The Health Care Professional Antibiotic Resistance Awareness Scale v1: report on development and testing

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Abbreviations

ABR – Antibiotic Resistance

ABU – Antibiotic Use

AMR – Antimicrobial Resistance

DIF – Differential Item Functioning

GAP – Global Action Plan

HCP – Healthcare Professional

ICC – Item Characteristic Curve

LMIC – Low- and Middle- Income Countries

NAP – National Action Plan

ODK – Open Data Kit

RMT – Rasch Measurement Theory

SD – Standard deviation

SEM – Standard error of measurement

WHO – World Health Organization

Glossary of terms

Conceptual model	Framework representing the conceptual definition of the construct to be measured.
Differential Item Functioning	The presence of bias in an item examined through the differences observed between the different levels of a person factor (e.g. disease type).
Item fit statistics	Tests of the degree to which observed item responses are consistent with the expected item responses predicted by a mathematical model – here the Rasch model.
Item locations	The position of items along a line (continuum) representing the construct of interest.
Person separation index (PSI)	A reliability statistic, comparable to Cronbach's alpha but computed from linear person measurements rather than raw summed scores. It quantifies the error associated with the measurements of people in this sample. Note: the PSI for any scale is sample dependent.
Psychometrics	Methods for constructing and evaluating measurement scales and measurement properties.
Rasch Measurement Theory analysis	A sophisticated psychometric technique for constructing and evaluating rating scales, and for analysing rating scale data. It tests the extent to which a scale is working as a measurement instrument, and if performing as such, enables linear measurements (with standard errors and fit statistics) to be constructed from the ordered category responses of rating scale items.
Reliability	The degree to which a measure is free from random error.
Targeting	Extent to which the theoretical range of the variable measured by the scale matches the actual range of that variable in the study sample.
Thresholds for item response options	Points of crossover between two adjacent response categories. The point on the continuum at which the probability of a person responding to two adjacent categories (e.g. 0 and 1) is equal (50%).

Executive Summary

As the threat of antimicrobial resistance (AMR) grows, multilateral bodies are mobilising support for national and global action. A cornerstone of action plans is to increase awareness of resistance. At present, little is known of the levels of awareness of resistance amongst different groups, including trained healthcare professionals (HCPs) who work in human or animal health. Understanding current levels of awareness is required for targeting interventions as well as for assessing change.

This project undertook to design a questionnaire tool to assess awareness of AMR amongst HCPs in different low- and middle-income countries. The content of the questionnaire was developed through two stages. First, the development of a conceptual framework of awareness of antibiotic resistance, involving qualitative research in a range of LMIC settings accompanied by a literature review of HCP awareness of resistance, resulting in a visual representation of the domains to capture in an awareness measurement tool. Second, the development of items within each domain of awareness, involving a review of existing tools to assess antibiotic resistance awareness, consultation with experts in human and animal health care and antibiotic resistance and intensive piloting and revisions in one setting – Uganda – with both human and animal HCPs.

In April to September 2018 a team of researchers from the London School of Hygiene & Tropical Medicine (LSHTM) carried out piloting in six LMICs of a questionnaire which aimed to assess awareness, practice and context of human and animal health care professionals. An 88-item questionnaire was completed online or on paper by a total of 1091 participants – 43 in Peru (human HCPs, in Spanish), 122 in Peru (animal HCPs, in Spanish), 112 in Nigeria (human HCPs, in English), 106 in Ghana (human HCPs, in English), 124 in Tanzania (human HCPs, in English) 40 in Tanzania (human HCPs, in KiSwahili), 253 in Vietnam (human HCPs, in Vietnamese), 183 in Vietnam (animal HCPs, in Vietnamese), and 43 in Thailand (animal HCPs, in Thai).

The awareness and awareness-in-practice sections of the questionnaire consisted of 49 items. The ability of these items to measure awareness on a scale was evaluated using modern psychometric analysis based on Rasch Measurement Theory. This analysis indicates the extent to which rigorous measurement is achieved by examining the difference (or 'fit') between the observed scores (persons' responses to items) and the expected values predicted from the data by the Rasch model. The analysis was carried out separately for the human HCP and the animal HCP questionnaires. Specifically, the data were examined for overall fit to the model, item fit validity, targeting, item dependency, reliability and item stability. Review of the results of these analyses underscored the importance of each item as contributing to the construct of ABR awareness, and a total of 26 items were removed from the instrument that would assess awareness. Items removed were mostly relating to the following domains: awareness that antibiotics are used to treat bacterial rather than other infections; having heard of antibiotic resistance; and the ways antibiotics are used in practice. Many were considered to be more resonant with practice or context than awareness of resistance itself. The Rasch analysis was then re-run on the remaining 23 items that now constitute the Health Care Professional (HCP) Antibiotic Resistance (ABR)

Awareness Scale v1 (Appendix 1). This Scale includes four domains: awareness of mechanisms of antibiotic resistance; the ways antibiotic use drives antibiotic resistance; the ways antibiotic resistant infections can be transmitted and controlled; and how antibiotic resistance can be recognised.

For the human HCPs, the 23 item HCP ABR Awareness Scale v1 was found to be most stable when restricted to English-language respondents. Within this sample (n=342 across Ghana, Nigeria and Tanzania) and the animal HCPs sample (n=348 across Peru, Vietnam and Thailand) we found the 23-item Scale to have high reliability (Pearson Separation Index 0.88 and 0.90, respectively), some problems with item fit validity, targeting and item dependency, and neither sets of data fitted the Rasch model. There was good stability across items by age and gender but several items with differential item functioning by country. The patterns in findings were similar between the human and animal questionnaires.

Overall, the 23-item HCP ABR Awareness Scale v1 performed sufficiently well to be used within certain parameters. Because not all items work well in the Scale across the different settings and languages, it is recommended that a further validation work is undertaken. It is also recommended that practice and context indicators are also collected, to capture antibiotic use as well as contextual factors that may explain levels of awareness.

Recommendations

The 23-item HCP ABR Awareness Scale v1 can be used at the group level for within-country analysis to assess ABR awareness among both human and animal health care professionals. The scale comprises items that assess awareness of mechanisms of antibiotic resistance; the ways antibiotic use drives antibiotic resistance; the ways antibiotic resistant infections can be transmitted and controlled; and how antibiotic resistance can be recognised.

To become a globally standardised scale that produces comparable data across settings and at the individual level, the HCP ABR Awareness Scale v1 would undergo further rounds of item testing in different scenarios. However, given that the nature of awareness of biomedical concepts is unlikely to be uniform across settings, even with comparable curricula, it may not be feasible to generate scores that retain exactly the same meaning across settings. Therefore, we recommend that the scores are used within rather than between countries, and at the group rather than individual levels. This v1 of the HCP ABR Awareness Scale can be used within certain parameters as listed below.

- The HCP ABR Awareness Scale v1 can be used in the following countries where it has been piloted: for the human health survey in Ghana, Nigeria and Tanzania; for the animal health survey in Vietnam, Thailand and Peru. The use of the tool in other countries and languages would require further validation.
- The wording of 23 items in the HCP ABR Awareness Scale v1 should remain unchanged when implementing this version of the questionnaire.

- The uptake of the questionnaire may be lower if only sent by email for online completion. Incentives to participate should be considered for each setting.
- Interpretation of the Scale should be at the group level rather than by individual.
- Comparison of scores between countries should be approached with caution as some items in v1 seem to be interpreted differently by country.
- The SPSS coding documents provided (Appendices 15 and 16) should be used to calculate the scores of users of the HCP ABR Awareness Scale v1 questionnaire.

In order to interpret the findings most fully, it is also recommended that two additional modules (HCP ABR Practices and HCP ABR Context) are included in questionnaires completed by health care professionals, to capture practice in relation to antibiotic use as well as contextual factors that may explain levels of awareness. It would be valuable to carry out further work to refine these questions and to test their relationships with the scoring data.

Introduction

Background

Antimicrobial resistance (AMR) constitutes a growing threat and global public health concern (1), the burden of which is most heavily felt across LMIC settings (2). Levels of awareness of the problem of AMR among HCPs are not well known or documented (3). Increasing awareness constitutes one of the core objectives of the World Health Organisation (WHO) Global Action Plan (GAP) on AMR (1), however, there is as of yet no standardised tool to measure awareness of AMR among the general population or among health care professionals who prescribe and dispense medicines such as antibiotics that contribute to the growing burden of antibiotic resistance (ABR).

In order to address this gap, the LSHTM Antimicrobial Resistance Centre, funded by the WHO and in collaboration with the OIE, developed, pre-tested and piloted a survey tool to assess awareness of ABR among human and animal health care professionals. The aim of the project was to produce a standardised survey tool and scoring system that could be used across settings to assess awareness of ABR among registered human and animal healthcare professionals.

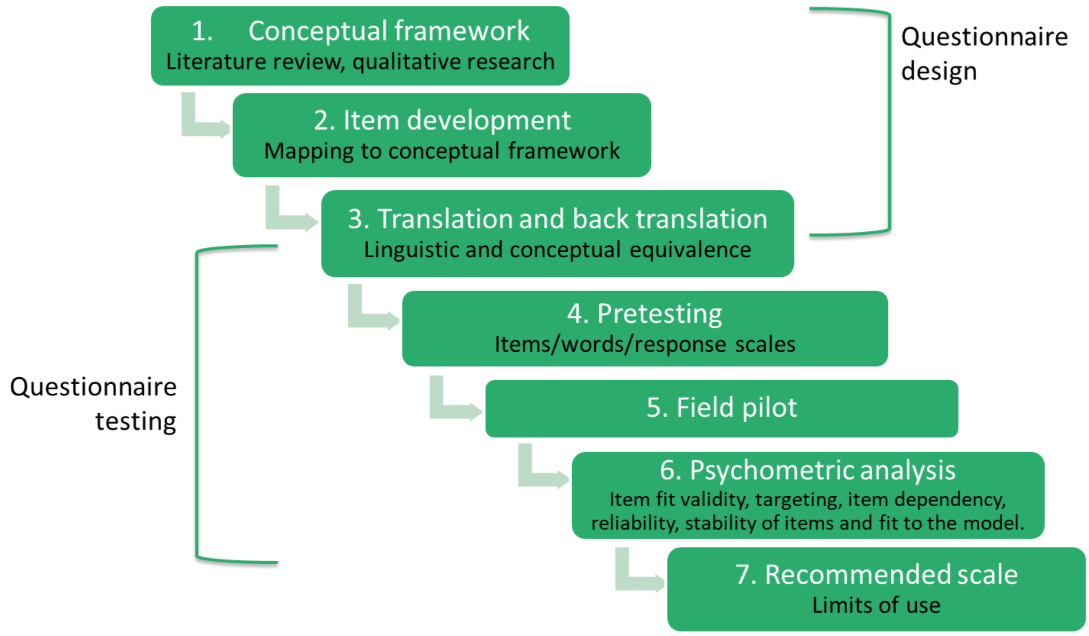
Objectives

- To develop a conceptual framework of antibiotic resistance awareness, practices and context amongst human and animal HCPs
- To develop a set of items that could serve as an instrument to assess awareness of antibiotic resistance, practices and context amongst human and animal HCPs
- To translate and pre-test items in different languages and contexts
- To pilot the pretested questionnaire with human and/or animal healthcare professionals across different settings and languages
- To analyse the pilot questionnaire data in order to produce recommendations on the use of the instrument to assess ABR awareness amongst human and animal HCPs

Approach

This project used qualitative methods and a review to design a questionnaire to measure HCP ABR awareness, ABR related practices and contextual factors, and quantitative psychometric methods to test the ability of the items constituting the ABR awareness scale to produce reliable and valid data. Figure 1 illustrates the steps in this process, which is described in more detail in the next sections.

Figure 1. Design and testing the HCP ABR Awareness Questionnaire



Questionnaire design

The content of the questionnaire was developed through two stages. First, the development of a conceptual framework of awareness of ABR, involving qualitative research in a range of LMIC settings accompanied by a literature review of HCP awareness of resistance, resulting in a visual representation of the domains to capture in an awareness measurement tool. Second, the development of items within each domain of awareness, involving a review of existing tools to assess antibiotic resistance awareness, consultation with experts in human and animal health care and antibiotic resistance and intensive piloting and revisions in one setting – Uganda – with both human and animal HCPs.

Initial Conceptual framework from Qualitative Research

Qualitative research

Research was undertaken in 2017 in nine study settings across six LMICs (Table 1) in order to explore and situate awareness of ABR among human and animal HCPs (4).

Table 1. Settings, sample population and sample size for 2017 study

Country	Region	Focus of Antibiotic use	Number of participants
Vietnam	Hanoi	Human	24
Nigeria	Abuja	Human and animal	24
India	West Bengal	Animal	8
	West Bengal	Human	19
	Chennai	Human	30

Philippines	Manila	Human	61
Ethiopia	Addis Ababa	Human	33
	Addis Ababa	Human	36
Sierra Leone	Freetown	Human	11

Methods included semi-structured interviews and rapid ethnographic observation were used. Data was analysed individually by country for site-specific themes and was later subject to secondary analysis by researchers at the LSHTM to identify key themes emerging across field sites. The findings were used to devise an initial conceptual framework for the awareness scale. Across the field sites awareness of AMR was high and was demonstrated through knowledge of key principles of AMR and through practices relating to ABR. Knowledge of key principles included having heard of AMR, knowing high level mechanisms of ABR, understanding ABU driving factors for AMR, and knowing antibiotics should be used to treat bacterial infections. Knowledge of ABR in practice included knowledge of ABR transmission, infection control, and detecting and recognising ABR. The qualitative research highlighted the relationship between contextual factors and AMR awareness and strongly indicated the inclusion of context-related questions in the survey to better situate findings. The findings of the qualitative research can be read here.

Literature review

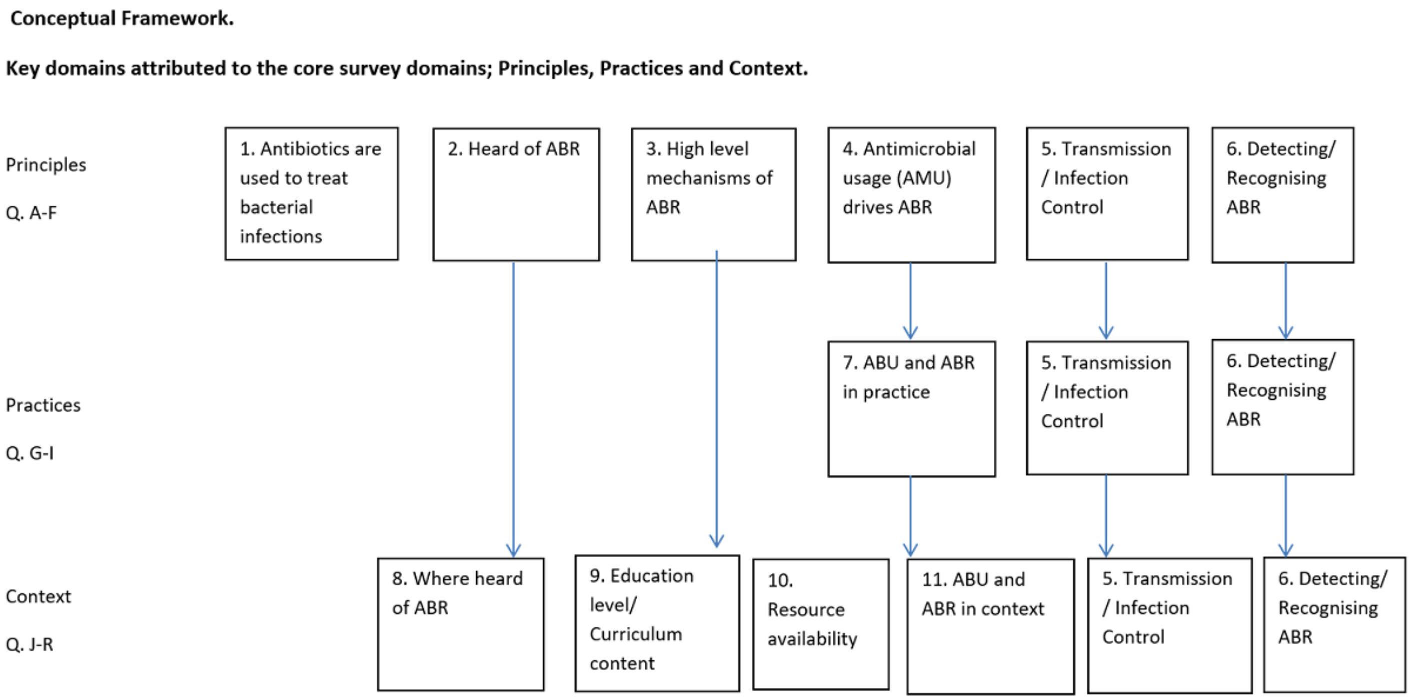
A literature review of HCP awareness of resistance in LMIC settings found studies documenting the relationship between HCPs and AMR. Many studies focused on the prescribing and dispensing of antibiotics among human HCPs assessed against best practice standards, with nonconforming practice such as prescribing and dispensing for self-limiting viral conditions, overprescribing and injudicious practice linked to rising rates of ABR (5-8). There was less empirical data available on prescribing and dispensing practices by animal HCPs although its contribution to the global burden of ABR is documented (9, 10). The available literature on animal HCPs reported practices such as large-scale prophylactic treatment of livestock animals as contributing to rising rates of ABR (11).

In the case of both human and animal HCPs, the review found less data that explicitly looked at HCP awareness of AMR. Literature on animal HCPs linked high usage of antimicrobials to a lack of awareness of AMR and the risks it poses to animal and human health (11, 12). LMIC based studies that focused on awareness of AMR among human HCPs found, in line with the qualitative work conducted for this project, high general awareness of AMR, including high awareness of driving factors of AMR or ABR (13-15). A systematic review of global qualitative research on antibiotic prescribing behaviour in hospitals found high general awareness of AMR among HCPs, but less awareness of the impact of prescribing practices such as using broad-spectrum antibiotics (16). Lack of access to local resistance patterns and lack of laboratory capacity alongside other contextual concerns such as patient mortality hindered the implementation of stewardship efforts such as minimizing use of antibiotics (15, 16). The literature review reiterates the relative dearth of information on how HCPs understand ABR (3), particularly animal HCPs.

Working conceptual framework

The qualitative research and literature review culminated in the first working conceptual framework. The conceptual framework encompassed Principles, Practices and Context, with high level domains of awareness being identified within each.

Figure 2. Conceptual framework



Item development

Tool review

Existing tools measuring awareness of AMR or ABR were identified using an online search. Relevant global health guidelines and policy documents were also analysed to identify key factors comprising ABR awareness. The content and format of tools were reviewed using an iterative process. The researcher interrogated the format, content, length, style and intended audience of each existing tool identifying cross-cutting themes and items as well any perceived gaps or assumptions. Tools and policy documents reviewed included:

- WHO Global interprofessional AMR competency framework for health workers' education and training available here
- WHO Mapping educational opportunities and resources for health-care workers to learn about AMR and Stewardship. Human Resources for Health Observer Series No. 21 available here
- The British Society of Chemotherapy's Massive Online Open Course (MOOC) on Antimicrobial Stewardship available here
- GP Omnibus 2017 – Survey on Antibiotic prescribing from GP's in the UK

- EU Insights: AMR and Antibiotics in Animal Farming and Human Health. Survey of Farmers/Veterinarians available here
- Essential Medicines and Health Technology Division of Health Systems World Health Organization Regional Office for the Western Pacific Wenjing Tao 2017 – Public Awareness Survey Draft; Australia
- Essential Medicines and Health Technology Division of Health Systems World Health Organization Regional Office for the Western Pacific Wenjing Tao 2017 – Survey of healthcare students' AMR awareness; China
- Online survey 2017 October – OM Antibiotics
- WHO Expert consultation meeting on health workforce education and AMR control 23/4 March 2017 Geneva available here
- Shrimp and Prawn Farms Questionnaire – Final Version 6th October 2017. Developed for Digital Network for Aquaculture
- WASHFIT core questions and indicators for monitoring WASH in health care facilities in the Sustainable Development Goals available here

Key policy documents stress the need for AMR awareness training as part of the medical curriculum and as part of continuing professional development (CPD). The WHO report on AMR education for HCPs encourages the implementation of Public Health England's five competencies; 1) Infection Prevention and Control (IPC), 2) AMR and antimicrobials, 3) Prescribing antimicrobials, 4) Antimicrobial Stewardship (AMS), 5) Monitoring and learning (17). The first three competencies were relevant to the conceptual framework.

To further develop individual items for the two separate human and animal HCP surveys, the findings of the qualitative field research and literature review were considered alongside an examination of existing awareness tools.

The tools reviewed included items that fitted with the conceptual framework section 'principles of ABR'. These included questions relating to high level mechanisms of resistance, drivers, detection, transmission of ABR and infection control. True/False questions regarding high level mechanisms of resistance and the types of infections antibiotics should be used for were common across the tools. The EU insights survey used True/False/Don't Know questions and Likert scale response schemes to obtain a wider picture of awareness, which encompassed items not limited to principles of ABR, but also fitting with the conceptual framework of practices and context such as questions regarding personal practice with antimicrobials and local sources of information on ABR. Most of the tools reviewed used a small number of free text boxes to capture longer answers on more complex questions.

Most of the tools were online or paper-based surveys. The online MOOC was interactive, requiring the participant to work through each section, watching a short video clip relating to AMR and to answer relevant quiz questions at the end. This interactive process provided the opportunity to learn, answer questions and to revise incorrect answers which could be an engaging way for an awareness survey tool to operate.

Gaps and assumptions

An ongoing limitation of existing awareness tools is their tendency to be written in English language and devised in Western settings. It may be difficult to use such tools across different country settings as their construct and content validity cannot be guaranteed. This is particularly true for multiple-choice answer formats, as answer choices may reflect the setting in which the survey was written.

Many of the tools included a ‘Don’t Know’ answer option. This may produce large gaps in the data collected, particularly where participants may use this answer box to evade questions they feel unwilling to answer. Given the intense focus on HCPs and their prescribing and dispensing behaviour, it is not unlikely that participants may claim they do not know in order to avoid scrutiny.

The review of existing tools provided a number of lessons for the development of the awareness scale survey. It helped shape individual survey items, particularly items that make up the scale score. It highlighted how different response choice options might condition answers and encouraged the research team to consider how different response choice options affect the type of analysis that can be performed. It also ensured researchers thought about the language the survey would be devised and delivered in and the potential biases that could result.

Initial draft stage

Insights from the 2017 study, literature review and analysis of policy documents and existing awareness tools were used to devise a first set of questionnaire items. Both drawing from, but also trying to push beyond the KAP model of existing tools reviewed, items were devised to fall within the overarching sections of 1) Principles of ABR 2) Practices relating to ABR 3) Contextual variables. Within each of these overarching sections of the conceptual framework, were the domains identified as key to awareness of AMR. Each of the domains was populated with multiple questionnaire items to ensure that all aspects of ABR awareness relevant to that domain would be suitably covered, for example; 1) Principles of ABR included domain 3) High level mechanisms of ABR. Within this domain individual items were developed to cover a basic biological understanding of what ABR is. This iterative process guided the development of individual items for all domains within the survey. The wording and answer format of the drafted questions drew heavily on the existing tools reviewed.

Expert consultation

Experts in ABR were consulted in order to validate the conceptual framework and survey items. Where possible experts were sent a digital copy of the survey in advance and later met with researchers from the LSHTM to discuss. Experts were asked to provide input on the content of items, their relevance to awareness of ABR, to indicate any items or aspects of awareness that might be missing and to highlight any terminology that might need changing.

Experts included medical doctors, veterinarians, pharmacists and a public health expert at Public Health England. Amendments were made to existing items and items were added following consultation. These amendments were communicated back to the experts consulted in order to validate the changes. All experts supported the conceptual framework.

Intensive revision stage

The two draft survey tools were taken for intensive testing and revision in Kampala, Uganda. A researcher from the LSHTM met with doctors, nurses, pharmacists, veterinarians and public health officials at the Ministry of Health in order to validate the survey tool. Informants supported the conceptual framework and the majority of items within the survey. Informants felt the language of certain items needed to be simplified for comprehension in the local context. The relevant questions were amended to ensure they could be clearly understood. It was also felt that the survey items focused on antibiotic prescribing and dispensing behaviour. As such it was decided that the tool should be designed specifically as an awareness of ABR measure as opposed to an awareness of AMR measure.

This process of research and consultation resulted in two final draft surveys, one for human HCPs and one for animal HCPs, ready to be tested in the field.

Questionnaire testing

Following the production of a final draft survey, an AMR Centre team undertook pre-testing and piloting of the survey tool in six LMIC settings.

Study sample

Fieldwork took place in six LMIC settings and covered either human HCPs only, animal HCPs only, or a combination of both human and animal HCPs.

Field site	Sample
Volta region, Ghana	Human
Abuja, Nigeria	Human
Lima, Peru	Human and Animal
Ho Chi Minh City, Vietnam	Human and Animal
Arusha, Tanzania	Human
Bangkok, Thailand	Animal

In order to maximise the validity of the awareness tool, countries were selected from across different geographical regions, including South America, Southeast Asia, East and West Africa. The total number and specific sites were determined by capacity of the team and partnerships with local host institutions.

Human and animal HCPs were recruited for both pre-testing and piloting using purposive sampling. Further participants were recruited using chain-referral or snowball sampling. A diverse sample was sought, with inclusion criteria set at all human and/or animal HCPs legally registered to prescribe and/or dispense antimicrobial medicines. A minimum of 8 participants were recruited to pre-test the survey tool in each setting, with researchers attempting proportionate representation of all human/animal HCPs legally registered to prescribe and/or dispense antimicrobial medicines. Researchers aimed for a sample of 100 participants for piloting. Due to time constraints, and potentially the use of online questionnaires only, the minimum sample size could not be reached for the Thai study cohort.

Field Site	**Number of respondents**	
	Human	**Animal**
Volta Region, Ghana	106	-
Abuja, Nigeria	112	-
Lima, Peru	43	122
Ho Chi Minh City, Vietnam	253	183
Arusha, Tanzania	164	-
Bangkok, Thailand	-	43
Total	**678**	**348**

Translation and pretesting

For three of the six field sites, surveys were pre-tested and piloted in the national language. In a further two field sites, the surveys were conducted in English, where English was considered the Lingua Franca. In the Tanzanian field site the survey was pre-tested and piloted in both Ki-Swahili and English, reflecting the common usage of both languages in everyday life, and a desire of participants to choose the language in which they responded to the survey. Researchers in the four settings using national languages hired a translator to forward and back translate the draft survey. Once the survey had been successfully translated, researchers identified key informants with whom to check the validity, coherence and relevance of each item within the survey tool. Following pre-testing, surveys were amended in order to reflect cultural variance, ensuring for purposes of later analysis that questions still had cross-country content validity.

Field site	**Language of survey**
Volta Region, Ghana	English
Abuja, Nigeria	English
Lima, Peru	Spanish
Ho Chi Minh City, Vietnam	Vietnamese
Arusha, Tanzania	English/Ki Swahili
Bangkok, Thailand	Thai

Piloting

In each country, a 49-item ABR awareness questionnaire was tested, with only minor edits between the items in the human / animal HCPs' questionnaires. An additional 39 items were included to assess practices and context of ABR.

The country specific survey tools were coded in Microsoft Excel and uploaded as individual surveys to the Open Data Kit (ODK) online survey platform by a researcher at the LSHTM. Piloting was done using paper and online versions of the two surveys. Researchers determined the best method of survey delivery during pre-testing based on interviews with informants about the feasibility of different modes of delivery.

The three African field sites and the Vietnamese field site used printed PDF paper-based versions of the ODK surveys only. Across these field sites participants were recruited by researchers and research assistants on the ground. Researchers approached a variety of human and animal healthcare facilities. Researchers distributed an information sheet explaining the purpose of the study, informed consent forms and surveys. Researchers collected completed surveys and entered the data into the online ODK platform.

The Peruvian and Thai field sites used online surveys only. Participants were recruited via email, completed the ODK survey themselves and submitted their answers electronically. Researchers identified potential participants through local institutions. For the Peruvian and Thai field sites, an invitation email to participate in the study was circulated between human and animal HCPs at hospitals, private clinics, professional bodies and post-graduate programmes. Second, a snowballing technique was used where emails were sent to potential participants identified by initial participants from their networks. Additionally, the Veterinary College of Surgeons in Peru agreed to send the invitation to all veterinarians registered in its medical body as did Mahidol University to its veterinarians in Bangkok.

Different incentive schemes were trialled across the field sites. Pre-testing participants in Peru received LSHTM merchandise. Participants who completed the survey were eligible to enter a prize draw for a medical text book. Pre-testing participants in Vietnam were reimbursed for their travel expenses and time. Participants who completed the survey were eligible to enter a prize draw for a book voucher. Pre-testing participants in Thailand received LSHTM merchandise. Pre-testing participants and survey participants in Ghana received LSHTM merchandise. Participants in the remaining two field sites were not offered incentives due to logistical constraints. The differing incentives, or lack of incentives may explain some of the variation in survey participation across the field sites.

Timeline

Fieldwork was carried out between May and September 2018 with researchers spending an average duration of five weeks in the field. In five of the six settings, researchers undertook both pre-testing and piloting of the tool. In the Thai field sites, the researcher undertook pre-testing only, with piloting conducted through partners at Mahidol University and OIE offices in Bangkok.

Ethics

Consent from participants for both pre-testing and piloting was obtained either in writing, or through a series of electronic consent tick boxes online. Paper-based surveys were accompanied by a written information sheet about the study and a written consent form to be signed by each participant. Online surveys began with a set of electronic consent tick boxes. Surveys were coded to prevent survey submission if any consent box was unchecked.

Ethical approval was granted from the LSHTM for each study site; Ghana 15167, Nigeria 15053, Peru 15258, Tanzania 15105, Thailand 15481, Vietnam 15255 and from local ethical committees; University of Health and Allied Science, Institute of Health Research, Research Ethics Committee Ho, Ghana: UHAS-REC A.8 [1] 17/18, the National Hospital Health Research Ethics Committee, Nigeria: NHA/EC/023/2018, the Institutional Ethics Committee of the Peruvian University Cayetano Heredia (UPCH, Peru) 102261, National Institute of Medical Research (NIMR) Tanzania: IX/2826, The Committee for Research Ethics (Social Sciences) Thailand MUSSIRB: 2017/197 (B2).

Implementation lessons

Issues arising from the pre-testing and piloting of the tool raise cautions and implementation advice for the future use of the tool.

While online surveys may be preferential for research teams in terms of time and human resources, pre-testing consultations revealed that paper-based surveys would be more suitable in many settings due to computer and internet constraints. Understanding the constraints of local contexts will be important for future use of the tool, especially in rural areas.

Survey uptake was much lower in settings where the survey was only available for distribution and completion online and where no primary researcher was on the ground. Where researchers distributed the survey on paper, and/or were able to follow up on the ground, uptake was higher. Therefore, mode of distribution and completion as well as human resources on the ground to help facilitate uptake must be considered in the case of future implementation.

Uptake was higher in study sites which offered incentives for participation. However, in order to protect participant confidentiality, prize draws had to be built as separate forms from the online survey. Both the benefits of incentivising participation and the practicalities of implementing incentives must be considered in the future use of the tool.

Finally, several respondents highlighted to our team that they would prefer to have a ‘don’t know’ option for questions. This was excluded from the tool because of the need in Likert scale measurement in psychometrics for a score to be based on numerics that indicate more or less alignment with a particular concept. A ‘don’t know’ option would be challenging to interpret in analysis and ultimately would not contribute data to a score. However, the desire of respondents to have this option indicates that either some items were insufficiently understood or there are some uncertainties in AMR awareness. This is an issue that could be explored further in subsequent implementation rounds of the survey.

Psychometric analysis

The performance of the ABR Awareness Questionnaire was evaluated using modern psychometric analysis based on Rasch Measurement Theory (RMT). RMT analysis indicates the extent to which rigorous measurement is achieved by examining the difference (or 'fit') between the observed scores (persons' responses to items) and the expected values predicted from the data by the Rasch model Georg Rasch (18). Two LSHTM psychometricians conducted two separate analyses of cross-country data: one for the human health care form of the questionnaire and the second for the animal health care form of the questionnaire. Specifically the analysis examined item fit validity, targeting, item dependency, reliability and item stability. See Appendix 5 for more background and details of the psychometric analysis methods.

The 49 items in the questionnaire were intended to create a single score representing the construct of "ABR awareness" and to be used across a range of different countries worldwide. Respondents rate each item on a 4-point Likert type scale *strongly agree/agree/disagree/strongly disagree*. Analyses were conducted first for individual countries and then on a combined sample across countries for human and animal health care forms separately. This report focuses on the combined country analyses as the aim was to develop a single scale that could be used across countries.

Results

Sample

Data were collected in 5 countries for the human health care form of the questionnaire: Ghana (English language, n=106); Tanzania (English language, n=124); Tanzania, Kiswahili language, n=40); Nigeria (English language, n=112); Peru (Spanish language, n=43); Vietnam (Vietnamese language, n=253). Data were collected from 3 countries for the animal health care form of the questionnaire: Peru (Spanish language, n=122); Vietnam (Vietnamese language, n=183); Thailand (Thai language, n=43).

Initial analyses were carried out per country, then based on the combined sample across countries for human (n=678) and animal health care forms (n=348) separately. Finally, the human health care analyses we restricted the sample to only those countries where the questionnaire was administered in English language (Ghana, Nigeria and Tanzania; n=342). This was because DIF by country had already been identified as a problem in the original analyses. Our intention was to reduce any differences in the analysis that were due to different language versions. In the animal health care form of the questionnaire the sample included all three countries (Peru, Vietnam and Thailand, N=348) as there was no common language across countries. As the intention was to develop a score that could be used internationally we then considered items that continued to show DIF by country as potential candidates for elimination, bearing in mind the inevitable trade-off with content validity.

Items

After completion of the first phase of analyses and discussion of the interpretation, the conceptual framework was revisited to identify those items that were most closely related to ABR awareness rather than other practice or context items. This resulted in the selection of 23 (out of 49) items which can be seen in Appendix 6 together with their location in the original conceptual framework. The original 49 items represented 7 domains whereas the sub-selection of 23 represent only 4 domains (High level mechanisms of ABR, antimicrobial usage (AMU) drives ABR, Transmission/infection control, Detecting/recognising ABR). Three domains are no longer represented (Antibiotics are used to treat bacterial infections, Heard of ABR and Abu and ABR in practice). Although there are some clear limitations in terms of content validity in using only this sub-selection of items, within the time and resource constraints available these items were considered as a possible best set to create a scale. This does not preclude the necessity of further work to improve the instrument.

Performance of Human HCP Scale v1

Overall the data from the human health care form of the questionnaire did not fit the Rasch model ($p<0.001$), based on 6 class intervals.

Item Fit Validity

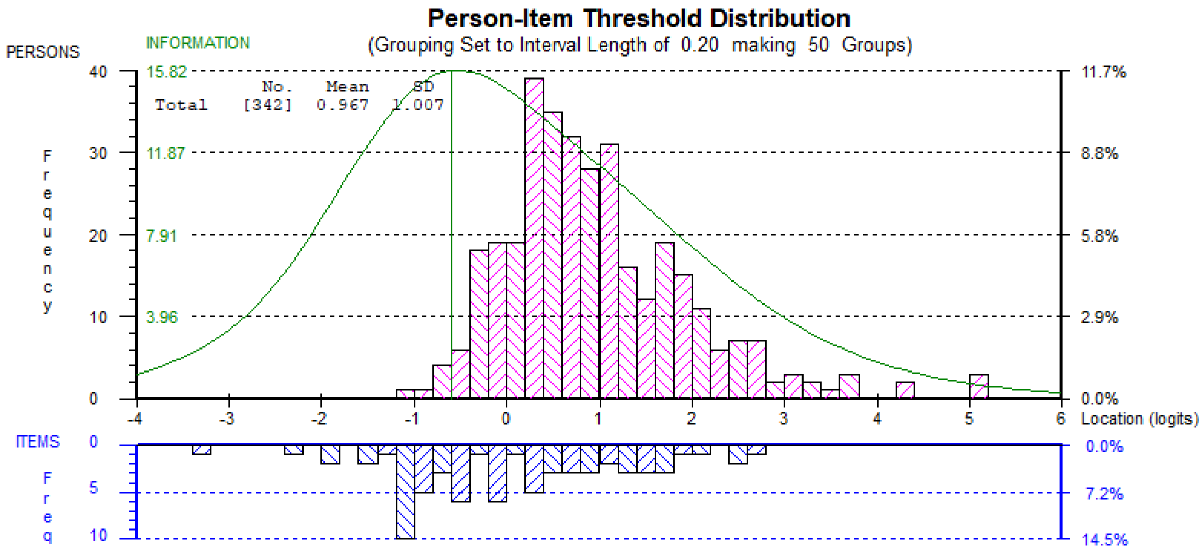
Two items had large fit residuals: D18 (2.694), and item G35 (3.783). No items had significant misfits (chi square). One item had marginal ICCs: G35. Item fit statistics are shown in Appendix 7, Table 7A. Considering the three indicators of possible item misfit (large fit residuals, significance of Chi Square statistics and visual inspection of the ICCs) together, no items appear to have problems with items fit to the Rasch model.

Seven items still had disordered thresholds (Appendix 7, Figure 7B). Examination of the category probability plots for these items (Appendix 7, Figures 7Ca to g) indicated that for these items response category “1” (representing “agree” or “disagree” depending on the question) was not clearly distinguished from its adjacent categories.

Targeting

The targeting of the ABR awareness scale (human health care form) is improved compared with the original analysis, but the targeting diagram (Figure 2) still indicates that there are a number of items that are too easy (i.e. the sample is more aware of ABR than the content of the items).

Figure 2 Targeting of human HCP scale (23 items)



Item dependency (Examination of residual correlations)

There are fifteen large (> .3) residual correlations (0.34-0.65). The pairs that have residual correlations >0.3 are shown in Appendix 7 Table 7D.

Reliability, Person Separation Index (PSI)

The reliability of the ABR awareness scale for animal HCPs was good. PSI was 0.88.

Stability of items (DIF)

No items showed DIF by gender or age of the respondent. Due to small group sizes we were not able to test for DIF by profession. Uniform DIF by country was evident for five items (C12, C13, D15, D18, E25).

Performance of Animal HCP Scale v1

Overall the data from the animal health care form of the questionnaire did not fit the Rasch model (p<0.001), based on 5 class intervals.

Item Fit Validity

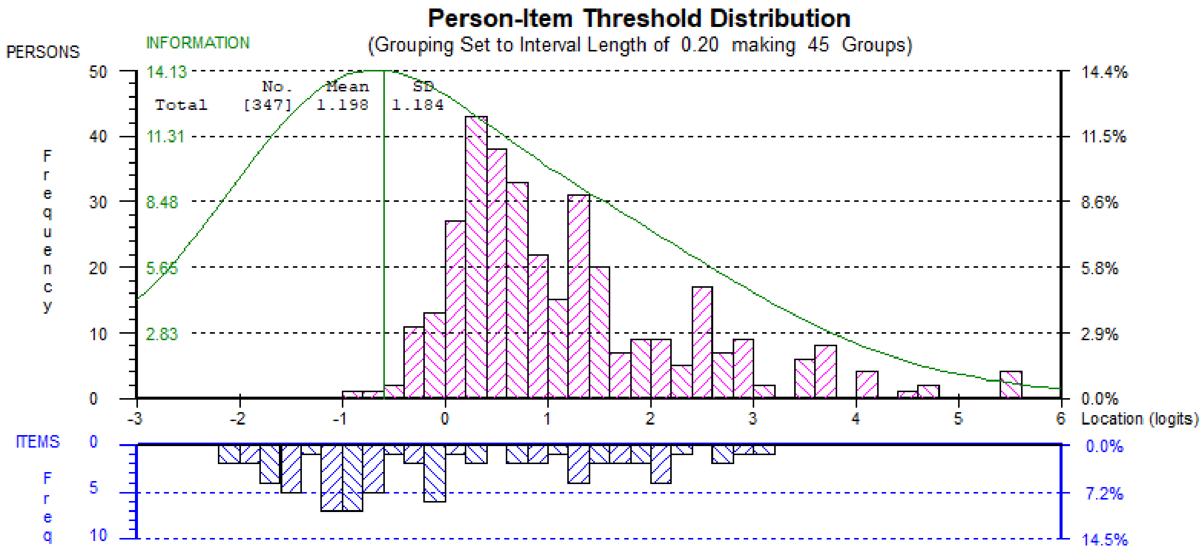
Three items had large fit residuals: D22 (6.690), item G35 (3.971), and item G37 (7.645). Three items had a significant misfit (ChiSq): item D22, E28, G37. Three items had marginal ICCs: D22, E28, and G37. Item fit statistics are shown in Appendix 8 Table 8A. Considering the three indicators of possible item misfit (large fit residuals, significance of Chi Square statistics and visual inspection of the ICCs) together, 2 items (D22 and G37) appear not to fit the Rasch model.

Five items had disordered thresholds: C10, C12, D15 D17, D20, E27, see Appendix 8 Figure 8B. As with the human HCPs data, examination of the category probability plots for these items indicated that response category “1” (representing “agree” or “disagree”) was not working as intended.

Targeting

The targeting of the ABR awareness scale (animal health care form) is not strong. The targeting diagram (Figure A6) indicates that there are still a number of items that are too easy (i.e. the sample is more aware of ABR than is reflected in the content of the items).

Figure 3 Targeting of animal HCP scale (23 items)



Item dependency (Examination of residual correlations)

Fourteen items showed large (> .3) residual correlations (range 0.30-0.63). Pairs of items showing response dependency are shown in Appendix 8 Table 8C.

Reliability, Person Separation Index (PSI)

The reliability of the ABR awareness scale for animal HCPs was good. PSI was 0.90.

Stability of items (DIF)

No items showed DIF by gender. One item showed non-uniform DIF by practice type (D18). One item showed uniform DIF by age of respondent (D14). Two items showed uniform DIF by profession of respondent: D22, E25. However, the n was very small in the category for "Veterinary drug seller". Uniform DIF was seen by country for 5 items (C10, D14, D22, E25, G37).

Interpretation

Awareness of ABR was measurable through a 23-item scale, the 'Health Care Professional (HCP) Antibiotic Resistance (ABR) Awareness Scale v1'. This Scale includes four domains: awareness of mechanisms of antibiotic resistance; the ways antibiotic use drives antibiotic resistance; the ways antibiotic resistant infections can be transmitted and controlled; and how antibiotic resistance can be recognised. A key challenge to implementation was uptake of the questionnaire. We found a lower uptake when the survey was sent online rather than delivered by person. In some settings, paper-based surveys were preferred due to computer and internet constraints. We also found people were more likely to respond when visited in person. Uptake was higher in study sites which offered incentives for participation, although how best to incentivise at scale would be a challenge.

For the human HCP respondents, the 23 item HCP ABR Awareness Scale v1 was found to be most stable when restricted to English-language respondents. Within this sample (n=342 across Ghana, Nigeria and Tanzania) and the animal HCPs sample (n=348 across Peru, Vietnam and Thailand) we found the 23-item Scale to have high reliability (Pearson Separation Index 0.88 and 0.90, respectively), some problems with item fit validity, targeting and item dependency, and neither sets of data fitted the Rasch model. There was good stability across items by age and gender but several items with differential item functioning by country. The patterns in findings were similar between the human and animal questionnaires.

Overall, the 23-item HCP ABR Awareness Scale v1 performed sufficiently well to be used within certain parameters. Because not all items work well in the Scale across the different settings and languages, it is recommended that a further round of validation work is undertaken. It is also recommended that two additional modules (HCP ABR Practices and HCP ABR Context) that formed the original wider questionnaire set of items are included in questionnaires completed by health care professionals, to capture practice in relation to antibiotic use as well as contextual factors that may explain levels of awareness.

Recommendations

The 23-item HCP ABR Awareness Scale v1 can be used at the group level for within-country analysis to assess ABR awareness among both human and animal health care professionals. The scale comprises items that assess awareness of mechanisms of antibiotic resistance; the ways antibiotic use drives antibiotic resistance; the ways antibiotic resistant infections can be transmitted and controlled; and how antibiotic resistance can be recognised.

To become a globally standardised scale that produces comparable data across settings and at the individual level, the HCP ABR Awareness Scale v1 would undergo further rounds of item testing in different scenarios. However, given that the nature of awareness of biomedical concepts is unlikely to be uniform across settings, even with comparable curricula, it may not be feasible to generate scores that retain exactly the same meaning across settings. Therefore, we recommend that the scores are used within rather than between countries, and at the group rather than individual levels. This v1 of the HCP ABR Awareness Scale can be used within certain parameters as listed below.

- The HCP ABR Awareness Scale v1 can be used in the following countries where it has been piloted: for the human health survey in Ghana, Nigeria and Tanzania; for the animal health survey in Vietnam, Thailand and Peru. The use of the tool in other countries and languages would require further validation.

- The wording of 23 items in the HCP ABR Awareness Scale v1 should remain unchanged when implementing this version of the questionnaire.
- The uptake of the questionnaire may be lower if only sent by email for online completion. Incentives to participate should be considered for each setting.
- Interpretation of the Scale should be at the group level rather than by individual.
- Comparison of scores between countries should be approached with caution as some items in v1 seem to be interpreted differently by country.
- The SPSS coding documents (Appendices 15 and 16) provided should be used to calculate the scores of users of the HCP ABR Awareness Scale v1 questionnaire.

In order to interpret the findings most fully, it is also recommended that two additional sets of information are collected – about practices and context. Practices may best be measured by means other than self-report, such as record reviews, direct observation or exit interviews. Context factors can be collected in a module within the questionnaire (such as the ABR Context module) as well as demographic variables, to capture relations between awareness and antibiotic use, contextual factors and individual backgrounds. It would be valuable to carry out further work to refine these questions and to test their relationships with the scoring data.

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Appendices

Appendix 1. 23-item Human and Animal HCP ABR Awareness Scales v1 in English

Appendix 2. Changes made to items during pre-testing in each country

Appendix 3. Complete survey with HCP Practices and HCP Context modules – Human

Appendix 4. Complete survey with HCP Practices and HCP Context modules – Animal

Appendix 5. Psychometric analysis methods

Appendix 6. Original 49 items vs the 23-item questionnaire

Appendix 7. RMT Human HCPs Analysis Tables and Figures

Appendix 8. RMT Animal HCPs Analysis Tables and Figures

Appendix 9. Human HCPs Survey Vietnamese

Appendix 10. Animal HCPs Survey Vietnamese

Appendix 11. Human HCPs Survey Kiswahili

Appendix 12. Human HCPs Survey Spanish Peru

Appendix 13. Animal HCPs Survey Spanish Peru

Appendix 14. Animal HCPs Survey Thai

Appendix 15. Scoring instructions for Human HCP ABR Awareness Scale v1

Appendix 16. Scoring instructions for Animal HCP ABR Awareness Scale v1