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Exploring challenges for infectious diseases diagnostics in human and veterinary medicine in 2023 in German speaking countries: A One-Health approach to Diagnostic Stewardship

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Abstract

Background

Diagnostic steps are often overlooked in antimicrobial stewardship programs, however, incorrect tests may lead to unnecessary treatments, increased costs, adverse health outcomes, and reduced antimicrobial drug efficacy. This One-Health-oriented study addresses interprofessional cooperation, knowledge and needs for improvement, thereby identifying problems along the diagnostic pathway and potential targets for diagnostic stewardship interventions.

Methods:

A web-based survey (166 items) among German-speaking healthcare workers in human and veterinary medicine was conducted using a snowball sampling approach. Data were analyzed descriptively and using t-tests and chi-squared tests. Specific questions to assess diagnostic knowledge were included, error rates for the different groups were computed. This paper presents analyses of the domains ‘interprofessional cooperation’, ‘knowledge level’ and ‘perceived need for improvement’.

Results:

Responses from 2,464 people were analysed. The 2,091 senders of microbiological samples comprised approximately 70% prescribers (physicians, veterinarians) and 30% allied healthcare workers, e.g. nurses. Around 50% of prescribers and 30% of allied health care workers (nurses, medical assistants, etc.) rated their diagnostics knowledge as good. Physicians had higher error rates than veterinarians when answering questions testing the knowledge level; medical assistants had higher error rates than physicians. Physicians reported delegating diagnostic-related tasks more often than veterinarians. Major reasons for not delegating were personnel unavailability and poor perceived reliability of allied health care

workers ($p<0.001$). Respondents indicated that they would appreciate additional information when requesting tests (cost, minimal sample volume, transport time, time-to-result) .

Conclusions:

Our data reveal knowledge gaps in all surveyed health care workers and a lack of available information in numerous domains at the time of testing, pointing towards possible targets for diagnostic stewardship interventions.

Keywords:

Infectious diseases, Diagnostics, Antimicrobial stewardship, Interdisciplinary collaboration, medical education

Background:

The diagnostic pathway for infectious diseases (ID) involves diverse professionals from various disciplines. These include physicians from different specialties, students, nurses, medical assistants and technical personnel, who may have different levels of awareness of the potential pitfalls (1). For example, ordering unnecessary microbiological tests and mistakes in the interactions between physicians and laboratories, may trigger unnecessary antimicrobial treatment (2,3). The potential consequences may include increased costs and adverse health outcomes, not to mention the predictable losses of antimicrobial drug efficacy, since antimicrobial misuse is considered to be mainly responsible for antimicrobial resistance (4–8).

Diagnostic stewardship (DS) improves diagnosis accuracy and reliability in ID testing. This includes appropriate testing, optimal sample handling and timely reporting of results. The goal of DS approaches is to improve patients' health outcomes, particularly through informing treatment decisions and averting antimicrobial misuse (1,9,10). While antimicrobial stewardship programs promote prudent use of antimicrobial drugs, the relevance of diagnostic steps in medical decision-making is often overlooked (11,12). Evidence on the potential contribution of DS approaches to guide antimicrobial prescription decisions is still scarce for human medicine, and virtually absent for veterinary medicine (2,3,13,14).

This paper provides insights into interprofessional cooperation, professional knowledge on diagnostics, and stated needs for improvement from a One-Health-oriented web-based survey. The success of diagnostic pathway for ID depends on the experience and training of each of the various professional groups involved. Previous studies focused separately on physicians or nurses (15–18), this study offers a broader perspective by including all involved professionals.

We surveyed human and veterinary healthcare workers (HCWs) and laboratory personnel, aiming to address the interrelations between human and veterinary health. The aim of this study was to identify possible pitfalls along the microbiological diagnostic pathway, and to explore targets for potential future interventions based on DS approaches.

Methods

Study design:

The study was designed as an open online survey (Lime Survey, version 5.6.38). A multidisciplinary panel from clinic and laboratory with different specializations developed a questionnaire to explore participants' knowledge, practices and perceived needs for improvements regarding ID diagnostic procedures. The survey addressed senders and recipients of samples as two main groups and contained 166 multiple-choice/ -selection and open-ended items in 24 domains. Senders of samples included physicians, veterinarians and allied HCWs as nurses, medical assistants and physician assistants. Recipients of samples comprised laboratory staff. All participants were asked questions about demographics and professional background, questions relevant to respondents with specific professional backgrounds were only shown to the respective groups. Questions regarding correct microbiological sampling in cases of suspected urinary tract infections were used as a proxy for the knowledge level of HCWs (see Additional file 1).

Data collection:

Data were collected between 7 October 2022 and 14 July 2023 using a convenient sampling strategy. The online survey was hosted on the website of the German "Network Young Infection

Medicine" (jUNITE). The survey was distributed using a snowball sampling method through affiliated societies, medical journals, medical/nursing chambers, social media, newsletters, and networks. We conducted regular recruitment analyses and intensified the advertising campaign in underrepresented professional groups if deemed necessary.

Data analysis and statistics:

Both complete and incomplete cases were eligible for analysis, as long as all socio-demographic and professional background questions were answered. Data cleaning and consistency checks were performed from the multidisciplinary panel. Results were summarised as the frequencies of responses for each question or as medians with interquartile ranges. The denominator for relative frequencies was the number of respondents who replied to the respective question to account for the tolerated item-non-response. Due to the multiple-selection character of the questions used to assess the knowledge levels, error rates were used in those analyses. Both non-selected correct answers and selected incorrect answers were counted as errors, the denominator was the maximum possible number of errors.

Statistical associations between categorial variables were tested using Pearson's chi-squared test, mean differences in continuous variables were tested using t-tests. Two-sided p-values <0.05 were considered to be statistically significant. Microsoft Excel (version 2019) and STATA (StataCorp LP, College Station, TX, USA, version 15) were used for data cleaning and analyses.

Results

Out of the 3,445 participants, 2,464 (71.5%) respondents were included in the analysis. Among them, 2,282 (92.6%) worked in Germany. About two-thirds were female and median work experience was over ten years (Table 1, attached below).

Over 70% of the respondents (n=1,489) belonged to occupational groups permitted to prescribe medication (n=1,095 physicians, n=394 veterinarians). Most questionnaires (n=2,091, 84.9%) were answered by senders. The following analyses focus on this group.

Interprofessional cooperation on the diagnostic path

Physicians and veterinarians were asked whether they performed microbiological test activities themselves, e.g. choosing adequate material, sampling, and sending or delegating to allied HCWs. Possible answers were: “always do it myself”, “always delegate”, and “sometimes delegate, sometimes do it myself”. Approximately a quarter of the respondents (24.6%, n=330) stated that they always delegate diagnostic testing, 33% of respondents stated that they never delegate, and most of the respondents (approximately 43%) delegate sometimes. Physicians stated more often that they delegate than veterinarians ($p<0.001$), and older respondents were more likely to report delegating ($p<0.001$). Male respondents stated more often either to delegate or to make a request themselves, whereas female respondents stated more often to do both ($p=0.007$). Professionals who stated that they delegate (72.2%) also expected the allied HCWs to enter the clinical information on the test request forms. In contrast, 66.4% of those who never delegated enter the clinical information form themselves ($p<0.001$).

Asked about the reasons against delegating, 42.2% of those who never delegated stated this was a formal requirement from their employer. Of those who delegate occasionally, 41.3% (n=232) considered delegating to be unreliable ($p<0.001$). In response to an additional open-ended question, over 50% of physicians stated personnel shortage and poor reliability as reasons not to

delegate diagnostic-related activities. Over half of the veterinarians stated that they had no assistants available, making delegating impossible.

Respondents' subjective estimates of the daily time spent for microbiological sampling differed between groups. Veterinarians stated to spent significantly more time on diagnostic testing than physicians ($p=0.003$). Allied HCWs in human medicine reported spending, on average, 26 minutes more per day on microbiological diagnostic tasks than physicians ($p<0.001$). There was no difference in perceived time spent on diagnostics between physicians who delegate and those who do not ($p=0.971$).

Diagnostic knowledge

Over 45% of physicians and over 50% of veterinarians, but less than 30% of the allied HCWs, assessed their microbiological diagnostics knowledge as good when asked for their self-rated skill level (Fig 1).

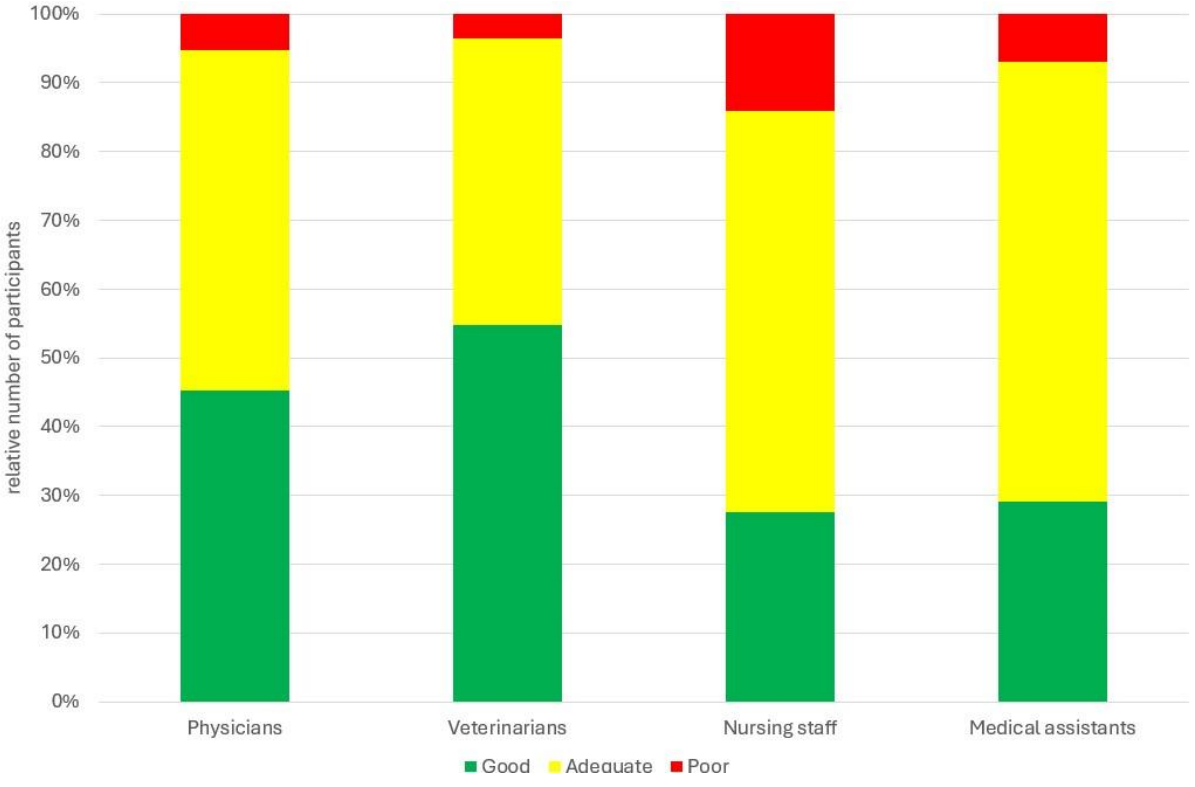


Figure 1: Self-assessment of diagnostics in various professional groups categorised as good, adequate, poor.

Physicians who always delegate exhibited higher error rates in the questions aiming to assess practical knowledge than those who never delegate ($p<0.001$). Veterinarians exhibited lower error rates than physicians overall and when comparing subgroups by delegation behavior ($p<0.001$, Fig 2). We observed no significant difference between physicians and allied HCWs in human medicine. However, within the group of allied HCWs, we observed a high degree of variability in error rates related to their professional group. Medical assistants, who receive the shortest training in our study population, had significantly higher error rates than physicians ($p<0.001$).

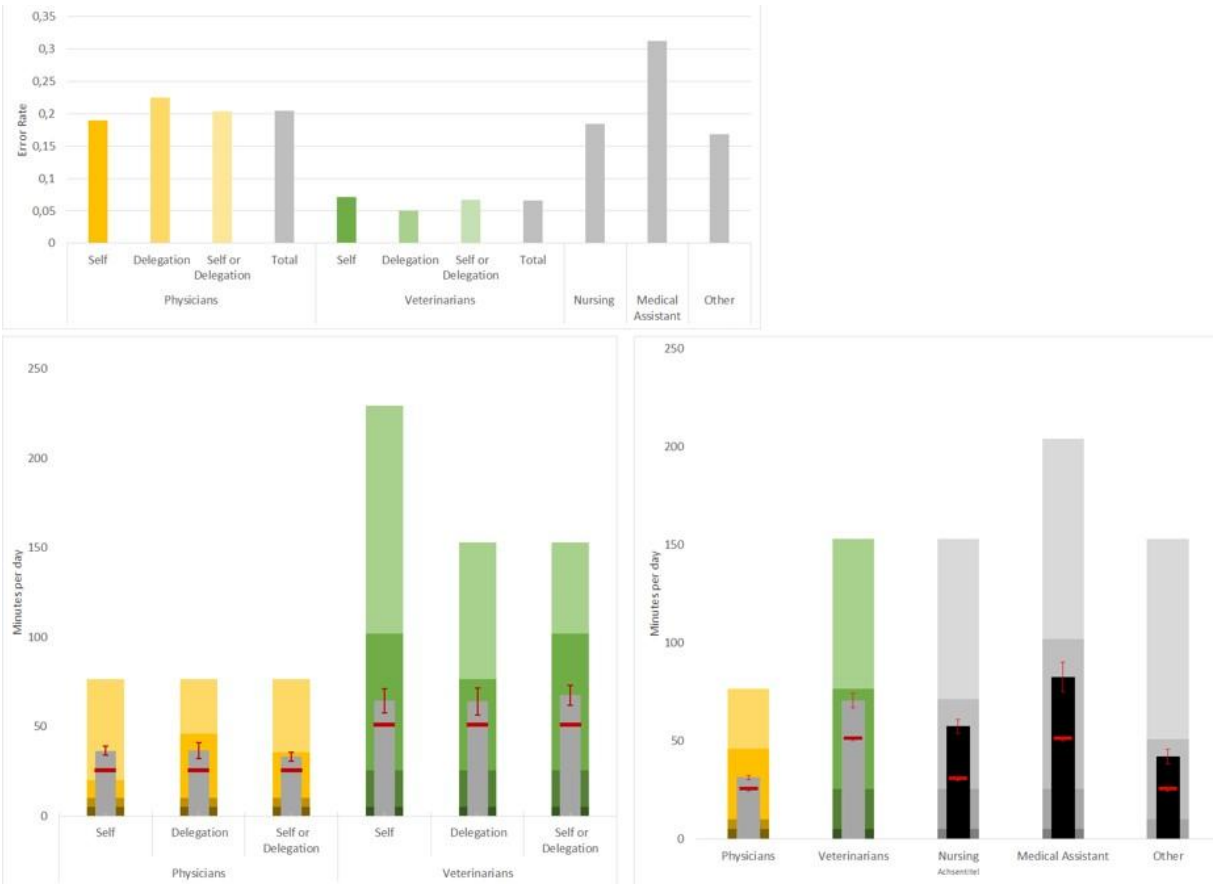


Figure 2: Illustration of the error rate in answering the question on microbiological urine diagnostics in the group of physicians and veterinarians and their behaviour in setting up or performing the test (self, delegation, both) (top panel). Average time in minutes per day for preparation of microbiological diagnostic requests in depending on delegation behaviour between physicians and veterinarians (bottom left panel) or in depending on the occupational groups (bottom right panel). Red bar: 50. quartiles, 5th-95th quartiles in shades of yellow/green, grey, grey/black bar: mean, SE= standard deviation of the mean

Available information when requesting diagnostic tests

Almost no respondent reported having access to information about time-to-analysis, time-to-result, and special diagnostic testing at the time of test requesting. Almost no physician was aware of the test costs and minimum sample volumes required, while most veterinarians had access to this information (Fig 3).

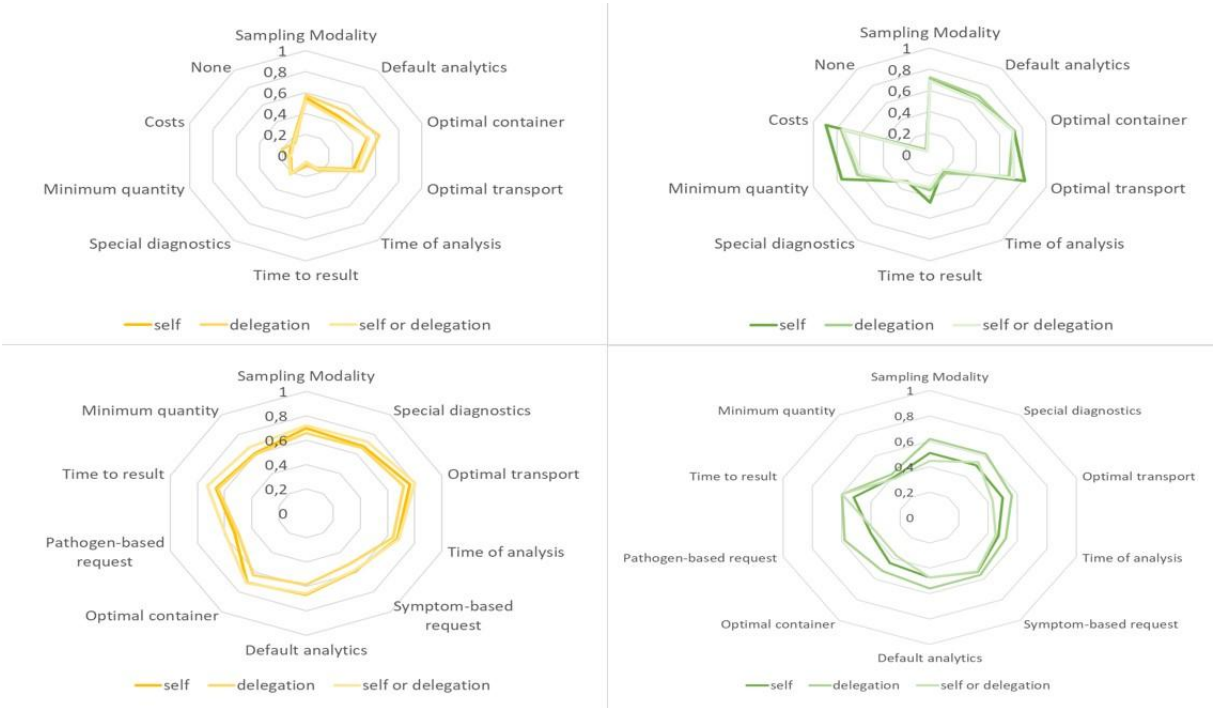


Figure 3: Information available at the time of sampling (top panels), information requested at the time of sampling (bottom panels), categorised by own performance, delegation, or both in the group's physicians (left panels) or veterinarians (right panels).

Approximately half of the physicians and 75% of veterinarians reported availability of information on appropriate sampling methods for respective material (e.g. urine), suitable containers for the respective diagnostics, and optimal transport (e.g. refrigerated) (Fig 3). Most veterinarians but almost no human medicine HCWs having information on costs and minimum quantities required, virtually no-one reported having information on time-of-analysis in the laboratory or receiving hints towards special diagnostics. Physicians and veterinarians expressed interest in receiving information on all these domains at the time of test ordering, but more veterinarians stated an interest in pathogen-based test requesting. The patterns were similar across different delegation behaviors.

Discussion:

This paper explored interprofessional cooperation, knowledge, and potential needs for improvement along the diagnostic pathway for ID among physicians, veterinarians and allied HCWs. The One-Health-oriented online survey provided a broader perspective on practices and attitudes in the different groups, as well as on potential needs for interventions based on DS approaches. To our knowledge, this is the first study in the field of ID and DS that brings together physicians, veterinarians and allied HCWs to gain insights into interprofessional collaboration and the distribution of knowledge and experience.

Physicians delegate diagnostics-related tasks to allied HCWs depending on local regulations and confidence in their colleagues' skills, where trends in delegation behavior correlate with higher age and lower levels of knowledge. This may be disadvantageous: First, the group of medical assistants among the allied HCWs exhibited higher error rates than physicians, which may point towards a higher risk of obtaining flawed samples when delegating. Second, those who always delegate forgo a daily hands-on practice. Our results suggest, however, that there is no perceived time-saving advantage for physicians who delegate compared to those who do not. Time-saving and cost-containment may be unlikely to offset potential adverse effects of delegating.

Veterinarians showed lower error rates in answers assessing their practical knowledge in comparison to the other groups, which may partly be explained by their longer professional experience. A second potential explanation might be that only one scientific society is responsible for issuing guidelines in the studied countries. In contrast, physicians often face different guidelines from multiple associations for the same disease. Probably more importantly, stringent regulations may have increased veterinarians' awareness of the importance of targeted and well-justified diagnostics. European regulations strictly constrain the use of antibiotics in animals to contain the propagation of antimicrobial resistances. Antibiotics may only be used for specific indications based on clinical assessment and antibiograms, and veterinarians are obliged to document and report their use of antibiotics (19). More than 50% of antibiotics in veterinary medicine were reduced between 2011 and 2021 after introduction of these rules (20).

In addition to new regulations, most animal owners bear the costs of diagnostics and treatment, whereas the costs in human medicine are mostly covered by health insurance. Financial considerations and the need to justify diagnostic procedures may therefore be higher for veterinarians than for physicians. This may incentivize more cautious choices of diagnostic procedures

compared to the broader sampling algorithms used in human medicine. The finding that approximately 90% of veterinarians stated knowing the costs of diagnostics at the time of requesting, whereas almost no physician was aware of test costs, supports this interpretation. Finally, many veterinarians explained not delegating with not having assistants, which may require veterinarians more than physicians to remain familiar with the correct techniques.

Diagnostic practices vary locally, making comparisons of studies across different regions or different professional groups challenging. Nonetheless, available literature identified significant knowledge gaps regarding microbiological diagnostics among physicians and nursing staff (17,18,21). For example, an international survey showed that nurses with previous antimicrobial and DS training had significantly higher capability and motivation to perform stewardship (16). Furthermore, about 70% of Dutch physicians expressed interest in guidance for appropriate microbiological testing, which may suggest a high level of awareness of the importance of correct diagnostics (15).

The literature on teaching practices regarding antimicrobial or DS at undergraduate and postgraduate medical education levels is still scarce, with heterogeneous results, and rarely addresses DS (22). Although allied HCWs comprise heterogeneous professional groups with different training levels, interprofessional education is often not part of current training concepts for healthcare professionals (23). Stewardship principles are rarely included in the training of allied HCWs despite their essential role at the bedside (24,25). Antibiotic stewardship programs almost exclusively target physicians and pharmacists in German-speaking countries, with DS often being overlooked. Involving allied HCWs in stewardship efforts and providing interprofessional education may be fundamental to improve the quality and safety of healthcare. Research and development in ID diagnostics focused mainly on molecular techniques and rapid

antigen tests to determine antibacterial resistance or susceptibility from primary samples or point-of-care tests in recent years (26–28). Future implementations of such tests should be complemented by adequate training for all professional groups along the diagnostic pathway to ensure a purposeful, safe and appropriate use of these new technologies.

We used a broad advertising strategy with a convenient sampling method to recruit participants with varying professional backgrounds, knowledge levels and awareness of the importance of DS. Consequently, the risk of bias cannot be ruled out, as it is possible that professionals who were already interested in diagnostics were more likely to respond. Even if this is the case, this study reveals noteworthy knowledge gaps even among this group with potentially higher interested than average and high confidence in their own knowledge. However, since analyses of response rates and non-responders are not feasible in this study design, the direction and extent of this bias has to remain subject to speculation. Furthermore, we faced difficulties in recruiting allied HCWs. This may reflect a limited interprofessional communication and awareness of the topic. Finally, questions about specialization and work place were not included. We were therefore not able to identify the type or ownership of healthcare providers in which our surveyed population works in. Group comparisons must therefore be interpreted with some caution, as size and organizational structures may vary considerably across institutions. Further research is needed to identify the role of ownership, size and organizational structure of healthcare providing institutions in the arrangements of diagnostic procedures, responsibilities and stewardship approaches.

Conclusions

We identified knowledge gaps and opportunities for improvement across all interviewed professional groups. Ordering, performing, and interpreting diagnostic tests are complex and error-

prone tasks in daily healthcare routines, where all involved professionals share the responsibility for the accuracy of diagnostic tests. All professional groups should therefore receive sufficient training in DS, which should focus on the interdisciplinary nature of medicine, and ID in particular. Policymakers should promote the development of effective DS approaches to upskill all involved professional groups, and to improve the accuracy of ID diagnostics procedures. These approaches should aim to reinforce collaboration and communication between all groups of HCWs, sensitize for the different levels of knowledge among different professional groups, and particularly address capacity building among allied HCWs with the lowest level of training.

Abbreviations:

ID Infectious Diseases

DS Diagnostic Stewardship

HCW Healthcare worker

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki.

A statement on data protection and confidentiality was included in the introduction to the survey, with the information that scientific analysis and publication were planned. Each participant signed a data protection declaration in accordance with the data protection declaration currently in force. The informed consent to participate was obtained from all of the participants in the study. Data were not included in the study if a declaration was not available.

Ethics approval was obtained from the University of Leipzig, Germany (No. 2022.07.20_eb_vv_3).

Consent for publication

Not applicable

Data Availability

All data is available and can be requested as a Stata dataset from the authors.

Competing interests

The authors declare no conflicts of interest relevant to this manuscript to disclose.

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Authors contributions:

SS, AS, VS, OJ, JB, TW, DK, NT and SK created the concept, AC, AAW, and AS programmed the software tool and edited the questionnaire. SS, AS, AAW, VS, OJ, JB, TW, AC; JP, KH, DK, NT and SK carried out the data acquisition. SS, AS, and OJ managed the project. MS, AS, JB, VS, SS and OJ performed the data validation and formal analysis. OJ, SS, AS, and MS wrote the first draft of the manuscript, and all authors contributed to the final version of the article. All authors were involved in validation, data acquisition and investigation.

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453 **Table 1:** Demographics of participants

	human medicine		veterinary medicine		total	
	n	%	n	%	n	%
occupational group						
physician	1,095	65.3	0	0.0	1,095	52.4
veterinarian	0	0.0	394	95.4	394	18.8
nurse	376	22.4	0	0.0	376	18.0
medical assistant	81	4.8	5	1.2	86	4.1
others	126	7.5	14	3.4	140	6.7
occupational status						
full-time	1,185	70.6	318	77.0	1,503	71.9
part-time	373	22.2	87	21.1	460	22.0
side job	120	7.2	8	1.9	128	6.1
work experience						
less than 2 years	230	13.7	14	3.4	244	11.7
2 - 3 years	88	5.2	25	6.1	113	5.4
4 - 5 years	248	14.8	20	4.8	268	12.8
6 - 10 years	286	17.0	48	11.6	334	16.0
over 10 years	826	49.2	306	74.1	1,132	54.1
age group						
18-25	107	6.4	3	0.7	110	5.3
26-35	661	39.4	77	18.6	738	35.3
36-45	432	25.7	90	21.8	522	25.0
46-55	261	15.6	112	27.1	373	17.8
56-65	189	11.3	106	25.7	295	14.1
>65	28	1.7	25	6.1	53	2.5
gender						
diverse	10	0.6	0	0.0	10	0.5
male	687	40.9	120	29.1	807	38.6
female	981	58.5	293	70.9	1,274	60.9
Total	1,678	100	413	100	2,091	100

454

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplement.docx
- DiagnosticStewardshipFigures.xlsx