the mechanisms that we can postulate as causing the experiences and events [74]. While reviewing (step iv) we are able to question the validity of our themes and causal explanations: are they intrinsically sensible? Are they appropriate? Do participants use these explanations themselves? [134].

Critical realism has become a popular theoretical positioning for reflexive thematic analysis [128]. It recognises the centrality of the researcher in any interpretation of phenomena, and allows interpretation of context-dependent, situated realities, rather than decontextualised truth: untangling how a participant's social and material circumstances affects how they understand the world, and how the researcher's positioning affects their interactions [128]. Approaching the data from a critical realist stance meant triangulating the data from interviews, FGDs, photographs and observations, to attempt to understand the reality of participants' lived experience, extrapolating from their words and, in some cases, images they took. This allowed the development of a clear narrative and analysis of the causal mechanisms and contextual factors that may have influenced participants' perceptions and understandings.

Reflexivity

Most participants had never been asked to discuss their views and experiences on any issue by anyone, particularly a researcher from a western country. While at times disadvantageous, outsider status can also be advantageous, as the personal experiences of 'insiders' – people perceived as part of the community – may affect what they discuss with participants [139]. Despite having a relatively good knowledge of Nepali culture, and having lived and worked in Nepal intermittently since 2006, ADB was aware that she brought her values, preconceptions, and assumptions into planning, doing and analysing the research. Being an objective observer is impossible, as researchers, with their social, political and educational values, their (implicit and explicit) motivations and hopes, are part of the research [8, 136, 137]. Researchers must remain aware of their 'foreign gaze' [138], keeping positionality in mind. This is one reason why we chose critical realism as the theoretical approach, as this is an important facet of this type of analysis, with its focus on elucidating both implicit and explicit factors and relating these to real-world implications.

Ethics

The Nepal Health Research Council (ref: 2193) and London School of Hygiene & Tropical Medicine Observational Research Ethics Committee (ref: 26507) provided ethics approval.

FINDINGS

Participant characteristics

Thirty-nine people (21 men, 18 women) from communities at six sites participated in semi-structured interviews. An additional 34 people (14 men, 20 women) participated in five FGDs at different sites (Table 1). Photographs were taken by nine interviewees and one FGD participant. This was judged a sufficient number for an exploratory study to demonstrate the effectiveness of photovoice as a method. Twenty Nepali healthcare professionals and policymakers were additionally interviewed in English (Table 2): 14 representing human health (13 men, one woman) and six representing animal health (three men, three women). Location information is not included for these participants to protect their anonymity.

Table 1. Community participant characteristics

Identifier	Gender	Estimated age	Language
Bhaktapur1	Female	45-50	Nepali
Bhaktapur2	Female	50-55	Nepali
Bhaktapur3	Male	35-40	Nepali
Bhaktapur4	Female	30-35	English
Chitwan1	Male	45-50	Nepali
Chitwan2	Male	70-75	Nepali
Chitwan3	Female	45-50	Nepali
Chitwan4	Male	40-45	English
Chitwan5	Male	35-40	Nepali
Chitwan6	Male	60-65	Nepali
Gulmi1	Female	65-70	Nepali
Gulmi2	Female	35-40	Nepali
Gulmi3	Female	55-60	Nepali
Gulmi4	Female	45-50	Nepali
Gulmi5	Male	60-65	Nepali
Gulmi6	Female	55-60	Nepali
Kathmandu1	Male	25-30	Nepali
Kathmandu2	Male	45-50	Nepali/English
Kathmandu3	Female	35-40	Nepali
Kathmandu4	Female	35-40	Nepali
Kathmandu5	Male	20-25	English
Mustang1	Female	45-50	Nepali
Mustang2	Female	40-45	Nepali
Mustang3	Male	20-25	Nepali
Mustang4	Male	40-45	Nepali
Mustang5	Female	35-40	Nepali
Mustang6	Male	40-45	Nepali
Mustang7	Male	45-50	Nepali
Pokhara1	Male	45-50	Nepali
Pokhara2	Male	20-25	Nepali
Pokhara3	Male	30-35	Nepali
Pokhara4	Female	50-55	Nepali
Pokhara5	Male	45-50	Nepali
Pokhara6	Female	50-55	Nepali
Pokhara7	Male	55-60	Nepali
Pokhara8	Male	55-60	Nepali
Pokhara9	Female	50-55	Nepali
Pokhara10	Female	35-40	Nepali
Pokhara11	Male	55-60	Nepali
Bhaktapur FGD	5 male, 4 female	20-70	Nepali/Newari
Chitwan FGD	1 male, 3 female	20-70	Nepali
Gulmi FGD	0 male, 9 female	20-70	Nepali
Mustang FGD	5 male, 1 female	20-70	Nepali
Pokhara FGD	3 male, 3 female	20-70	Nepali

Table 2. Healthcare professional participant characteristics

Identifier	Type	Gender	Interview
Health1	Infectious disease specialist	Male	In-person
Health2	Clinician/NGO	Male	In-person
Health3	Public health specialist	Male	In-person
Health4	Consultant for health NGOs/iNGOs	Male	In-person
Health5	Government/NGO	Female	In-person
Health6	Infectious disease specialist	Male	In-person
Health7	Government/clinician	Male	In-person
Health8	Consultant for health NGOs/iNGOs	Male	In-person
Health9	Government/infectious disease specialist	Male	In-person
Health10	Consultant for health NGOs/iNGOs	Male	Remote
Health11	Infectious disease specialist/academic	Male	Remote
Health12	Public health specialist	Male	Remote
Health13	Consultant for health NGOs/iNGOs	Male	Remote
Health14	Government/public health specialist	Male	Remote
Livestock1	Government/veterinarian	Male	In-person
Livestock2	Government/veterinarian	Male	In-person
Livestock3	Government/veterinarian	Female	In-person
Livestock4	Government/veterinarian	Male	In-person
Livestock5	Government/veterinarian	Female	Remote
Livestock6	Government/veterinarian	Female	Remote

iNGO: international non-governmental organisation; NGO: non-governmental organisation

Thematic findings

Analysis of the interview and FGD transcripts and the photographs, with a critical realist lens, generated four themes: i) existing mitigatory practices, ii) cultural factors, iii) experience of community programmes, and iv) community priorities and co-production.

Existing mitigatory practices

The first theme of mitigatory activities to prevent illness and reduce disease risk included 3 sub-themes: (i) healthcare-seeking behaviours (for humans and animals); (ii) hygienic practices (food, water, personal protective equipment, disposal of dead animals), and (iii) pest management.

Healthcare-seeking behaviours

Accessing healthcare usually meant visiting a local health post for non-serious illness and visiting a hospital in the nearest town for more serious events. Health posts are sited in larger villages and provide immunisation, family planning, and maternal healthcare, with basic preventative healthcare services. There are 25 federal hospitals in the entire country, which provide comprehensive healthcare services, including emergency healthcare. There is one specialist infectious disease hospital in Nepal, based in Kathmandu. These hospitals take more time (sometimes days), money and effort to reach, and at least one participant questioned the expertise of the healthcare professionals there:

‘We will first go to clinic because it is more easy for us and quick rather than going in hospital because in hospital it takes a bit long time for ticket and all the systems[…]we go to hospital if we have to do some more detailed check-ups and test.’ [Bhaktapur4]

‘If it is a mild cough and cold, we take them to the health post nearby. Otherwise, we take them to the Jomsom hospital in case of severe condition.’ [Mustang1]

An FGD participant discussed being admitted to hospital for 15 days after contracting an illness from one of her livestock. After experiencing lung complications in the hospital, she became more ill:

‘[It] was near to death experience and the doctors too were not completely sure of the animals that caused the wound and the illness. The causing agent is still unknown.’ [Chitwan FGD]

Most participants with livestock or pets stated that they would contact a veterinarian if their animals became ill but again they would try other options first, including waiting to see if the animal’s condition improved and administering traditional medicine:

‘When we feel the buffalo is sick first few days we wait and see whether it eats[…]If it is a little bit serious then we call the veterinary doctor and he comes on and then he find out that some problem, he gives injection or whatever.’ [Chitwan4]

‘If the goat does not pee, we feed the leaf of the eggplant. If the homemade treatment does not work, we take them to the vet.’ [Gulmi2]

Lack of veterinary services in the local area adversely affects animal health, with people not able to easily access affordable services if they do exist:

‘People ask us to take them to the vet but to get there it takes 3-4 days. Till then the buffaloes may already be healthy or have died due to the sickness. There is no proper service here.’ [Pokhara3]

Vaccination of dogs against rabies was widespread, with reasons including disease prevention and ability to demonstrate vaccination records to others:

‘So many street dogs are there nearby my house[…]They do bite and when we got dog bite, we scared that they might be rabies disease. And then people took them to the hospital[…]For their rabies vaccination.’ [Chitwan4]

> ‘If it is on the vaccination card then it is okay. Only if they [*veterinarian*] see that something is missing on the card, then they will tell[…]it’s a proper record. If the dog bites somebody then we can show that it’s vaccinated.’ [Pokhara2]

This was also true of pet dogs in the informal settlement: all pet dogs here are vaccinated against rabies, as part of a campaign run by veterinarians, for which the owner pays 250 rupees (about US$2), according to Kathmandu3.

Hygienic practices

Participants were keen to explain what they did to keep themselves healthy, including washing their hands after touching animals, destroying objects and foods contaminated by rats, and ensuring a clean supply of water:

> ‘Yes, we do wash our hands [*after touching livestock*]. We also change our clothes if it gets dirty.’ [Chitwan6]

One participant was adamant that she threw away objects touched by rats:

> ‘We don’t even wear the clothes that has been touched by the rats[…]If my clothes are touched and torn by rat, I don’t wear them, I throw them.’ [Pokhara6]

Many participants talked about food hygiene, with some stating that they threw away food or grain in which they found rat faeces or urine:

> ‘The rats usually live under the cupboard and we see poop around there. We clean and throw it outside. We also clean the food and grains.’ [Bhaktapur2]

Pokhara7 took a photograph of a rodent trap that he used in his kitchen. This participant was aware that rats could spread disease:

> ‘I usually close all the rat holes inside the house and cover all the food that we consume. We usually try to control it as the rats can cause another disease. I usually don’t use poison and use mouse trap in which we use apple, peanut and pumpkin seed.’ [Pokhara7]

Photograph 1: Rodent trap (Pokhara7)

Animal corpses were seen in and around water sources, and people were aware that this was a hygiene issue:

> 'I have not seen dead rats around the house but what you have noticed is that those rats drown in the water pots and we find the dead bodies after we have consumed the water. Inside the big water tankers there is no filter[...]The rats drown there and decay and as we are unaware, we drink water from there.' [Pokhara3]

One participant in Mustang took a photograph of a water course running outside her home, along a main road and adjacent to her cultivated fields and animal shelters. She stated that community members throw animal corpses into this water course, irrespective of how the animal died (e.g., poison, killed by feral dog, diseased domestic animal). She recognised the potential importance of this as a conduit for disease spread. This was supported by a comment from another participant in the same community, who clearly understood that the corpses then reached a larger water course:

> 'I have seen dead bodies of the rats that we throw out in the water canal that connects to the river.' [Mustang5]

Photograph 2: Polluted water course (Mustang1)

Disposal of dead animals, especially rodents, was common, although there were many different ways of doing so. All participants who mentioned disposal emphasised that the corpses were thrown as far away as possible, or in some cases pragmatically added to the gobar (dried cow dung) gas maker, making them useful:

> 'As I don't use any poison I put the dead mouse in the gobar maker. We do not put the dead mouse that we find around the house in the gobar gas maker and usually bury them outside because they can be poisoned, which can affect the bacteria in the gobar gas.' [Pokhara7]

One participant explicitly linked dead animals and disease:

> 'We find them [*dead rodents*] and throw it outside. Sometimes we also bury them because it's said that it can also bring some kinds of diseases.' [Pokhara6]

Participants boiled water and milk before consumption, even if they were unsure why they were asked to do so:

> 'We do boil the milk first. First, we believed that after we drink unboiled milk we can get disease so we used to put salt in the milk.' [Mustang FGD]

> 'I started boiling the water as the doctors asked us to do so and I am not aware of the benefits it has.' [Gulmi2]

Personal protective equipment (e.g., gloves, masks, boots) is not worn during rice transplanting in water-logged paddy fields, which can be a reservoir for leptospirosis spirochetes. Rice-planting is treated as a celebration by some community members. When asked about working in his parents' paddy fields, one participant stated that planting the paddy was like a festival, everyone wearing their usual clothes and no protective gloves or boots:

> 'We wear normal clothes […]I never heard of this [*leptospirosis*]. So usually in the rice field we used to do manually and it's like a festival for us and we enjoy a lot in the mud, and we play like Holi [*water festival*]. It's like a celebration.' [Kathmandu5]

Other participants mentioned that boots are not used while transplanting paddy as it would make the process more difficult:

> 'No gloves but maybe boots when it is rainy but usually they work barefoot. It's more I think comfortable for them without those things.' [Bhaktapur4]

> 'We work barefoot and with naked hands and feet.' [Chitwan1]

Suggesting that it is partly a financial or availability issue, one participant stated that she would use protective clothes when looking after livestock if they were available:

> 'I have not used [*gloves/boots*] yet. If such facilities are provided I am always ready to use them.' [Gulmi5]

When protective clothing was used, e.g., when looking after animals, this was pragmatic, as a way of staying clean rather than about preventing disease spread:

> 'I wear boots and slippers while growing corn, wheat, mustard and also when milking the cows to make sure we are clean but not to control disease.' [Chitwan6]

Pest management

Community participants considered rodents to be the main nuisance animal in their environment, destroying property (clothes, furniture, grain) and crops in fields. Photographs taken included homemade rat traps, household damage, faeces in food storage, and disposal of rodent corpses. Most participants had experience of close contact with rodents (bites, crop damage, presence in homes) and some were resistant to the idea that this contact could become a health issue. Most participants had experience of managing community dogs or rodents in and around their community. This included use of traps and poison for rodents, and

efficient disposal of dead animals. A shopkeeper in the informal settlement discussed the damage rodents cause to her stock. She had used conventional traps in an effort to prevent this damage but the rats were so large that they were able to drag themselves and the trap out of the shop. She photographed her homemade rodent trap, which was made of a piece of round, flat metal covered in lentils and glue. Once the rats are stuck on the metal she kills them and throws them in the river that runs beside the settlement.

Photograph 3: Homemade glue trap (Kathmandu3)

Other mitigation against pest animals included the use of poison, as demonstrated by one photovoice participant who took a photograph of the substances used in his house to control rodents. When asked to explain why he killed rodents, his response was related to disease, although he may have been confused on which disease had killed the person:

> 'Rats also transmit rabies. I heard a case when a rat bit an old woman I had known in the thumb and she did not take good care of it and died due to it.' [Pokhara11]

Photograph 4: Selection of rodent poisons (Pokhara11)

A participant who ran a farm discussed the use of traps and poison, and how controlling rodents was a topic that farmers talked about together:

> 'In the field we find wheat mixed with poison that we keep near the hole that the rat eats and dies. In the house we use traps and also, we mix meat with wheat balls mixed with poison to kill it. We also discuss with other workers to control rats.' [Pokhara1]

Importantly, some mitigatory activities were more specific to certain regions or cultures, e.g., participants in the Mustang FGD talked about how they used a local plant to protect their meat from rodent damage:

> 'As they not only get into food but also cut the clothes it is important to control it[…]As we have a culture of cutting yak and while we are storing the yak meat, we use these thorns that prevents the rats from getting to the meat. These thorns are very sharp and thin.' [Mustang FGD]

Although widespread, the disadvantages of using poison were recognised, including the smell of decomposing rats and danger of inadvertently poisoning livestock, with one participant suggesting that their community stopped eating rats in case they had been poisoned:

> 'Some people had brought poison in the past. Also, people spray poison in the tunnel to kill rats. And as they are poisoned, we throw it in the toilet as the chickens might eat them.' [Gulmi3]

‘Some rats could consume poison so we stopped eating it.’ [Mustang2]

Cultural factors

Nepal is a deeply religious country, with the overwhelming majority of people professing to either Hinduism or Buddhism. One of the most popular gods of the Hindu pantheon, Ganesh, has a rodent (variously described as a mouse or rat) as a vehicle, while the first Buddhist precept is to refrain from killing any living being. These religious factors were mentioned by some participants as to why they would not harm rodents or other animals, and so would not use poisons or traps, but would instead live alongside them:

‘People who believe in Buddha do not allow to kill the rats as it is considered a sin.’ [Mustang FGD]

‘Some kinds of rats are not harmed as they as known as the vehicle of Lord Ganesh.’ [Pokhara11]

One participant who runs a small roadside shop took a photograph of a water bottle from his stock that had been chewed and destroyed by a rodent. Despite the negative effect on his income, he stated that he did not kill rodents due to his beliefs:

‘We haven’t applied any measures. We worship Lord Shiva and do not believe in killing rats.’ [Chitwan1]

Photograph 5: Rodent-damaged water bottle (Chitwan1)

Another participant stated that they did not use poison as they were worried that children would come into contact with it, but also had another poignant point to make, identifying with the pest animal:

‘We are scared to use poison as there are many children in our family. Also, my mother is against killing them as they have a family as well. They eat the grains and go but we cannot shoot them or capture them.’ [Pokhara3]

Experience of community programmes

Most participants had limited experience of any community awareness or engagement programmes, although some described general health camps (where medical professionals provide basic health check-ups and health advice), and actions that had been taken in their communities to address issues such as nuisance dogs.

Existing community programmes

Dog vaccination programmes, which involve some engagement to encourage communities to attend, are organised by local authorities in some areas:

‘People can complain if any dog creates a mess or dirt. People also collect 100 rupees per year and dogs get vaccinated, which started in Pokhara at first. In our ward a notice has been published recently.’ [Pokhara1]

Dog sterilisation was organised in some communities, although this was usually initiated by non-governmental organisations rather than as a formal activity through governmental channels:

‘They sterilise dogs and also kill them if their number increases. These are mostly conducted by NGOs.’ [Bhaktapur FGD]

‘We have given the dog rabies vaccine when people came to us to make us aware. People also made the dog sterile by conducting an operation. People has come to vaccinate her and also took 20 rupees.’ [Pokhara FGD]

Three informal settlement participants independently mentioned a health promotion initiative run by an NGO in the form of a drama session. Presenting information visually and involving the audience was effective for these participants. They were able to tell us about information that had been discussed during the session. This is particularly important as people who live in these settlements are likely to have low literacy and have fewer financial resources to access healthcare:

> ‘Sometime people come here and distribute medicine for free and also screening and health awareness programmes get conducted. I don’t know where they come from but people do drama and give medicine without cost[…]it’s really helpful for poor people.’ [Kathmandu2]

Health-related information was disseminated in hospitals and health camps, which were often focused on one specific issue, e.g., diabetes or COVID-19. Again, these are often administered by NGOs rather than government:

> ‘COVID-related awareness programmes and training on how to be safe and wash hands were also conducted. Specific vaccination programmes on measles or diarrhoea were conducted in this area from time to time by the village development councils. These programmes are mostly conducted by rural municipality.’ [Mustang3]

> ‘Some organisations, NGO or iNGO, they call the public to talk about the diabetes or pressure or other types of disease. They make a camp, which is free camp. Also some time some dentist, they come and they make a camp, and they check up the public villagers’ teeth.’ [Chitwan4]

Community engagement was discussed at length by the policymaker/practitioner participants, who explained why involving communities in any programmes designed to benefit them was so important. Firstly, working with community leaders and local health workers who are known to communities and gaining community trust is key, otherwise initiatives are unlikely to work:

> ‘If they know these people [*community leaders*] are involved then the trust factor is increased. And when the trust factor is enhanced, people seem to work closely with us.’ [Health10]

> ‘Female community health volunteers organise a monthly meeting among the women’s groups[...]They talk about health issues, like general health issues mainly, sometimes women’s issues. So regarding zoonotic disease as well, we go through them.’ [Health14]

Secondly, involving end-users in the design of programmes and feeding back results ensures that people feel they are being heard and that their contributions have value:

> ‘Every year we have a meeting[..]there will be the farmers and people from government[…]farmers will say we are facing this problem[…]based on that information, we prioritise the disease and then we can do research on that topic.’ [Livestock3]

> ‘The data they collect, they present in Nepali in front of them, what is their health status, what are they lacking, what is the nutrition status, so the village development committee’s leader and female community health volunteer teacher, they gather them and present in front of them.’ [Health11]

Thirdly, receiving feedback from community participation helps in designing effective programmes, and ensuring they are relevant to the specific community:

> ‘[*Do you get good feedback from community members?*] Yes of course, that is a very important part for us.’ [Health11]

Community members are receptive to attending programmes that they feel will help them:

> ‘We do have really a good experience regarding community people and if we do data collection they will offer a meal, and sometimes they give us gifts too, like vegetables and fruits.’ [Health12]

Community-led programmes

There was general agreement among participants that community-led initiatives in general did not exist, with little co-operation between residents. Most control measures were taken by individuals:

> ‘We have not done any discussion or measure [*to control rodents*] among the village group. We deal with it individually.’ [Chitwan5]

> ‘The people who have dogs get them vaccinated themselves. But no one in the community has made any plans or programmes for the stray dogs.’ [Gulmi FGD]

One community discussed rodent control practices, including provision of poison from local government:

> ‘What they do is provide poison by the people from agriculture centre to kill them and also gives tips on when not to use it such as while cultivating the food or around the food.’ [Mustang FGD]

One exception to the consensus around a lack of community-led initiatives was in Mustang. Mustangi participants discussed a women’s group who initiated fines for villagers who allowed their dogs to run around outside the home, worrying animals, destroying crops, and biting people:

> ‘Fines have to be paid by those who does not follow the rule, up to 100 rupees that increases if they still do not follow the rules. These are looked by the executive members of mothers’ group. Mothers’ group

have developed a fund from fines which goes for social works. The money they collect from the fine system are used for cleanup programmes or buying dustbins.' [Mustang3]

Community priorities and co-production

What communities want to know

As discussed in Chapter 4, there was little general awareness of zoonotic disease among participants at the six study sites. Participants claimed interest in learning more about zoonotic disease and taking part in health programmes in general, especially if they were tailored to health issues relevant to them:

'I think it is important and these programmes should be conducted by the government rather than the organisations. As a lot of people suffer from sugar [*diabetes*] and [*blood*] pressure, programmes related to this disease should be conducted[…]this information is very important.' [Bhaktapur1]

'I want to know about the new diseases. I have only studied till class 3 but want to be more aware. I also make people aware of the information I know like the luto [*demodicidosis*] I talked about.' [Chitwan6]

'This is a rural area and many people are rearing pet animals like dogs, cats, pigs, hens but most of the people don't know that disease get transmitted from animals inside the home. Such a programme would definitely help people to know about such disease and can prevent themselves [*becoming ill*].' [Pokhara10]

Only one participant suggested that awareness campaigns were irrelevant for her because neither she nor her animals were ever ill:

'I don't care for it [*knowledge on zoonotic disease*]. Our animals and we haven't been sick in a long time[…]the rangers from forest and sometimes others come and give us some information. But we don't give that much attention.' [Pokhara4]

A participant who had recently finished his degree described what he had learned in school and recognised that people who had not received a formal education were disadvantaged:

'When I was at school, there was a separate subject for that. In health, there was transmissible disease and how to avoid[…]If people didn't go to school they have to be made aware by the programmes, or we could do in the radio or the television, broadcasting[…]Government should invest some money for that [*laughing*].' [Kathmandu5]

Practitioners expressed views on community enthusiasm for programmes and discussed their experiences with running these:

> 'Our finding was that they are quite poor in knowledge nowadays and the practice was not so good. No safety and hygiene, and also the attitude toward this avian influenza, the transmission[…]the attitude was good actually because they really want to learn and adopt the practices, but practice was a mess.' [Health2]

Responsibility for programme administration

When discussing who should take responsibility for directing programmes, many participants stated that government should do so as the information would be more believable, and more people would attend:

> 'Programme initiated by government would be very powerful and effective, rather than from other organisations because people would have more belief, and they would be more supportive if the government can initiate the programme from their own level[…]I think that would be more durable as well, rather than small programmes occasionally from private organisations.' [Bhaktapur4]

> 'I am totally agreed that health-related programmes are pivotal for the community. Local government should conduct such programme in the regular basis. But unfortunately, there is not a single such programme so far.' [Gulmi5]

However, members of one FGD held an alternative view:

> 'Effectiveness is seen when such programmes are conducted by NGOs as people attend such programmes as compared to the municipalities. People often do not attend the programmes conducted by the municipality. [*Why?*] People are just more interested in programme when the NGOS conduct it.' [Mustang FGD]

Fostering community co-production

Recognising community members as the experts in their own context is key to effective knowledge sharing and implementation, and healthcare professionals suggested that they must be included from the beginning of any initiative:

> 'Community people are the most powerful resources[…]they could be a powerful weapon if they are provided with real information, and they are provided with the capacity to deal with those outbreaks.' [Health3]

‘They don't involve the community members, they don’t involve them during the writing phase. So this is what I learned. The community engagement is lacking in the project cycle.’ [Health2]

Inclusion can be facilitated by fostering trust, ensuring that sessions or materials are produced in local languages, and acknowledging local customs and beliefs:

‘When we go to communities[…]I engage familiarly with them and I talk simply, let them feel that I am also like them. So they don’t need to be intimidated. I eat with them, drink with them and then they are a little bit friendly, a bit comfortable. When they start to express their feelings then I feel like ok they are now familiar with me[…]after that we start asking them what problems they are having with animals.’ [Livestock3]

‘There’s a language issue, that’s why [*redacted organisation*] uses things like local songs, that’s always quite effective. People like communication in their own language, in their own context.’ [Health4]

‘Once you get the trust, they will listen to you. So how do you get the trust? So one is the language[...]When I speak their language, they talk to me, they have several questions. And once they feel that their question is answered, they sit, and want to know more.’ [Health8]

Female community health volunteers (CHVs) are respected members of local communities and are responsible for much of the general human and animal health awareness and vaccination programmes that are run in Nepal. This group was mentioned many times by participants, both community and practitioner, underlining the position they hold and the potential leverage that these women have:

‘Sometimes FCHVs visit each household for vaccination.’ [Bhaktapur1]

‘Municipality send FCHVs in wards and they spread health related education to general public.’ [Bhaktapur3]

‘The health post conducts these programmes with the help of female community health workers in different villages. They also provide training and awareness programmes.’ [Pokhara7]

‘We have an extensive network of female community health volunteers. They work in the community, they are not directly affiliated with health institutions. They are often expected to visit every house in the

community and they have good relations with the community. We often engage them in the process, so it has been relatively easy for us to work with the community.' [Health13]

'In Nepal we have female community health volunteers, so we have to reach to that level, make them aware and make them the leader of the community campaign because they are the ones who are most connected with the villagers, so to prevent misuse of the vaccinations, they will trust these volunteers.' [Livestock6]

In Gulmi, which was a more rural site than those in Bhaktapur and Pokhara, participants stated that FCHVs began to come to the community about 12 years ago but these women are more involved in microfinance initiatives than in healthcare, while a participant in the same area talked about the lack of programming:

'There are FCHVs round here. People talk about conducting programmes but no actions have been taken. After COVID people also have started washing their hands and are taking sanitation seriously but no programmes related to that have been conducted.' [Gulmi2]

DISCUSSION

In this study, grounded in a critical realist perspective in which context is central, we collaborated with community members using interviews, FGDs and photovoice to identify aspects of zoonotic and infectious disease that are important to them in their context, in an effort to facilitate future co-production of research and practice around zoonotic disease risks. As far as we are aware, this is the first study to do so in Nepal. There is an increasing realisation by both policymakers and practitioners that working with and within communities is central to effective healthcare initiatives: listening to what community members know, what they feel, what they do (and why), and what they would like to know and do to deal with their own issues, as identified by them [63, 251, 260]. This involves recognising communities as the experts in their own context and taking into consideration language, culture and religion, as exemplified by the participants in this study.

Key findings

Chapter 4 explored community awareness and perspectives on zoonotic disease in the communities involved in this study. Awareness does not always correspond with practice [28, 40], so comparing awareness to participant practices was illuminating. For example, a male participant (Chitwan5) discussed how, despite (unidentified) officials visiting the community to raise awareness of zoonotic disease and the role of hygiene in mitigation, there was a lack of village co-ordination around rodent control and disease prevention, and residents dealt with problem animals individually. A female participant (Pokhara10) discussed how people in her community have pets and livestock but are unaware of potentially related diseases. In the next sentence,

she stated that she knew about these diseases but did not pay any attention as she had not personally experienced such issues. This suggests a disjoint between comprehension and practice that is not related to a lack of awareness and needs to be investigated further. However, other participants did demonstrate a connection between awareness and practice. One male participant (Chitwan6) who kept livestock was aware of demodicidosis and believed that washing his hands and changing clothes after contact with his animals would help prevent transmission. A female participant (Pokhara6) stated that she would throw away clothes or foods that had been contaminated by rodents – she knew that rats could transmit disease but was unable to name any specifically. Interestingly, one participant (Gulmi2) discussed a behaviour (boiling water before consumption) that she did not understand the significance of but knew that medical professionals recommended it. Because of this advice from a respected member of the community she participated in the behaviour, even without being aware of why. This complex relationship between awareness and behaviour supports our use of critical realist theory, as this allows unpicking of implicit processes that underlie behaviours and practices that otherwise may appear counter-intuitive [1].

Photovoice, which has been used in other critical realist research [114], was effective in getting participants involved in sharing their views. It was an ideal method to give participants an opportunity to not just talk, but to do something they felt was constructive to illustrate their thoughts. For the researchers, it was enriching to be able to visualise participant priorities, hearing in their own words and seeing through their eyes, as far as possible. People in the communities we visited were enthusiastic about taking photographs once we explained why we wanted them to do so. This was despite the fact that many of them had not used a camera before and were not sure what to do with it. Nobody refused to take photographs and nobody had to deliberate for long on what they wanted to show us. Most participants said that they appreciated the opportunity as they had never been asked to voice their opinion in this (or any) way. If they agreed, participants were given the camera at the end of this interview, and we walked around with them while they explained what they were taking photographs of and why.

Photovoice has been used as a method of empowering participants to speak [115], and encouraging discussion around sensitive subjects [114]. This was reflected in our study. One participant from the informal settlement, a marginalised group in Nepal, was enthusiastic about taking photographs and produced one of the most informative descriptions of the whole study. Including underserved populations who are rarely, if ever, given the opportunity to discuss their opinion, was a rich source of information and will likely suggest ways of being more inclusive when designing initiatives [34]. The experience in the informal settlement was especially informative for us because disadvantaged groups lacking power and with limited means of amplifying their voices are potentially more likely to be reluctant to talk as they are nervous about potential ramifications of doing so, particularly with researchers who look different and where power relations are not clear [230]. Conversely, one of the informal settlement participants took the opportunity to voice her strong

views on the political situation in Nepal, and how it was typical that we had taken the time to visit her and ask her opinions, whereas politicians never came to the settlement unless it was to draw up plans to remove it. Participation of marginalised communities or groups in a method like photovoice may motivate them to think about what kind of changes they would like to make [261]. However, this may be distressing, if people understand that they are unable in practice to make any changes as a result of their situation. Studies have demonstrated that, although communities may know that they can protect themselves and their communities from potential exposure to disease by taking specific mitigatory actions, they do not do so. This has been seen in studies of behaviour around rabies prevention and vaccination in Pakistan [162], India [156] and Bhutan [158], spillover of bat coronavirus in rural China [26], and spread of Nipah virus in Bangladesh [101]. This was demonstrated in the present study, as although participants were sometimes aware of and able to discuss mitigatory practices that could prevent risk of disease or damage from pest animals, they did not always take these actions. One of the clearest examples of this is the shopkeeper in Chitwan, who experienced loss of stock due to rodents, but did not attempt to trap or kill these rodents as this practice did not conform with his religious beliefs. This example underlines the centrality of working with communities to understand what might be culturally acceptable in their context, as well as practical and effective.

Implications

In the present study, some mitigatory activities were more specific to certain regions or cultures, for example, participants in the Mustang FGD talked about how they used a local plant to protect their meat from rodent damage. Without this discussion we would not have known this, reflecting the importance of treating each community as a separate entity and tailoring potential programmes or activities to the specific context. This has been shown in a community-based One Health project in South Africa, where a training programme aimed at increasing disease risk mitigation was specifically designed for local agro-pastoralist communities [262]. This programme, which involved local facilitators who ran workshops with community members, resulted in 98% of participants implementing risk mitigation strategies (e.g., improved animal housing, improved personal hygiene, improved garbage disposal) during a 3-month follow-up period. The authors state that such programmes should be context-dependent, and emphasised the leverage of local facilitators, which encouraged community ownership of the programmes and potential solutions identified by the community members themselves [262].

As demonstrated by some of the photographs and descriptions in this study, cultural or religious beliefs have a role in control of rodents, a major pest in Nepal, and must be taken into account in any attempt to mitigate damage from rats. People may prefer to live with the damage or potential illness caused by rats rather than kill them. This underlines the significance of working with communities and having these discussions, becoming aware of these culturally appropriate factors and experiences that may prevent mitigatory behaviours. One key example of this was paddy transplanting, during which people stand in stagnant water

for hours, with no boots, gloves or other protective equipment. Although one participant suggested that this was because they did not have access to this equipment, most discussed paddy transplanting as a celebratory time, while others suggested that bare feet grip better on wet soil and boots would impede this. Potential mitigatory practices are unlikely to be effective if there are cultural or practical issues that would prevent these being used. For example, taboos around the use of predatory animals (snakes and owls) to control rodents, as these are believed to be used in witchcraft, prevented this potential mitigation from being implemented in Madagascar [263]. When participants discussed methods of preventing rodent damage, this prevention was usually perceived as necessary because of financial loss, rather than potential effects on health. People understandably prioritise having enough to eat rather than worrying about becoming ill. These drivers must be considered when planning interventions or policies.

Key to encouraging co-production of initiatives is recognising that communities are the experts and should be consulted at all stages of design and implementation of any initiative. A recent review on engaging communities with communicable disease control in low- and lower-middle-income countries found a range of initiatives that improved effectiveness of communicable disease control programmes: some involved community members in identifying relevant disease control issues, some involved them in developing materials and messages to be used in programmes, and some helped community members form coherent groups (e.g., women's groups) that then became central to programming [251, 264]. The significance of working in local languages and respecting cultures, relating projects to the everyday life of communities, and ensuring that local leaders such as village heads and CHVs are involved, was discussed by both community members and practitioners. Leveraging existing experience and structures, such as that provided by CHVs, may increase receptiveness of communities to messages. This has been demonstrated for diseases such as AIDS and tuberculosis, and for maternal and newborn health in disparate areas of the globe [251]. In Nepal, female CHVs are the only link between many rural communities and healthcare facilities and are trusted and respected members of the community [265]. Studies in Nepal demonstrated that involving these CHVs increased acceptance of contraception, and improved delivery of basic maternity and perinatal care [266-268]. Working with traditional medicine practitioners, who are based in villages and are often consulted before people visit an allopathic doctor, is another option, especially as studies have shown that some people in Nepal believe that illness is conferred by the gods, and related to karma, fate and destiny, and traditional medicine practitioners are perceived as the only people qualified to alleviate or prevent these illnesses [234, 235]. In Mozambique, traditional healers have been trained in symptom identification (particularly for HIV/AIDS, TB and malaria) and patient referral, and incorporated into the allopathic healthcare system [237-239]. This training resulted in better identification of health issues and an increased number of referrals, although the authors state that clinicians were unwilling to accept these referrals from the healers, as they did not accept their diagnoses [237], and so need to be encouraged to work together with the healers instead of in opposition to them. When healers were trained to perform directly observed therapy for people with

HIV, patient adherence to treatment increased, and they reported positive psychosocial effects of the intervention [238]. These findings suggest that integration of traditional medicine practitioners into the allopathic healthcare system, although not straightforward, is achievable if patients, clinicians and healers themselves agree to co-operate. These healers, with an extensive knowledge of local beliefs and what is culturally acceptable, could be involved in designing context-specific strategies to address zoonotic disease risk. Healers could be trained to recognise symptoms of specific diseases, or to at least discuss with community members their behaviours and how this may affect their health. For example, if a person came to the healer after experiencing an animal bite, the healer could refer them to a health post for vaccination, stressing the importance of doing so, or they could even be supplied with injections that they can administer themselves.

A recent review of community-focused responses to the COVID-19 pandemic found that using local languages encouraged marginalised groups to express themselves and participate fully in planning and administering programmes [269]. This was supported in our research as participants highlighted the significance of working in local languages, which worked to increase trust between communities and outsiders. Related to this is working closely with people who are trusted members of the local community: village heads and community health workers, who are often based in or close to the village they are serving. Peer-led delivery of programmes consistently led to more effective engagement with communities [255], and it is important that community participants perceive the entire research and implementation process as appropriate to their needs, and gives them a space in which to discuss their issues and potential solutions [270]. Trust has been demonstrated as a key factor in other contexts such as the Ebola outbreak in west Africa in 2014 [271]. Involving community members in spreading information on how to protect against the disease resulted in an increased adherence to reducing number of interactions, and observing safe burial practices.

Most practitioners suggested that communities were not consulted before programme implementation, so whether initiatives would be welcome, or even necessary, was unclear. One exception was a veterinarian, who discussed farmers taking part in discussions on what affected their livelihoods, and what they wanted to know about how to prevent their animals becoming ill. This example could be built on, with consultations held with smallholders and farmers, discussing their priorities and explaining what they can do to safeguard both their health and their livelihoods, with the added benefit of promoting economic inclusion in poorer areas. Interventions that do exist tend to focus on general health, which is an existing platform on which to build co-production initiatives. A scoping review found that implementing community-based interventions through existing platforms (e.g., maternal and antenatal programmes and immunisation campaigns) is effective, reducing prevalence of risky behaviours and reducing infectious disease burden [272]. However, this review did not find a clear answer to whether integrated or stand-alone programming was more

effective: stand-alone interventions are easier to implement as they require fewer coordination partners, but integrated interventions that allow delivery of multiple vaccinations or treatments may be cheaper [272].

Participants claimed interest in learning more about zoonotic disease and taking part in health programmes, especially if they were tailored to prevalent issues in their local community. Drama productions were also discussed as an effective means of delivering information by participants in the informal settlement. This might be particularly effective for people with low literacy and those lacking financial resources to enable them to easily access healthcare. When discussing who should take responsibility for directing programmes, many participants stated that government should do so as the information would be more believable, and more people would attend. Interestingly, one systematic review found that programmes run jointly by different stakeholders, e.g., NGOs and government representatives, were more sustainable than others, probably as a result of political support and concomitant financing [273]. A study focused on messaging around Ebola during the 2014 outbreak in Liberia found that, as the outbreak worsened and more people were affected, government messages, originally thought to be 'false', became more influential and people began to be more engaged [274]. These findings suggest that, as discussed by some participants, government support may be central to an effective intervention. Feedback to communities, potentially presenting findings on presence of disease or success of existing initiatives, was mentioned as important. To encourage participation, community members should be shown a 'result' of their time and effort in attending programmes or providing researchers with information.

Women are more likely to be the main caregivers for livestock, and for children, as they are often at home during the day, and women-led groups may effectively support community initiatives, although there needs to be a specific benefit in participating, as these initiatives would involve more (and likely unpaid) work. Mustang participants discussed the women's group in their local community, who have taken on the responsibility for addressing issues around community dogs. These types of groups might be a natural forum for discussing zoonotic disease and potential mitigation of both risk and spread. Working with female CHVs, context-specific initiatives, run by and for the community, that do not rely on government-led programmes, could be designed and implemented. These types of women-led groups have been demonstrated to be effective in areas as different as agricultural development in west Bengal, India [275] and improving perinatal care [266] and female household agency in Nepal itself [276].

However, awareness of availability or otherwise of resources to channel into research and implementation must also be factored into any initiative. As Agyepong and colleagues note, a country has to have secure human and financial resources before it can strengthen capacity for co-production of health research and programming [277]. One participant in our study pointed out that these structural issues will affect community responses, stating that people might attend programmes but are not necessarily able to follow

advice. If the closest health post is 4 hours' walk away, and there is no pharmacy to fill a prescription, then why should people spend time and energy attending programmes?

Limitations

Limitations include that we focused on six regions of Nepal, and participants in other areas may have had different experiences. Many interviews involved translation: concepts in Nepali may differ from those in English, with different nuances and analogies that may not fully make sense in another language. Most community participants had not been interviewed before and so we worked to make them as comfortable as possible with the process. ADB is a different demographic to the participants, which may have affected perceived power relations. She worked hard to build a rapport with participants, explaining what we were doing and why, and discussing her experience living and working in Nepal, which is recommended as a method of encouraging participants to share their experiences [278]. During planning, interviewing, analysis and writing stages of the study she assessed her positionality, assumptions, preconceptions, values and motivations for doing the research. With these caveats, we believe this study contributes to the limited body of evidence on potential co-production of public health and infectious disease programming in Nepal.

Conclusion

This study demonstrated the importance of working with communities to understand context and priorities, that critical realism adds meaning in this type of exploratory study, and that photovoice is welcomed as a participatory method by participants. Using indigenous languages, respecting community cultures, listening to viewpoints, involving community leadership (religious leaders, traditional medicine practitioners, village heads, community health workers), and working with or through existing programmes are all factors that could make these more effective. Engagement between health professionals and communities, tailoring interventions to work with local priorities and co-developing effective solutions addressing drivers of zoonotic disease, are positive steps toward achieving workable solutions to potential disease risk.

5.3 Chapter summary

This chapter analysed topics around mitigatory activities to prevent risk and spread of zoonotic disease in the participating communities, including what might prevent or encourage these activities, and how policymakers and healthcare professionals might engage with community members to co-produce these mitigatory activities. In Chapter 6, I discuss how an effective One Health approach to zoonotic disease could be operationalised in Nepal, and what this might look like.

Chapter 6: Expert perspectives on a multi-sectoral One Health approach to address zoonotic disease risk in Nepal

6.1 Chapter introduction

This chapter presents findings from my discussions with policymakers and healthcare professionals in Nepal, aiming to identify how an effective One Health approach to addressing zoonotic disease risk could realistically be operationalised in the country. Our analysis closely mapped onto the three One Health High-Level Expert Panel (OHHLEP) pathways, with participants discussing themes such as One Health as a concept and opportunity; policy and politics; financing; and catalysts to raising awareness (Pathway 1); power relations and multi-sectoral collaboration; capacity building; community engagement; and collaboration with international partners (Pathway 2); and lack of data and research on zoonotic disease that could inform a One Health approach in Nepal (Pathway 3). The government was perceived as generally supportive, endorsing a One Health approach with the incorporation of technical working groups involving all three sectors. However, participants also recognised that healthcare in general is underfunded, with little data on zoonotic disease, resulting in a lack of awareness at governmental levels of the importance of the issues. Many participants were positive about the potential for a One Health approach in Nepal, although recognising the context-dependent barriers (e.g., complexities of the federal system) to implementation of any strategy. Similar barriers and enablers to progress were discussed by representatives of both human and animal health sectors, which suggests there is space for mutual understanding that could feed into a workable and effective method of implementing a One Health approach in Nepal.

6.2 Research manuscript

The cover sheet is presented below, followed by the manuscript.

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed <u>for each</u> research paper included within a thesis.

<u>SECTION A – Student Details</u>

Student ID Number	1408190	**Title**	Ms
First Name(s)	Anna		
Surname/Family Name	Durrance-Bagale		
Thesis Title	Drivers of zoonoses spillover in Nepal: Community priorities		
Primary Supervisor	Associate Professor Natasha Howard		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

<u>SECTION B – Paper already published</u>

Where was the work published?			
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Where is the work intended to be published?	Health Policy & Planning
Please list the paper's authors in the intended authorship order:	Anna Durrance-Bagale, Hari Basnet, Nanda Bahadur Singh, Steven R Belmain, James W Rudge, Natasha Howard
Stage of publication	**Not yet submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I performed the data collection and analysis, wrote the first draft of the paper, and incorporated other authors' comments into this final draft.

SECTION E

Student Signature	
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Supervisor Signature	
Date	

Expert perspectives on a multi-sectoral One Health approach to address zoonotic disease risk in Nepal

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ABSTRACT

Background

One Health is a multidisciplinary approach involving human, animal and environmental health professionals, working together to understand the risks of and control/mitigate emerging infectious diseases and other issues. A recent One Health High-Level Expert Panel (OHHLEP) acknowledged the interdependent and complex relationships between these sectors and described three pathways: (i) policy, advocacy, and financing: (ii) organisational development, implementation, and sectoral integration; and (iii) data, evidence, education, and knowledge exchange.

Methodology

Through interviews with 20 healthcare professionals and policymakers working in the three sectors in Nepal, we aimed to identify how an effective One Health approach could realistically be operationalised in the country. We used reflexive thematic analysis to interpret the data.

Findings

Our analysis mapped onto the three OHHLEP pathways, with participants discussing themes such as One Health as a concept and opportunity; policy and politics; financing; and catalysts to raising awareness (Pathway 1); power relations and multi-sectoral collaboration; capacity building; community engagement; and collaboration with international partners (Pathway 2); and lack of data on zoonotic disease that could inform One Health programming approaches in Nepal (Pathway 3). Many participants were positive about the potential for a comprehensive One Health strategy in Nepal. The government was perceived as generally supportive, endorsing a One Health plan with the incorporation of technical working groups involving all three sectors. However, participants also recognised that healthcare in general is underfunded, with little data on zoonotic disease, resulting in a lack of awareness at governmental levels of their importance. Many participants had experience co-ordinating or taking part in community interventions around human and animal health; these were usually welcomed by local communities.

Discussion

Collaboration between the animal, human and environmental sectors must be developed further, possibly through rotation of leadership of any One Health approach among stakeholders; policymaker awareness of relevant issues must be increased to promote allocation of finances to research and health promotion; and existing community initiatives focused on health could be expanded to include information on zoonotic disease risk and prevention. Similar barriers and enablers to progress were discussed by representatives of both human and animal health sectors, which suggests that there is a space for mutual understanding that could feed into a workable and effective method of implementing a One Health approach in Nepal.

INTRODUCTION

The concept of 'One Medicine', linking human and non-human animal health, was introduced by Calvin Schwabe in 1976 [57]. With a more holistic focus, adding an ecosystem or environmental aspect, One Medicine then became One Health [57, 58]. The concept has been developed further recently, following the formation in 2021 of the One Health High-Level Expert Panel (OHHLEP) by the Food and Agriculture Organization (FAO), the World Organization for Animal Health (WOAH), the United Nations Environment Programme (UNEP), and the World Health Organization (WHO) [6]. This grouping defined One Health more inclusively as 'an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent' [6]. One Health acknowledges the interdependent and complex relationship between humans, animals, the environment and ecosystems [58]. The related paradigms of planetary health and eco-health have also developed over recent years: the former centres on the importance of environmental and ecosystem health, while eco-health focuses on ecocentric rather than anthropocentric issues [6]. In this paper, we focus on One Health in the context of intersectoral collaboration between human, animal and environmental health professionals, working together to respond to emerging infectious disease.

The OHHLEP, which acts as an adviser to the WHO, UNEP, FAO and WOAH ('the quadripartite'), considers the '4 Cs' as fundamental to implementing any successful One Health approach: communication, coordination, collaboration, and capacity building [6, 279]. Additionally, the OHHLEP theory of change details three pathways for strategies focused on One Health: Pathway 1: policy, advocacy, and financing; Pathway 2: organisational development, implementation, and sectoral integration; and Pathway 3: data, evidence, education, and knowledge exchange [280]. This concept as a whole underlines the complex and multi-faceted nature of One Health, and that the human, animal and environment sectors, along with rural, urban and mobile communities, must be involved in any attempt to work toward a sustainable future with healthy animals, humans and ecosystems [6].

The COVID-19 pandemic reinforced the pivotal importance of understanding anthropogenic drivers of disease spillover and outbreaks of emerging and re-emerging disease, and the key role of the One Health approach in addressing these threats [281-283]. This pandemic followed closely behind other high-profile outbreaks of zoonotic origin, exemplified by Severe Acute Respiratory Syndrome and Ebola Virus Disease, along with numerous spillover events involving infectious agents which continue to circulate in animal reservoirs and are considered pandemic threats, including Nipah virus and Highly Pathogenic Avian Influenza (HPAI) [284, 285]. The threat posed by zoonotic diseases is especially pertinent in countries such as Nepal, classified as 'least developed' by the United Nations. Factors increasing the risk of, and vulnerability to, disease outbreaks in Nepal include lack of investment in the healthcare system, with an approximate annual

spend of US$53 on healthcare per capita [36, 37], and lack of access to health posts, especially in rural areas [42], coupled with a lack of data meaning that the incidence and prevalence of these diseases is not clear [54].

Although zoonotic diseases are likely to place a huge and potentially increasing socio-economic burden on Nepal, little research has been done and there are almost no policies in place to address these issues [54]. Nepal has three tiers of government: federal, state and local, which, coupled with a weak regulatory capacity, make policy formulation and implementation complex [54]. As with other countries, there is no governmental body devoted to One Health, with the Ministry of Health and Population representing human health concerns and the Ministry of Agriculture and Livestock Development representing animal health. The Epidemiology and Disease Control Division, under the Department of Health Services, contains a Zoonotic Disease section, but animal health within this section is represented by one veterinarian [54]. At the provincial and district levels no institution is leading on One Health. The focus is understandably on managing disease outbreaks rather than on how to prevent these occurring, and donor support (technical, administrative and financial) is pivotal [54].

In December 2022, Nepal voluntarily underwent the WHO's joint external evaluation of international health regulation core capacities (known as the JEE) [39]. This mission identified a need for governance mechanisms to 'ensure consistent, institutionalized intra- and multi-sectoral and One Health coordination and collaboration (i.e. the horizontal harmonization of actions) that is less dependent on individuals', which does not just occur during emergencies, such as outbreaks. Although Nepal has made a clear start on a One Health approach, with a multi-sectoral, cross-agency strategy endorsed by the government in 2019 and a priority list of zoonotic diseases constructed by national experts [39], operational mechanisms to action these need to be designed and implemented.

A recent review found that One Health approaches can be effective when applied to the control of neglected and endemic tropical diseases, although the interface between the animal, human and environmental sectors is not optimal [33]. Successful One Health initiatives must remove siloes and promote interdisciplinarity, with stakeholders cooperating with each other and with communities [33]. However, this is not straightforward to address, as ensuring that the disparate views and potentially competing interests of different stakeholders are taken into account is complex [263], as is working within financial, cultural and administrative constraints. Recognition of the complex nature of the relationship between the human, animal and environmental sectors [58], and the necessity for an integrated One Health approach to healthcare is a step forward, but One Health research remains compartmentalised, and the need for a social science approach to One Health, recognising the significance of contextual factors, although discussed, is not often seen in practice [24, 30-32, 59-62]. Through interviews with healthcare professionals and policymakers working in animal, human and

environmental health in Nepal, we aimed to assess the existing situation, and explore opportunities and challenges to realistically operationalising an effective One Health approach in the country.

METHODS

Study design, sampling and recruitment

Study design was previously described in Chapter 4 and Chapter 5. Briefly, this qualitative study reanalysed interviews with Nepali health-workers, veterinarians, and policymakers. ADB used purposive sampling and snowballing, first generating a seed list of Nepali human or animal healthcare professionals and national or regional policymakers, who asked colleagues in Nepal to nominate potential interviewees from appropriate organisations in the country. ADB contacted all by email, with two not responding or refusing due to time constraints, and asked participants at the end of their interview to nominate others who might have useful experiences or viewpoints.

Consent procedures

ADB explained the study to potential participants, allowing time for questions and discussion. Those agreeing to participate, signed a consent form confirming they understood the study information sheet and participated willingly.

Data collection and management

We developed a topic guide covering participants' relevant experience, views on community awareness, and comprehension of and views on governmental policy on zoonotic and infectious diseases.

ADB, who had post-graduate training in social science research and interview methods, collected data between April and July 2022. Interviews were conducted in English and lasted around 30 minutes. Most participants were interviewed in their place of work or a local café, as they judged appropriate, and to protect their anonymity. Additionally, ADB conducted 7 interviews remotely using Zoom software (Zoom Video Communications Inc, San Jose), which were audio-recorded with automatic transcription enabled as all participants gave permission. ADB reviewed and corrected transcripts against audio files, assigned an alphanumeric code to all participants and files to ensure confidentiality, and scanned and shredded completed informed consent forms. ADB transcribed all interviews. Electronic data were password-protected and only accessible to the study team.

Analysis

ADB imported interview transcripts into NVivo software (QSR International Pty Ltd, Version 12, 2018) for data management and coded all transcripts using reflexive thematic analysis to generate themes and sub-themes.

Analysis involved six steps: (i) data familiarisation; (ii) generating initial codes; (iii) generating themes; (iv) reviewing potential themes; (v) defining/naming themes; and (vi) synthesising findings [128, 133].

Ethics

The Nepal Health Research Council (ref: 2193) and London School of Hygiene & Tropical Medicine Observational Research Ethics Committee (ref: 26507) provided ethics approval.

FINDINGS

Participant characteristics

Twenty Nepali healthcare professionals and policymakers were interviewed (Table 1): 14 representing human health (13 men, one woman) and six representing animal health (three men, three women). Two identified as also being involved in environmental health projects (Health10 and Health13). Location information is not included to protect confidentiality.

Table 1: Participant characteristics

Identifier	Type	Gender	Interview
Health1	Infectious disease specialist	Male	In-person
Health2	Clinician/NGO consultant	Male	In-person
Health3	Public health specialist	Male	In-person
Health4	Consultant for health NGOs/iNGOs	Male	In-person
Health5	Government/NGO consultant	Female	In-person
Health6	Infectious disease specialist	Male	In-person
Health7	Government/clinician	Male	In-person
Health8	Consultant for health NGOs/iNGOs	Male	In-person
Health9	Government/infectious disease specialist	Male	In-person
Health10	Consultant for health NGOs/iNGOs	Male	Remote
Health11	Infectious disease specialist/academic	Male	Remote
Health12	Public health specialist	Male	Remote
Health13	Consultant for health NGOs/iNGOs	Male	Remote
Health14	Government/public health specialist	Male	Remote
Livestock1	Government/veterinarian	Male	In-person
Livestock2	Government/veterinarian	Male	In-person
Livestock3	Government/veterinarian	Female	In-person
Livestock4	Government/veterinarian	Male	In-person
Livestock5	Government/veterinarian	Female	Remote
Livestock6	Government/veterinarian	Female	Remote

iNGO: international non-governmental organisation; NGO: non-governmental organisation.

Thematic findings

Themes generated during analysis closely aligned with the three OHHLEP theory of change pathways [279, 280], so we adapted this as an organising framework. Pathway 1 focuses on fostering political will, and policy, regulation, financing and governance issues. Pathway 2 addresses more grassroots issues such as community

engagement, capacity building, equity and collaboration. Pathway 3 focuses on knowledge, data, specialist education, technology, research and development, and how to formulate and formalise best practices.

Pathway 1: Policy, advocacy, and financing

Four themes under Pathway 1 were: (i) One Health as a concept and opportunity; (ii) policy and politics; (iii) financing; and (iv) catalysts to raising awareness.

One Health as a concept and opportunity

All participants discussed the need for a One Health approach and for sectors to co-operate to address the risk that infectious diseases could affect not just human health but also economics nationwide:

> 'Because now the old concepts won't work, animal health only, human health only, that doesn't work. You need to understand where the source is, and we need to jointly fix it[...]like this African Swine Fever, it has less zoonotic risk but it has a huge impact on animals. And the economy related with it. So being a citizen of this country and being a person who is working for the system I need to understand that aspect as well.' [Health9]

One participant stated that although One Health is discussed at high levels, there is still a lack of understanding of what it actually is, which means that trying to operationalise any One Health approach is not simple:

> 'There are some policies, but in real ground still there is some gap in understanding of One Health among the managers. I know very well about the One Health concept, but actually all the sectors, the environmental sector, the animal sector, and us need to understand in the same way, you know, One Health.' [Health14]

Policy and politics

One human health participant mentioned the process of forming a working group to facilitate a One Health strategy for zoonotic disease in Nepal, discussing who was involved in policy formation. The government was aware that successfully addressing issues around zoonotic disease necessitated a multi-sectoral approach involving different groups and worked to support policymaking by the Technical Working Group:

> 'We started compiling the information received from different sources, the OIE [World Organisation for Animal Health] information, WHO information and regional offices information from WHO and the CDC itself, and then we decided to formulate one National Technical Working Group on zoonotic diseases. We started and a memo was issued and then ministry and the department of health services both agreed and

we formulated a multidisciplinary group from human health, animal health and then environment and then food and drug, water and sanitation, laboratories, both animal and human laboratories, and wildlife.' [Health9]

Formulating the policy was a positive way of establishing and cementing a relationship between the human and animal health sectors, as they had to work together to produce a coherent and effective document:

'That list of 10 priority zoonotic diseases was done with a very healthy relationship with all the stakeholders especially animal health[…]we have a very healthy and very good relationship.' [Health9]

The policy-making process was discussed by an animal health participant, who confirmed what his human health counterpart had stated. This participant was positive about the process, which is demonstrating a clear way forward for both sectors:

'Department of [Human] Health Services and Department of Livestock Services, and other One Health partners, they came together[…]a partner meeting was conducted, and that meeting has prioritised 10 zoonotic diseases as the priority for Nepal[…]It was done on a mutually agreed consensus, especially between the animal health services and the health services, and also like environment and other partners, but main role was from the health and animal health side.' [Livestock2]

The Nepali government has approved a One Health strategy with the cooperation and shared leadership of the human and animal health sectors:

'[In] 2020 Government of Nepal approved One Health Strategy[…]then for the time being, the Department of Health and Department of Livestock Services mutually agreed to prioritise some diseases[…]So, now, the government has a plan of prioritising 10 diseases[…]just 2 weeks before we have a meeting of a technical committee that is chaired by the Director General of Department of Livestock Services and the Director General of Animal Health[...]then the next meeting will be chaired by the human health.' [Livestock4]

This was reiterated by a second participant, who described how the One Health strategy had come into being:

'At the time of prioritisation of diseases, we worked with the One Health approach, like everyone was given equal rights, the full voting rights were there, and even environmental. And we had national technical working group on zoonotic diseases, that is also functional[…]all the emerging and re-emerging

we say it's 75% but 100% are of the zoonotic origin nowadays, so the public health cannot exclude veterinary or livestock people and we have to work together.' [Livestock6]

One participant discussed the importance of health experts being interested enough to interact with policymakers:

'The concerned people and policymaker must be interested on this issue. And they have to always welcome and try to help those people who are actually dedicated in this field[…]If the policymaker also wants to do something, but if they don't find any dedicated people, just me, then it's also a waste of money.' [Health1]

The government was perceived as being invested and political will as present by one positive participant, who described the aftermath of a recent avian influenza outbreak in Nepal, including formation of a multi-sectoral committee focused on this disease, although this was reactive, occurring after an outbreak of disease, not proactive:

'That [committee] is headed by the Director General of Department of Livestock Services. But there are representations from human health and also the wildlife and some other areas. So after every bird flu outbreak, they convene together, and they decide, they make a lot of decisions on how to control it. So from that perspective, I think we're going in the right direction.' [Livestock2]

Other participants were not as positive. A key infectious disease figure suggested that lack of comprehension of the significance of zoonotic disease and a related One Health approach in Nepal starts with the government, so it is unsurprising that knowledge does not filter down to communities:

'Nobody cares, at least policymakers aren't giving attention[…]That means that zoonotic disease is ignored from the upper tier[…]So of course, at the bottom, if somebody is bitten by the dog, they ignore. 'It is a very small wound, why should I have to go [*to the hospital*]?' So this kind of thing, from top to bottom, still we have to do hard work to convince them that zoonotic diseases are one of the very serious public health problems in Nepal. So we are still failing, and the concerned persons are really not giving attention to these diseases.' [Health1]

Policy exists but is not put into practice and this is perceived as a failure of the animal and human health sectors to work together:

‘In humans, we have EDCD [*Epidemiology and Disease Control Division*]. So we're planning to establish some Centre for Disease Control in Nepal. The policy, we are writing it, but I don't know about the operation because same people in the same place, same decision. So the human disease for one part is the basis. Second part is like, even we prioritise zoonotic disease and One Health policies, they don’t materialise it. So it's quite difficult.’ [Health6]

‘The people working across the agencies hardly communicate with each other, hardly communicate about the resources they have, the expertise they have, and what they can share to solve the problems related to infectious disease or zoonotic disease.’ [Health3]

The federal system of governance in Nepal poses a challenge, with less than successful integration of departments with different priorities causing problems:

‘With the change in the governance structure in the country, kind of the communication institution for the veterinary side has been merged with the agriculture one[...]it's the same politics, dynamics with agriculture and livestock sector, we have the same ministry, and the livestock sector and the agriculture council with the same ministry, and the agriculture sector out populates us, you know, and at times, it's difficult for us to get heard. We don't have proper representations from our side in the institution. So we have had challenges.’ [Livestock1]

Financing

Four participants explicitly mentioned lack of funding as an obstacle to a coherent national One Health approach, with little to no financing for research or prioritisation of other areas such as staffing:

‘The lack of expertise in the country, because only one or two people are interested in this topic. And they are most of the time busy seeing the patients or maybe busy attending some meetings, or not doing research and research on this topic is very primitive, or let's say even doesn't exist, because of lack of funding.’ [Health2]

‘Whenever we want to work, budgets are always the constraint.’ [Livestock6]

Financing was acknowledged as a complex issue, especially as the different levels of government (federal, provincial and local) are able to allocate funding for projects, and this can lead to a lack of coherent planning and implementation. However, the main issue is the under-funding of the health system in general, with different sectors competing to receive the funding that does exist:

'It's quite tough to get the complete picture, but in general we can say that it [*the health system*] is under-funded because we have to set priorities where we need to expand infrastructure, development of human resource, and so on. So it's quite a general conclusion that it's under-funded, but to what extent it's under-funded, is quite a difficult question.' [Health13]

'We have little resources and all sectors will fight, the livestock sector will also demand more budget, construction sector also demands more budget, so we need to prove to them [government] why we are important, why public health is important. Simply asking for budget and programme is not a good idea, we need to convince them with cost-utility analysis, cost-benefit, economic analysis, economic evaluation approach, we need more research on that and why it is important to invest in public health[…]actually the government is spending very little.' [Health14]

However, there was a feeling that the government is aware of the issue and political will is present, but money is not being prioritised:

'So in that way government people are willing, they are supporting the local people or they are working on these things, but not at the level where it has to be. It has to be given the priority at the national level, at our annual budget, at larger scale.[…]I will not say that the political party doesn't know about it, they are giving it the priority but not at that optimum level where it has to be.' [Livestock6]

Catalysts to raising awareness

Antimicrobial resistance (AMR) and COVID-19 have both pushed One Health awareness for policymakers up the agenda:

'One thing that has led to some increase in One Health, broadly speaking, is AMR, the issue of antimicrobial resistance, so that's where I've worked very closely with the community and also scientists, researchers, policy people[…]trying to find ways to mitigate it in Nepal from a policy point of view. So that has led to an enhanced awareness of One Health and also zoonotic diseases. The One Health perspective has come across[...]COVID was very bad for us in many ways but COVID actually helped enhance our understanding of One Health and zoonotic diseases.' [Health10]

When outbreaks occur, stakeholders take a pragmatic view and tend to collaborate in a reactive manner to address the acute issue, but otherwise One Health is not prioritised:

‘Co-ordination in Nepal is just based on need, unless we need them we don’t communicate[…]So if there is nothing, if there is no outbreak going on, no zoonotic diseases are coming in the community, so, in that case, we hardly co-ordinate.’ [Health14]

Pathway 2: Organisational development, implementation, and sectoral integration

Themes under Pathway 2 addressed: (i) power relations and multi-sectoral collaboration; (ii) collaboration with international partners; (iii) capacity building; and (iv) community engagement.

Power relations and multi-sectoral collaboration

The many stakeholders that must be represented in an effective One Health approach, and the implicit power relations, were discussed as a barrier to effective policy formation and collaboration by a cross-section of participants:

‘The majority of the people, they understand the importance of having the good connection in animal health and human health domains, but there are certain people who have different ideologies. They want to work in silos. So that's actually giving it a disconnect.’ [Health8]

Siloing was mentioned again by one animal health professional, who used the inaction on Nipah virus to illustrate an issue with animal and human health staff working together, suggesting that the human health sector saw any potential investigation of the presence of Nipah virus as being ‘their’ responsibility and others as encroaching on their territory, yet nothing was done by them either:

‘We had some kind of discussions with the public health sector. And we also discussed about doing some surveillance kind of thing in bats. But there was this kind of issue of encroachment. And actually, we discontinued it. We ended up deciding nothing.’ [Livestock1]

Another participant suggested that this siloing and lack of sectoral integration means that some diseases are neglected as there is not enough funding to cover everything and duplication of effort leads to both sectors spending money that could be more effectively pooled:

‘The interdisciplinary research culture is not established in Nepal. And the people are working in silos[…]for example, veterinarians, they are working very independently and not collaborating with clinical or medical researchers. Same with the environmentalists. So I think the first gap is the intersectionality and that's why these diseases are neglected.’ [Health2]

Another issue is the under-development of the environmental sector in Nepal, which is perceived as having little capacity to focus on One Health:

> 'For the environmental health, that's the Department of Environment. But those people are not much interested on it. They are almost at the primitive stage, just trying to establish something with laboratories, so that they can work on One Health. So for the time being, it is difficult to find the expert.' [Livestock4]

Despite the invisibility of the environmental or wildlife sector, as perceived by some participants, others recognised the significance of this sector for addressing risk of zoonotic disease:

> 'In Nepal the barrier between humans and wild animals is reducing, because the buffer zones are getting less and less, and with jungle there's always the chance that we will be more in contact with animals and therefore we will be subject to, as of now, not-exposed viruses.' [Health10]

Many participants detailed difficult relationships between human, animal and wildlife health practitioners as preventing effective collaboration:

> 'When we talk One Health mostly the animal health people are interested but very difficult for human health to be convinced that it is your job too. Physicians, surgeons will not spare their time for that so that compartmentalisation has to be broken.' [Health11]

> 'It's not like we cannot collaborate with them but the problem is it's very difficult to collaborate even with human and even with wildlife[…]we don't get good results.' [Livestock3]

> 'The Department of Livestock Services are doing something, the Department of Health Services are doing something, but they are not cross-fertilising, they are not connected.' [Health8]

Attempts to design a control strategy for rabies illustrated the division between the animal and human health sectors, according to one animal health participant:

> 'The One Health Strategy was one of the biggest achievements that animal health sector needed. For rabies, rabies control. Just 1 year ago, we were in a meeting with the WHO, OIE, animal health and human health people. And human health people were just not interested in control or investing in rabies. But rabies has a big burden. Even they don't like to diagnose, it's difficult for them to diagnose.' [Livestock4]

The situation was described as one in which partners need to feel equal: this is not the case, and so working together is not a possibility because one group feels (or is perceived to be) inferior to the other:

> ‘Any [*approach to*] zoonotic disease requires both of the entities to be in a similar position, equal. Because we have learned from the past, because there is a kind of inferiority and superiority kind of things are there, and we have heard it often[…]I'm doing it for the betterment of people, betterment of animal, betterment of environment. So for that both the parties should be in a win-win position.’ [Health9]

This tension was demonstrated clearly during the COVID-19 pandemic, when animal health facilities were key to the health system response but staff were not credited with any role:

> ‘Animal health has not received proper attention[…]when the COVID came in, the public health in Nepal, they just had a single laboratory in the country that could diagnose COVID[…]people realised that animal health side had those kinds of labs throughout the country. They had the BSL2 level set-up and all of our laboratories were used by the public health sector for COVID diagnosis[…]they didn’t spell out that it was from the veterinary lab, and we had to raise our voices, that you have to mention it.’ [Livestock1]

One animal health participant suggested that stakeholders may feel threatened by working with others who may have a better understanding of an issue than they do, and so prefer to work in silos in which they feel secure in their knowledge and experience:

> ‘Not just politics, but also kind of depends on what level of knowledge you have, what kind of attitude you have, if you regard the other profession as proficient or not, if you think it's actually needed or not, I think so that's kind of a problem. And when we talk about different professions, I would say that we love not having people from other professions in our comfort zone[…]I see that happening in Nepal, in many places.’ [Livestock1]

Lack of leadership was discussed, with participants suggesting that the government was not taking a leading role and so the sectors involved had nobody to follow:

> ‘Lack of coordination from the government side, like policymakers, there are no joint committees to look at this topic from a whole systems role, discipline, multidisciplinary approach, although there are different committees in different ministries, but not like that integrates all.’ [Health2]

> ‘For this kind of research, the government, they should have some plan, systematic plan[…]they have to give us some direction[…]if they start from their side it would be easy for us. But that thing is missing, that’s why we are not having One Health projects.’ [Livestock3]

One animal health participant stated that there are problems but also recognised that this is a universal issue and not specific to Nepal:

> ‘Whenever we work for the One Health approach, there is always some ego type of problem everywhere [*laughing*], everyone wants to be ‘I know everything, I want to be at the top, I’m responsible for this, if this is to go forward this has to be me’, or something like that is always there[…]it’s human nature, everyone wants to be at the supreme level or everyone wants to coordinate it their way. I think this is a problem everywhere.’ [Livestock6]

When necessary, different sectors do work together, including at governmental levels. A human health worker stated that there was a good working relationship among different government departments and external agencies:

> ‘We have linked up with Department of Health Services, Department of Livestock Management, also to some extent Nepal Agricultural Research Council, and Agriculture Ministry[…]my colleagues who are working on One Health as their focus have to do so, but as an organisation we make sure we have good linkages with all these ministries so the work gets done.’ [Health10]

Another discussed the effects that personalities can have on trying to present a united front to deal with potential zoonotic disease outbreaks, but was overall positive:

‘If you look at COVID, here's the perfect system, where human and animal health are working together[…]if the persons are very compatible with each other, then very coherent working environment is created. But sometimes if the people, their tuning doesn't match, then in this case, there is no communication[…]compared to the past, now we're progressing in the right direction in terms of human-animal interactions, and then One Health approach, and lots of areas we are working together.’ [Livestock2]

Collaboration with international partners

Many participants discussed positively how they collaborate with international partners, with some working as consultants in these organisations alongside their primary roles. There was a feeling that One Health as a concept was being pushed forward by these collaborations, as financing is provided by international organisations who are then, to an extent, in control of thematic programming:

‘When there is a project funded from UK, the USAID, World Bank, we are more focused on that. During 2012 or 2013 there was a zoonoses control project. So there are lots of awareness workshops for the policymakers, technicians, even veterinarians, even human medicos.’ [Livestock4]

‘There's this Fleming Fund in Nepal. And it has been doing quite a great job, I would say. So it supports both the public health and animal sector.’ [Livestock1]

International collaborations can bring other pressures, as once external funding from the partner organisations is removed, projects are often closed due to lack of further financial support. One participant had another view on how international funding can drive the agenda, allowing funders to prioritise certain diseases or healthcare issues, which may not be as relevant to Nepal as to other countries:

> ‘When I had just entered into public health, at that time HIV was given so much priority because a lot of funding came to HIV and sexual and reproductive health, right, and the maternal health side. But when the funding opportunities are less the funding switches from one disease to another disease, then the priorities also become different’. [Health12]

Another participant had a poignant comment to make on how this international funding affected priorities in his country, with politicians and international NGO staff perhaps enjoying discussing programming in expensive hotels, but translating this to the village level, and actually implementing healthcare provision that is relevant to local communities is not so straightforward:

> ‘Because our health priorities are to some extent driven by international development partners, we could not take our health activities from 5-star hotel to village. Most of our public health activities remain in the 5-star hotel to talk, and it is our duty to bring them to the real field, that is the challenge lying in front of us who are working in public health. You can quote me, how to bring public health from 5-star hotel to the village [*laughing*].’ [Health11]

Governmental support is key to effective collaboration with international organisations, even if it does not provide any funding:

‘We [*a Nepali healthcare NGO*] work closely with the government, because every work we do is very difficult to do without government support. We need people to go in the field and for that we need a support letter, which is provided by the Nepal government, different agencies. And we tend to work with funding from, for example, let’s say WHO or USAID or other international organisations[…]We don’t get

funding from the government *per se*, but we do use government help and support networks in order to facilitate the work.' [Health10]

Capacity building

Insufficient human resources and diagnostic equipment, lack of facilities in remote areas, and 'brain drain' were all discussed by participants as affecting healthcare, with some relating this specifically to effects on surveillance and prevention of infectious disease outbreaks:

'The diagnostic capacity was exposed due to COVID-19 because there were no sophisticated laboratory facilities. So, we can assume that there is a lack in infrastructure, lack in training, lack in equipment, diagnostics[…]there is not much focus on building the capacity of health workers, building the capacity of the system to deal with outbreaks[…]there is a national public health laboratory at the central level, but it cannot manage, it has limited human resource capacity to do the diagnostics. It cannot diagnose all the outbreaks[…]at the community level, at the local level, the health posts, or the primary health centres or the district hospitals, they do not have that capacity to diagnose or to detect the outbreaks.' [Health3]

'We train many people, but brain drain is a big issue. The person who are well qualified and get trained and experience they shift to the NGO or then to foreign country.' [Health7]

There was a perceived rural-urban dichotomy, with human and animal health workers preferring to work in urban areas with better facilities and transport infrastructure. Arranging training for rural workers is also more difficult, with potential participants unable to travel to bigger cities for events, which impacts on provision of awareness programmes in communities:

'In the urban areas I think most of the health workers are trained, but in the rural areas the training might be lacking[...]They basically prefer to go into the urban setting, so those who do not get an opportunity in the urban setting are most often travelling to the rural setting and it's quite difficult to organise the training, it's quite difficult for them to participate in the training, organised at federal or provincial level.' [Health13]

'What is actually happening in our country is that well-educated veterinarians are there but due to the lack of facilities of government they are not working properly. And there is also limitation of transportation and that's why the government must focus on providing facilities so that they can be actively involved in awareness raising programmes in rural areas.' [Livestock5]

Community engagement

Some participants had experience of involvement with community engagement programmes, usually led by NGOs, and suggested that, in general, community members were keen to take part, despite their apparent lack of understanding of the issues. One participant discussed visiting a poultry farm and talking to workers there, who, although keen to learn, had little comprehension of hygiene practices or how these could prevent transmission of avian influenza (Health2). Other participants discussed the lack of community involvement in earlier stages of design and implementation of projects, while others made a point of stating that this was part of their process:

> 'They do a lot of consultation workshops and stakeholder workshops, but maybe they do it after the project is approved, or maybe they just want to go, once funding is approved, they just want to go to the community or they have already gone there. They don't do stakeholder workshops, or they don't involve the community members, they don't involve them during the writing phase. So this is what I learned. The community engagement, enrollment is lacking in the project cycle.' [Health2]

> 'We work with the community in designing health interventions, and evaluating the effectiveness of these interventions[…]we generally want to make sure that the community has trust in us[…]we somehow on-board the people who have influence at the community level.' [Health13]

Involving local community members, especially leaders to create trust and a sense of ownership, was identified as important by an animal health participant:

> 'We have to do something like meeting local people, local leaders, first we have to make them aware. If we just go to the community, we will get nothing. Because we have to convince someone who is the leader there. So we have to train them. Whenever I have the opportunity to organise some programmes, I focus on the mayors, the leaders there, the politicians, in the community. I just try to convince them first and then they will support the programme.' [Livestock4]

<u>Pathway 3: Data, evidence, education, and knowledge exchange</u>

The theme under Pathway 3 was lack of zoonotic disease data, from either surveillance or research, that could inform a One Health approach in Nepal.

Lack of zoonotic disease data

Participants from all sectors noted the significant lack of data on zoonotic disease in Nepal, and stated that this hinders awareness, advocacy, planning and prioritisation of these diseases. Without data it is impossible to convince politicians and policymakers that these issues should be addressed:

‘The first thing is the data management for the zoonotic diseases. Because we have the cases, but we do not know about these things.’ [Livestock6]

‘We don't have that information, what is the real state of zoonotic diseases in Nepal? What are the diseases we need to fight?[…]Zoonotics, infectious diseases, the notification is very poor. In humans but I should say also in animal, because we had a meeting but they said we don't have data.’ [Health6]

Lack of data (or data sharing) was seen as an impediment to working toward a more holistic, One Health approach:

‘There are so many issues where we need the studies to confirm, like in case of the human there is more research, so we have more robust evidence, but in case of animal health or the zoonotic disease, there are very few. So, we need to increase the communication between the human health sector, animal health sector and environmental health sectors to address those diseases in a holistic approach, because only one sector alone, either the animal or the human health, cannot address this problem.’ [Health7]

This is a vicious circle: without funding there is no research or data, but without research (and the resultant data) there is no governmental funding:

‘That's still where we are, still failing to convince the policymakers. So this is very important. That's why we're still not getting funding, because I'm just sitting and I'm not telling them, they're not funding sufficient money for to do the research.’ [Health1]

One participant suggested that clinicians do not want to share available data with researchers within Nepal, although they are happy to present their work outside the country, so little progress is made and this results in stakeholders not being made fully aware of the need for funding or more collaboration:

‘Although this part of the world has the high prevalence, high burden of neglected tropical diseases and zoonotic diseases, some rare cases is being reported to international societies[…]but the data is not presented, not disseminated inside, it's going outside. Researchers, they are constantly looking for those data, even samples to test. And they are using it for their own academic practice, but the local researchers and clinicians who own this data and have the knowledge of these things, they really don't want to come up and discuss with the stakeholders in Nepal[…]When I approached them, they are hesitant to collaborate.’ [Health2]

DISCUSSION

This study examined issues around operationalising the One Health approach in Nepal, through the perspectives of policymakers and practitioners focused on animal or human health. We were not successful in identifying people who are focused primarily on the environmental or wildlife component of One Health in Nepal, although some participants stated that they had worked on projects with a minor involvement in this sector. During snowballing, when asked to provide names of people working in the environmental, ecological or other relevant sectors, participants were unable to do so. This finding is not specific to this study, as other authors have noted that the environmental sector is generally under-represented in approaches to One Health [286]. Despite this, the discussions were rich and full of information, and many participants were positive about the potential for the national One Health strategy in the country, within contextual limitations. Similar barriers and enablers to progress, e.g., intersectoral politics, prominence of human healthcare professionals, lack of comprehension of the One Health concept at policy-implementation level, were discussed by representatives of both sectors, which suggests that there is a space for negotiation and compromise that could feed into a workable and effective pathway to implementing a One Health approach.

National One Health strategies, taking into account as many human, animal and environmental health factors as possible, are essential if countries are to successfully manage outbreaks of zoonotic disease [10]. Design and implementation of these strategies is complex, especially in countries that must factor in issues such as poor comprehension at all levels of the causes and effects of zoonotic disease, fragmented health systems with poor surveillance mechanisms, lack of resources, and absence of multi-sectoral working [28]. This was reflected in interviews, with participants discussing lack of interest by policymakers, lack of data to inform policies and programmes, and budgetary constraints not allowing a coherent, unified One health approach in the country. However, adopting tailored, effective strategies could have a positive effect on the health and economic security of communities everywhere [287].

The recent JEE examining Nepal's core capacities gave the country a score of 2 out of 5 for surveillance and response to zoonotic disease, and recommended enabling reporting and data-sharing between One Health stakeholders [39]. The report acknowledged the work already done in Nepal on a One Health strategy, but stated that mechanisms to allow animal and human health personnel to work together to investigate and respond to outbreaks of zoonotic disease, and to share information that might prevent such outbreaks, need to be developed [39]. This was underlined by participants in our study, who commented on the lack of collaboration between sectors.

As stated in the recent Lancet One Health series, and underlined in these interviews, it is essential that One Health strategies involve communication, coordination, technical support, and are informed by community participation [33]. A key issue is leadership, who 'owns' these projects and initiatives? One possibility is to

rotate leadership between animal, human and environmental sectors, although this may, particularly at first, be complicated and involve much diplomacy and discussion, and ownership is complicated by the number of actors, and power dynamics between these actors, that must be involved. Siloing of the different sectors was discussed by study participants, as was 'encroachment' of one sector upon what is perceived as another's territory. This lack of cross-sector collaboration has been reported elsewhere, and is complicated by the traditional focus on addressing single diseases (often as they occur as an outbreak) rather than as an attempt to address disease more holistically [288]. In Nepal, this was exemplified by the discussion of the response to COVID-19, with animal health laboratories used by human health personnel as diagnostic laboratories, but with no recognition of the animal health sector contribution. Other researchers have found similar issues in Nigeria, Tanzania and Uganda, and suggest that a focus away from pandemics, and on to endemic or neglected diseases that have more significance in the specific context, will encourage adoption of a One Health approach and increased intersectoral collaboration [289].

Pathway 1 of the OHHLEP theory of change is focused on policy and governance issues, which were reflected in our findings. Comprehension of the issues at governmental level and the resulting effects on political will was a strong theme in many interviews. It is essential that policymakers understand the importance of a One Health approach, but even if they do the resource constraints, including lack of infrastructure, data and staffing capacity, may prevent effective implementation. Without sufficient data clarifying what should be a priority, and where, a One Health approach to tackling zoonotic disease is not feasible, as policymakers and NGOs focus on issues with clear and measurable targets and deliverables, which makes securing funding easier.

The current public health situation in Nepal may be too fragmented to allow a consistent and workable One Health approach, with three tiers of government financing (federal, state and local), funding from NGOs for specific programmes, and many different types of actors who should be consulted (e.g., healthcare professionals, traditional healers, community health volunteers, community members). However, there is a clear will to make this happen, both at policymaker and practitioner levels, and this needs to be taken advantage of. Ensuring that Nepali professionals have ownership of any One Health response is complicated by the fact that much funding comes from international donors and the government is widely perceived as not having enough information (e.g., data on prevalence/incidence of zoonotic disease) to make prioritising funding for programming or allocating staff focused on zoonotic disease a sensible idea. This lack of prioritisation needs to be addressed, but is complicated by the lack of data that can be shown to government officials to convince them of the necessity of doing so.

Non-governmental organisations, government and other stakeholders need to work together to put into place the infrastructure necessary for an effective and sustainable One Health approach [260]. This is context-

dependent and needs to account for disease burden, available capacity, political will, economics and behavioural drivers. It is essential that environmental organisations are fully involved [260] although, as we found, these organisations may be far less involved in policy formation or implementation than those from the human and animal health sectors. A recent study found that only 60% of One Health networks identified involved stakeholders from human health, animal health, and environmental sectors, and only 28% discussed issues around wildlife health [260]. Participants in this study discussed the lack of partners from the wildlife and forestry sectors, with a clear understanding of their importance, as due to habitat encroachment wild animals are coming into contact with both domesticated animals and humans in more rural areas, which could lead to virus spillover in some communities. Strengthening One Health governance, globally and nationally, includes involving the environmental and wildlife sectors in operationalising solutions to One Health issues; working with social scientists and communities, to be as inclusive as possible; and building capacity through collaboration [290].

In terms of political will, the government was perceived by many as listening to the experts and doing its best to address issues around zoonotic and infectious disease, with the incorporation of technical working groups involving all three sectors. However, participants also recognised that Nepal is a resource-constrained country and healthcare in general is underfunded, with little extant data on zoonotic disease, resulting in a lack of awareness at governmental levels of the importance of the issues. Financing for health may instead be channelled toward something more tangible that has immediate results, for example, eye health camps, where numbers of patients helped can be easily recorded, which is especially important when there is a lack of political continuity, with politicians changing roles frequently.

Pathway 2 of the OHHLEP theory of change relates to the importance of collaboration and cooperation between sectors, and between healthcare professionals and community members [280]. Ensuring that representatives of animal, human and environmental health are included in any coordinated approach, with the concomitant issues around different power relations and ways of working, was discussed as a barrier to effective policy formation and collaboration by participants. Despite stakeholders knowing that working together is necessary to construct and implement an effective one Health strategy, this is not everyday practice. They may feel uncomfortable sharing ideas, data and work (especially in what is a relatively new field to many people). Participants suggested that stakeholders do collaborate when necessitated by outbreaks but otherwise One Health is not a priority. However, this could be because little data on the disease landscape in Nepal exist, and so there is little evidence to suggest that zoonotic disease, with the potential exception of rabies, is an issue. In addition, it may be that the concept of One Health itself is not well defined, and so there is little understanding of what form a co-operative One Health approach should actually take. As one of the participants stated, high-level stakeholders such as politicians have little understanding of the concept, and this is reflected in a lack of co-operation by human and animal healthcare professionals who

are involved in providing healthcare in communities. Consensus around what One Health actually means has taken time to develop, but possibly, with the incorporation of the OHHLEP, a coherent vision is finally beginning to be realised.

In neighbouring India, development of a One Health approach to infectious disease policy was stimulated by the emergence of HPAI and Ebola Virus Disease [291]. Contingency plans and standard operating procedures were instituted for avian influenza, and successfully eliminated the virus from most of the country. However, as Chatterjee and colleagues discuss, the resulting intersectoral collaborations, and the National Health Policy of 2015, were more reactive than proactive, and culminated in duplication of effort, as all sectors attempted to address disease threats using their own, existing systems, rather than working together. For example, the Ministry of Health and the Indian Council for Agricultural Research separately began their own zoonotic disease centres, while there are already 300 bodies in the country, spread across different ministries and sectors, which are involved in various zoonotic research projects [291]. Hitziger et al analysed implementation of 15 One Health initiatives across Africa, Asia and Europe to identify what makes approaches successful [292]. They concluded that the more successful initiatives engaged external stakeholders, shared data willingly, included diverse competencies, and addressed power distributions and conflict resolution from the beginning. Acknowledgement that initiatives are iterative and mutable, and evaluating processes as a learning opportunity, was important to success of the approach [292]. The participants in our study identified lack of inter-sectoral collaboration, sharing of data, and difficult power relations as issues preventing a One Health approach that might begin to address absence of surveillance data and research within Nepal. Recognising these gaps is a starting point around which to build policy that might effectively address zoonotic disease risk in Nepal.

If sectors were better integrated, with less perceived siloing, resources could be pooled and issues more effectively addressed. However, this is not easy to achieve: as one participant stated, there is a tendency for one sector to feel (and be perceived as) inferior to another, and so a more pragmatic approach is necessary, one in which people need to identify as One Health practitioners rather than as specifically focusing on animal or human health, to work together and find a more holistic solution to issues that affect humans, animals and the environment. The WHO has recently instigated National Bridging Workshops, in an attempt to address lack of collaboration between the different sectors involved in One Health. The website states that these workshops are to bring together animal and human health representatives, with other sectors (wildlife, environment, police, media) also involved. A key output is a Strengths, Weaknesses, Opportunities and Threats analysis for co-ordination between the animal and human health sectors, with the aim to improve prevention, detection and response to zoonotic disease [293]. Although including representatives of other sectors, this initiative's main focus is on animal and human health connections, with a stated objective 'to analyse and improve the collaboration between the two sectors in the prevention, detection and response

to zoonotic diseases and other health events at the animal-human interface' [293]. Including representatives of other sectors is a step in the right direction to multisectoral collaboration, recognising the importance of a more holistic approach to increasing capacity to detect and address zoonotic disease globally. This type of approach is being taken in Nepal, with a National Bridging Workshop in the pipeline that will hopefully begin to devote effort to bringing different stakeholders together to discuss what can realistically be done in the country to promote collaboration between these sectors. As encroachment on wildlife habitat and concomitant exposure of humans to potentially infected animals is a key route of disease spread, it is pivotal that representatives of the environmental, ecosystem and wildlife management sectors are also included in these workshops, to ensure that a more holistic plan is developed, with formation of workable solutions that can realistically be implemented in the country.

Strengthening the evidence base and gathering data on incidence of zoonotic disease in Nepal is a key facet of Pathway 3 [280]. The issues highlighted by study participants underscore the necessity of the One Health approach in medical education, emphasising the importance of creating and sharing data between academics and clinicians, and ensuring that practitioners are cognisant of the opportunities and benefits of the approach [294]. In a review of the benefits of One Health approaches on health security, Zinsstag and colleagues suggest that the focus needs to be on investing in preventing disease risk, education and awareness, and understanding disease drivers, rather than dealing with acute issues after an outbreak [33].

Other key stakeholders in any One Health approach to addressing threats from zoonotic disease are communities living in affected areas. Health professionals need to work with communities to implement coherent research and practice [28, 260]. Community members are experts in their own context, and we found that they are potentially more likely to be aware of zoonotic disease as a result of the COVID-19 pandemic (see Chapter 5). Both human and animal health participants discussed their interactions with communities, and underlined the importance of involving community members in design and implementation of programmes that would directly affect them. Two participants, who had run projects involving community members and taking direction from community leaders, stated that this increased trust and ownership. This is likely to lead to a more effective implementation as issues that community members have identified themselves as important are addressed. Including communities in the design, implementation and evaluation of One Health approaches is necessary not just ethically, but also as a means of ensuring interventions are contextually appropriate and therefore more likely to be effective. Communities hold a wealth of relevant knowledge and best placed to know what will and will not work, and why (not). Zoonotic diseases, both emerging and endemic, are likely to have a disproportionate impact on people living in under-resourced areas, with a lack of data on disease incidence and impact compounding the lack of accessible options for diagnosis and treatment [295]. The recent JEE report on Nepal states that there is currently no mechanism for marginalised and vulnerable populations in the country to feedback to healthcare staff on

their requirements, and that this needs to be rectified using a more holistic and inclusive approach [39]. Promoting available interventions such as vaccination of humans and animals may decrease the severity of economic and health effects experienced in communities, especially those less able to access healthcare efficiently. Working with communities and developing an understanding of their context is also a way of beginning to address issues around equity [296].

Limitations

Several limitations should be considered. First, as the network of animal and human health practitioners and policymakers in Nepal is relatively small and tightly connected, some participants may not have wanted to discuss various aspects of One Health, as they may have been concerned about making themselves identifiable from their statements and opinions, especially when discussing their personal experiences. Some participants, particularly those employed by the government, may not have felt comfortable discussing issues that they perceived as politically sensitive. To address this we reassured them that we would not include any information that could identify them. However, this is a sensitive subject and it is possible that participants were not as open as they might have wanted to be. Second, we were unable to find participants who identified themselves as solely representing the environmental sector, although two participants stated that they were involved in this sector as well as the animal or human health sectors. With these caveats, we believe that the opinions of the participants contribute to a way forward for an effective One Health approach to researching and implementing infectious disease control in Nepal.

Conclusion

Existing connections between animal and human health professionals should be strengthened, and links with environmental sector representatives created, potentially through multisectoral workshops that take place around the country and involve representatives at all levels of policymaking, from ministers to community healthcare practitioners to community members, to provide a strong network that can be leveraged for effective future collaboration. Although there has been progress on a One Health strategy in Nepal, much work remains to be done: research on the burden of zoonoses to inform advocacy, planning and prioritisation; identifying secure funding for research to produce relevant data; strengthening existing links, such as that being created with the National Bridging Workshop initiative. Communities must be recognised as key stakeholders in any One Health approach and their input on what is relevant to them in their context should be incorporated into all initiatives.

6.3 Chapter summary

This chapter concludes the three findings papers. In it I examined barriers and enablers to a coherent One Health approach that might effectively address issues around zoonotic disease in Nepal, and how communities might participate in the design and implementation of any interventions aimed at decreasing the threat that these diseases may pose to them.

Chapter 7: Discussion

In this thesis I focused on community concerns and priorities related to zoonotic disease, awareness of these diseases, and mitigatory practices people use or potentially could use to prevent or mitigate zoonotic risks. The analysis has provided insights into how communities, healthcare practitioners, and policymakers think about these issues, and how this might feed into attempts to co-produce research and interventions focused on zoonotic disease. The theoretical underpinning of critical realism informed study conceptualisation, implementation, and analysis, and allowed for interpretation of how contextual factors might influence causal mechanisms, events and understandings [74, 122, 131, 132, 134]. Having a diverse body of data, from interviews, FGDs and unstructured observations, meant that I was able to converge findings across these methods and check that codes and themes were valid, were appropriate and made sense. Using an example from Chapter 4, focused on awareness: data = transcripts, observations and photographs; codes = experience of disease, perceptions of rabies, livestock and disease, and sources of information; and themes = disease awareness, and beliefs and behaviours. I judged that these codes and themes made intrinsic sense and were appropriate to the context, and were therefore likely to be valid [134].

In this chapter I review and synthesise the key findings across the scoping review and three primary research chapters. I then detail the implications these findings have for a One Health approach to practice around zoonotic disease research and intervention implementation in Nepal, describing the conceptual framework informed by this analysis, and discussing findings with respect to the theory of fundamental causes (and what my research can add to this theory). Finally, I discuss the limitations of the work, and conclude with personal reflections on my PhD journey over the last 4 years.

7.1 Summary of findings

The scoping review in **Chapter 3**, which was conducted to inform the rest of the study, including the topic guide for the interviews and FGDs, identified various behavioural, cultural and environmental factors that may drive zoonotic disease risk in the Indian subcontinent. Most of the primary sources included in the review addressed drivers of rabies, Nipah virus disease and leptospirosis. Potential drivers included lack of awareness, cultural practices such as use of traditional medicines, and lack of hygienic behaviours (e.g., handwashing, use of protective clothing). We concluded that although behaviour change is essential to preventing spillover events from animals to humans, increasing community members' knowledge and awareness alone is unlikely to be sufficient to successfully enact this change. Further research, using interdisciplinary and participatory methods, will improve understanding of risks and risk perceptions, and pinpoint how people might already be addressing risk in their communities, and thus help in co-designing context-specific, relevant interventions.

Chapter 4 aimed to characterise the contextual factors and mechanisms driving awareness (or otherwise) of risk factors, prevention and treatment of zoonotic diseases in selected communities in Nepal. I generated two major themes: disease awareness (sub-themes: experience of disease; perceptions of rabies; livestock and disease; sources of information), and beliefs and behaviours (sub-themes: traditional medicine use; bushmeat consumption; hygiene practices). Participants were aware of diseases that they perceived might affect their family or livelihood (e.g., rabies, avian influenza) or that they had experienced themselves. This was especially true of rabies, with most participants able to discuss how the disease is transmitted, and actions that should be taken pre- and post-bite. Information on disease in general was usually spread informally, between networks of friends and family members, with little experience of organised programming by governmental or other bodies. Use of traditional medicine was widespread, although there was some discussion around whether this was an anachronism, with some participants seeing this behaviour as pragmatic, as accessing traditional healers is often easier (and cheaper) than visiting health posts. Consumption of bushmeat was seen as something that 'others' do, although some participants stated that bushmeat could be medicinal, and others dichotomising 'clean' and 'dirty' rodents. Hygiene practices were perceived as necessary to remove dirt, but this was not usually linked explicitly to illness. I concluded that understanding the contextual factors at work with(in) communities, through discussion with community members and health professionals, is essential to unpicking the complexities around behaviours that might increase disease risk, especially in communities that lack resources to mitigate these threats.

In **Chapter 5** I addressed issues around working with communities to co-produce research and interventions in Nepal. This chapter reports the findings of the photovoice component of the project, using this to identify how zoonotic diseases and their control are perceived and enacted: what people do, why, how this differed in the past or could be improved in future. I generated four overarching themes: i) existing mitigatory practices, ii) cultural factors, iii) experience of community programmes, and iv) community priorities and co-production. I found that community participants, despite strong opinions and desire to participate in disease control interventions, had experienced little or no attempt by intervention organisers to engage them in design, implementation, evaluation, or accountability. Most had no experience of programmes at all. Discussions with participants highlighted the significance of working in 'local' languages, understanding and respecting religio-cultural realities, relating initiatives to lived experience, and ensuring that local leaders and respected community members are involved. I concluded that meaningful co-production requires recognising communities – through legitimate leadership/representation - as the experts and equal partners who can 'work alongside' at all stages of any intervention or piece of research.

In **Chapter 6** I discussed findings with relevance to a One Health approach to responding to emerging infectious disease in Nepal, in the context of intersectoral collaboration between human, animal and environmental health professionals. My analysis of the healthcare practitioner and policymakers interviews

closely mapped onto the three One Health High-Level Expert Panel (OHHLEP) pathways [280], with participants discussing themes such as One Health as a concept and opportunity; policy and politics; financing; and catalysts to raising awareness (Pathway 1); power relations and multi-sectoral collaboration; capacity building; community engagement; and collaboration with international partners (Pathway 2); and lack of data and research on zoonotic disease that could inform a One Health approach in Nepal (Pathway 3). The government was perceived as generally supportive, endorsing a One Health plan with the incorporation of technical working groups involving all three sectors. However, participants also recognised that healthcare in general is underfunded, with little data on zoonotic disease, resulting in a lack of awareness at governmental levels of the importance of the issues. Many participants were positive about the potential for the One Health approach in Nepal, although recognising the context-dependent barriers (e.g., complexities of the federal system) to implementation of any strategy. Existing connections between animal and human health professionals must be strengthened, and links with environmental sector representatives created, potentially through country-wide, multisectoral workshops involving representatives at all levels of policymaking, from ministers to community healthcare practitioners to community members, to provide a strong network that can be leveraged for effective future collaboration. Although there has been progress on a One Health strategy in Nepal, much work remains to be done: research on the burden of zoonoses to inform advocacy, planning and prioritisation; identifying secure funding for research to produce relevant data; strengthening existing links, such as that being created with the National Bridging Workshop initiative.

Together, these chapters demonstrate the importance of having a community-centred approach to research and interventions designed to make people safer, incorporating human, animal and environmental health, while considering key contextual factors such as religion and culture (e.g., unwillingness to kill pest rodents, use of traditional rather than allopathic medicine, belief in spirits and deities that are responsible for causing, and healing, illness).

7.2 Fundamental Cause Theory and the conceptual framework

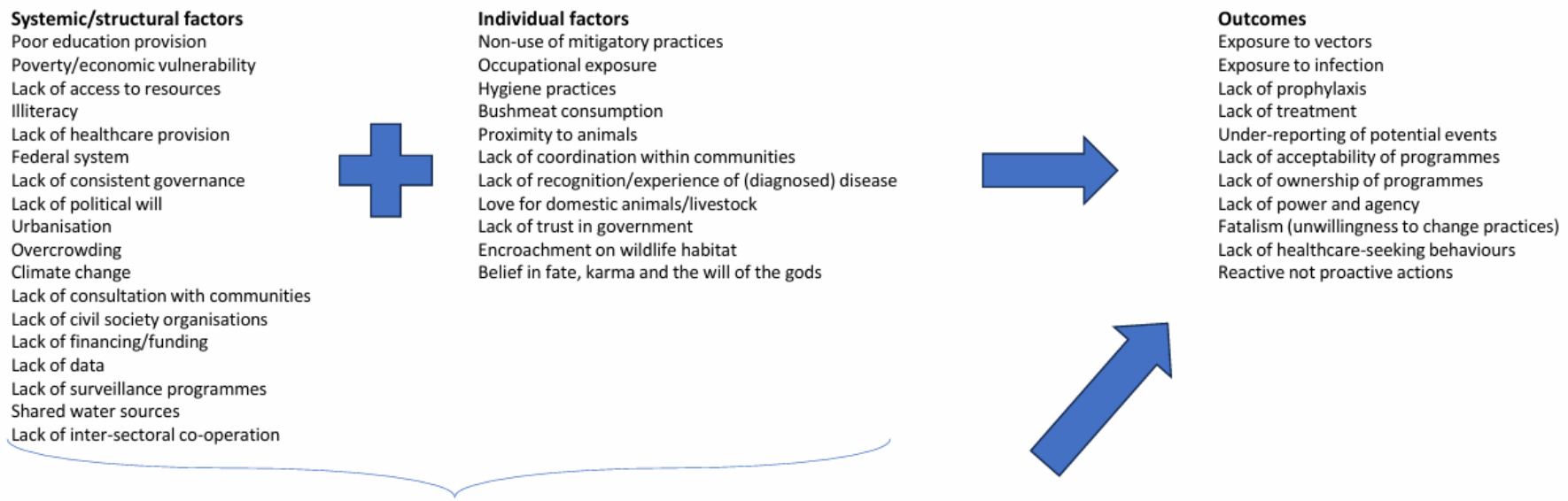
As described in the Introduction (Chapter 1) Fundamental Cause Theory highlights the importance of contextualising factors around disease risk [103, 104]. This theory, while important and useful, focuses primarily on the contextualisation of social and socio-economic factors (e.g., social support and socio-economic status), rather than more subtle, implicit, harder-to-explain factors such as individual perceptions, power relations, and religious and cultural beliefs [297]. Community priorities may well be different to those anticipated by researchers or healthcare professionals. Communities may be used to living with illness or disease and not perceive this as a priority or a reason to seek treatment, and may have different explanations for illness [60]. This insight highlights the central importance of consulting and working with communities rather than implementing practices or policies that may be irrelevant to the community in question.

Noppert and colleagues expand the theory by discussing how an individual's social environment can affect their risk of disease by increasing both likelihood of exposure to pathogens and susceptibility to infection [297]. For example, people with fewer resources (temporal and financial), living in over-crowded settlements, may be less able both to use appropriate mitigatory practices to avoid infection, and to access effective preventive or curative healthcare [297]. They suggest that the emphasis must be moved from individual responsibility to an examination of why some people are at greater risk, taking into account structural factors such as lack of access to healthcare and poverty. Working with communities and developing an understanding of their context is one avenue to beginning to also address issues around sufficient access to resources [296].

Through discussions with community members, healthcare practitioners and policymakers, attempting to clarify their priorities, my research demonstrated the importance of these individual and structural factors, but also supports the centrality of trying to see through a 'community lens', involving less concrete, more subtle factors such as perceptions, beliefs and understandings of the community in which the research or intervention is situated. Examples of these from the interviews include religious beliefs resulting in an unwillingness to trap and kill rodent pests, reluctance to discuss issues such as bushmeat consumption, and the perception of rabies as something that 'powerful' men could not possibly catch from an infected animal. In my research I involved communities directly, discussing with them what members think might lead to exposure to risk, and what they can do about these issues to try and prevent illness, while recognising that risks are dynamic and malleable, and not always avoidable. For example, living with rodents or other ubiquitous pest animals, drinking polluted water as it is all that is accessible, eating bushmeat as it is freely available, are examples of factors that some communities experience on a daily basis, and need to be considered when we look at WHY people are at risk [103, 104]. This will allow the design of mitigatory interventions that take into account issues around the inability to avoid certain risk factors, without which these interventions are unlikely to be effective. Involving communities in identifying which implicit factors might lead to exposure to zoonotic disease risk, and why, rather than focusing solely on behaviours, may help to promote efficacy of research and interventions [103, 104]. This fits well with the 'experiences, events and causal mechanisms' that inform a critical realist analysis [74, 97]: experiences include feelings and perceptions, events are what we experience, and causal mechanisms are what lead to or cause events. Multiple causal mechanisms may be at work, as we can see below in Figure 1.

Findings from the interviews, focus groups, observations and photovoice helped me generate an overarching conceptual framework that presents factors influencing zoonotic disease risk in communities in Nepal (Figure 1).

Figure 1: Conceptual framework: Factors influencing zoonotic disease risk in communities in Nepal



This framework has four main sections: the systemic and structural (upstream) factors, the individual (downstream) factors, the likely outcomes, and the community context – the lens through which the upstream and downstream factors must be filtered for the outcomes to appear logical and coherent.

One relevant example from the study is the non-use of protective gear when planting paddy: ***upstream factor*** – there is a lack of access to resources (e.g., gloves, boots and face masks); ***downstream factors*** – paddy farmers are occupationally exposed and do not use mitigatory practices; ***outcome***: workers are exposed to potential pathogens (e.g., leptospirosis) and have an increased likelihood of becoming infected with the illness. Unsurprisingly, financial (upstream) aspects were mentioned during interviews: if participants did get sick they have no choice but to carry on, not having the time or financial resources to be ill, otherwise there will not be any rice to eat. There is no money to pay for a healthcare appointment. They do not have the time to travel to a health post that might not be open, to get a prescription that pharmacies might not be able to fill, or to find out that they have an illness that they cannot treat.

However, when the community lens or perspective is added into this formula, we can see that the upstream and downstream factors are too simplistic to allow a clear understanding. Participants discussed many reasons behind the lack of personal protective equipment, including the lack of perceived importance of this protective gear, they have never seen the need to use it, they have never been sick from any disease they perceive as related to paddy planting, it is easier to plant paddy in bare feet as they can grip the soil, and wearing gloves makes the fine movements necessary for planting too difficult. Paddy planting day (*Asar Pandhra*) is an annual festival in the Nepali calendar: every generation of a family is involved and once the planting is done, people enjoy throwing each other into, and rolling around in, the mud. Each family sends at least one representative to help with planting, and songs and dances are performed to encourage a good harvest. People living in urban areas, who may not directly participate in the planting, will eat *dahi* and *chiura* (curd/yoghurt and beaten rice) during the day, as these foods are traditionally eaten during the festival.

A second example that informed the framework is the use of traditional medicine, which was discussed frequently during the interviews. An ***upstream factor*** for this use could be lack of healthcare provision: some participants perceived traditional medicine use as pragmatic, as access to it can be easier and cheaper than visiting health posts, which may be under-staffed or closed; ***downstream factors*** – lack of trust in government: some participants perceived government as not doing anything to help them in their daily lives, and so may not trust healthcare provided by the government; ***outcome***: lack of (effective?) treatment or prophylaxis; increased likelihood of becoming infected or infecting others.

Again, when we include community perspectives, we can see that the upstream and downstream factors are too simplistic. Traditional medicine practitioners are often widely respected elders within communities and

will understand the context of local illness; generations of families have used this type of medicine and have by definition lived to carry on their lineage; traditional medicine may be perceived as more effective or holding more meaning than allopathic medicine (although this could result from a lack of availability of these medicines). One participant, when gently probed for their opinion, explained that traditional medicines are sometimes more effective than allopathic treatment and so they will visit a traditional healer before trying other options. A study in 2020 examining barriers to treatment for people with tuberculosis in Nepal found that, when unwell, people visited traditional healers and only attended healthcare centres if their health did not improve [234]. The researchers stated that this practice was related to an inherent belief that sickness is a result of karma, and therefore a reflection of behaviours in past lives – and so there is little that can be done to prevent such sickness in the present. Paudel and colleagues, researching the relationship between perinatal mortality and morbidity and fatalism in mountain regions of Nepal, suggest that communities perceived perinatal deaths in three ways: as a natural occurrence; as related to the actions of gods and goddesses; and as related to karma, fate and destiny [235]. They believe that traditional medicine practitioners are chosen by gods and can prevent or alleviate pain or illness. Paudel *et al* conclude that, without taking lay beliefs and knowledge (e.g., cultural and religious beliefs) into account, medical interventions will not work to prevent perinatal deaths (or other health issues). They suggest that healthcare staff should collaborate with practitioners of traditional medicine and community religious leaders, and that these traditional beliefs and values must be incorporated into any policy for it to be effective [235]. This suggestion is supported by the findings of this PhD on the importance of the community lens. As one participant stated, if you get caught by a spirit (and therefore become ill) you must make an offering to get better. Work on incorporating these healers into the healthcare system has already begun in Nepal (see Section 7.3.1 below).

These examples highlight the importance of considering disparate cultural and religious beliefs, especially in a country such as Nepal which, in the 2021 census, included 142 castes and ethnicities, 10 religions and 124 languages [298]. As some of the photographs taken by participants in this project demonstrated, people may prefer to live with the disadvantages of, for example, synanthropic rodents (which may carry disease), rather than transgress their religious beliefs by killing them. Research on addressing rodent pests in Madagascar found that taboos can affect mitigatory measures: use of predators (owls and snakes) to control rodents was unacceptable in the local community as these animals are perceived as related to witchcraft [263]. When practices like rodent consumption are complicated by association with cultural practices and beliefs, we can begin to see the necessity of unpicking drivers of behaviours that may, on the surface, appear incomprehensible or even irresponsible. Other factors may include pride: the dichotomy evident in some interviews, between people who did and did not eat rodents, may have also been caused in part by the perception that people who eat rodents are by definition poor and so people who don't eat them are rich enough to either buy meat or to rear livestock to eat. Contextually, the communities believed to eat rodents

in Nepal are often perceived as having low literacy or being poor or badly educated (or all three) and so the dichotomy becomes easier to understand, as people distance themselves (and their group) from these negative attributes. This 'othering', where we dissociate ourselves from behaviours which we may feel are anachronistic or potentially harmful [228], was exemplified by a participant in the informal settlement, who was of Tharu ethnicity (widely believed by participants to consume rodents), but who told us that although western Tharu might eat rats, she, an eastern Tharu would not.

Chhaupadi, a practice indirectly related to risk of infectious disease, illustrates the complex links that exist between cultural and religious beliefs and behaviours in Nepal, and demonstrates the complex nature of attempting to influence ingrained cultural practices [299, 300]. Chhaupadi is a monthly seclusion of women in huts during their menstrual period, and also post-partum, when they are deemed to be impure and unclean, and unable to share food or lodging with their families. Many women have died from exposure, suffocation due to poorly ventilated huts, or snakebites during their seclusion. In one study, 84% of 221 adolescent girls included in the study practised chhaupadi, and this was more likely if they were aged 15–17, or if their mother was illiterate [300]. The practice is officially illegal, and anyone who forces a woman or girl to stay in these huts can, theoretically, be arrested and fined [300]. However, women and their families and communities appear to be more concerned with punishment from the gods than punishment from the authorities, and one male interviewee stated that NGOs are trying to destroy the local culture by encouraging women not to participate in the practice [299]. Women who do not conform are stigmatised, and are believed to bring misfortune to their families [300]. Some communities have begun to address the issue themselves, offering financial rewards for women who do not go into seclusion, while the government is running awareness programmes and curtailing economic support for villages that still practise chhaupadi [299]. One international NGO has worked with community leaders to raise awareness of the negative effects of the practice and stated some success, including a reduction in serious incidents during chhaupadi, but they concluded that some local (male) leaders use these traditional practices to maintain their power and status in the community, making it difficult to challenge the behaviour [301]. Overall, chhaupadi is an informative example of a practice that is deeply engrained in cultural and religious beliefs, and overturning this tradition without co-operation from communities and local governments will be difficult [300].

Without incorporation of the community lens, providing an insight into the more complex, context-specific reasons why people behave as they do, we cannot begin to address behaviour change to reduce zoonotic disease risk. The significance of the community lens has been demonstrated in many other contexts and communities, and for other health issues and practices: for example, in the west African Ebola Virus Disease outbreak in 2014-2016 [60, 253, 254, 259], H5N1 in Thailand [70, 71], for agro-pastoralists in South Africa [262], bushmeat consumption and human-wildlife interactions [24, 72], women's health in Laos [236], and HIV/AIDS programmes in Mozambique [237-239]. This is why involving communities in any healthcare

programme or research agenda is so essential: promoting community ownership of an intervention or research is likely to increase both effectiveness and value-for-money.

7.3 Implications for co-production of research and interventions with communities

Community engagement and co-production of healthcare initiatives and research should have at least two aims: improving health outcomes for individuals and communities, and empowerment, working with communities to enable greater control over this aspect of their lives [255]. Co-producing healthcare aims to ensure that communities have (at least some) ownership of the design and implementation of any related intervention, that it is relevant to them, and, in an ideal world, should allow them to hold health providers accountable [69, 90]. Arnstein described engagement as a continuum, ranging from an 'empty ritual' to 'real' power [256]. This idea was developed further by Popay, who saw informing and increasing awareness as the least powerful type of engagement, whereas community control, with the aim of enabling communities to 'define their own needs and solutions' and providing support for them to do so, is the most powerful [257].

In the communities included in this research, all participants, with the exception of one older lady, evinced interest in zoonotic disease: what it is, what they could do to prevent it in their households and communities, what significance it held for them, and were enthusiastic to learn more. For many, this was the first time they had heard of the concept of animal to human transmission of illness. Although this interest could be perceived as a politeness, as not wanting to show a lack of respect to someone who had come into their community to talk to them about this, most participants appeared genuinely enthusiastic to discuss relevant issues. Many told us that they had never been asked for their opinions on anything related to this subject before. After some explanation, those participants asked to take photographs took the camera with enthusiasm and provided us with excellent images portraying their ideas and concerns.

So what can the conceptual framework, in conjunction with the findings from this PhD, tell us about how to do co-production with(in) communities?

7.3.1 Promoting trust through inclusion of prominent community members

The importance of ensuring that trusted and respected local leaders such as village heads and female community health volunteers (FCHVs), who are likely to have an inherent understanding of relevant cultural mores and be trusted by the community, are involved in any project from the inception was discussed by community members and healthcare practitioners during interviews. A rapid realist review of healthcare services and community engagement found that fostering a comfortable and trusting environment effectively facilitated engagement and citizens' input [302]. Researchers achieved this by ensuring that meetings and activities were held at a time and place convenient for participants, language was simple, and working with community leaders to try and ensure that all materials and activities used with ethnic minority

groups were sensitive to culture and beliefs [302]. Research in other contexts has demonstrated the centrality of trust in working with communities, for example during the 2014 west Africa Ebola outbreak [271]. Involving local community members in disseminating information on how to protect against the disease resulted in better adherence to observing safe burial practices and reducing number of interactions. Trust can also be built by actively working to build relationships, for example, researchers sharing food with participants or taking part in local festivals, demonstrating that shared practices and understandings do exist [3] and that maybe the groups are not so 'alien' to each other. In my case, my half-Nepali surname appeared to win the trust of some participants, perhaps making me appear less foreign and as someone who had an understanding of Nepali cultural practices (at least to an extent).

FCHVs represent a substantial healthcare resource in Nepal, with approximately 50,000 of these women across the country [303]. Volunteers are often the sole link between rural communities and health facilities [265], and communities may be more receptive to messaging coming from these groups, as they are known to communities and widely respected and trusted. FCHVs are selected by mothers' groups, themselves formed to discuss health issues, and are trained on maternal and child healthcare and basic health promotion for 18 days. This training has been demonstrated effective at allowing FCHVs to deliver basic maternity care in rural areas of Nepal [267]. Working with women's groups and FCHVs increased acceptance of contraception [268] and improved perinatal care in rural areas of Nepal [266]. Findings from a systematic review suggest that peer-led delivery of programmes consistently fostered more effective engagement with communities [255]. In this PhD, participants in Mustang discussed their local community women's group, which has assumed responsibility for addressing issues around community dogs. These groups could work with FCHVs already in the community, to design a context-specific initiative, run by and for local people, that does not rely on government-led programmes or funding. Women-led groups were effective in areas as diverse as agricultural development in west Bengal, India [275] and increasing female household agency in Nepal [276].

Liverani and colleagues discuss the significance of lay health workers (village health volunteers) in Laos – these volunteers receive basic healthcare training and are then involved in health promotion, patient referral, and treatment of common and minor illnesses. Local stakeholders interviewed suggested that these volunteers should be fluent in both Lao and the language of their own ethnic group, should be representative of their community, and that more female volunteers should be involved, as many women prefer to discuss health problems with other women [236]. In addition, using existing experience and structures, such as that provided by CHVs, may increase communities' receptiveness to healthcare messages. This has been demonstrated for maternal and newborn health, and for diseases such as AIDS and tuberculosis, in different regions [251]. Community participants must have opportunities to help direct the entire research and implementation process and ensure it is appropriate to their needs, while having a safe space in which to

discuss any issues and their potential solutions [270]. One study found that women volunteered as it gave them a sense of empowerment, and an opportunity to do work that they perceived (rightly) as important [267]. The experience and understanding of these volunteers could theoretically be leveraged to work with communities to co-produce research and initiatives on other aspects of healthcare.

There are obvious disadvantages and limitations to a system that uses FCHVs extensively, including the fact that they are volunteers and so any initiative that depends on them and their goodwill may be precarious [265]. They may also perceive themselves (and be perceived) as inferior to more qualified healthcare workers [304]. Coupled with this is the potential for exploitation, as FCHVs often work alongside, and work similar hours to, salaried health workers. In 2023, a systematic review of 112 studies from 19 countries found that 59% of unsalaried community healthcare volunteers experienced labour exploitation, and almost one-fifth of these workers had to work for more than 40 hours every week to meet their assigned responsibilities [305]. However, another study found that a feeling of moral duty, the pride that volunteers felt, and the respect gained in their community through their role, helped prevent volunteer attrition [306]. As volunteers are almost always female, this imbalance may reinforce accepted gender roles and disparities, and increase inequalities, especially within communities that may be traditional and unaccepting of female empowerment [263, 267].

Respecting and working with traditional medicine practitioners, who are often consulted before allopathic healthcare representatives, was discussed at the Alma-Ata conference on primary health care in 1978, with the meeting report stating that 'indigenous practitioners can become important allies in organizing efforts to improve the health of the community' [307]. Traditional healers are not formally recognised as legitimate health practitioners in Nepal, although their integration into the primary healthcare system in the country is currently being discussed at governmental level [308]. These healers are trusted and respected community members, sharing a culture, and are consulted on emotional, spiritual and psychosocial problems, as well as physical illnesses [308]. Reflecting our findings, one study found that 85% of people living in rural areas of Nepal visit traditional healers before any others, partly as a result of proximity and ease of access, but also as a result of being more culturally accessible than allopathic practitioners may be [309]. Taken together, this suggests that this group of people, who are already present in the community, are a key target for incorporation into public healthcare provision.

Traditional healers have been incorporated into allopathic healthcare provision in countries as diverse as Mozambique [237-239], Ghana, Mexico and Bangladesh [241], and Ethiopia [240]. To use HIV/AIDS as an example, Audet and colleagues, working in Mozambique, discuss the involvement of traditional healers in relevant programmes. Healers are trained to refer patients to allopathic services for HIV testing and other issues, using a pictorial form that depicts symptoms of maternal, paediatric and adult conditions that are

commonly seen in the region and that require referral to a healthcare facility [237, 239]. Sessions aimed at increasing symptom identification resulted in increased awareness of malaria, TB and HIV symptoms and treatment, and increased referral rates. However, fewer than 4% of patients referred to allopathic practitioners were tested, suggesting that clinicians often ignored the healers' potential diagnoses or recommendations for testing [237, 239]. The authors suggest that formal roles in the healthcare system must be agreed for traditional healers, and that pictorial referral forms should be used, as healers often have low literacy or have little schooling; clinicians should be encouraged to work with healers; and patients need to recognise the complementarity of the two systems [237]. In a trial in which people with a recent HIV diagnosis were given access to traditional healers, patients reported receiving home-based, psychosocial and educational support from the healers, who also participated in directly observing patients taking their medications, resulting in increased adherence to treatment [238]. Reflecting this success, in Nepal training of traditional healers on transmission and prevention of HIV resulted in significant improvement in healers' knowledge of these issues, facilitating the provision of culturally acceptable education to local communities, and reducing the perceived stigma around HIV/AIDS [242]. This is particularly important in Nepal, where discussing sex and condoms is often not culturally acceptable in some areas [242]. Taken together, these studies suggest that traditional healers could be used to deliver initiatives around zoonoses in Nepal, possibly providing communities with culturally acceptable and contextually relevant advice on what (and what not) to do when they feel unwell in specific situations, for example, when their domestic animals are ill or they have been bitten by an animal. The importance of these healers was evident in this PhD, as most people visited them before (or instead of) consulting an allopathic practitioner, as discussed above.

7.3.2 Inclusion of local languages

A review examining community-focused responses to the COVID-19 pandemic suggests that use of local languages can promote inclusion of marginalised groups, encouraging people to feel confident expressing their opinions and participate in planning and administration of healthcare programmes [269]. This was also demonstrated in a scoping review of health system evaluations in conflict-affected countries [310], and in research with highly vulnerable participants in Syria [311]. In this PhD, participants highlighted the importance of media and interventions being presented in languages that they can understand easily, increasing trust between themselves and people coming into their community. We conducted the FGD in Bhaktapur in both Nepali and Newari, as, although all participants were fluent in both languages, some participants felt better able to discuss their views in the language which they identified as their 'own', rather than in Nepali. If able to use their own language when consulting health professionals, participants may use words to explain or understand concepts that they cannot easily communicate in another language, reducing likelihood of misunderstandings and, potentially, misdiagnosis and incorrect treatment [312]. A study on use of local languages to describe women's health conditions in South Africa found that participants who were able to discuss their health issues in their own indigenous language received more effective treatment more

quickly than those who were not [313]. Setting aside practicalities like this, having to communicate with health professionals in a language not usually spoken may reinforce power imbalances that are already present as a result of the health professional probably being better educated and not from the patient's locality [312]. Other research demonstrates that maintaining and using indigenous language has a positive effect on health, and can improve quality of care [314, 315].

7.3.3 Use different media

Theatre and drama have been demonstrated as useful conduits for disseminating information, especially for underserved or low-literacy communities [243, 316]. In Africa, drama workshops and community theatre have incorporated experiences relevant to the context, using local languages, to propagate and reinforce health messages around HIV and related stigma. Mbizvo states the necessity of clarifying and analysing any barriers that the audience consider might prevent them changing behaviours, through debate and role play [243]. She describes a campaign leveraging the influence of mothers' clubs to work with young people to promote safe sexual behaviours, which has been successful in allowing people to discuss this contentious in a safe space, and to think through potential solutions to problems for themselves, in a non-didactic way [243].

Drama has also been used as a means of community engagement in rural Cambodia in communities that are predominately poorly educated and have low literacy [316]. The performance, using funny caricatures, music and dance, focused on increasing awareness of the importance of using bednets and repellents to prevent malaria transmission. Interviews with both healthcare staff and villagers demonstrated the efficacy of this type of engagement. Villagers stated that they were entertained and that this was their preference for engagement, and they would attend similar performances in the future [316].

These findings are especially interesting given the opinions of the participants living in the informal settlement in Kathmandu. With no prompting, three of the four participants enthusiastically, and separately, discussed the drama session run by a non-governmental organisation (NGO) in their settlement. They had actively enjoyed these sessions, partly because it demonstrated that someone was interested in their welfare, and that this was not a government initiative. Two of the three participants had very little schooling and stated that they had low literacy. The third had some education and learned English through listening to the radio, another medium that might be useful for health promotion.

The PREDICT project, supported by the United States Agency for International Development, is focused on detecting, preventing and controlling infectious disease risk in people and animals globally, and incorporates social scientists in an effort to identify and examine behaviours in communities at human-animal-environment interface judged high risk for virus emergence [244]. The team found that people who reported

hunting bats were mostly adult men, and were more likely than other people to report influenza-like illness in the preceding year. Most respondents in rural areas (and some in urban sites) reported eating raw meat, or animals that had been sick or were found dead, and so were likely to be at risk of disease. Local leaders from all countries involved in the research recommended a picture book format that could be easily understood by community members. The result was a book, 'Living safely with bats', which includes simple text and graphics, illustrating the importance of bats to ecosystems, the threat they may pose as a disease vector, and how people can safely live with bats in their environment [245]. A community leader presents the book's content, discussing each image with the audience and their responses to them. The book has now been disseminated in local language in over 20 countries in Asia and Africa, although no efficacy study has been conducted [246].

Taken together, these findings suggest that an effective awareness campaign might benefit from audience participation or role-playing elements, so participants can place themselves into the situation and imagine what they would do and feel. This may make health education more inclusive and more effective, especially in under-served communities with little to no easy geographical or financial access to healthcare.

7.3.4 Be realistic and pragmatic about resources

Being realistic about the financial and human resources available to communities and governments to enable them to co-produce research and interventions is key to ensuring that these have the best chance of succeeding, and also to help prevent over-promising and under-delivering. As Agyepong and colleagues discuss, without secure human and financial resources governments are unlikely to prioritise capacity strengthening or provide core funding to allow co-production of health research and interventions [277]. A pragmatic acceptance of the need to respect other perspectives and forms of knowledge (for example, the belief in the efficacy of traditional medicine), commitment to working together to achieve a solution, and power-sharing and building relationships between different groups is central to the process of co-production [69]. This is difficult to do, especially when resources are unavailable and partners are unwilling to question or change the existing power dynamics [252].

In a 2020 review on co-production and One Health research, Barnett and colleagues discuss the implications for both researchers and participants of doing this type of research [61]. They state that epidemiological research around zoonotic disease tends to be didactic and focused on behaviour change, which places the focus centrally on the population in question, and so interventions informed by this are unlikely to be effective as they ignore social, cultural and economic factors. This supports the conceptual framework described in this chapter, in that it underlines the need to have a more holistic understanding. They also discuss the fact that co-production and joint decision-making can be challenging, involving a substantial

investment of time and potentially uncomfortable discussions around power, different roles, and rigour versus relevance [61].

As one participant in this PhD pointed out, other structural issues will affect community responses to co-production initiatives – people might want to attend programmes but are not necessarily able to afford the time or money to do so. If the closest health post is 4 hours' walk away, and there is no pharmacy to make up a prescription that is unaffordable, people are unlikely to spend time and energy attending programmes, even if they have been consulted on the content. Being honest about how effective an intervention might be is essential to manage community expectations, as interventions and research alone, without structural change, are unlikely to have a significant effect on other aspects of community life, such as poverty and lack of access to resources [263]. The success of these initiatives should be measured by communities themselves, in sessions convened for people to give their feedback: did communities find initiatives useful, what worked, what did not work, and why not.

7.4 Implications for a One Health approach to addressing zoonotic disease risk in Nepal

Discussions with policymakers and healthcare practitioners pointed up the potential for an integrated One Health approach to addressing zoonotic disease risk in communities in Nepal, as well as identifying issues that might complicate such an effort. Such an approach is especially challenging in resource-poor countries, encompassing a lack of comprehension of zoonotic disease at community and governmental levels, fragmented health systems with poor surveillance mechanisms, lack of financial and human capacity, and siloed working, with little connection between human, animal and environmental sectors [28, 33]. I was unable to identify people who considered themselves to be representing exclusively the environmental sector in Nepal, although two participants were involved in environmental health projects. This gap in knowledge and expertise (and lack of connection between the three pillars of One Health this implies) is significant (and has been found elsewhere [260, 286, 288]) because of the evidence implicating climate change, deforestation and land use change in spillover of zoonotic diseases such as Ebola and Nipah [10, 35, 317-319]. One illustrative example of why it may be difficult to involve representatives of the environment or ecological sector in a coherent One Health approach in Nepal is encapsulated by the experience of a vocal advocate for animal conservation and prevention of wildlife trafficking in Nepal, Kumar Paudel. Paudel recently took the Nepali government to court in an attempt to force them to create a list of people who possess a registered licence to own wildlife parts (e.g., tiger pelts) – doing so without a licence is, in theory, illegal in Nepal. During the trial, a recurring theme was the right of Nepali people to practise their culture – wildlife parts have religious and cultural significance in some areas of the country. After a 5-year battle, which involved threats of arrest from an official of the environment ministry, Paudel won. The government must create a register, and confiscate any wildlife parts that are illegally owned [320]. This case demonstrates the extremes people may have to go to, to force change, and highlights tensions between government and

advocates who are trying to protect wildlife and related cultural practices. As human encroachment on wildlife habitat is one potential avenue for spread of zoonotic disease [15, 16, 227, 284], involving these types of stakeholders is key to any comprehensive One Health approach.

Many participants saw the potential of a One Health approach to health in Nepal, and all evinced enthusiasm about collaborating on projects in the future. One positive aspect was that human and animal healthcare representatives are already closely networked, with participants often referring to others, sometimes in different geographical regions of the country or with different roles. This is encouraging, as it suggests that this existing network might be leveraged to work together more closely to implement a realistic approach in the future. Although some cross-sectoral research and initiatives have been implemented in Nepal, participants did discuss issues around power imbalances, with human healthcare representatives widely perceived as being more involved and consulted more often by the government, which has been noted elsewhere [321]. One of the potential barriers to a concerted approach was lack of comprehension by policymakers, partly as a result of a lack of data on zoonotic disease in general, which means that persuading them of the importance of these diseases is difficult. Resource constraints, including lack of infrastructure and staffing capacity, mean that finance for health may be channelled toward projects likely to give immediate results (and win votes). Coupled with the general underfunding of the health sector in Nepal, this is a large barrier to overcome, but some participants were optimistic that it could be done.

In terms of interactions with communities in Nepal, healthcare professional participants stated that there was little to no awareness of zoonotic diseases, with the exception of disease that affects people directly: for example, rabies in community dogs, avian influenza in backyard chickens, and COVID-19, which was targeted with a large information campaign in the country. Approximately half of this group of participants had experience co-ordinating or taking part in community programmes, and reported that these were usually welcomed by local communities and feedback received was generally positive, with participants asking for more programmes in the future. Communities are key stakeholders in any One Health approach, the experts in their own context, and should be incorporated into any network that is attempting to address One Health-related issues [260]. As zoonotic diseases are likely to disproportionately affect communities in under-resourced areas, it is ethically necessary (as well as likely to increase efficacy) to ensure that these communities are able to participate in the design, implementation and evaluation of research and initiatives that are aimed at them [295]. As the recent Joint External Evaluation of Nepal made clear, currently there is no mechanism for vulnerable or marginalised groups to feed back their views or needs to healthcare staff [39].

One example of an effective One Health initiative involving co-production with a local community comes from Bolivia, where the NGO Wildlife Conservation Society partnered with the Takana, an indigenous

community [322]. The One Health approach used here aimed to improve community-based resource management, domestic animal health and husbandry practices, and establish a surveillance network for both domestic and wild animal disease. Benefits for local people included empowerment of the community to implement culturally sensitive solutions to issues that they identified, increased availability of protein, reduction in zoonotic disease prevalence, and improved natural resource management [322]. In Rwanda, community members play a role in risk reduction with respect to zoonotic disease spread, performing surveillance in their communities and communicating findings to relevant stakeholders. Community health workers, animal health workers, farmers and park rangers (which is also relevant to the Nepali context, as the country has many national parks) are all leveraged to act as sentinels. They know what is 'usual' in their community and therefore are able to recognise, for example, unusual numbers of animals dying, which might signal an incipient outbreak that can then be addressed [323]. The importance of local, contextual knowledge was demonstrated in our study, as certain mitigatory practices were specific to certain regions or cultures. In this PhD, Mustang FGD participants discussed using a local, thorny plant to protect their meat from rodent incursion, a behaviour we had never heard of previously. This reflects the need to treat each community as a separate entity and tailor potential interventions or activities to the specific context, in an attempt to encourage community ownership and increase benefit to the local community. This was shown in a community-based One Health project in South Africa, where a training programme aimed at increasing disease risk mitigation was specifically designed for local communities of agro-pastoralists. This programme used local facilitators to run workshops with community members, and resulted in 98% of participants implementing risk mitigation strategies (e.g., improved animal housing, improved personal hygiene, improved garbage disposal) during a 3-month follow-up period [262]. These participatory examples illustrate how working with local communities and applying the One Health concept can lead to multiple positive outcomes. These examples are relevant to the Nepali context, as there are groups involved in conservation of wildlife and biodiversity that could work with healthcare providers and members of local communities to address specific threats from zoonoses, which is particularly relevant in rural areas of Nepal, where many people have smallholdings and therefore may be more at risk of diseases carried by both domestic and wild animals.

7.5 Implications for future research

7.5.1 Encouraging community participation using photovoice

The six communities involved in this PhD research were generally enthusiastic about taking part in interviews and focus groups, despite this having been the first time they had been asked to do this. This was especially true of those participants who were asked to take photographs, which supports the concept of photovoice as an effective means of involving people and eliciting their views and opinions in an interesting (and to some, exciting) way. It allowed participants an opportunity to present their ideas constructively, producing something they could actually see, not just talking.

Photovoice has been described as an empowering research method [115, 261] that can offer participants from marginalised groups a safe way to discuss sensitive or uncomfortable topics [114]. Photovoice may give participants the opportunity to work with researchers to produce a rich source of information, making clear the importance of this method to including underserved populations [34]. This was reflected in my experience in the informal settlement, where a participant produced a photograph which provided key insights.

While the utility of this method is evident, it is important to consider ethical implications of using photovoice. Asking people to take photographs may be perceived as a first step toward solving a problem or addressing an issue, rather than just as a means of eliciting information. It may lead to the photographer assuming (understandably) that something tangible will be done to help them, and when they realise that this is not necessarily true, it may cause distress. It is also important to consider that asking people to take photographs of something that they consider a potential threat or worry may itself be distressing, or may even involve them exposing themselves to this threat [324, 325]. In a study in the Philippines that used photovoice to illustrate answers to the question 'what does malaria mean to you?', children exposed themselves to mosquitoes (and were bitten), increasing the risk of contracting malaria in the interest of the study [324].

7.5.2 Strengthening zoonotic disease research and initiatives in Nepal

Throughout this thesis I have acknowledged the structural factors that might complicate a coherent and effective approach to strengthening research and interventions around zoonotic disease in Nepal, working in conjunction with local communities to ensure that their priorities are considered. Coupled with these structural issues is the top-down nature of policymaking, with little consideration of local community priorities and concerns. As Link and Phelan make clear, policymakers in any country should ensure that any intervention aimed at individuals involves an analysis of WHY individuals are at risk, rather than just focusing on simple behaviour change with no research to suggest this might be efficacious in this particular community [103]. As I found in the literature review for this PhD (Chapter 3), most authors did not address whether awareness of disease transmission is necessary to change behaviour, or discuss why people may choose not to change their behaviours, even with this knowledge. This is too simplistic, placing the onus firmly on individuals rather than looking holistically, and considering which other aspects might be important. As I suggested in the conceptual framework, it is imperative that researchers and policymakers consider those factors that are less explicit and potentially more challenging for people not living in those contexts to understand.

In the future, research should focus on providing evidence to support a coherent approach to working with(in) communities, involving all One Health stakeholders, identifying community priorities, concerns and

needs, and what explicit and implicit barriers and enablers to effectively addressing zoonotic disease risk factors might exist.

7.6 Limitations of the study

I worked with six communities and so the findings, although generally coherent across these communities, may not be generalisable across what is a country patchworked with different ethnicities, religions, cultures and belief systems. Some participants were from vulnerable groups, had low literacy, were living in informal settlements, and were not used to being asked for their views or beliefs. In addition, the process of interviewing was new to most community participants, who had never been asked their opinions on this or any other public health topic by researchers or government representatives before. There was a limit to the number of people who could participate in the photovoice component; however, no one person is ever going to be representative of an entire community and so selecting enthusiastic participants was pragmatic.

I was asking participants to discuss with me, an outsider, behaviours and practices that they may have perceived to be sensitive, or taboo, or anachronistic, for example, consuming bushmeat or using traditional medicine in preference to allopathic medicine. Bushmeat was frequently discussed, but framed as something that 'others' do or did. Reluctance to admit to a certain behaviour may be a function of potential embarrassment at discussing topics perceived as sensitive [230] (or of course may be a genuine denial of a practice). This perceived taboo, reflected by participants' reluctance to discuss it without some gentle probing, means that it may be challenging to address or even discuss these behaviours, as the first step will be encouraging people to admit that the phenomenon exists.

I am clearly a different demographic to the participants, which may have affected perceived power relations and led to people not being as open as they might have liked to be. Some community participants were keen to make sure that I had not been sent by the government before agreeing to take part. During interviews I worked to build a rapport with participants, explaining why we were doing what we were doing and discussing my personal experiences living and working in Nepal, which may have encouraged participants to share their experiences [278]. This was obviously easier with policymaker and practitioner interviews, as we had a language in common, a similar level of education and, to an extent, a shared worldview. However, as described elsewhere in this thesis, participants were in general keen to talk to us and those asked to take photographs were enthusiastic about doing so.

In terms of healthcare professional and policymaker participants, some, particularly those employed by the government, may not have felt comfortable discussing issues that they perceived as politically sensitive. The network of animal and human health professionals in Nepal is relatively tight and well connected and so some participants may have been concerned that they were making themselves identifiable from their

statements and opinions, especially when discussing their personal experiences. It is possible that participants did not feel able to be as open as they would have liked. We were unable to find participants who identified themselves as solely representing the environmental sector, although two participants stated that they were involved in this sector as well as the animal or human sectors. Snowballing, which is used frequently in qualitative studies to identify potential participants, may lead to bias as participants may recommend people with similar views. I addressed this by creating a diverse seed list, including people working for the government and those working for NGOs, who may have held different opinions, and including people who have been vocal both for and against government policy in Nepali media.

Community interviews almost all involved simultaneous translation and some meaning may have been lost during this process. Concepts in Nepali may differ from those in English, with different nuances and analogies that may not fully make sense in another language or context. However, everyone (except me) involved in the interviewing, translation and transcription processes were fluent in both Nepali and English, and had a good understanding of both cultures, so I believe that concepts described by participants were understood clearly by all involved.

In an attempt to mitigate the impact of some of these limitations, during the various planning, interviewing, analysis and writing stages of the study I remained cognisant of positionality, including my own assumptions, preconceptions, values and motivations for doing the research. More on reflexivity is provided in the section below.

7.7 Reflections: my PhD journey

During the fieldwork in Nepal I spent at least a short time every evening noting down thoughts and observations from the day's activities. I discussed with Hari, my Nepali colleague, how things had gone that day. As we were staying within the communities, sometimes I talked again briefly with a participant, to confirm things they had said and also to bounce ideas off them. All this was invaluable in helping me shape my ideas.

During the entire PhD process I spent time every day for reflections on the project and how I felt about it. This was an interesting process for me as the participants in this PhD fell into two broad categories: community members and then the 'professionals', animal and human health practitioners, NGO workers, government staff. Originally I was unenthusiastic about interviewing the second group; I really wanted to concentrate on the people I perceived as most important, the people living in local communities who had direct experience of issues around accessing healthcare, accessing knowledge and information about health that had an impact on their lives, people who were perhaps more likely to experience the illnesses we were discussing. But as the research progressed I realised that the two halves complemented each other well, and

they became a coherent whole as I worked more deeply with the transcripts, analysing and reflecting. And the two groups of interviews fed into each other, so although a more sophisticated analysis was often evident in the expert interviews, realistically the discussions with this group reflected what people in communities were telling me. There was a coherence in what people were saying, in the photos they were taking. Many of the 'experts' were one or two generations at most away from the remote, rural areas where their families, often formally 'uneducated' and with low literacy, lived in Nepal. All were likely to return 'home' regularly to participate in religious gatherings or for special occasions, and could identify with what people in communities were saying.

There was a deep sense of frustration in many of the interviews – people in communities are used to being ignored by the government and their representatives, and I lost count of the number of times I had to look away as the realisation that someone wanted to listen to their views hit participants. I will always remember their kindness as they brought us fizzy drinks and small snacks, apologising for what they perceived as their inability to organise and explain their thoughts properly. Many community members needed a little encouragement to speak, to believe that what they were saying was valuable and useful. In a country like Nepal (and many others) where there is little accountability, where politicians often say one thing and do another entirely, where people are used to giving officials a small bribe to turn a blind eye to some minor infraction of the law, accepting that they were able to talk freely without repercussion, that we were genuinely interested in what they had to contribute, was an eye-opener for many participants. Many of the experts were tired of fighting: for respect, for funding, for someone to listen to them, for collaboration with other countries and other institutions. But they all patiently and enthusiastically talked to me, explained things, discussed. My respect for all the participants grew and grew during the fieldwork.

And reflecting on all this brought back to me, again and again, how inherently privileged anyone choosing to travel to another part of the world, 'simply' to talk to people about their issues with animals, with disease, with government, is. This has been made especially clear recently, with the COVID-19 pandemic reinforcing the message that current public health research and practice is inequitable, that it must be decolonised and re-focused, and that the needs and wishes of people in marginalised communities in all countries can no longer be ignored [326]. This realisation has been at the front of my mind throughout. During the fieldwork, a few times people drew aside my Nepali colleague to whisper to him and check that I was REALLY asking about rat damage, about disease, about their cows. Why should I be interested? Didn't I have animals in my country? Couldn't I just do this work there? Why come to Nepal? And these were really helpful, grounding questions for me. Another valid point of view – why WAS I doing this? Well, hopefully this thesis goes some way toward answering that question. And hopefully I can carry on this work, with at least some of the people in these communities, in the future.

7.8 Conclusion

To conclude, this PhD contributes to a small body of literature on community priorities, zoonotic disease threats, and One Health perspectives on working most effectively with(in) communities to address these threats. The findings illustrate the key importance of acknowledging the multi-dimensional religious, cultural, educational, financial and social contexts in which people live, and how these influence their beliefs, needs and priorities. I have demonstrated the utility of both critical realism and participatory approaches (photovoice) in this type of research. This PhD provides and develops insights to inform the design and implementation of research and interventions addressing drivers of zoonotic disease risk in conjunction with, and tailored to, communities in Nepal.

'We sit in the mud, my friend, and reach for the stars' Ivan Turgenev, 1862

References

1. Haigh F, Kemp L, Bazeley P, Haigh N. Developing a critical realist informed framework to explain how the human rights and social determinants of health relationship works. BMC Public Health. 2019;19(1):1571.
2. Centers for Disease Control and Prevention. Bushmeat 2022 [Available from: https://www.cdc.gov/importation/bushmeat.html.
3. Adhikari B, Pell C, Cheah PY. Community engagement and ethical global health research. Global Bioethics. 2020;31(1):1-12.
4. Centers for Disease Control and Prevention. Principles of community engagement.1997. Available from: https://www.atsdr.cdc.gov/communityengagement/pce_intro.html.
5. Warwick University. What is critical realism? 2020 [Available from: https://warwick.ac.uk/fac/soc/ces/research/current/socialtheory/maps/criticalrealism/.
6. Adisasmito WB, Almuhairi S, Barton Behravesh C, Bilivogui P, Bukachi SA, Casas N, et al. One Health action for health security and equity. The Lancet. 2023;401(10376):530-3.
7. Brown N. Reflexivity and Positionality in Social Sciences Research [Internet]. Social Research Association.2022. [cited 2023]. Available from: https://the-sra.org.uk/SRA/SRA/Blog/ReflexivityandPositionalityinSocialSciencesResearch.aspx.
8. Green J, Thorogood N. Qualitative Methods for Health Research, 3rd Edition. : SAGE Publications; 2014.
9. Academy of Social Sciences. What is Social Science? 2024 [Available from: https://acss.org.uk/what-is-social-science/.
10. Gibb R, Franklinos LHV, Redding DW, Jones KE. Ecosystem perspectives are needed to manage zoonotic risks in a changing climate. BMJ. 2020;371:m3389.
11. Fryer T. A short guide to ontology and epistemology: why everyone should be a critical realist. 2nd edition. 2022 [Available from: https://tfryer.com/ontology-guide/.
12. World Health Organization. Zoonoses. 2020 [Available from: https://www.who.int/news-room/fact-sheets/detail/zoonoses.
13. Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, et al. Global trends in emerging infectious diseases. Nature. 2008;451(7181):990-3.
14. Lawler OK, Allan HL, Baxter PWJ, Castagnino R, Tor MC, Dann LE, et al. The COVID-19 pandemic is intricately linked to biodiversity loss and ecosystem health. The Lancet Planetary Health. 2021;5(11):e840-e50.
15. Karesh WB, Dobson A, Lloyd-Smith JO, Lubroth J, Dixon MA, Bennett M, et al. Ecology of zoonoses: natural and unnatural histories. Lancet. 2012;380(9857):1936-45.
16. Taylor LH, Latham SM, Woolhouse ME. Risk factors for human disease emergence. Philos Trans R Soc Lond B Biol Sci. 2001;356(1411):983-9.
17. Morand S, Blasdell K, Bordes F, Buchy P, Carcy B, Chaisiri K, et al. Changing landscapes of Southeast Asia and rodent-borne diseases: decreased diversity but increased transmission risks. Ecol Appl. 2019;29(4):e01886.
18. Plowright RK, Parrish CR, McCallum H, Hudson PJ, Ko AI, Graham AL, et al. Pathways to zoonotic spillover. Nature Reviews Microbiology. 2017;15(8):502-10.
19. Huong NQ, Nga NTT, Long NV, Luu BD, Latinne A, Pruvot M, et al. Coronavirus testing indicates transmission risk increases along wildlife supply chains for human consumption in Viet Nam, 2013-2014. PLOS ONE. 2020;15(8):e0237129.
20. Friant S. Human behaviors driving disease emergence. Evolutionary Anthropology: Issues, News, and Reviews.n/a(n/a):e22015.
21. Wolfe ND, Dunavan CP, Diamond J. Origins of major human infectious diseases. Nature. 2007;447(7142):279-83.
22. Allen T, Murray KA, Zambrana-Torrelio C, Morse SS, Rondinini C, Di Marco M, et al. Global hotspots and correlates of emerging zoonotic diseases. Nature Communications. 2017;8(1):1124.
23. Gibb R, Redding DW, Chin KQ, Donnelly CA, Blackburn TM, Newbold T, et al. Zoonotic host diversity increases in human-dominated ecosystems. Nature. 2020;584(7821):398-402.

24. Wolfe ND, Daszak P, Kilpatrick AM, Burke DS. Bushmeat hunting, deforestation, and prediction of zoonoses emergence. Emerg Infect Dis. 2005;11(12):1822-7.
25. Johnson CK, Hitchens PL, Pandit PS, Rushmore J, Evans TS, Young CCW, et al. Global shifts in mammalian population trends reveal key predictors of virus spillover risk. Proceedings of the Royal Society B: Biological Sciences. 2020;287(1924):20192736.
26. Li H, Mendelsohn E, Zong C, Zhang W, Hagan E, Wang N, et al. Human-animal interactions and bat coronavirus spillover potential among rural residents in Southern China. Biosafety and Health. 2019;1(2):84-90.
27. Holmes EC. COVID-19 - lessons for zoonotic disease. Science. 2022;375(6585):1114-5.
28. Durrance-Bagale A, Rudge JW, Singh NB, Belmain SR, Howard N. Drivers of zoonotic disease risk in the Indian subcontinent: A scoping review. One Health. 2021;13:100310.
29. United Nations. Least Developed Country Category: Nepal Profile. 2023 [Available from: https://www.un.org/development/desa/dpad/least-developed-country-category-nepal.html.
30. Woldehanna S, Zimicki S. An expanded One Health model: integrating social science and One Health to inform study of the human-animal interface. Soc Sci Med. 2015;129:87-95.
31. Craddock S, Hinchliffe S. One world, one health? Social science engagements with the one health agenda. Soc Sci Med. 2015;129:1-4.
32. Paige SB, Malavé C, Mbabazi E, Mayer J, Goldberg TL. Uncovering zoonoses awareness in an emerging disease 'hotspot'. Soc Sci Med. 2015;129:78-86.
33. Zinsstag J, Kaiser-Grolimund A, Heitz-Tokpa K, Sreedharan R, Lubroth J, Caya F, et al. Advancing One human-animal-environment Health for global health security: what does the evidence say? The Lancet. 2023;401(10376):591-604.
34. Wolking D, Karmacharya D, Bista M, Shrestha R, Pandit P, Sharma A, et al. Vulnerabilities for Exposure to Emerging Infectious Disease at Urban Settlements in Nepal. EcoHealth. 2020;17(3):345-58.
35. Murray KA, Daszak P. Human ecology in pathogenic landscapes: two hypotheses on how land use change drives viral emergence. Curr Opin Virol. 2013;3(1):79-83.
36. World Bank. World Bank Country and Lending Groups. 2023 [Available from: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.
37. World Bank. Current health expenditure (% of GDP) - Nepal. 2020 [Available from: https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS?locations=NP.
38. Logan M. Nepal's scramble to piece together a health budget amid rumoured cuts. BMJ. 2023;382:p1824.
39. World Health Organization. Joint external evaluation of IHR core capacities of Nepal: mission report, 28 November-2 December 2022. Geneva: World Health Organization; 2023.
40. Kelly TR, Bunn DA, Joshi NP, Grooms D, Devkota D, Devkota NR, et al. Awareness and Practices Relating to Zoonotic Diseases Among Smallholder Farmers in Nepal. Ecohealth. 2018;15(3):656-69.
41. Mickleburgh S, Waylen K, Racey P. Bats as bushmeat: a global review. Oryx. 2009;43(2):217-34.
42. Ashworth HC, Roux TL, Buggy CJ. Healthcare accessibility in the rural plains (terai) of Nepal: physical factors and associated attitudes of the local population. Int Health. 2019;11(6):528-35.
43. Epstein JH, Anthony SJ, Islam A, Kilpatrick AM, Ali Khan S, Balkey MD, et al. Nipah virus dynamics in bats and implications for spillover to humans. Proceedings of the National Academy of Sciences. 2020;117(46):29190-201.
44. Luby SP, Hossain MJ, Gurley ES, Ahmed BN, Banu S, Khan SU, et al. Recurrent zoonotic transmission of Nipah virus into humans, Bangladesh, 2001-2007. Emerg Infect Dis. 2009;15(8):1229-35.
45. World Health Organization. Nipah virus infection - India. 2023 [Available from: https://www.who.int/emergencies/disease-outbreak-news/item/2023-DON490.
46. World Health Organization. Prioritizing diseases for research and development in emergency contexts 2023 [cited 2024 02 February]. Available from: https://www.who.int/activities/prioritizing-diseases-for-research-and-development-in-emergency-contexts/prioritizing-diseases-for-research-and-development-in-emergency-contexts.
47. Pantha S, Subedi D, Poudel U, Subedi S, Kaphle K, Dhakal S. Review of rabies in Nepal. One Health. 2020;10:100155.

48. THE HIMALAYAN TIMES. Hospital receives 150 dog bite cases per day. 2019 [Available from: https://thehimalayantimes.com/kathmandu/hospital-receives-150-dog-bite-cases-per-day/
49. Fitzpatrick JL, Dyer JL, Blanton JD, Kuzmin IV, Rupprecht CE. Rabies in rodents and lagomorphs in the United States, 1995-2010. J Am Vet Med Assoc. 2014;245(3):333-7.
50. Costa F, Hagan JE, Calcagno J, Kane M, Torgerson P, Martinez-Silveira MS, et al. Global Morbidity and Mortality of Leptospirosis: A Systematic Review. PLOS Neglected Tropical Diseases. 2015;9(9):e0003898.
51. Shrestha R, McKenzie JS, Gautam M, Adhikary R, Pandey K, Koirala P, et al. Determinants of clinical leptospirosis in Nepal. Zoonoses Public Health. 2018;65(8):972-83.
52. Murdoch DR, Woods CW, Zimmerman MD, Dull PM, Belbase RH, Keenan AJ, et al. The etiology of febrile illness in adults presenting to Patan hospital in Kathmandu, Nepal. Am J Trop Med Hyg. 2004;70(6):670-5.
53. Bhattachan B, Battachan A, Sherchan J, Dhoubhadel B, Sherchand J. Leptospirosis: An Emerging Infectious Disease in Nepal. Journal of the Institute of Medicine. 2016;38:2-3.
54. Acharya KP, Karki S, Shrestha K, Kaphle K. One health approach in Nepal: Scope, opportunities and challenges. One Health. 2019;8:100101.
55. Gautam A, Upadhayay P, Ghimre D, Khanal A, Gaire A, Kaphle K. Prioritised Zoonotic Diseases of Nepal: A Review. International Journal of Applied Sciences and Biotechnology. 2021;9.
56. Academy of Social Sciences. Perspectives on social sciences (1): What are the social sciences and why do they matter? 2024 [Available from: https://acss.org.uk/category/perspectives-on-social-science/.
57. Zinsstag J, Schelling E, Waltner-Toews D, Tanner M. From "one medicine" to "one health" and systemic approaches to health and well-being. Prev Vet Med. 2011;101(3-4):148-56.
58. Lancet. One Health: a call for ecological equity. The Lancet. 2023;401(10372):169.
59. Giles-Vernick T, Owona-Ntsama J, Landier J, Eyangoh S. The puzzle of Buruli ulcer transmission, ethno-ecological history and the end of "love" in the Akonolinga district, Cameroon. Soc Sci Med. 2015;129:20-7.
60. Hewlett BS. Evolutionary Cultural Anthropology: Containing Ebola Outbreaks and Explaining Hunter-Gatherer Childhoods. Current Anthropology. 2016;57(S13):S27-S37.
61. Barnett T, Pfeiffer DU, Ahasanul Hoque M, Giasuddin M, Flora MS, Biswas PK, et al. Practising co-production and interdisciplinarity: Challenges and implications for one health research. Prev Vet Med. 2020;177:104949.
62. Wolf M. Is there really such a thing as "one health"? Thinking about a more than human world from the perspective of cultural anthropology. Soc Sci Med. 2015;129:5-11.
63. Osborne J, Paget J, Napier D, Giles-Vernick T, Kutalek R, Rodyna R, et al. Addressing vulnerabilities in communities facing infectious disease threats: A need for social science-driven assessments. J Glob Health. 2021;11:03003.
64. One Health Commission. One Health Social Sciences Initiative. 2024 [Available from: https://www.onehealthcommission.org/en/programs/one_health_social_sciences_initiative/.
65. Giles-Vernick T, Kutalek R, Napier D, Kaawa-Mafigiri D, Dückers M, Paget J, et al. A new social sciences network for infectious threats. Lancet Infect Dis. 2019;19(5):461-3.
66. Shapin S. Hard science, soft science: A political history of a disciplinary array. History of Science. 2022;60(3):287-328.
67. Farr M, Davies P, Andrews H, Bagnall D, Brangan E, Davies R. Co-producing knowledge in health and social care research: reflections on the challenges and ways to enable more equal relationships. Humanities and Social Sciences Communications. 2021;8(1):105.
68. Tugendhaft A, Hofman K, Danis M, Kahn K, Erzse A, Twine R, et al. Deliberative engagement methods on health care priority-setting in a rural South African community. Health Policy and Planning. 2021;36(8):1279-91.
69. Turk E, Durrance-Bagale A, Han E, Bell S, Rajan S, Lota MMM, et al. International experiences with co-production and people centredness offer lessons for covid-19 responses. BMJ. 2021;372:m4752.
70. Leach M, Scoones I. The social and political lives of zoonotic disease models: narratives, science and policy. Soc Sci Med. 2013;88:10-7.

71. Gilbert M, Chaitaweesub P, Parakamawongsa T, Premashthira S, Tiensin T, Kalpravidh W, et al. Free-grazing ducks and highly pathogenic avian influenza, Thailand. Emerg Infect Dis. 2006;12(2):227-34.
72. LeBreton M, Prosser AT, Tamoufe U, Sateren W, Mpoudi-Ngole E, Diffo JLD, et al. Patterns of bushmeat hunting and perceptions of disease risk among central African communities. Animal Conservation. 2006;9(4):357-63.
73. Catley A, Alders RG, Wood JL. Participatory epidemiology: approaches, methods, experiences. Vet J. 2012;191(2):151-60.
74. Fryer T. A critical realist approach to thematic analysis: producing causal explanations. Journal of Critical Realism. 2022;21(4):365-84.
75. Maxwell J. A Realist Approach for Qualitative Research. . LA, USA: Sage Publications; 2012.
76. Adhikari B, Vincent R, Wong G, Duddy C, Richardson E, Lavery JV, et al. A realist review of community engagement with health research. Wellcome Open Res. 2019;4:87.
77. Wang C, Burris MA. Empowerment through Photo Novella: Portraits of Participation. Health Education Quarterly. 1994;21(2):171-86.
78. Catalani C, Minkler M. Photovoice: a review of the literature in health and public health. Health Educ Behav. 2010;37(3):424-51.
79. Oliver K, Kothari A, Mays N. The dark side of coproduction: do the costs outweigh the benefits for health research? Health Research Policy and Systems. 2019;17(1):33.
80. Cash DW, Clark WC, Alcock F, Dickson NM, Eckley N, Guston DH, et al. Knowledge systems for sustainable development. Proceedings of the National Academy of Sciences. 2003;100(14):8086-91.
81. Boaz A, Hanney S, Borst R, O'Shea A, Kok M. How to engage stakeholders in research: design principles to support improvement. Health Research Policy and Systems. 2018;16(1):60.
82. Gray JAM. Evidence based policy making. BMJ. 2004;329(7473):988-9.
83. Ghate D. Developing theories of change for social programmes: co-producing evidence-supported quality improvement. Palgrave Communications. 2018;4(1):90.
84. Conklin A, Morris Z, Nolte E. What is the evidence base for public involvement in health-care policy?: results of a systematic scoping review. Health Expectations. 2015;18(2):153-65.
85. Flinders M, Wood M, Cunningham M. The politics of co-production: risks, limits and pollution. Evidence & Policy. 2016;12(2):261-79.
86. Goodyear-Smith F, Jackson C, Greenhalgh T. Co-design and implementation research: challenges and solutions for ethics committees. BMC Medical Ethics. 2015;16(1):78.
87. Oliver S, Liabo K, Stewart R, Rees R. Public involvement in research: making sense of the diversity. Journal of Health Services Research & Policy. 2015;20(1):45-51.
88. Farr M. Power dynamics and collaborative mechanisms in co-production and co-design processes. Critical Social Policy. 2018;38(4):623-44.
89. USAID. Bringing the Community Together to Plan for Disease Outbreaks and Other Emergencies.; 2019.
90. Vennik FD, van de Bovenkamp HM, Putters K, Grit KJ. Co-production in healthcare: rhetoric and practice. International Review of Administrative Sciences. 2016;82(1):150-68.
91. Dore I. Doing Knowing Ethically – Where Social Work Values Meet Critical Realism. Ethics and Social Welfare. 2019;13(4):377-91.
92. Fletcher AJ. Applying critical realism in qualitative research: methodology meets method. International Journal of Social Research Methodology. 2017;20(2):181-94.
93. Pilgrim D. Some implications of critical realism for mental health research. Social Theory & Health. 2014;12.
94. Gong D, Jiang Q, Chantler T, Sun FY, Zou J, Cheng J, et al. Health System Barriers and Facilitators to Delivering Additional Vaccines through the National Immunisation Programme in China: A Qualitative Study of Provider and Service-User Perspectives. Vaccines (Basel). 2021;9(5).
95. Gorski P. "What is Critical Realism? And Why Should You Care?". Contemporary Sociology: A Journal of Reviews. 2013;42:658-70.
96. Correia T, Willis K. Applying critical realism to the COVID-19 pandemic to improve management of future public health crises. The International Journal of Health Planning and Management. 2022;37(2):599-603.

97. Bhaskar R. A Realist Theory of Science. London, UK: Routledge; 2008.
98. Olsen W. Critical Realist Explorations in Methodology. Methodological Innovations Online. 2007;2(2):1-5.
99. Maxwell J, Mittapalli K. SAGE Handbook of Mixed Methods in Social & Behavioral Research. 2010. CA, USA: SAGE Publications, Inc. Available from: https://methods.sagepub.com/book/sage-handbook-of-mixed-methods-social-behavioral-research-2e.
100. Sims-Schouten W, Riley SCE, Willig C. Critical Realism in Discourse Analysis:A Presentation of a Systematic Method of Analysis Using Women's Talk of Motherhood, Childcare and Female Employment as an Example. Theory & Psychology. 2007;17(1):101-24.
101. Nahar N, Paul RC, Sultana R, Gurley ES, Garcia F, Abedin J, et al. Raw Sap Consumption Habits and Its Association with Knowledge of Nipah Virus in Two Endemic Districts in Bangladesh. PLOS ONE. 2015;10(11):e0142292.
102. Samarakoon YM, Gunawardena N. Knowledge and self-reported practices regarding leptospirosis among adolescent school children in a highly endemic rural area in Sri Lanka. Rural Remote Health. 2013;13(4):2360.
103. Link BG, Phelan J. Social conditions as fundamental causes of disease. J Health Soc Behav. 1995;Spec No:80-94.
104. Phelan JC, Link BG, Tehranifar P. Social conditions as fundamental causes of health inequalities: theory, evidence, and policy implications. J Health Soc Behav. 2010;51 Suppl:S28-40.
105. Patton M. Qualitative research & evaluation methods: Integrating theory and practice.: Sage Publications; 2014.
106. Palinkas LA, Horwitz SM, Green CA, Wisdom JP, Duan N, Hoagwood K. Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. Adm Policy Ment Health. 2015;42(5):533-44.
107. Parker C, Scott S, Geddes A. Snowball Sampling. London2019. Available from: https://methods.sagepub.com/foundations/snowball-sampling.
108. Lavrakas P. Encyclopedia of Survey Research Methods. Thousand Oaks, California2008.
109. Brinkmann S. Qualitative Interviewing: Oxford University Press; 2013.
110. Kvale S, Brinkmann S. Interviews: Learning the craft of qualitative research interviewing: Sage; 2009.
111. Chrzanowska J. Interviewing groups and individuals in qualitative market research: Sage; 2002.
112. Glaw X, Inder K, Kable A, Hazelton M. Visual Methodologies in Qualitative Research:Autophotography and Photo Elicitation Applied to Mental Health Research. International Journal of Qualitative Methods. 2017;16(1):1609406917748215.
113. Bignante E. The use of photo-elicitation in field research. EchoGéo. 2010;11.
114. Mukumbang FC, van Wyk B. Leveraging the Photovoice Methodology for Critical Realist Theorizing. International Journal of Qualitative Methods. 2020;19:1609406920958981.
115. Mtuy TB, Mepukori J, Lankoi J, Lees S. Empowering Maasai women behind the camera: Photovoice as a tool for trachoma control. Research Involvement and Engagement. 2021;7(1):51.
116. Teti M. The Murky Ethics of Visual Qualitative Methods: Picturing a Clear Path Forward. International Journal of Qualitative Methods. 2019;18:1609406919884810.
117. Harper D. Talking about pictures: A case for photo elicitation. Visual Studies. 2002;17(1):13-26.
118. Fetters MD, Rubinstein EB. The 3 Cs of Content, Context, and Concepts: A Practical Approach to Recording Unstructured Field Observations. Ann Fam Med. 2019;17(6):554-60.
119. Yunus NA, olde Hartman T, Lucassen P, Barton C, Russell G, Altun A, et al. Reporting of the Translation Process in Qualitative Health Research: A Neglected Importance. International Journal of Qualitative Methods. 2022;21:16094069221145282.
120. Geertz C. Thick description: toward an interpretive theory of culture. Interpretation of Cultures: Selected Essays. New York, NY, USA.: Basic Books; 2000.
121. Scambler G. Critical realism and health. 2016 [Available from: https://www.grahamscambler.com/critical-realism-and-health/.
122. Mukumbang FC. Retroductive Theorizing: A Contribution of Critical Realism to Mixed Methods Research. Journal of Mixed Methods Research. 2023;17(1):93-114.

123. Danermark B. Applied interdisciplinary research: a critical realist perspective. Journal of Critical Realism. 2019;18(4):368-82.
124. Westhorp G. Understanding Mechanisms in Realist Evaluation and Research. 2018. p. 41-58.
125. Danermark B, Ekström M, Karlsson JC. Explaining Society: Critical Realism in the Social Sciences (2nd ed.). Routledge; 2019.
126. Greenhalgh J, Manzano A. Understanding 'context' in realist evaluation and synthesis. International Journal of Social Research Methodology. 2022;25(5):583-95.
127. Maxwell JA. Causal Explanation, Qualitative Research, and Scientific Inquiry in Education. Educational Researcher. 2004;33(2):3-11.
128. Braun V, Clarke V. Thematic Analysis: A Practical Guide.: SAGE Publications Ltd; 2021.
129. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006;3(2):77-101.
130. Hennessey M, Barnett T. Method in limbo? Theoretical and empirical considerations in using thematic analysis by veterinary and One Health researchers. Prev Vet Med. 2023;221:106061.
131. Mukumbang FC, Kabongo EM, Eastwood JG. Examining the Application of Retroductive Theorizing in Realist-Informed Studies. International Journal of Qualitative Methods. 2021;20:16094069211053516.
132. Jagosh J. Retroductive theorizing in Pawson and Tilley's applied scientific realism. Journal of Critical Realism. 2020;19(2):121-30.
133. Byrne D. A worked example of Braun and Clarke's approach to reflexive thematic analysis. Quality & Quantity. 2022;56(3):1391-412.
134. Wiltshire G, Ronkainen N. A realist approach to thematic analysis: making sense of qualitative data through experiential, inferential and dispositional themes. Journal of Critical Realism. 2021;20(2):159-80.
135. Thapa D, Omland HO. Four steps to identify mechanisms of ICT4D: A critical realism-based methodology. THE ELECTRONIC JOURNAL OF INFORMATION SYSTEMS IN DEVELOPING COUNTRIES. 2018;84(6):e12054.
136. Sims D. Reimaging reflexivity through a critical theoretical framework: Autoethnographic narratives on becoming a (de)colonised researcher. Critical Studies in Teaching and Learning (CriSTaL). 2023;11(1).
137. Berger R. Now I see it, now I don't: researcher's position and reflexivity in qualitative research. Qualitative Research. 2015;15(2):219-34.
138. Abimbola S. The foreign gaze: authorship in academic global health. BMJ Glob Health. 2019;4(5):e002068.
139. Dwyer SC, Buckle JL. The Space Between: On Being an Insider-Outsider in Qualitative Research. International Journal of Qualitative Methods. 2009;8(1):54-63.
140. World Health Organization, editor Expert Meeting On "Innovative Control Approaches Of Rodent-Borne Epidemic Diseases And Other Public Health Consequences Of Rodents' Proliferation" – Meeting Report. Peru, Lima 20-21 March 2019. Innovative Control Approaches Of Rodent-Borne Epidemic Diseases And Other Public Health Consequences Of Rodents' Proliferation; 2019; Peru.
141. Gupta R. Recent outbreak of rabies infections in Brazil transmitted by vampire bats. Euro Surveill. 2005;10(11):E051110.3.
142. World Health Organization. R&D Blueprint and Nipah Virus. 2020 [Available from: https://www.who.int/teams/blueprint/nipah.
143. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. Implement Sci. 2010;5:69.
144. Khalil H, Peters M, Godfrey CM, McInerney P, Soares CB, Parker D. An Evidence-Based Approach to Scoping Reviews. Worldviews Evid Based Nurs. 2016;13(2):118-23.
145. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. International Journal of Social Research Methodology. 2005;8(1):19-32.
146. Peters MD, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. Int J Evid Based Healthc. 2015;13(3):141-6.
147. European Environment Agency. Anthropogenic processes. 2020 [Available from: https://www.eea.europa.eu/archived/archived-content-water-topic/wise-help-centre/glossary-definitions/anthropogenic-processes.

148. Oxford English Dictionary. Definition of behaviour. 2020 [Available from: https://www.lexico.com/definition/behaviour.
149. University of Minnesota. What is Culture? 2020 [Available from: https://carla.umn.edu/culture/definitions.html.
150. GreenFacts. Definition of driver. 2020 [Available from: https://www.greenfacts.org/glossary/def/driver.htm.
151. Oxford Learner's Dictionary. Definition of environmental. 2020 [Available from: https://www.oxfordlearnersdictionaries.com/definition/english/environment.
152. Ahmed T, Hussain S, Zia UU, Rinchen S, Yasir A, Ahmed S, et al. Knowledge, attitude and practice (KAP) survey of canine rabies in Khyber Pakhtunkhwa and Punjab Province of Pakistan. BMC Public Health. 2020;20(1):1293.
153. Alam AN, Siddiqua M, Casal J. Knowledge and attitudes about rabies in dog-bite victims in Bangladesh. One Health. 2020;9:100126.
154. Ghosh S, Chowdhury S, Haider N, Bhowmik RK, Rana MS, Prue Marma AS, et al. Awareness of rabies and response to dog bites in a Bangladesh community. Vet Med Sci. 2016;2(3):161-9.
155. Singh U, Choudhary S. Knowledge, Attitude, Behavior and Practice Study on Dog-Bites and Its Management in the Context of Prevention of Rabies in a Rural Community of Gujarat. Indian J Community Med. 2005;30(3):81-3.
156. Brookes VJ, Gill GS, Singh BB, Sandhu BS, Dhand NK, Aulakh RS, et al. Challenges to human rabies elimination highlighted following a rabies outbreak in bovines and a human in Punjab, India. Zoonoses Public Health. 2019;66(3):325-36.
157. Ichhpujani RL, Chhabra M, Mittal V, Bhattacharya D, Singh J, Lal S. Knowledge, attitude and practices about animal bites and rabies in general community--a multi-centric study. 2006.
158. Rinchen S, Tenzin T, Hall D, van der Meer F, Sharma B, Dukpa K, et al. A community-based knowledge, attitude, and practice survey on rabies among cattle owners in selected areas of Bhutan. PLOS Neglected Tropical Diseases. 2019;13(4):e0007305.
159. Singh T, Mahajan S, Dahiya N. A cross-sectional study of awareness and practices regarding animal bites in rural community, North India. J Family Med Prim Care. 2020;9(6):2751-7.
160. Kapoor P, Baig VN, Kacker S, Sharma M, Sharma M. A cross-sectional study of knowledge regarding rabies among attendees of anti-rabies clinic of a teaching hospital, Jaipur. J Family Med Prim Care. 2019;8(1):194-8.
161. Herbert M, Riyaz Basha S, Thangaraj S. Community perception regarding rabies prevention and stray dog control in urban slums in India. J Infect Public Health. 2012;5(6):374-80.
162. Khan A, Ayaz R, Mehtab A, Naz K, Haider W, Gondal MA, et al. Knowledge, attitude & practices (KAPs) regarding rabies endemicity among the community members, Pakistan. Acta Trop. 2019;200:105156.
163. Tenzin T, Namgyal J, Letho S. Community-based survey during rabies outbreaks in Rangjung town, Trashigang, eastern Bhutan, 2016. BMC Infect Dis. 2017;17(1):281.
164. Ichhpujani RL, Mala C, Veena M, Singh J, Bhardwaj M, Bhattacharya D, et al. Epidemiology of animal bites and rabies cases in India. A multicentric study. J Commun Dis. 2008;40(1):27-36.
165. Massei G, Fooks AR, Horton DL, Callaby R, Sharma K, Dhakal IP, et al. Free-Roaming Dogs in Nepal: Demographics, Health and Public Knowledge, Attitudes and Practices. Zoonoses Public Health. 2017;64(1):29-40.
166. Tenzin, Dhand NK, Rai BD, Changlo, Tenzin S, Tsheten K, et al. Community-based study on knowledge, attitudes and perception of rabies in Gelephu, south-central Bhutan. Int Health. 2012;4(3):210-9.
167. Tiwari HK, O'Dea M, Robertson ID, Vanak AT. Knowledge, attitudes and practices (KAP) towards rabies and free-roaming dogs (FRD) in Shirsuphal village in western India: A community based cross-sectional study. PLoS Negl Trop Dis. 2019;13(1):e0007120.
168. Tenzin, Sharma B, Dhand NK, Timsina N, Ward MP. Reemergence of rabies in Chhukha district, Bhutan, 2008. Emerg Infect Dis. 2010;16(12):1925-30.

169. Matibag GC, Kamigaki T, Kumarasiri PVR, Wijewardana TG, Kalupahana AW, Dissanayake DRA, et al. Knowledge, attitudes, and practices survey of rabies in a community in Sri Lanka. Environmental Health and Preventive Medicine. 2007;12(2):84-9.
170. Mohankumar P, Sivagurunathan C, Umadevi R. Profile of animal bite cases attending rural health centre in Kanceepuram District, Tamil Nadu. Int J Pharm Bio Sci. 2015;6(2):426-9.
171. Khan MA, Latif MZ, Gilani SA, Bukhari I. Risk Factors of Leptospirosis in Rice Cultivators as Compared to non Rice Cultivators in Punjab, Pakistan. Annals of King Edward Medical University Lahore Pakistan. 2017;23(4):536-9.
172. Parveen SM, Suganyaa B, Sathya MS, Margreat AA, Sivasankari K, Shanmughapriya S, et al. Leptospirosis Seroprevalence Among Blue Metal Mine Workers of Tamil Nadu, India. Am J Trop Med Hyg. 2016;95(1):38-42.
173. Schonning MH, Phelps MD, Warnasekara J, Agampodi SB, Furu P. A Case-Control Study of Environmental and Occupational Risks of Leptospirosis in Sri Lanka. EcoHealth. 2019;16(3):534-43.
174. Agampodi SB, Agampodi TC, Thalagala E, Perera S, Chandraratne S, Fernando S. Do people know adequately about leptospirosis? A knowledge assessment survey in post-outbreak situation in Srilanka. International Journal of Preventive Medicine. 2010;1(3):158-63.
175. Madhusudhana MV, Chandrashekar SV, Revathy R. An Epidemiological Investigation of Leptospirosis Outbreak in Shimoga District of Karnataka, India. Indian Journal of Public Health Research & Development. 2015;6:106.
176. Masali KA, Pulare MV, Kachare VK, Patil MB, Reddi S. Control and prevention of rat fever (Leptospirosis) outbreak in six villages of Raichur district, Karnataka. J Indian Med Assoc. 2007;105(11):632, 4-6.
177. Parmar PC, Momin MH, Godara NR, Kantharia SL. Profile of Leptospirosis Patients Admitted in Tertiary Care Centre of South Gujarat. Indian Journal of Public Health Research & Development. 2016;7(3).
178. Sohan L, Shyamal B, Kumar TS, Malini M, Ravi K, Venkatesh V, et al. Studies on leptospirosis outbreaks in Peddamandem Mandal of Chittoor district, Andhra Pradesh. J Commun Dis. 2008;40(2):127-32.
179. Regmi L, Pandey K, Malla M, Khanal S, Pandey BD. Sero-epidemiology study of leptospirosis in febrile patients from Terai region of Nepal. BMC Infect Dis. 2017;17(1):628.
180. Sohail ML, Khan MS, Muhammad I, Omer N, Zahida F, Ahmad AS, et al. Seroprevalence and risk factor analysis of human leptospirosis in distinct climatic regions of Pakistan. Acta Tropica. 2018;181:79-83.
181. Arunkumar G, Chandni R, Mourya DT, Singh SK, Sadanandan R, Sudan P, et al. Outbreak Investigation of Nipah Virus Disease in Kerala, India, 2018. J Infect Dis. 2019;219(12):1867-78.
182. Chakraborty A, Sazzad HM, Hossain MJ, Islam MS, Parveen S, Husain M, et al. Evolving epidemiology of Nipah virus infection in Bangladesh: evidence from outbreaks during 2010-2011. Epidemiol Infect. 2016;144(2):371-80.
183. Hegde ST, Sazzad HMS, Hossain MJ, Alam MU, Kenah E, Daszak P, et al. Investigating Rare Risk Factors for Nipah Virus in Bangladesh: 2001-2012. Ecohealth. 2016;13(4):720-8.
184. Rahman MA, Hossain MJ, Sultana S, Homaira N, Khan SU, Rahman M, et al. Date palm sap linked to Nipah virus outbreak in Bangladesh, 2008. Vector Borne Zoonotic Dis. 2012;12(1):65-72.
185. Luby SP, Rahman M, Hossain MJ, Blum LS, Husain MM, Gurley E, et al. Foodborne transmission of Nipah virus, Bangladesh. Emerging infectious diseases. 2006;12(12):1888-94.
186. Montgomery JM, Hossain MJ, Gurley E, Carroll GD, Croisier A, Bertherat E, et al. Risk factors for Nipah virus encephalitis in Bangladesh. Emerg Infect Dis. 2008;14(10):1526-32.
187. Gurley ES, Hegde ST, Kamal H, Sazzad HMS, Hossain MJ, Mahmudur R, et al. Convergence of humans, bats, trees, and culture in Nipah virus transmission, Bangladesh. Emerging Infectious Diseases. 2017;23(9):1446-53.
188. Khan S, Islam M, Rahman M, Islam A, Sazzad H, Epstein J, et al. Nipah virus shedding among Pteropus bats in the context of a human outbreak in Bangladesh, 2012. In: ASTMH, editor. ASTMH 62nd Annual Meeting; Washington, DC, USA.2013.
189. Khan SU, Gurley ES, Hossain MJ, Nahar N, Sharker MA, Luby SP. A randomized controlled trial of interventions to impede date palm sap contamination by bats to prevent nipah virus transmission in Bangladesh. PLoS One. 2012;7(8):e42689.

190. Br A, Dovih P, Ramakrishnan U, Liang E, Mendenhall I, Hong DLW, et al. Evidence of filovirus and henipavirus in bats and bat harvesters, India. International Journal of Infectious Diseases. 2019;79:60.
191. Homaira N, Rahman M, Hossain MJ, Epstein JH, Sultana R, Khan MS, et al. Nipah virus outbreak with person-to-person transmission in a district of Bangladesh, 2007. Epidemiol Infect. 2010;138(11):1630-6.
192. Islam MS, Sazzad HM, Satter SM, Sultana S, Hossain MJ, Hasan M, et al. Nipah Virus Transmission from Bats to Humans Associated with Drinking Traditional Liquor Made from Date Palm Sap, Bangladesh, 2011-2014. Emerg Infect Dis. 2016;22(4):664-70.
193. Openshaw JJ, Hegde S, Sazzad HMS, Khan SU, Hossain MJ, Epstein JH, et al. Bat Hunting and Bat-Human Interactions in Bangladeshi Villages: Implications for Zoonotic Disease Transmission and Bat Conservation. Transbound Emerg Dis. 2017;64(4):1287-93.
194. Openshaw JJ, Hegde S, Sazzad HM, Khan SU, Hossain MJ, Epstein JH, et al. Increased Morbidity and Mortality in Domestic Animals Eating Dropped and Bitten Fruit in Bangladeshi Villages: Implications for Zoonotic Disease Transmission. Ecohealth. 2016;13(1):39-48.
195. Hahn MB, Epstein JH, Gurley ES, Islam MS, Luby SP, Daszak P, et al. Roosting behaviour and habitat selection of Pteropus giganteus reveals potential links to Nipah virus epidemiology. J Appl Ecol. 2014;51(2):376-87.
196. Hahn MB, Gurley ES, Epstein JH, Islam MS, Patz JA, Daszak P, et al. The role of landscape composition and configuration on Pteropus giganteus roosting ecology and Nipah virus spillover risk in Bangladesh. Am J Trop Med Hyg. 2014;90(2):247-55.
197. Rahman M, Hossain M, Sultana S, Homaira N, Khan S, Rahman M, et al. Date palm sap linked to Nipah virus outbreak in Bangladesh, 2008. In: (US). IoM, editor. Improving Food Safety Through a One Health Approach: Workshop Summary Washington DC.: National Academies Press (US). 2012.
198. Cortes MC, Cauchemez S, Lefrancq N, Luby SP, Jahangir Hossain M, Sazzad HMS, et al. Characterization of the Spatial and Temporal Distribution of Nipah Virus Spillover Events in Bangladesh, 2007-2013. J Infect Dis. 2018;217(9):1390-4.
199. Arif S, Thomson PC, Hernandez-Jover M, McGill DM, Warriach HM, Heller J. Knowledge, attitudes and practices (KAP) relating to brucellosis in smallholder dairy farmers in two provinces in Pakistan. PLoS One. 2017;12(3):e0173365.
200. Deka RP, Magnusson U, Grace D, Shome R, Lindahl JF. Knowledge and practices of dairy farmers relating to brucellosis in urban, peri-urban and rural areas of Assam and Bihar, India. Infection Ecology & Epidemiology. 2020;10(1).
201. Yadav N, Aggarwal D. Potential Risk Factors of Brucellosis in Dairy Farmers of Peri-urban Areas of South West Delhi. Indian J Community Med. 2020;45(Suppl 1):S12-S5.
202. Biswas S, Chatterjee P, Mukherjee C, Pal P, Pradhan N. Awareness of farmers regarding hygienic handling of their cattle to prevent zoonotic diseases. Explor Anim Med Res. 2015;5(2):207-12.
203. Kochar DK, Gupta BK, Gupta A, Kalla A, Nayak KC, Purohit SK. Hospital-based case series of 175 cases of serologically confirmed brucellosis in Bikaner. J Assoc Physicians India. 2007;55:271-5.
204. Pathak AD, Dubal ZB, Doijad S, Raorane A, Rodrigues S, Naik R, et al. Human brucellosis among pyrexia of unknown origin cases and occupationally exposed individuals in Goa Region, India. Emerg Health Threats J. 2014;7:23846.
205. Datta S, Sen S, Sengupta B. A study on knowledge and practice related to bird flu in a rural community of Hooghly District of West Bengal. Indian J Public Health. 2010;54(4):216-8.
206. Roess AA, Winch PJ, Akhter A, Afroz D, Ali NA, Shah R, et al. Household Animal and Human Medicine Use and Animal Husbandry Practices in Rural Bangladesh: Risk Factors for Emerging Zoonotic Disease and Antibiotic Resistance. Zoonoses Public Health. 2015;62(7):569-78.
207. Sultana R, Rimi NA, Azad S, Islam MS, Khan MS, Gurley ES, et al. Bangladeshi backyard poultry raisers' perceptions and practices related to zoonotic transmission of avian influenza. J Infect Dev Ctries. 2012;6(2):156-65.
208. Chakraborty A, Rahman M, Hossain MJ, Khan SU, Haider MS, Sultana R, et al. Mild Respiratory Illness Among Young Children Caused by Highly Pathogenic Avian Influenza A (H5N1) Virus Infection in Dhaka, Bangladesh, 2011. J Infect Dis. 2017;216(suppl_4):S520-S8.
209. Chattopadhyay UK, Rashid M, Sur SK. Knowledge, attitude and practices about zoonoses with reference to Campylobacteriosis in a rural area of West Bengal. Indian J Public Health. 2006;50(3):187-8.

210. Dhakal S, Stephen C, Ale A, Joshi DD. Knowledge and practices of pig farmers regarding Japanese encephalitis in Kathmandu, Nepal. Zoonoses Public Health. 2012;59(8):568-74.
211. Khadayata V, Aggarwal D. Knowledge, Attitude, and Practice about Hygiene among Livestock Keepers in Peri-Urban Area of Vadodara District, Gujarat. Indian J Community Med. 2020;45(Suppl 1):S16-S20.
212. Kothalawala K, Makita K, Kothalawala H, Jiffry AM, Kubota S, Kono H. Knowledge, attitudes, and practices (KAP) related to brucellosis and factors affecting knowledge sharing on animal diseases: a cross-sectional survey in the dry zone of Sri Lanka. Trop Anim Health Prod. 2018;50(5):983-9.
213. Khattak I, Mushtaq MH, Ahmad MU, Khan MS, Haider J. Zoonotic tuberculosis in occupationally exposed groups in Pakistan. Occup Med (Lond). 2016;66(5):371-6.
214. Haleem S, Niaz S, Qureshi NA, Ullah R, Alsaid MS, Alqahtani AS, et al. Incidence, Risk Factors, and Epidemiology of Cystic Echinococcosis: A Complex Socioecological Emerging Infectious Disease in Khyber Pakhtunkhwa, Province of Pakistan. Biomed Res Int. 2018;2018:5042430.
215. Hundal JS, Sodhi SS, Gupta A, Singh J, Chahal US. Awareness, knowledge, and risks of zoonotic diseases among livestock farmers in Punjab. Vet World. 2016;9(2):186-91.
216. Mangalgi SS, Sajjan AG, Mohite ST, Kakade SV. Serological, Clinical, and Epidemiological Profile of Human Brucellosis in Rural India. Indian J Community Med. 2015;40(3):163-7.
217. Mangalgi SS, Sajjan AG, Mohite ST, Gajul S. Brucellosis in Occupationally Exposed Groups. J Clin Diagn Res. 2016;10(4):DC24-7.
218. Sah J. A study on knowledge and preventive practices related to Avian Influenza among Higher Secondary School Students of Rajbiraj Municipality, Nepal. Al Ameen Journal of Medical Sciences. 2017;10:276-80.
219. Manandhar K, Chataut J, Khanal K, Shrestha A, Shrestha S, Shrestha S. Awareness regarding preventive measures of avian influenza among the adult people of Thimi Municipality, Nepal. Kathmandu Univ Med J (KUMJ). 2013;11(41):45-9.
220. Rajkumar K, Bhattacharya A, David S, Balaji SH, Hariharan R, Jayakumar M, et al. Socio-demographic study on extent of knowledge, awareness, attitude, and risks of zoonotic diseases among livestock owners in Puducherry region. Vet World. 2016;9(9):1018-24.
221. Dhakal S, Joshi DD, Ale A, Sharma M, Dahal M, Shah Y, et al. Regional variation in pig farmer awareness and actions regarding Japanese encephalitis in Nepal: implications for public health education. PLoS One. 2014;9(1):e85399.
222. Islam MS, Hossain MJ, Mikolon A, Parveen S, Khan MS, Haider N, et al. Risk practices for animal and human anthrax in Bangladesh: an exploratory study. Infect Ecol Epidemiol. 2013;3.
223. Gupta VK, Agrawal RD, Gupta P. Canine echinococcosis: Prevalence and risk perception of the zoonotic infection to community. Veterinary Practitioner. 2014;15:145-8.
224. Haider N, Khan MSU, Hossain MB, Sazzad HMS, Rahman MZ, Ahmed F, et al. Serological evidence of hepatitis E virus infection in pigs and jaundice among pig handlers in Bangladesh. Zoonoses Public Health. 2017;64(7):572-7.
225. Chinchwadkar P, Panda P. An Assessment of Knowledge Regarding the Risk of Zoonoses and Hygiene Practices among Females with Livestock in South-West Delhi, India: A Cross-Sectional Study. Indian J Community Med. 2020;45(Suppl 1):S38-s42.
226. Patel K, Saxena D. Self-reported selected zoonotic diseases among animal handlers in Urban Ahmedabad, India. Vet World. 2019;12(1):176-82.
227. Namusisi S, Mahero M, Travis D, Pelican K, Robertson C, Mugisha L. A descriptive study of zoonotic disease risk at the human-wildlife interface in a biodiversity hot spot in South Western Uganda. PLoS Negl Trop Dis. 2021;15(1):e0008633.
228. Akbulut N, Razum O. Why Othering should be considered in research on health inequalities: Theoretical perspectives and research needs. SSM Popul Health. 2022;20:101286.
229. Curtis VA. Dirt, disgust and disease: a natural history of hygiene. J Epidemiol Community Health. 2007;61(8):660-4.
230. Adler P, Adler P. The reluctant respondent. . In: Holstein JA, JF. G, editors. Inside interviewing: new lenses, new concerns,: SAGE Publications Inc; 2003.

231. Kurpiers LA, Schulte-Herbrüggen B, Ejotre I, Reeder DM. Bushmeat and Emerging Infectious Diseases: Lessons from Africa. Problematic Wildlife. 2015;21:507-51.
232. Meerburg BG, Singleton GR, Kijlstra A. Rodent-borne diseases and their risks for public health. Crit Rev Microbiol. 2009;35(3):221-70.
233. Ter Meulen J, Lukashevich I, Sidibe K, Inapogui A, Marx M, Dorlemann A, et al. Hunting of peridomestic rodents and consumption of their meat as possible risk factors for rodent-to-human transmission of Lassa virus in the Republic of Guinea. Am J Trop Med Hyg. 1996;55(6):661-6.
234. Marahatta SB, Yadav RK, Giri D, Lama S, Rijal KR, Mishra SR, et al. Barriers in the access, diagnosis and treatment completion for tuberculosis patients in central and western Nepal: A qualitative study among patients, community members and health care workers. PLOS ONE. 2020;15(1):e0227293.
235. Paudel M, Javanparast S, Dasvarma G, Newman L. Religio-cultural factors contributing to perinatal mortality and morbidity in mountain villages of Nepal: Implications for future healthcare provision. PLOS ONE. 2018;13(3):e0194328.
236. Liverani M, Phongluxa K, Phommasone K, Chew R, Chandna A, Pongvongsa T, et al. Prospects for the development of community-based care in remote rural areas: a stakeholder analysis in Laos. BMC Health Services Research. 2024;24(1):55.
237. Audet CM, Hamilton E, Hughart L, Salato J. Engagement of Traditional Healers and Birth Attendants as a Controversial Proposal to Extend the HIV Health Workforce. Curr HIV/AIDS Rep. 2015;12(2):238-45.
238. Audet CM, Pettapiece-Phillips M, Tian Y, Shepherd BE, Vermund SH, Salato J. "If it weren't for my traditional healer, I would be dead": Engaging traditional healers to support people living with HIV in rural Mozambique. PLOS ONE. 2022;17(6):e0270565.
239. Audet CM, Salato J, Blevins M, Amsalem D, Vermund SH, Gaspar F. Educational intervention increased referrals to allopathic care by traditional healers in three high HIV-prevalence rural districts in Mozambique. PLoS One. 2013;8(8):e70326.
240. Gietaneh W, Simieneh MM, Endalew B, Tarekegn S, Petrucka P, Eyayu D. Traditional healers' roles, and the challenges they face in the prevention and control of local disease outbreaks and pandemics: The case of the East Gojjam Zone in northwestern Ethiopia. Frontiers in Tropical Diseases. 2023;4.
241. Hoff W. Traditional Health Practitioners as Primary Health Care Workers. Tropical Doctor. 1997;27(1_suppl):52-5.
242. Poudel KC, Jimba M, Joshi AB, Poudel-Tandukar K, Sharma M, Wakai S. Retention and effectiveness of HIV/AIDS training of traditional healers in far western Nepal. Tropical Medicine & International Health. 2005;10(7):640-6.
243. Mbizvo E. Essay: Theatre - a force for health promotion. The Lancet. 2006;368:S30-S1.
244. Saylors K, Wolking DJ, Hagan E, Martinez S, Francisco L, Euren J, et al. Socializing One Health: an innovative strategy to investigate social and behavioral risks of emerging viral threats. One Health Outlook. 2021;3(1):11.
245. USAID. Living Safely With Bats. 2018.
246. Martinez S, Sullivan A, Hagan E, Goley J, Epstein JH, Olival KJ, et al. Living Safely With Bats: Lessons in Developing and Sharing a Global One Health Educational Resource. Glob Health Sci Pract. 2022;10(6).
247. Grace D, Lindahl J, Wanyoike F, Bett B, Randolph T, Rich KM. Poor livestock keepers: ecosystem–poverty–health interactions. Philosophical Transactions of the Royal Society B: Biological Sciences. 2017;372(1725):20160166.
248. Shultz JM, Cooper JL, Baingana F, Oquendo MA, Espinel Z, Althouse BM, et al. The Role of Fear-Related Behaviors in the 2013-2016 West Africa Ebola Virus Disease Outbreak. Curr Psychiatry Rep. 2016;18(11):104.
249. Asaaga FA, Young JC, Srinivas PN, Seshadri T, Oommen MA, Rahman M, et al. Co-production of knowledge as part of a OneHealth approach to better control zoonotic diseases. PLOS Global Public Health. 2022;2(3):e0000075.
250. MonkeyFeverRisk. What is KFD? 2024 [Available from: https://monkeyfeverrisk.ceh.ac.uk/what-kfd.
251. Questa K, Das M, King R, Everitt M, Rassi C, Cartwright C, et al. Community engagement interventions for communicable disease control in low- and lower- middle-income countries: evidence from a review of systematic reviews. International Journal for Equity in Health. 2020;19(1):51.

252. Tembo D, Hickey G, Montenegro C, Chandler D, Nelson E, Porter K, et al. Effective engagement and involvement with community stakeholders in the co-production of global health research. BMJ. 2021;372:n178.
253. Wilkinson A, Parker M, Martineau F, Leach M. Engaging 'communities': anthropological insights from the West African Ebola epidemic. Philos Trans R Soc Lond B Biol Sci. 2017;372(1721).
254. Kutalek R, Wang S, Fallah M, Wesseh CS, Gilbert J. Ebola interventions: listen to communities. Lancet Glob Health. 2015;3(3):e131.
255. Brunton G, Thomas J, O'Mara-Eves A, Jamal F, Oliver S, Kavanagh J. Narratives of community engagement: a systematic review-derived conceptual framework for public health interventions. BMC Public Health. 2017;17(1):944.
256. Arnstein SR. A Ladder Of Citizen Participation. Journal of the American Institute of Planners. 1969;35(4):216-24.
257. Popay J. Community Empowerment and Health Improvement: The English Experience. In: Morgan A, Davies M, Ziglio E, editors. Health Assets in a Global Context: Theory, Methods, Action. New York, NY.: Springer New York.; 2010.
258. Li HY, Zhu GJ, Zhang YZ, Zhang LB, Hagan EA, Martinez S, et al. A qualitative study of zoonotic risk factors among rural communities in southern China. Int Health. 2020;12(2):77-85.
259. Jacobsen KH, Aguirre AA, Bailey CL, Baranova AV, Crooks AT, Croitoru A, et al. Lessons from the Ebola Outbreak: Action Items for Emerging Infectious Disease Preparedness and Response. Ecohealth. 2016;13(1):200-12.
260. Mwatondo A, Rahman-Shepherd A, Hollmann L, Chiossi S, Maina J, Kurup KK, et al. A global analysis of One Health Networks and the proliferation of One Health collaborations. Lancet. 2023;401(10376):605-16.
261. Nykiforuk CIJ, Vallianatos H, Nieuwendyk LM. Photovoice as a Method for Revealing Community Perceptions of the Built and Social Environment. International Journal of Qualitative Methods. 2011;10(2):103-24.
262. Berrian AM, Smith MH, van Rooyen J, Martínez-López B, Plank MN, Smith WA, et al. A community-based One Health education program for disease risk mitigation at the human-animal interface. One Health. 2018;5:9-20.
263. Scobie K, Lambin X, Telfer S, Rasahivelo MF, Raheliarison RN, Rajerison M, et al. Living with rodent pests: Unifying stakeholder interests to prioritise pest management in rural Madagascar. People and Nature. 2023;5(2):713-25.
264. Prost A, Colbourn T, Seward N, Azad K, Coomarasamy A, Copas A, et al. Women's groups practising participatory learning and action to improve maternal and newborn health in low-resource settings: a systematic review and meta-analysis. Lancet. 2013;381(9879):1736-46.
265. Khatri RB, Mishra SR, Khanal V. Female Community Health Volunteers in Community-Based Health Programs of Nepal: Future Perspective. Frontiers in Public Health. 2017;5.
266. Morrison J, Tamang S, Mesko N, Osrin D, Shrestha B, Manandhar M, et al. Women's health groups to improve perinatal care in rural Nepal. BMC Pregnancy and Childbirth. 2005;5(1):6.
267. Panday S, Bissell P, van Teijlingen E, Simkhada P. The contribution of female community health volunteers (FCHVs) to maternity care in Nepal: a qualitative study. BMC Health Services Research. 2017;17(1):623.
268. Shrestha S. Increasing contraceptive acceptance through empowerment of female community health volunteers in rural Nepal. J Health Popul Nutr. 2002;20(2):156-65.
269. Loewenson R, Colvin CJ, Szabzon F, Das S, Khanna R, Coelho VSP, et al. Beyond command and control: A rapid review of meaningful community-engaged responses to COVID-19. Glob Public Health. 2021;16(8-9):1439-53.
270. Yoeli H, Dhital R, Hermaszewska S, Sin J. A meta-ethnography of participatory health research and co-production in Nepal. Social Science & Medicine. 2022;301:114955.
271. Mbonye AK, Wamala JF, Nanyunja M, Opio A, Makumbi I, Aceng JR. Ebola viral hemorrhagic disease outbreak in West Africa- lessons from Uganda. Afr Health Sci. 2014;14(3):495-501.
272. Bhutta ZA, Salam RA, Das JK, Lassi ZS. Tackling the existing burden of infectious diseases in the developing world: existing gaps and the way forward. Infectious Diseases of Poverty. 2014;3(1):28.

273. Shigayeva A, Coker RJ. Communicable disease control programmes and health systems: an analytical approach to sustainability. Health Policy Plan. 2015;30(3):368-85.
274. Abramowitz S, McKune SL, Fallah M, Monger J, Tehoungue K, Omidian PA. The Opposite of Denial: Social Learning at the Onset of the Ebola Emergency in Liberia. Journal of Health Communication. 2017;22(sup1):59-65.
275. Carter L, Cosijn M, Williams LJ, Chakraborty A, Kar S. Including marginalised voices in agricultural development processes using an ethical community engagement framework in West Bengal, India. Sustainability Science. 2022;17(2):485-96.
276. Gram L, Skordis-Worrall J, Manandhar DS, Strachan D, Morrison J, Saville N, et al. The long-term impact of community mobilisation through participatory women's groups on women's agency in the household: A follow-up study to the Makwanpur trial. PLOS ONE. 2018;13(5):e0197426.
277. Agyepong IA, Godt S, Sombie I, Binka C, Okine V, Ingabire M-G. Strengthening capacities and resource allocation for co-production of health research in low and middle income countries. BMJ. 2021;372:n166.
278. Gilmore B. Realist evaluations in low- and middle-income countries: reflections and recommendations from the experiences of a foreign researcher. BMJ Global Health. 2019;4(5):e001638.
279. One Health High-Level Expert P, Adisasmito WB, Almuhairi S, Behravesh CB, Bilivogui P, Bukachi SA, et al. One Health: A new definition for a sustainable and healthy future. PLOS Pathogens. 2022;18(6):e1010537.
280. World Health Organization. One Health theory of change.; 2022.
281. Ruckert A, Zinszer K, Zarowsky C, Labonté R, Carabin H. What role for One Health in the COVID-19 pandemic? Can J Public Health. 2020;111(5):641-4.
282. Bonilla-Aldana D, Dhama K, Rodriguez-Morales A. Editorial : Revisiting the One Health Approach in the Context of COVID-19: A Look into the Ecology of this Emerging Disease. Advances in Animal and Veterinary Sciences. 2020;8:1-3.
283. de la Rocque S, Errecaborde KMM, Belot G, Brand T, Shadomy S, von Dobschuetz S, et al. One health systems strengthening in countries: Tripartite tools and approaches at the human-animal-environment interface. BMJ Glob Health. 2023;8(1).
284. Cunningham AA, Daszak P, Wood JLN. One Health, emerging infectious diseases and wildlife: two decades of progress? Philosophical Transactions of the Royal Society B: Biological Sciences. 2017;372(1725):20160167.
285. Alam AM. Nipah virus, an emerging zoonotic disease causing fatal encephalitis. Clin Med (Lond). 2022;22(4):348-52.
286. Barrett MA, Bouley TA. Need for Enhanced Environmental Representation in the Implementation of One Health. Ecohealth. 2015;12(2):212-9.
287. Okello AL, Gibbs EPJ, Vandersmissen A, Welburn SC. One Health and the neglected zoonoses: turning rhetoric into reality. Veterinary Record. 2011;169(11):281-5.
288. Lee K, Brumme ZL. Operationalizing the One Health approach: the global governance challenges. Health Policy Plan. 2013;28(7):778-85.
289. Okello AL, Bardosh K, Smith J, Welburn SC. One Health: Past Successes and Future Challenges in Three African Contexts. PLOS Neglected Tropical Diseases. 2014;8(5):e2884.
290. Elnaiem A, Mohamed-Ahmed O, Zumla A, Mecaskey J, Charron N, Abakar MF, et al. Global and regional governance of One Health and implications for global health security. The Lancet. 2023;401(10377):688-704.
291. Chatterjee P, Kakkar M, Chaturvedi S. Integrating one health in national health policies of developing countries: India's lost opportunities. Infect Dis Poverty. 2016;5(1):87.
292. Hitziger M, Berezowski J, Dürr S, Falzon LC, Léchenne M, Lushasi K, et al. System Thinking and Citizen Participation Is Still Missing in One Health Initiatives - Lessons From Fifteen Evaluations. Front Public Health. 2021;9:653398.
293. World Health Organization. Bridging human and animal health sectors. 2024 [Available from: https://www.who.int/activities/bridging-human-and-animal-health-sectors.
294. Rabinowitz PM, Natterson-Horowitz BJ, Kahn LH, Kock R, Pappaioanou M. Incorporating one health into medical education. BMC Med Educ. 2017;17(1):45.

295. Halliday JE, Allan KJ, Ekwem D, Cleaveland S, Kazwala RR, Crump JA. Endemic zoonoses in the tropics: a public health problem hiding in plain sight. Vet Rec. 2015;176(9):220-5.
296. Cleaveland S, Sharp J, Abela-Ridder B, Allan KJ, Buza J, Crump JA, et al. One Health contributions towards more effective and equitable approaches to health in low- and middle-income countries. Philos Trans R Soc Lond B Biol Sci. 2017;372(1725).
297. Noppert GA, Hegde ST, Kubale JT. Exposure, Susceptibility, and Recovery: A Framework for Examining the Intersection of the Social and Physical Environments and Infectious Disease Risk. Am J Epidemiol. 2023;192(3):475-82.
298. Anonymous. Number of castes, ethnicities in Nepal increases to 142. The Kathmandu Post. 03 June 2023.
299. Adhikari R. Bringing an end to deadly "menstrual huts" is proving difficult in Nepal. BMJ. 2020;368:m536.
300. Thakuri DS, Thapa RK, Singh S, Khanal GN, Khatri RB. A harmful religio-cultural practice (Chhaupadi) during menstruation among adolescent girls in Nepal: Prevalence and policies for eradication. PLoS One. 2021;16(9):e0256968.
301. Restless Development. Community Action Against Chhaupadi. 2021 [Available from: https://restlessdevelopment.org/2021/05/community-action-against-chhaupadi/.
302. De Weger E, Van Vooren N, Luijkx KG, Baan CA, Drewes HW. Achieving successful community engagement: a rapid realist review. BMC Health Services Research. 2018;18(1):285.
303. Adhikari B, Mishra SR, Schwarz R. Transforming Nepal's primary health care delivery system in global health era: addressing historical and current implementation challenges. Global Health. 2022;18(1):8.
304. Schwarz D, Sharma R, Bashyal C, Schwarz R, Baruwal A, Karelas G, et al. Strengthening Nepal's Female Community Health Volunteer network: a qualitative study of experiences at two years. BMC Health Services Research. 2014;14(1):473.
305. Ballard M, Olaniran A, Iberico MM, Rogers A, Thapa A, Cook J, et al. Labour conditions in dual-cadre community health worker programmes: a systematic review. Lancet Glob Health. 2023;11(10):e1598-e608.
306. Glenton C, Scheel IB, Pradhan S, Lewin S, Hodgins S, Shrestha V. The female community health volunteer programme in Nepal: Decision makers' perceptions of volunteerism, payment and other incentives. Social Science & Medicine. 2010;70(12):1920-7.
307. United Nations, World Health Organization, editors. International Conference on Primary Health Care. Alma-Ata, USSR, 6-12 September 1978.
308. Subedi B. Perspective Chapter: Integrating Traditional Healers into the National Health Care System – A Review and Reflection. In: Christian R, editor. Rural Health. Rijeka: IntechOpen; 2023. p. Ch. 2.
309. Pham TV, Koirala R, Kohrt BA. Satisfaction in the Soul: Common Factors Theory Applied to Traditional Healers in Rural Nepal. Ethos. 2020;48(1):93-128.
310. Marzouk M, Durrance-Bagale A, Lam ST, Nagashima-Hayashi M, Ung M, Aribou ZM, et al. Health system evaluation in conflict-affected countries: a scoping review of approaches and methods. Conflict and Health. 2023;17(1):30.
311. Douedari Y, Alhaffar M, Duclos D, Al-Twaish M, Jabbour S, Howard N. 'We need someone to deliver our voices': reflections from conducting remote qualitative research in Syria. Conflict and Health. 2021;15(1):28.
312. Al Shamsi H, Almutairi AG, Al Mashrafi S, Al Kalbani T. Implications of Language Barriers for Healthcare: A Systematic Review. Oman Med J. 2020;35(2):e122.
313. Rasweswe MM, Peu MD, Mulaudzi FM. The importance of local language in healthcare: naming and defining dysmenorrhea. Journal of Communication in Healthcare. 2023;16(2):205-14.
314. Whalen D, Moss M, Baldwin D. Healing through language: Positive physical health effects of indigenous language use [version 1; peer review: 2 approved with reservations]. F1000Research. 2016;5(852).
315. Hemberg J, Sved E. The significance of communication and care in one's mother tongue: Patients' views. Nordic Journal of Nursing Research. 2021;41(1):42-53.
316. Lim R, Tripura R, T JP, Sareth M, Sanann N, Davoeung C, et al. Drama as a community engagement strategy for malaria in rural Cambodia. Wellcome Open Res. 2017;2:95.

317. Pulliam JR, Epstein JH, Dushoff J, Rahman SA, Bunning M, Jamaluddin AA, et al. Agricultural intensification, priming for persistence and the emergence of Nipah virus: a lethal bat-borne zoonosis. J R Soc Interface. 2012;9(66):89-101.
318. Redding DW, Atkinson PM, Cunningham AA, Lo Iacono G, Moses LM, Wood JLN, et al. Impacts of environmental and socio-economic factors on emergence and epidemic potential of Ebola in Africa. Nat Commun. 2019;10(1):4531.
319. Daszak P, Zambrana-Torrelio C, Bogich TL, Fernandez M, Epstein JH, Murray KA, et al. Interdisciplinary approaches to understanding disease emergence: the past, present, and future drivers of Nipah virus emergence. Proc Natl Acad Sci U S A. 2013;110 Suppl 1(Suppl 1):3681-8.
320. Bolakhe S. I took my case to Nepal's highest court to improve conservation. Nature. 2024.
321. Spencer J, McRobie E, Dar O, Rahman-Shepherd A, Hasan N, Hanefeld J, et al. Is the current surge in political and financial attention to One Health solidifying or splintering the movement? BMJ Global Health. 2019;4(1):e001102.
322. Mazet JA, Uhart MM, Keyyu JD. Stakeholders in One Health. Rev Sci Tech. 2014;33(2):443-52.
323. Henley P, Igihozo G, Wotton L. One Health approaches require community engagement, education, and international collaborations—a lesson from Rwanda. Nature Medicine. 2021;27(6):947-8.
324. Iskander D. Re-imaging malaria in the Philippines: how photovoice can help to re-imagine malaria. Malar J. 2015;14:257.
325. Black GF, Davies A, Iskander D, Chambers M. Reflections on the ethics of participatory visual methods to engage communities in global health research. Glob Bioeth. 2018;29(1):22-38.
326. Büyüm AM, Kenney C, Koris A, Mkumba L, Raveendran Y. Decolonising global health: if not now, when? BMJ Global Health. 2020;5(8):e003394.

Appendices

Appendix 1: Topic guides

Topic Guide for Semi-Structured Interviews: Community members

Demographics and personal information

- Gender
- How old are you?
- Have you been to school? Until what age/grade?
- How many people live in your household? How many adults/children?
- What type of work do you and other members of your family do?

Human-animal contact

- Do you have any pets? Where do they live?
- Do you have any livestock? Where do these animals live?
- Who takes care of the animals? [probe: do children help?]
- Do you see animals (rats, community dogs, bats) outside or inside your home?
- Do animals ever damage your house?
- Do you see animal urine or faeces inside your house or food storage? If so, where? What do you do if you see this?
- What do you do if these animals come inside your house? [probe: traps, poison]
- Has the community taken action together against pest animals? What happened?
- What would you do if you found a sick or dead animal outside or inside your house?

Biosecurity

- Where do you store your grain and food?
- Do you use covers for your rice/grain storage?
- Where do you get your water from? [probe: tap, standpipe, river, well]
- Do you do anything to the water before you use it to cook or wash with?
- Do you see animals near the water source?
- Do you eat meat in your house? Where does it come from? [probe: do they eat bushmeat?]
- Do people in your community eat wild animals like bats or rats or other animals? Where do these come from?

Health

- What do you do if someone in your house is ill?
- What kinds of illness do your family usually have?
- Does anyone ever go to hospital or the health post? [probe: what symptoms, why/why not, how far?]
- What kind of medicine do you use? [probe: Western, traditional, home remedies]

Environment

- Has there been any change in your local environment over the last few years? [probe: deforestation, building work, roads]
- Have you noticed weather patterns changing? [probe: hotter, wetter etc]
- Have any of these changes affected you? How?

Awareness

- Did you know that you can catch diseases from animals? Which kinds of disease?
- Do you wash your hands after handling animals?
- Are your animals vaccinated?

- Do your animals get ill? What kind of disease? What do you do if they are ill? [probe: do you see a vet/go to an animal health shop]
- Have you ever heard of a health awareness programme in your community?
- If so, did you attend?
- What kind of things did they discuss?
- Who ran the programme?
- Do you think they are useful? Did you enjoy taking part?
- Who do you think should run these programmes?
- What would you like to know about diseases?
- Have you heard anything about these kind of things from your friends/family or newspapers/radio/television?

Topic Guide for Semi-Structured Interviews: Policymakers, Human and Animal Healthcare Professionals

Demographics and personal information

- Gender
- What is your position in the organisation? Please could you tell me a little about your role?

Awareness

- What do you think are the main zoonotic disease risks in your community? Why?
- What factors or behaviours do you think increase the risk of these types of disease?
- Do you think people in communities in Nepal know about zoonotic disease?
- Have you or your organisation ever organised any kind of programme or training about zoonotic disease in a community? [probe: or any kind of activity like this]
- If so, was it successful? Why did it work? What kind of feedback did you get from the community?
- What worked and what didn't during the session?
- Do you think these types of initiatives are useful? Why/why not?

Policy

- Does the Nepali government have a policy on zoonotic disease?
- Which departments/ministries are responsible for this kind of topic?
- If so, do you know which diseases are focused on?
- Do they mention the role of communities in addressing the issues around zoonotic disease?
- Do you know of any iNGOs or NGOs working on this issue in Nepal?

Topic Guide for Focus Group Discussions

Human-animal contact

- Do you have any animals (pets or livestock)?
- Where do these animals live?
- Who takes care of the animals? [probe: do children help?]
- Do you see animals (rats, community dogs, bats) outside or inside your home?
- What do you do if these animals come inside your house? [probe: traps, poison]
- Do you see animal urine or faeces inside your house or food storage? If so, where?
- Has the community taken action together against pest animals? What happened?
- What would you do if you found a sick or dead animal outside or inside your house?

Biosecurity

- Where do you store your grain and food?
- Do you use covers for your rice/grain storage?
- Where do you get your water from? [probe: tap, standpipe, river, well]

- Do you do anything to the water before you use it to cook or wash with?
- Do you see animals near the water source?
- Do people in your community eat wild animals like bats or rats? Where do these come from?

Health

- What do you do if someone in your house is ill?
- What kinds of illness do your family usually have?
- Did anyone ever go to hospital? [probe: what symptoms]
- Where is your nearest doctor/health post?
- How much does it cost to visit the doctor/health post?
- What kind of medicine do you use? [probe: Western, traditional, home remedies]

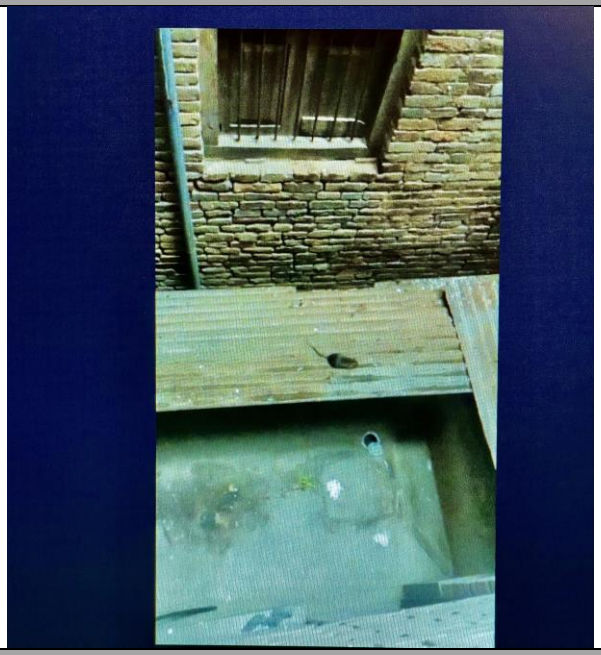
Environment

- Has there been any change in your local environment over the last few years? [probe: deforestation, building work, roads]
- Have you noticed weather patterns changing? [probe: hotter, wetter etc]
- Have any of these changes affected you? How?

Awareness

- Did you know that you can catch diseases from animals? Which kinds of disease?
- Do your animals get ill? What kind of disease? What do you do if they are ill? [probe: do you see a vet/go to an animal health shop]
- Have you ever heard of a health awareness programme in your community?
- If so, did you attend?
- What kind of things did they discuss?
- Who ran the programme?
- Do you think they are useful?
- Who do you think should run these programmes?
- What would you like to know about diseases?

Appendix 2: Photovoice images

Participant	Image	Description
Bhaktapur4		This participant took me to a grassed area behind her house in Bhaktapur and took this photo of fruit bats hanging from the trees. She explained that she was more aware of potential disease risk threats from bats like this as a result of the COVID-19 pandemic.
		This is a still from a video that the participant filmed from a window of her house, of a rat calmly walking around in the outside area. She wanted to show me how normal this was: the rat was not scared by our presence, and the participant was not unnerved by the rat.

Participant	Image	Description
Chitwan1		This photograph, of a rodent-damaged water bottle, was taken by the participant, who runs a small roadside shop. Despite the damage to his stock and indirectly his income, he stated that he did not kill rodents due to his beliefs: 'We haven't applied any measures. We worship Lord Shiva and do not believe in killing rats.'

Participant	Image	Description
Gulmi1		This participant was keen to show us damage done by rodents, and especially to demonstrate the proximity of these animals to their food storage. Image 1 shows stored potatoes chewed by rodents.
		Image 2 is of holes dug by rodents in their kitchen garden.

		Image 3 shows open storage system of food items, which are easily accessible by rodents and birds that may fly in.

Participant	Image	Description
Gulmi2		This participant was keen to show that the goats 'live in a shed that is far from the house' and therefore not in close proximity to them and their family.
		'The rats have been affecting us a lot and I have been killing 2 to 3 rats a day'. This was a rat hole just outside the house.

		The participant took a photo of the hole a rat had made above the bed.
		Again, the goats are kept away from the house, and the pen is clean and well kept.

Participant	Image	Description
Kathmandu3		This participant, a shop owner in the informal settlement, showed us her produce, suggesting that it is easy for animals to access this fresh food.
		A rat hole in her shop, which faces the heavily polluted river running just outside.

		She discussed the damage rodents cause to her stock. She had used conventional traps in an effort to prevent this damage but the rats are so large that they were able to drag themselves and the trap out of the shop. She photographed her homemade rodent trap, which was made of a piece of round, flat metal covered in lentils and glue. Once the rats are stuck on the metal she kills them and throws them in the river that runs beside the settlement.

Participant	Image	Description
Mustang1		The animal pen backing on to the participant's house, where hens and rabbits are kept. 'All of the members in my family help in taking care of the animals.'

		The participant wanted to show us her rat trap: 'Yes, I will show it to you. The rats are so strong as it collects a lot of grains.' Dead rats are thrown into the river (see photograph below).
		This participant took a photograph of a water course running outside her home, along a main road and adjacent to her cultivated fields and animal shelters. She stated that community members throw animal corpses into this water course, irrespective of how the animal died (e.g., poison, killed by feral dog, diseased domestic animal). She recognised the potential importance of this as a literal conduit for disease risk. The image has been cropped slightly to protect the participant's anonymity, as identifiable houses are present in the background.

Participant	Image	Description
Pokhara7		This participant took a photograph of a rodent trap that he used in his kitchen. This participant was aware that rats could spread disease: 'I usually close all the rat holes inside the house and cover all the food that we consume. We usually try to control it as the rats can cause another disease. I usually don't use poison and use mouse trap in which we use apple, peanut and pumpkin seed.'
		Rodent faeces is present in this grain store (*bhakhari*) as small black objects. The participant said that the faeces would be removed and the grain cleaned and eaten as usual.

		The food store in the house, with bags of grain.

Participant	Image	Description
Pokhara8		A bag of grain has been chewed by a rodent, which may be inside the sack.
		This participant showed us his chickens, which have been bitten by rodents that might be attracted by the easily accessible food.

		This is a gobar (dried cow dung) gas maker in the garden of the house. Household waste and buffalo excrement is thrown into this stone receptacle, which is usually covered (although it wasn't when we were present). This produces gas that can be used for household purposes. 'Rats also are seen a lot that poops around the house, that stinks. I killed three mouses today and dumped it in the gobar gas pit.'

Participant	Image	Description
Pokhara11		This participant took a photograph of the substances used in his house to control rodents. When asked to explain why he killed rodents, his response was related to disease, although he may have been confused on which disease had killed the person: 'Rats also transmit rabies. I heard a case when a rat bit an old woman I had known in the thumb and she did not take good care of it and died due to it.'
		This goat faeces was lying just outside the entrance to the participant's house, on the step up into the house.

		The participant's wife points out the open bhakhari storage for this grain, which rodents can easily access.

Participant	Image	Description
Pokhara FGD		This participant was keen to demonstrate her homemade rat traps, one baited with a potato. 'We throw the rat away. Some are dead and some are alive in the trap. I just throw the rats in the road and the eagles take them.'
		The ground floor of this participant's house is the goat shed. The image has been cropped slightly to protect the participant's anonymity, as identifiable buildings are present in the background. She wanted to show us her closely she lives to her animals.