

Mapping emerging trends and South–South cooperation in regional knowledge networks: A bibliometric analysis of avian influenza research in Southeast Asia

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Abstract

This paper maps emerging trends and South-South cooperation in regional knowledge networks through a bibliometric analysis of avian influenza research in Southeast Asia, between 2004 and 2019. The findings indicate that a substantial research output involving researchers and organisations in the region was generated. However, wide disparities between countries existed, both in terms of output and participation in the regional network, which was largely driven by non-regional actors. A more proactive involvement of institutions for regional cooperation such as the Association of Southeast Asian Nations (ASEAN) would increase local ownership, sustainability and redress imbalances in the regional research system.

KEYWORDS

avian influenza, regional knowledge networks, research collaboration, Southeast Asia, South–South cooperation

1 | INTRODUCTION

In the past decade or so, new patterns of research collaboration in low- and middle-income countries (LMICs) have emerged, with the potential to reshape the global geography of science. In Brazil, local research organisations have engaged in extensive collaborations with partners in Argentina, Chile and Mexico (Martinez & Sá, 2020). Similar processes have been documented in Africa (Adams et al., 2014; Landini et al., 2015), the Middle East (Moed, 2016)

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and Southeast Asia (Ong, 2021). In the words of the director of the Institute for Scientific Information Jonathan Adams, these 'new regional networks are reinforcing the competence and capacity of emerging research economies, and changing the global balance of research activity' (Adams, 2012).

From a public good perspective, the strengthening of research networks in LMICs is a desirable outcome, particularly in regional contexts where neighbouring countries share common challenges such as infectious disease control or environmental hazards (Liverani et al., 2018). In these settings, research networks can facilitate the sharing of data, information and expertise to better understand phenomena that transcend national borders, improve regional governance through the research-policy interface and promote capacity building between more and less resourced countries (Fanning et al., 2021). In view of this, research consortia have been established in different regions to foster cross-border links between researchers, organisations and laboratories. For example, the East African Consortium for Clinical Research (EACCR) is a capacity building network, involving research institutions from six countries in East Africa (Miiro et al., 2013).

Furthermore, these networks are an important manifestation of South–South cooperation (SSC), defined as 'a process whereby two or more developing countries pursue their individual or collective development through cooperative exchange of knowledge, skills, resources and technical expertise' (UNDP, 2007). The concept of SSC emerged in the 1950s in the context of postcolonial experiences and solidarity between Southern countries in their common struggle to gain true emancipation from Western dominance. Following a decline in interest during the 1980s, in the 1990s SSC resurfaced on the agenda of international development, but its focus shifted from alternative political movement to technical cooperation and capacity building (Morvaridi & Hughes, 2018). In the process, new forms of 'triangular' cooperation have emerged, where traditional donors provide financial and technical support to facilitate cooperation between countries in the South. Notably, one of the objectives of the Sustainable Development Goal 17—*Partnerships for the goals*—is 'to enhance North–South, South–South and triangular regional and international cooperation on and access to science, technology, and innovation and enhance knowledge sharing on mutually agreed terms' (UN, 2015). Today, there is a consensus that such partnerships can foster more sustainable pathways to development, local ownership and relevance of research products, self-reliance and independence (Gosovic, 2016; OECD, 2019; UNOSSC, 2022).

At the same time, these developments have occurred amidst growing awareness that the achievement of fair and equitable partnerships is a major challenge. In the literature, concerns have been raised that SSC may reflect power imbalances between countries in the global South, reinforcing inequities and marginalisation (Cesarino, 2012). Despite the rhetoric of mutual learning and equal participation, SSC may be shaped by dominant Southern partners at the expense of the poorest countries (Tarp & Cold-Ravnkilde, 2015). Another concern is that such partnerships may disproportionality be driven by traditional donors involved in triangular cooperation schemes, undermining the core principles of SSC (Chandy & Kharas, 2011). In this sense, triangular cooperation can be seen as an attempt to protect and replicate familiar patterns of coloniality, with beneficiary states acting as little more than passive recipients of donor-driven agendas (McEwan & Mawdsley, 2012).

While the dilemmas of SSC have been recognised in the literature, to date little efforts have been made to map these issues in the research landscape. In development studies, the debate on SSC has tended to focus on institutional change and policy, international relations, and aid flows (e.g., Bergamaschi et al., 2017). By contrast, less attention has been paid to examine SSC 'beyond aid' (Janus et al., 2015) in specific fields of practice, including scientific research. To be sure, critical studies of global health have long scrutinised power relations in research partnerships (Chetwood et al., 2015; Franzen et al., 2017; Gautier et al., 2018; Geissler, 2013), highlighting persisting inequities in terms of decision-making, access to resources, funding and publishing opportunities (Murphy et al., 2015). For example, a recent commentary concluded that 'to date, partnership approaches have sustained old ghosts: North–South dependency, distorted health research priorities, weak and unprepared health care systems, underutilized local professionals and knowledge, unfair distribution of risks and benefits and insufficient access to life-saving interventions for populations most in need' (Ward et al., 2018: 2). In recognition of these issues, toolkits, guidelines, and other resources have been produced to encourage more equitable collaborative practices (Monette et al., 2021). With few

exceptions (Fonseca et al., 2018; Schneider & Maleka, 2018; Van der Veken et al., 2017), however, the debate in global health has focused on relationships between academic institutions based in the North (particularly Europe and the United States) and local organisations in the South, where the research is conducted. Comparatively, the study of South–South research networks has been neglected. As a result, key open questions remain about the geographies of such collaborations, to what extent they are driven by Northern or Southern partners, and patterns of exclusion/inclusion. These questions are important not only for understanding the evolving landscape of international development—they are also crucial to inform research policy in emerging contexts of regional cooperation, where action can be taken to harness local resources and leadership, and to redress imbalances in participation.

The present article aims to gain a better understanding of these issues through a bibliometric and network analysis of avian influenza research in Southeast Asia. As described in the section below, this is a suitable case to map evolving patterns in South–South research cooperation, given the cross-border dimension of the disease and its importance for regional economic development as well as global health security. Specifically, we aim to identify drivers and patterns of regional cooperation, with a view to informing the debate in research and policy communities. After a description of the case study and the research methods, we present the findings from the analysis of this publication domain, including the involvement of regional and non-regional actors, the centrality of different actors in the regional research network, funding arrangements and thematic areas for collaboration. In the last section, the implications of the research findings for regional policy are discussed.

2 | AVIAN INFLUENZA AND REGIONAL COOPERATION IN SOUTHEAST ASIA

Socio-economic drivers of disease emergence and transmission in Southeast Asia are multiple and interrelated in complex ways. Increasing deforestation and other environmental changes, such as those associated with urbanisation and the intensification of livestock production, have profoundly altered the population ecologies of, and interactions between, wildlife, livestock, and humans, in ways that may promote disease emergence and evolution (Coker et al., 2011; Liverani et al., 2013). Furthermore, the process of regional trade liberalisation, sponsored by the Asian Development Bank (ADB) and the Association of Southeast Asian Nations (ASEAN), has led to a substantial increase in the mobility of labourers and traded goods along the so called ‘economic corridors’ that cut across porous borders through improved road infrastructure (Fujimura, 2017). While these processes have been crucial to economic growth and demographic change in the region, frequent movements of seasonal labourers (Skeldon, 2000; WHO, 2017) and the regional trade in livestock and other animals (ADB, 2016) contribute to the cross-border spread of infections, posing significant challenges to disease prevention and control. In this context, the epidemiology of many infectious diseases has a clear regional dimension, including artemisinin-resistant malaria (Ashley et al., 2014), avian influenza H5N1 and variants (Pfeiffer et al., 2011) and, most recently, COVID-19 (Corwin et al., 2021).

Since the early 2000s, avian influenza (also known as ‘bird flu’) has been one of the most serious health challenges in Southeast Asia (Eagles et al., 2009; Gilbert et al., 2008). While outbreaks of low pathogenic avian influenza (LPAI) have occurred in poultry for many decades, the Asian lineage of highly pathogenic avian influenza (HPAI)-A/H5N1 viruses has been of special concern in recent times, causing widespread production losses and infections in humans. Available evidence indicates that HPAI-A/H5N1 emerged in the late 1990s, with the first known cases of transmission to humans reported in 1997 in Hong Kong (Chan, 2002). The culling of all poultry in Hong Kong ended the first wave of H5N1, although the virus continued to circulate among birds in southern China and then likely spread to Vietnam through cross-border poultry trade routes (Wang et al., 2008). By the end of 2004, multiple outbreaks were reported throughout Southeast Asia, with cases of human infections in Vietnam, Thailand and, subsequently, Indonesia, Cambodia, Laos and Myanmar. In addition to the burden on human health (with case-fatality rates up to 70%), the virus caused widespread disruption to poultry production and trade in the region, where the three leading producing countries (Indonesia, Thailand and Vietnam) suffered substantial losses to their GDP (Pongcharoensuk et al., 2012). Between 2007 and 2008, the H5N1 human infections and outbreaks in poultry gradually reduced, although cases

continued to be reported worldwide, including in Bangladesh, Egypt, Indonesia, Cambodia, Vietnam and China. Furthermore, while the circulation of H5N1 has declined over recent years, there are increasing concerns about the regional spread of other avian influenza strains such as H5N6 (Kang et al., 2017).

In the wake of this and other cross-border health threats, regional programmes and initiatives involving some form of cooperation between experts in affected countries have increased. In the research arena, intraregional collaborations have been established within large multi-country projects, typically funded by organisations in high-income countries. In addition, efforts have been made to develop and sustain regional research networks. For example, the Asia Pacific Emerging Infectious Disease Research (APEIR) programme is a 'trust based' network, established in 2006 to promote collaboration on emerging infectious diseases between human and animal health researchers in Cambodia, China, Laos, Indonesia, Thailand and Vietnam (Silkavute et al., 2013). Similarly, the South East Asia Infectious Disease Clinical Research Network (SEAICRN) was a collaborative partnership between hospitals and research institutions in Thailand, Vietnam, Indonesia, the US, and the UK, formed in September 2005 to conduct collaborative clinical research on avian influenza and other diseases (Wertheim et al., 2010).

These initiatives have taken place within a wider context of increasing regional cooperation in Southeast Asia (Engel, 2019). Historically, Indonesia has played an important role for the promotion of SSC since the Bandung conference in 1955, which is widely credited as the inception of this movement. Today, the Indonesian government is committed to revitalising SSC in Southeast Asia and beyond, although the focus has shifted from political solidarity to an emphasis on technical cooperation, in line with mainstream approaches in the international community (Winanti & Alvian, 2021). One example is the Technical Cooperation Program (TCP), a capacity building programme designed as 'a means to share the Indonesian experience among the developing countries in the effort to develop knowledge, expertise and a vision to address common critical needs and problems' (ISTTC, 2010). Thailand is also engaged in several SSC initiatives, including training and exchange programmes with Cambodia, Laos, Myanmar, and Vietnam, provided by the Thai government through the Neighbouring Countries Economic Development Cooperation Agency (TICA, 2022). These countries are also members of multilateral organisations for economic cooperation in Southeast Asia, including ASEAN and sub-regional programmes such as the Greater Mekong Subregion (GMS), sponsored by the Asian Development Bank, and the Ayeyawady-Chao Phraya-Mekong Economic Cooperation Strategy (ACMECS), involving Cambodia, Laos, Myanmar, Thailand and Vietnam.

3 | MATERIALS AND METHODS

In order to map intraregional patterns of collaborative research on avian influenza, this study relied on the analysis of co-authorship in published papers and other bibliometric indicators. This approach has some limitations in that it only captures a thin layer of collaboration dynamics, providing no description of research practice. However, as Fonseca et al. (2018) pointed out, 'co-authorship of a technical document is a written statement of the involvement of two or more authors or organizations' (2018:2). As such, bibliometric analysis remains a valuable and widely used method to chart, at least in broad strokes, trends in international collaboration (i.e., who has collaborated with whom (Morvaridi & Hughes, 2018)), map priority thematic areas for collaboration, and identify structural patterns in research networks including the role of brokers and funders (Glanzel & Schubert, 2005; Lukkonen et al., 1993; Melin & Persson, 1996). In addition, the availability and systematic sorting of publications in online databases provide an efficient tool to facilitate data collection and analysis.

3.1 | Data collection

Considering the regional epidemiology of avian influenza and its disease burden (that is, the report of at least one human case in the country and/or sustained animal transmission), data collection for this study focused on six

countries in Southeast Asia: Cambodia, Indonesia, Laos, Myanmar, Thailand and Vietnam. Based on these criteria, papers were selected if at least one of the authors was affiliated with an organisation in one of the six countries. Searches were conducted in the Web of Science database by Thomson Reuters using the advanced search features and query strings with the keyword 'avian influenza', the six country names, and with search limits defined to retrieve articles published between 2004 and 2019, based on the chronology of the disease outbreaks in Southeast Asia and the time of data collection. All possible variants of country names were included (e.g., 'Laos' and 'Lao PDR', 'Vietnam' and 'Viet Nam'). No language limitations were applied, although all search terms were in English. Using this strategy, we cannot rule out the possibility that some non-English language papers of relevance were excluded from the analysis. However, we do not believe that such exclusions would have substantially impacted on the findings because English is the lingua franca of international scientific communications in Asia; and even non-English peer-reviewed articles will typically include an abstract and/or key words in English. Finally, no restrictions were applied in terms of study types and disciplinary area, although only research papers, letters and reviews were included in the study. Papers that were not focused primarily on avian influenza were discarded.

3.2 | Data extraction and processing

Data from the papers that met the inclusion criteria were extracted and imported into Microsoft Excel using a uniform data collection tool, including the following variables: (1) year of publication and title, (2) category, (3) geographic focus, (4) funding information, (5) affiliation(s) of the first author and (6) affiliation(s) of the other authors. Adopting widely accepted classifications of health research (Frenk, 1993), selected studies were categorised into four domains: basic research, clinical research, epidemiological research, health policy and/or implementation research. Funding information was also extracted from each paper. In line with the approach of Kelaher et al. (2017), funding patterns were classified into bilateral, multilateral, private/philanthropic and none if not specified or declared. In addition, a separate Excel spreadsheet was compiled with the attributes of every institution involved, including: type of organisation (i.e., government, research organisation, multilateral organisation, NGO, private sector, hospital and other), locality (whether the organisation is based in or outside Southeast Asia) and sector (i.e., human health, animal health, environment or other). When categorising the locality of organisations based in one of the six case countries, a further distinction was made between local organisations, overseas facilities of non-regional organisations, and country or regional offices of international organisations such as the WHO or FAO. In the 'overseas facilities' category, we included all research institutes, centres or other types of organisations based in one of the six case countries, but administered by, or linked with, parent organisations outside the region, typically in high-income countries. In some cases, the classification was ambiguous and was decided on a case-by-case basis, based on public information or personal communications. For example, the Pasteur Institute in Vietnam is fully nationalised, therefore it was classified as local organisation. By contrast, the Pasteur Institute in Cambodia is a Franco-Cambodian institution ran by both French and Cambodian staff, so it was classified as overseas facility. When categorising by sector, decisions were also made on a case-by-case basis. For example, centres or departments for communicable disease control were placed in the human health sector since this is the main mandate of these institutions, even though animal health specialists may work there. In case of ambiguities, the expertise of each individual author was checked.

3.3 | Data analysis

The dataset was explored using descriptive statistics and network analysis. First, we considered the institutional affiliation of all authors named in each paper, counting the unique co-occurrences of country pairs in the same paper. Based on this, we plotted a matrix with the total number of co-occurrences in all papers to provide absolute measures of regional cooperation (Lukkonen et al., 1993). This approach does not account for important variables such as

the country size; yet it is a useful method to explore centre–periphery dynamics and which countries are the most important collaborative partners to another country, as well as the ‘propensity’ of individual countries to engage in regional and non-regional collaborations. To cast a wide net in the search for intraregional cooperation, collaborations between researchers in these countries and other members that are part of the ASEAN were computed, thereby also including Brunei Darussalam, Malaysia, Philippines and Singapore. Second, we used social network analysis (SNA) techniques to explore structural patterns of collaboration and the role of ‘brokers’, that is, the actors who connect otherwise disconnected actors. In SNA, there are different methods to measure the connectedness or *centrality* of different nodes in a network and associated brokerage functions (Scott, 2006). In our study, we prioritised three different yet complementary measures: *degree*, *betweenness* and *Bonacich power*. *Degree* is simply the number of ties a node has. If a node has many ties, that node has a central position in the network. In this study, each organisation of affiliation was one node in the network. Thus, for example, if one author affiliated with Mahidol University in Thailand was named in a publication with co-authors from four other organisations, that would count as four ties for Mahidol University. *Betweenness* quantifies the number of times a node acts as a bridge along the shortest path between two other nodes. In other words, it is a method to measure the extent to which a node connects other nodes to each other. *Bonacich Power* is a more sophisticated measure of centrality, which also considers the extent to which all ties one actor has are well connected with other ties. The analysis of centrality was computed using the analytical tools in UCINET, while the network graphs were produced using Gephi.

4 | RESULTS

4.1 | Overview

In total, 815 papers were included after selection and screening for eligibility. Table 1 provides a breakdown of co-authorship patterns for the six case countries in the period 2004–2019. In keeping with the analytical approach by Boshoff (2010), the table makes a distinction between four types of papers: (1) single-authored papers; (2)

TABLE 1 Co-authorship patterns of research papers on avian influenza involving at least one author from Cambodia, Indonesia, Lao PDR, Myanmar, Thailand or Vietnam, 2004–2019

	Cambodia	Indonesia	Lao PDR	Myanmar	Thailand	Vietnam	Overall ^a
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	
Single-authored papers	-	5 (2.8%)	-	-	1 (0.3%)	1 (0.4%)	7 (0.9%)
Co-authored within own country only	4 (5.4%)	38 (20.9%)	2 (9.1%)	-	126 (32.8%)	11 (3.9%)	181 (22.2%)
Co-authored with other ASEAN countries only	3 (4.1%)	5 (2.8%)	1 (4.6%)	2 (28.6%)	10 (2.6%)	3 (1.1%)	14 (1.7%)
Co-authored with other ASEAN and non-ASEAN countries	18 (24.3%)	42 (23.1%)	8 (36.4%)	4 (57.1%)	72 (18.7%)	81 (28.6%)	97 (12.0%)
Co-authored with non-ASEAN countries only	49 (66.2%)	92 (50.6%)	11 (50%)	1 (14.3%)	176 (45.7%)	187 (66.1%)	516 (63.3%)
TOTAL	74 (100%)	182 (100%)	22 (100%)	7 (100%)	385 (100%)	283 (100%)	815 (100%)

^aOverall column summarises results for all unique publications ($N = 815$) included in the dataset. Values are not equal to the sum of counts across the six case countries, since some papers included co-authors from more than one of these countries. Abbreviation: ASEAN, Association of Southeast Asian Nations.

TABLE 2 Heat-map of international collaborations on avian influenza research for countries in Southeast Asia, indexed in the Web of Science, 2004–2019. The most frequent collaborators are listed on the vertical axis and ordered by volume of their total collaboration with countries in the region. Values in each cell display the number of papers for which there is co-authorship between the two countries. Darker colors indicate higher values.

USA	1	14	20	59	100	113
Japan	2	3	1	23	62	81
United Kingdom	1	4	11	17	40	45
China	2	5	22	16	39	56
Australia	1	3	11	49	19	26
France	-	2	26	5	28	34
Italy	2	2	1	10	28	15
Netherlands	-	-	-	19	11	15
Belgium	-	-	1	2	27	15
Singapore	-	-	9	7	8	12
South Korea	-	1	2	-	-	18
Switzerland	1	-	4	4	13	15
	Myanmar	Laos	Cambodia	Indonesia	Thailand	Vietnam

papers co-authored within own country only (with authors based in the same organisation or other organisations); (3) co-authored with other ASEAN countries only; (4) co-authored with other ASEAN and non-ASEAN countries; (5) co-authored with non-ASEAN countries only. As we can see in the table, the majority of papers across the six case countries (75.2% overall, and ranging from 64.4% for Thailand and up to 94.7% for Vietnam) included at least one co-author from a non-ASEAN country (Table 1). The United States was the most frequent research partner, followed by Japan, the United Kingdom and, notably, China (Table 2). By contrast, only a minority (13.6%) of papers included partners from two or more ASEAN countries, with relatively few papers (1.7%) exclusively co-authored by ASEAN country partners. Another clear pattern is that many more papers involving authors from local institutions in Thailand (385; 47.2%), Indonesia (182; 22.3%) and Vietnam (283; 34.7%) were published in comparison to those involving the other countries. In addition, Thailand and Indonesia were the only countries with a substantial share of papers produced by local authors only—33.1% and 22.7%, respectively.

4.2 | Intraregional collaborations

In our dataset, 83 (10.2%) of the papers featured intraregional collaborations between co-authors from at least two case countries (i.e., Cambodia, Indonesia, Laos, Myanmar, Thailand and Vietnam). The full list of intraregional papers is provided in [Supporting Information S1](#). Of those, 65 (78.3%) involved two of these countries, 14 (16.9%) involved three countries, and only four papers (4.8%) featured four or more countries. We can examine these patterns in more detail, using the co-occurrence of different countries in each publication. In [Figure 1](#) we can see there are strong connections between Thailand, Vietnam and Indonesia, reflecting their greater research output. Meanwhile, ties between the other three countries were relatively weak, reflecting the lower number of papers co-authored between these countries. There were no ties between Laos and Myanmar.

Furthermore, only 4 (4.8%) of these intraregional papers can be categorised as purely South–South collaborations, with no involvement of co-authors from UN agencies or research organisations associated with high-income countries. This small subset of papers includes two papers focused on disease epidemiology in Indonesia including authors from Thailand and Indonesia (Eyoer et al., 2011; Lestari et al., 2019), one paper on disease epidemiology in Myanmar involving authors from Myanmar and Thailand (Mon et al., 2012), and one paper on the efficacy of animal vaccination involving Thailand and Vietnam (Huyhn et al., 2019).

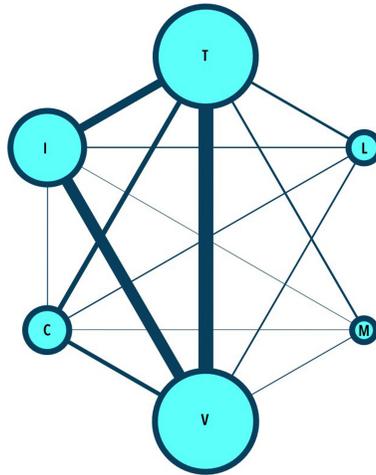


FIGURE 1 Intraregional collaboration on avian influenza research for countries in Southeast Asia, indexed in the Web of Science, 2004–2019. The size of the node represents the level of participation of each study country in the regional network (on the basis of its connections), while the width of the linking lines (the ‘edges’) reflects the number of collaborations between two countries. C=Cambodia; I=Indonesia; L=Laos; M=Myanmar; T=Thailand; V=Vietnam

Information on funding sources was available in 67 (80.7%) of the 83 intraregional papers. Most frequently, selected papers reported funding by non-regional actors, either through bilateral or multilateral channels. In line with co-authorship patterns, US agencies were the most cited sponsors of intraregional collaborations, with US funding sources acknowledged in 31 (46.2%) of the 67 papers for which funding information was available. This was followed by Japan (10; 14.9%), France (9; 13.4%), the United Kingdom (7; 10.4%) and other countries or categories including charities and multilateral organisations. Only a handful of papers reported funding from countries in the region: five papers acknowledged financial support from the Thai Research Council and/or Thai universities (Huynh et al., 2019; Lestari et al., 2019; Mon et al., 2012; Monteerarat et al., 2010; Win et al., 2014) and one paper benefitted from a scholarship by the Indonesia Endowment Fund for Education (Indrawan et al., 2018).

Lastly, intraregional collaborations occurred across different thematic areas, including epidemiology (29/83), basic research on disease biology (18/83), policy and/or programme implementation (17/83), clinical studies (16/83) and others such as reviews or studies of diagnostics (3/83). However, only 20/83 papers had a clear regional dimension, involving epidemiological studies or comparative policy analysis in more than one case country. In these papers, the regional scope is variably defined as the ‘Mekong’, ‘Southeast Asia’, ‘Asia’, ‘eastern Asia’ or ‘the Western Pacific’.

4.3 | Organisational networks

In our dataset 229 organisations were involved in intraregional collaborations on avian influenza research in Southeast Asia. Of those, the majority were research organisations (59%), followed by local government structures under the ministries of health and the ministries of agriculture (20.5%). However, even in this subset of intraregional collaborations, most co-authors (56.8%) were based outside the region, largely at universities in high-income countries. Table 3 shows the top-ranking organisations according to their degree (i.e., the number of ties in the network), with additional scores on their Bonacich power (the extent to which all ties one actor has are well connected with other ties) and betweenness (the extent to which a node connects other nodes to each other). Based on this table, we can highlight two patterns. First, despite the weight of non-regional organisations in the regional network, local organisations in the region retain a position of higher centrality. In particular, the Ministry of Agriculture and Rural Development (MARD) and the National Institute of Hygiene and Epidemiology (NIHE) in Vietnam had the highest degree,

TABLE 3 Centrality measures of organisations involved in intraregional collaborations on avian influenza research in Southeast Asia

	Degree	Bonachich power	Betweenness
Ministry of Agriculture and Rural Development, Vietnam	65	11753.369	4496.524
National Institute of Hygiene and Epidemiology, Vietnam	56	9007.858	3621.092
Centres for Disease Control and Prevention, US	55	10398.188	2450.67
Food and Agriculture Organization, Vietnam	52	8679.281	1702.387
National Institute of Veterinary Research, Vietnam	50	8453.301	2390.231
Oxford University Clinical Research Unit (OUCRU), HCMC, Vietnam	49	9217.383	2305.75
French Agricultural Research Centre for International Development	49	9745.916	1674.545
University of Hong Kong, Li Ka Shing Faculty of Medicine	48	10724.397	1882.892
FAO Regional Office Asia Pacific	46	6927.635	1374.662
Mahidol University, Faculty of Medicine, Bangkok, Thailand	41	6827.705	1814.761
Pasteur Institute, Phnom Penh, Cambodia	40	9079.937	929.536
Cambodia, Communicable Disease Control Department	38	8428.581	1229.811
Communicable Disease Policy Research Group, LSHTM	34	4688.791	1906.704
FAO Headquarters	34	4985.411	687.578
Université libre de Bruxelles	32	6265.386	363.293
Ministry of Public Health, Thailand	32	3895.582	1016.106
World Health Organization, Geneva	31	6911.298	413.489
National Institutes of Health, US	31	7665.087	530.999
Department of Livestock Development, Thailand	30	6450.612	536.363
Airlangga University, Tropical Diseases Center, Indonesia	30	4304.017	763.977

having contributed to multiple collaborations with different partners and in different projects. MARD was also a key regional broker, with the highest betweenness score in the network. The US Centres for Disease Control and Prevention (CDC) was another important actor in terms of degree, but a less central broker than the two organisations in Vietnam. In contrast, the University of Hong Kong has lower betweenness but occupies a highly strategic position, maintaining ties with the most connected nodes in the networks as indicated by the high Bonachich power score. The important brokering role of local organisations is also apparent in Figure 2a.

Second, collaborations involved different types of actors, but universities and other research organisations remained highly central within the observed network structure, as shown in Figure 2a. These include both local and international organisations as well as 'overseas' research facilities of organisations from or with strong links with high-income countries outside the region (Figure 2b). Relatively high betweenness for such institutions indicates that, if we removed them from the network, this would create critical gaps in the regional flow of data and information. Lastly, regional networking was dominated by organisations within the human health sector and, to a lesser extent, the animal sector (Figure 2c). In contrast, there was relatively little involvement of research organisations working on environmental health and ecosystems.

5 | DISCUSSION

This study mapped patterns of cross-border research collaborations in Southeast Asia through the systematic analysis of publications on avian influenza. The findings indicate that a substantial research output involving researchers and organisations in the region was generated in the period 2004–2019. However, wide disparities can be observed

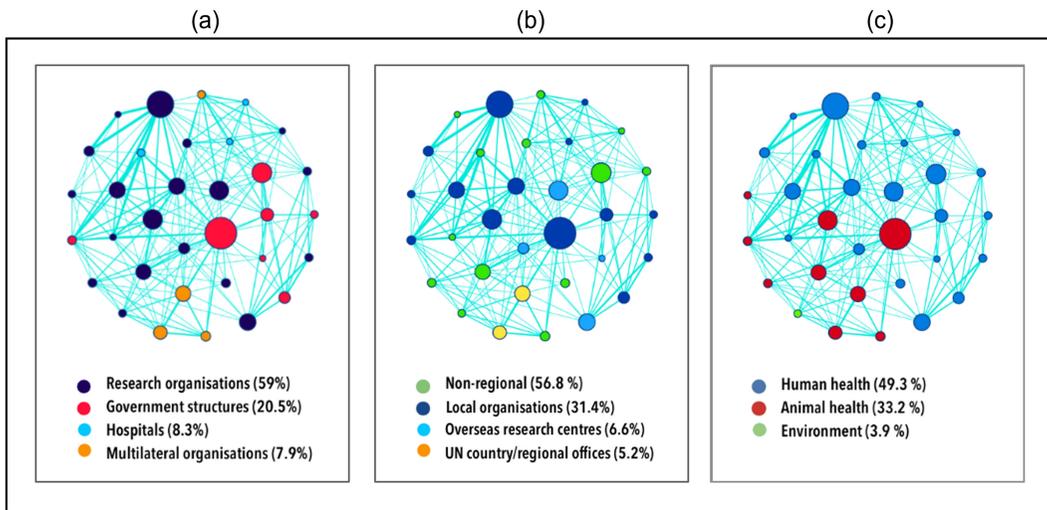


FIGURE 2 Betweenness centrality of organisations involved in intraregional collaborations on avian influenza research in Southeast Asia by (a) type of organisation, (b) locality and (c) sector, illustrated by node size. Only organisations with a degree >30 are included.

between the study countries. Thailand stands out as a regional leader in this knowledge domain, with a relatively large number of papers and a fair share of 'self-sufficient' contributions with no participation of authors affiliated with institutions in high-income countries. Researchers from Vietnam, Indonesia, and Cambodia were also involved in many publications, although their output was more frequently associated with international collaborations, as found in other bibliometric analyses (Goyet et al., 2015; Nguyen et al., 2017). By contrast, organisations in Myanmar and Laos were scarcely represented, despite multiple outbreaks of avian influenza in these countries. The regional research network closely reflects these patterns, revealing clustering and marginalisation.

Another key finding from this study is that South-South cooperation among neighbouring countries was largely driven by non-regional research organisations, sponsors, or overseas research centres based in Southeast Asia. As we have seen, only a fraction of intraregional papers were purely South-South, while the majority of papers can be described as triangular cooperation, involving UN agencies or research organisations associated with high-income countries as co-authors and funders. Some of these organisations, such as the Pasteur institutes, have worked in the region for a long time and continue to play a central role as brokers of intraregional cooperation (Bréchet, 2016). In some cases, they are partly or fully integrated into local structures and management. In others, they maintain strong connections with the parent organisation in high-income countries. The considerable involvement of research organisations in Japan and China must also be noted, although organisations from Western countries retained a central role in the network.

These findings have important implications for both regional policy and our understanding of the evolving landscape of international cooperation. First, the visible role of Japan, China, and other Asian countries in the regional research network questions established notions of 'North' and 'South' in discourses of global health and development. In particular, our study contributes further evidence that the current architecture of global health research is defined by a diversity of actors and organisations, and a decentralised geopolitical framework where the core and periphery are more difficult to discern than in the past, when US and European actors were predominant. This shift towards a 'polycentric' development landscape has been documented in previous studies and is not unique to Southeast Asia (e.g., Mawdsley, 2018). It is well recognised that a growing number of states have launched or expanded humanitarian programmes, technical cooperation and development finance, often in concert with diplomatic, trade and investment agendas. Together with other development actors such as private foundations, these so-called 'non-traditional' partners are reshaping the global landscape of international cooperation, challenging some

aspects of mainstream development philosophies (Mawdsley, 2018). In Asia, the role of Japan as aid provider is well established along with its distinctive approach, characterised by 'quiet and patient diplomacy' and the respect for social and cultural values in partner countries (MOFA, 2020; Trinidad, 2014). More recently, China and South Korea have also become key providers of foreign aid and technical support to other countries in Asia with an emphasis on nonconditionality of assistance, although questions remain whether they will bring truly alternative visions to the aid architecture (Cordell, 2021; Mawdsley et al., 2017). While these processes have been documented in international relations and development studies, their effects on research collaborations and the flow of data, information and expertise across borders have not been examined in depth. Our study provides a tentative map of these emerging connections based on the analysis of one publication domain, but these issues certainly deserve further scrutiny, also considering the need for timely regional response to public health crises in light to the COVID-19 pandemic. Of great importance are also the implications of the involvement of new actors for research practice and norms, including those around data sharing, intellectual property rights, and research ethics. In addition, research on other diseases of regional distribution such as research on malaria, dengue fever or Japanese encephalitis, would enable triangulation of the findings and might reveal differing patterns.

Second, there are issues of local ownership and stewardship. As we have seen, the regional research network involves a wide range of actors and organisations from high-income countries and, to a large extent, is dependent on their financial and technical support. The input of these organisations in HICs has been crucial to network formation and maintenance, contributing to capacity building, knowledge production, and the wide circulation of data, information, and expertise in and outside the region. Great reliance on non-regional actors, however, raises key questions about the sustainability of intraregional collaborations. In addition, there are no mechanisms in place to monitor and improve the inclusiveness of the network, other than the initiative of local or international research entrepreneurs. As a result, the risk of marginalisation is high, resulting in gaps in information flow and potentially hampering regional health security efforts.

Considering these challenges, we argue that institutional platforms for economic and political cooperation in Southeast Asia could become more involved in health research policy and funding, given their potential to bridge structural gaps in the research network and improve sustainability. In the past, ASEAN has played an important stewardship role in steering regional response to infectious diseases, including SARS and avian influenza (Curley & Thomas, 2004; Liverani et al., 2012; Thomas, 2006). Today, ASEAN continues to be involved in regional health affairs and public health initiatives (Greer et al., 2021). For example, the work programme of the ASEAN health cluster (2016–2020) included several activities for the prevention and control of infectious diseases as well as plans to develop a regional health research agenda (ASEAN, 2017). In addition, since the 1970s ASEAN has a Committee on Science and Technology (ASEAN COST), which was established to promote innovation, knowledge exchange and human resource development across member states. Currently, the ASEAN Plan of Action on Science, Technology and Innovation (2016–2025) supports student exchanges and university twinning programmes with top educational institutions in ASEAN countries (Scott-Kemmis et al., 2021). These initiatives are important steps towards the development of stronger links between academies and research organisations in the region. However, the strengthening of a regional research system would require more than this, including a mechanism of research funding at the regional level.

To achieve this, years of experience with the regional research system in the European Union (EU) can provide useful lessons. From the 1980s, the EU has made substantial investments to support cross-border research and development activities, becoming the largest research funder in the world (Abbott & Schiermeier, 2019). While the EU system has been criticised for being overly bureaucratic and not always fair to all member states, it provides a centralised mechanism with pooled research funds, which can be accessed by scientists and institutions in countries with weaker research systems. In addition, the European Commission has implemented several initiatives for capacity building, including partnerships between leading research institutions and those in less resourced countries, the secondment of top researchers at new member-state institutes, and training to improve the quality of grant proposals (Abbott & Schiermeier, 2019). In Southeast Asia, these initiatives would be particularly helpful, given wide gaps and

imbalances between countries with advanced and well-funded research systems (such as Singapore) and countries such as Laos and Myanmar, with no national budget for research. At the same time, similar to the EU, centres of research excellence and key brokers could be further supported with special grants to act as catalysts and promote the generation, sharing and uptake of research in the region. In this respect, it is also worth mentioning that the EU is actively involved in promoting research partnerships with organisations in Southeast Asia. Since 2017, the Southeast Asia-Europe Joint Funding Scheme for Research and Innovation (JFS) has been an innovative funding instrument under which national, regional and local funding agencies and ministries from Southeast Asia and Europe come together to support bi-regional research and innovation projects. Besides providing material support for research collaborations, this mechanism facilitates the sharing of experiences and policy transfer (SEA-EU, 2022).

That said, the establishment of a regional research area in Southeast Asia, locally owned and sustained, remains a major challenge. Most importantly, there is lack of funding. In the EU, the approved budget for the period 2021–2027 exceeds 1 trillion euros, representing more than 1% of the gross national income of the EU member states (EC, 2021). As such, it can support several major policies in research and other areas of regional integration such as agriculture, education, and health as well as economic and social cohesion, with specific funds earmarked for the poorer regions. In the field of research, the 2021–2022 budget for the Europe Horizon alone, the main EU research funding programme, was nearly 16 billion euros. By contrast, ASEAN has been chronically underfunded, with a small budget mainly used to support regional meetings and cover the administrative costs of the secretariat in Jakarta. In fact, most ASEAN activities are funded by individual member states through the ASEAN country offices. As a result of these constraints, the development and implementation of regional programmes and initiatives has been modest, even in key areas for regional cooperation. In April 2020, for example, ASEAN foreign ministers agreed to set up a COVID-19 ASEAN Response Fund to support member states in the detection, control and prevention of COVID-19 transmission (ASEAN, 2020). At the end of 2020, however, contributions to the fund had reached only US\$2.3 million. Similarly, the development of an ASEAN research area has never really been achieved for lack of financial resources, despite the long-standing ASEAN commitment to research and innovation (Dobrzanski & Bobowski, 2020).

In the future, opportunities might arise as a result of steady economic growth in ASEAN member states. There are also signs that wealthier countries are increasing their investments in research. While Singapore has long developed strong research capacities, other countries in the region are rapidly catching up, allocating increasing funds to support national research policy. In Thailand, for example, the volume of public investments in research has grown steadily over the past 10 years and the government has recently committed to reaching the 2% of GDP target by 2027 (Bangkok Post, 2022). As part of this process, Thailand and other resourced countries in the region may allocate more funds to promote research partnerships with neighbouring countries through bilateral or regional agreements. However, this process will likely take time, given the wide development gaps between countries in the region and the worsening effects of the COVID-19 pandemic on national economies.

6 | CONCLUSION

Avian influenza has been an important public health and economic concern in Southeast Asia, involving a large community of researchers and other stakeholders in joint transnational efforts to better understand and address this problem. As such, it provides a vantage point to examine current trends in SSC and their links with wider processes of global change. As discussed, one of the key questions in development studies has been whether these trends feature new connections and centres of power, or they are rather driven by established donors via triangular cooperation arrangements (Chandy & Kharas, 2011; McEwan & Mawdsley, 2012). Another important concern in the literature is about the effect of power hierarchies between Southern partners on the practice of SSC, potentially resulting in uneven participation and other inequities (Tarp & Cold-Ravnkilde, 2015).

Our study sheds some light on these issues, mapping 'who has collaborated with whom' (Morvaridi & Hughes, 2018) in a particular context of knowledge production and the key actors driving these partnerships. The

findings confirm the emergence of an increasingly diversified development landscape, characterised by new actors and multipolarity (Gürçan, 2019). In this landscape, local organisations in Southeast Asia have been able to position themselves strategically, acting as key brokers in far-reaching global networks of knowledge. However, our analysis identified wide disparities in the level of participation, reflecting imbalances in access to resources and national research systems. Furthermore, the engagement of local organisations in SSC has been fairly limited compared to their wider international outlook, and strongly associated with the participation of HICs. Thus, the case of avian influenza research further supports the thesis that 'traditional' development partners remain key drivers of SSC, through the politics of funding and their normative orientation towards international collaboration (Morvaridi & Hughes, 2018). While a great deal of support to SSC come from the South, questions remain about the extent to which this impetus has led to truly alternative cooperative modalities, as documented in other contexts (e.g., Diko & Sempijja, 2021). Considering these issues, we suggest that a stronger research policy at the regional level has the potential to enhance local ownership and create a more balanced research environment with multiple collaborative arrangements, and a larger number of South–South networks fully developed and sustained by local actors and resources.

Finally, our paper highlights the relevance and the utility of bibliometric analysis as a research approach to chart these trends and the underlying power dynamics, responding to recent calls for methodological innovation in studies of South–South cooperation (Mawdsley et al., 2019). In general, research networks provide a fruitful terrain to identify and explore structural patterns and drivers of SSC, given that scientific work does not take place in a vacuum but reflects wider issues of process and power in international relations. Some limitations should be noted, however. Bibliometric and network analyses are useful tools to draw relational maps in broad strokes but cannot explore in any depth the range of perspectives, interests, challenges and motivations of different categories of the actors involved. In the future, therefore, other methods could be used to develop a more nuanced understanding of these phenomena, including in-depth interviews with researchers and policy makers and other qualitative methods. The analysis of case studies in other knowledge domains and regions would also provide evidence for comparative analysis and triangulation.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the supporting information of this article.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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