Telehealth as a Component of One Health: a Position Paper

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Summary

Introduction: One Health (OH) refers to the integration of human, animal, and ecosystem health within one framework in the context of zoonoses, antimicrobial resistance and stewardship, and food security. Telehealth refers to distance delivery of healthcare. A systems approach is central to both One Health and telehealth, and telehealth can be a core component of One Health. Here we explain how telehealth might be integrated into One Health.

Methods: We have considered antimicrobial resistance (AMR) as a use case where both One Health and telehealth can be used for coordination among the farming sector, the veterinary services, and human health providers to mitigate the risk of AMR. We conducted a narrative review of the literature to develop a position on the inter-relationships between telehealth and One Health. We have summarised how telehealth can be incorporated within One Health.

Results: Clinicians have used telehealth to address antimicrobial resistance, zoonoses, food borne infection, improvement of food security and antimicrobial stewardship. We identified little existing evidence in support of the usage of telehealth within a One Health paradigm, although in isolation, both are useful for the same purpose, i.e., mitigation of the significant public health risks posed by zoonoses, food borne infections, and antimicrobial resistance.

Conclusions: It is possible to integrate telehealth within a One Health framework to develop effective inter-sectoral communication essential for the mitigation and addressing of zoonoses, food security, food borne infection containment and antimicrobial stewardship. More research is needed to substantiate and investigate this model of healthcare.

Keywords

One health; telehealth; mHealth; eHealth; telemedicine

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1 Introduction

The World Health Organization (WHO) defines One Health (OH) at the level of programme, policy, legislation design and implementation where players in the ecosystem health, animal health and human health communicate and work together in order to achieve better population health outcomes [1]. OH integrates public health, animal health and ecosystem health in the context of a larger healthcare system [2, 3]. One digital health (ODH) is a related concept whose overarching goal is to facilitate interactions between the One Health and Digital Health communities [4]. ODH poses challenges of integration and resolution of issues around connectivity and impacts across human health, animal and environmental systems. Both OH and telehealth enable systems-based approaches for addressing global health needs [5]

Digital Health includes telehealth along with other bioinformatics approaches such as human factors, data analysis and artificial intelligence. Telehealth could enable many of the OH needs, such as providing practice guidelines for veterinary and human care providers at the point of care, besides complementing other aspects like artificial intelligence (AI), enable the design of more robust biomedical informatics tools and approaches to support the ODH goals [6, 7]. Telehealth not only supports the delivery of clinical services (*e.g.*, patient consultations or assessments), but also non-clinical services such as disseminating health education, supply chain support, and epidemiological tracking of diseases [5].

Remote care was initially defined as "Telemedicine" and was about data transmission rather than people moving for health care delivery. With expansion of the scope of telemedicine, and inclusion of health education and public health, it was defined as telehealth [8]. Telehealth is an enabler for ensuring ac-

cess to health services for those in need of care in remote areas. Telehealth provision can be cost effective by minimizing the prohibitive cost of transport to a health facility. Kuziemsky *et al.* [7] has defined telehealth ("TH") as the use of technology to deliver healthcare services over a distance as well as across the spectrum of care. It includes synchronous and asynchronous delivery modalities.

One Health principles have been used to address the problems of zoonoses, antimicrobial resistance (AMR), foodborne infections leading to food insecurity, and in fostering antimicrobial stewardship (AMS) among clinicians. AMR is a case in point, accounting for nearly five million deaths in 2019 [9]. Interventions to mitigate AMR require collaboration across different sectors and the ability to exchange information in a timely manner, including streamlining antibiotic usage practices and as a means of early identification and ongoing surveillance of international transmission between animals, humans and the environment [10, 11]. Likewise, foodborne infections intersect human and animal health. Oliver [12] estimated for the United States, based on 2015 data, that about 16% people in the United States report foodborne infection each year; almost 130,000 of these individuals were hospitalized and 3,000 died. Smith *et al.* [13] estimated 15% of emerging infectious diseases (EID) were associated with foodborne transmission. Foodborne disease outbreaks cross national boundaries, for example, the 2011 outbreak of Escherichia coli O104:H4 affected a host of countries and was ultimately traced back to fenugreek seeds from Egypt that were distributed to locations across Europe [14].

Constant movement of foods and people between countries makes surveillance of AMR and foodborne infection challenging. International migration patterns further complicate this. It is easy to obtain antibiotics in one country and transport them to another. Immigration-associated AMR is poorly studied. Data sharing across borders, e.g. the International Patient Summary effort, are welcome steps in this direction [15]. Data sharing of veterinary issues can lead to even greater benefit.

Telehealth can be integrated into OH in order to enable better and more efficient collaboration and coordination across ecosystem health, animal health, and human health

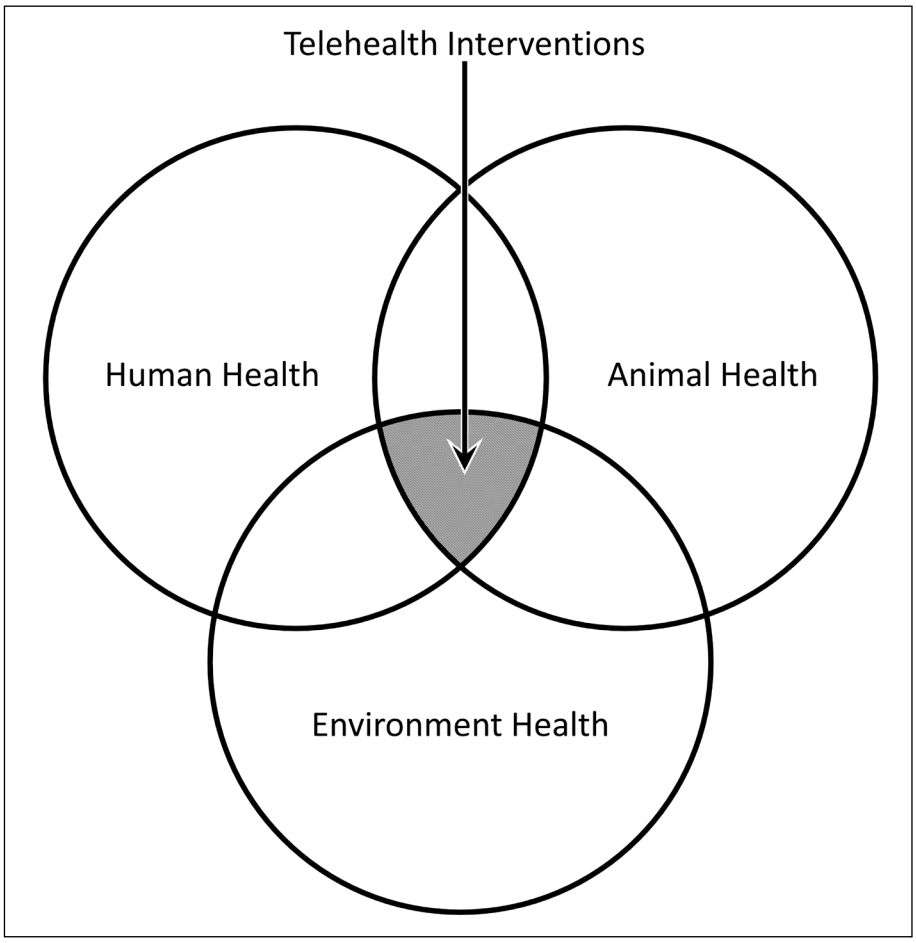

Fig. 1 The triad of One Health.

in the context of health systems beyond the delivery of care and management of diseases, and instead appreciating the system where health is delivered (Figure 1). Telehealth can drive OH by enabling information exchange, inter-professional communication, capacity building and cross-sector collaboration. These will lead to evidence-informed decision-making practices.

2 Materials and Methods

We conducted a narrative review with respect to our position on the place and role of telehealth in One Health. We examined the following question, „How might we integrate Telehealth and the One Health vision as part of a One Digital Health approach for Antimicrobial Stewardship?"

We conducted a broad-based search of the literature on One Health approach to Antimicrobial Resistance and Stewardship and Telehealth in Pubmed/Medline [16] database with the following search terms:

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((“One Health”[All Fields] OR (“one health”[MeSH Terms] OR (“one”[All Fields] AND “health”[All Fields]) OR “one health”[All Fields])) AND (“2012/08/27 00:00”:”3000/01/01 05:00”[Date - Publication] AND “loattrfree full text”[-Filter] AND “loattrfull tex-
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t"[Filter] AND "humans"[MeSH Terms] AND "english"[Language]) AND (("antimicrobial stewardship"[MeSH Terms] OR ("antimicrobial"[All Fields] AND "stewardship"[All Fields]) OR "antimicrobial stewardship"[All Fields]) AND ("loattrfree full text"[Filter] AND "review"[Publication Type] AND "loattrfull text"[Filter] AND "humans"[MeSH Terms] AND "english"[Language])) AND ((ffrft[Filter]) AND (review[Filter]) AND (fft[Filter]) AND (humans[Filter]) AND (english[Filter]))
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The inclusion and exclusion criteria for this search were as follows:

- All peer reviewed publications published in English language since 1st January 2012;
- As part of the studies to be peer-reviewed, we did not consider letters and editorials;
- We considered both primary and secondary data analyses and reviews. If two studies were from the same project, we obtained literature data from the latest study on the topic.

We scanned the title and abstract of the studies to remove studies irrelevant for application of telehealth, One Health and AMR/AMS. We conducted a separate search for telehealth and antimicrobial resistance and antimicrobial stewardship. Our search for both telehealth OR telemedicine AND One Health yielded no result. We then conducted a narrative summary of the key messages on these papers. Based on the summary, we derived themes to develop an evidence-based position on the role that telehealth could play in managing antimicrobial stewardship and antimicrobial resistance as part of implementing the ODH vision.

3 Results

A total of 43 studies were identified. Out of 43 studies that met our criteria, 31 (72%) were published between 2017-2021 indicating the recency of our evidence base (Table 1)

Table 1 Count and percentage of studies by year of publication.

Year of Publication	Count	Percent
2021	14	28
2018	9	18
2017	8	16
2019	5	10
2022	4	8
2016	4	8
2020	3	6
2014	1	2
2013	1	2
2012	1	2

We further scrutinized full texts of the retrieved studies and matched with our objectives of relevance to One Health. On this basis, we identified five relevant studies for this narrative review and supplemented this review with other more broad-based discussions on the topic (Table 2). We identified the following themes.

3.1 Theme 1: Effectiveness of Telehealth for Management of Related One Health Problems

Evidence from studies conducted in clinical practice settings including programme evaluation suggest that telehealth can be successfully implemented to foster appropriate antimicrobial usage and antimicrobial stewardship. Avent *et al.* [17] evaluated a telehealth based antimicrobial stewardship programme in Rural Australia (Queensland) where the experts and consultants worked with the local rural clinicians in advising them on the use of antimicrobials. They used remote specialist services to deliver multimodal programmes and telehealth platforms as an aid to optimise antibiotic usage based on a retrospective cohort study with two phases (baseline and intervention). They reported statistically significant increment in the adherence to appropriate antimicrobial prescription. Despite methodological limitations, results from this study suggest that in practice settings, it is possible to achieve antimicrobial stewardship in a centralised telehealth-based programme. Halpen-Ruder *et al.* [18] tested the hypothesis that telemedicine practitioners are less likely to adhere to evidence-based practice of prescription of antibiotics and more likely to overprescribe. Using a programme named "Choosing Wisely", they compared adherence to antibiotic prescribing guidelines for sinusitis in the context of telemedicine videoconferencing direct-to-consumer (DTC) visits to care received through "in-person" visits in usual care and the emergency department (ED). They found that the pattern of prescription or appropriateness of prescription as per 'Choosing Wisely' programme did not differ between telehealth practitioners, and others. Gillies *et al.* [19] conducted an interrupted time series study on the impact of COVID-19 restrictions and moving practices to telehealth on antibiotic dispensing during a COVID-19 induced lockdown period using analyses of national claims data in Australia to investigate antibiotic dispensing trends from November 2015 (pre-COVID era) to October 2020 (COVID-19 pandemic when practices were moved to telehealth). They observed a sustained 36% (95% CI: 33-40%) reduction in antibiotic dispensing from April 2020 and restrictions that led to adoption of telehealth were associated with a substantial reduction in community dispensing of antibiotics. Similar results in optimisation of the usage in antibiotics and effective antimicrobial stewardship was also observed in other settings [20, 21].

Table 2 Description of seminal papers.

Authors	Year	Study type	Methods	Findings
Avent et al. [17]	2021	Pre-post implementation	Centralised telehealth service at a rural hospital in Queensland, Australia	2-year post-implementation follow-up showed a 20% improvement in adherence and 18.7% appropriateness of antimicrobial prescribing
Halpren-Rueder et al. [18]	2018	Retrospective Chart review	Tested if the difference between adherence to recommended antibiotic regimen for sinusitis differed between Telehealth vs face to face in an emergency or urgent care (N = 570)	Nonsignificant difference (p = 0.29) in adherence
Pedrotti et al. [20]	2021	Case series	Analysis of case records of antibiotic prescription of telehealth practitioners (N = 2328 patients)	In most cases, prescribed antibiotics were in line with institutional stewardship protocols
Ceradini et al. [21]	2017	Pre-post implementation of an antimicrobial stewardship programme in Italy	Evaluation of a remote infectious disease consultancy program via telemedicine in a high-specialized pediatric cardiac hospital.	A significant reduction in the multi-drug resistant isolation rate; the infectious disease meeting via telemedicine has been an effective tool for economic and professional development and multidisciplinary management of complex patients.
Gillies et al. [19]	2022	Retrospective review of claims data on antimicrobial prescriptions in Australia around COVID pandemic	Analysis of national claims data	Reduction in community dispensing of antibiotics primarily used to treat respiratory infections, coincident with reported reductions in respiratory viral infections

The results from these practice-based studies indicate the feasibility of telehealth to address One Health problems. Given the evidence, community-based randomised controlled trials are in order to substantiate efficacy of telehealth in an OH approach. Despite the need for more evidence, from the perspective of implementation, telehealth can enable antimicrobial stewardship and help to mitigate antimicrobial resistance. The more difficult challenge is to get all the stakeholders, i.e., the patients, farmers as well as the care providers - human as well as veterinary - under one 'umbrella'.

3.2 Theme 2: Need for Coordination among Various Sectors for One Health-based Management

Diverse professional cohorts need to be brought under the same overarching framework, and relevant data need to be integrated and modelled for One Health approach to be successful. Both present unique challenges. Human and animal health providers and data systems need to 'talk' to each other to build effective AMS and AMR.

Van der Giessen *et al.* [22] reported the results of a pilot project in the Netherlands, using a group of medical and veterinary experts from public health (National Institute for Public Health and the Environment, RIVM), animal health (Wageningen Bioveterinary Research, WBVR, and Royal GD) and the Netherlands Food and Consumer Product Safety Authority (NVWA), titled National Signalling Forum for Zoonoses, or SO-Z. The 18-expert member committee was tasked to share and assess signals of emerging zoonotic pathogens and informing the necessary parties within the Zoonoses Structure and build a blueprint for a systematic approach of sharing and assessing signals of emerging zoonotic pathogens in humans and animals between veterinary and medical professionals. Over a ten-year period (2011-2021), this group assessed 390 signals of zoonotic pathogens in animal reservoirs and humans and this network ended up avoiding two notable zoonoses — that of tularaemiasis (2015), and human-to-mink transmission of SARS-COV-2 in 2020. Akinsuyi *et al.* [23] conducted a review of the epidemiology and possible solutions to reducing the spread of MDR bacterial zoonoses in Nigeria using a One Health approach. Even though they found little evidence in the surveillance of antimicrobial resistance in Nigeria, they noted that One health based collaborative efforts would be instrumental in understanding and containment of the spread of zoonoses.

Beyond building collaborations, availability of reliable antimicrobial utilisation (AMU) data at the level of the end-user and prescriber or provider of the medicinal products (farmer, veterinarian, pharmacies, or feed mills), is vital for guiding farm- and sector-specific AMU practices targeting unnecessary or inappropriate use, encouraging improvements in animal husbandry, disease prevention and control, and enabling detailed risk and trend analyses [24-27]. At the European Union (EU)/European Economic Area (EEA) level, such data are collated by the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project of the European Medicines Agency (EMA). Given that human and animal health are closely interrelated and the cost of assembling new data is high, the integration and reuse of routinely collected data is necessary for the surveillance of zoonoses. Shanbehzadeh *et al.* [28] have initiated to develop a consistent

minimum dataset (MDS) in order to establish a collaborative surveillance system across organisations using Delphi technique to address the need for an interoperable zoonotic disease surveillance system.

3.3 Theme 3: Cross-sector Interoperability Issues and Need for Inter-professional Collaboration

So far, the evidence points to the feasibility of using telehealth for achieving the aims of One Health in containment of AMR and fostering AMS, and that, when diverse players are coordinated, and data organised, these are achievable yet enabling the 'cross-talk' remains a challenge for various reasons. Timme *et al.* [29] have noted the importance of cross-sector data exchange and interoperability and inter-disciplinary communication and collaboration. The UK Royal College of Veterinary Surgeons (RCVS) held a consultation in 2017 on the views of the veterinary and veterinary nursing professions, animal owners, and stakeholders on the use of telemedicine in veterinary clinical practice to identify potential risks associated with telemedicine, and areas where it may help address the needs of both clinicians and the public, and to support the potential development of new professional standards and guidance. A majority of professional respondents (65%) were able to identify the issues around improved access and benefits: for those in geographically remote areas with inability to bring their animals to a vet; access to specialists or second opinion; less stress for animals, reduced unnecessary vet visits and advantages of seeing animal in the home environment; triage benefit, providing general advice or in relation to minor conditions and preventative medicine. The respondents also identified that risk of error, lack of examination, limitations of technology, owner competencies, knowledge or trust as significant barriers [30]. Steele *et al.* [31] conducted a cross-sectional survey of over 1,000 GPs and veterinarians in 2019 in Australia on participant experience, concern, confidence and practices regarding zoonotic diseases. They found that veterinarians were more concerned and confident in the diagnoses about zoonoses; more veterinarians reported that they had diagnosed a zoonotic disease in a patient; both GPs and veterinarians reported more frequent presentations of zoonotic diseases; GPs were less likely than veterinarians to express any level of concern about zoonoses; and that, veterinarians showed disquiet about the potential of both undiscovered zoonoses and the increasing risk of antimicrobial-resistant bacteria. These findings suggest a need for strengthening inter-professional collaboration among the GPs and the Veterinarians. The authors suggest a revision of training curricula and government actions.

These three themes — that telehealth is feasible for management of related One Health problems, an expressed need for coordination among various sectors for One Health based management, and a related need for cross-sector interoperability issues and inter-professional collaboration present opportunities but also pose challenges. So far, telehealth and One Health have been used in isolation to address similar problems in their own way. The power of the two approaches, when combined, to bear upon the problems of zoonoses surveillance through solving the problems of food insecurity, could be more than the sum of their individual contributions.

4 Discussion

Overall, cumulating evidence suggest that telehealth is feasible for enabling antimicrobial stewardship and addressing zoonoses but needs a cross-sectoral collaboration between the environmental specialists, veterinarians and clinicians. In parallel, this supports the premise of One Health call for cross-sectoral collaboration across ecosystem health, animal health, and human health. More importantly, when it comes to prevention of pandemics, as the recent experience with COVID-19 pandemic has shown, environmental monitoring of ecosystem health, animal health, in particular companion animals and animals for food, and human health are mutually interdependent. 'Disturbance' in one sector spills over into the other.

Recent experience with COVID-19 suggests that telehealth is an enabler of health services during a period when people in most countries went into social isolation [5]. Traditionally, telehealth has been applied as more of an after-thought after a global or even a widespread local epidemic. On the other hand, within the framework of One Health, telehealth might be positioned as a first line of response to an emerging outbreak, identified in the ecosystem first, and then used to coordinate pre-empting zoonoses and their eventual spillover to humans. In this mode, telehealth is part of a frontline 'attack' to aggressively pre-empt pandemics and build one health-based surveillance.

The COVID-19 pandemic has also shown the power of social media (application of information technology that facilitates 'liking' and sharing of ideas, thoughts, and spread of information through virtual networks and communities) and the role it can play in telehealth services. Being internet-based, it affords users quick electronic communication of content, such as personal information, documents, audio signals, videos, and photographs. This will enable utilising citizen science, a component of One Digital Health and a process that can effectively bind One Health and Telehealth [32].

5 Our Position: Telehealth as a Core Component of One Health

As a core component of One Health, telehealth can integrate the three service providers in the same way it has facilitated health services delivery by uniting providers and patients across time and distance. In this case, livestock farmers, environmental scientists, veterinarians, epizootiologists (those who study animal disease or zoonosis outbreaks), clinicians, public health specialists and epidemiologists. For example, environmental conditions and weather reports are monitored by the environmental specialists using remote sensing technologies connected over a network. This Information is shared with the farmers. The farmers share their information on livestock grazing or animal farming practices and diseases with the environmental specialists and the veterinarians. In the overarching framework we propose information can flow across the sectors that also form the trifecta of the One Health: ecosystem health, animal health, and human health (Figure 2).

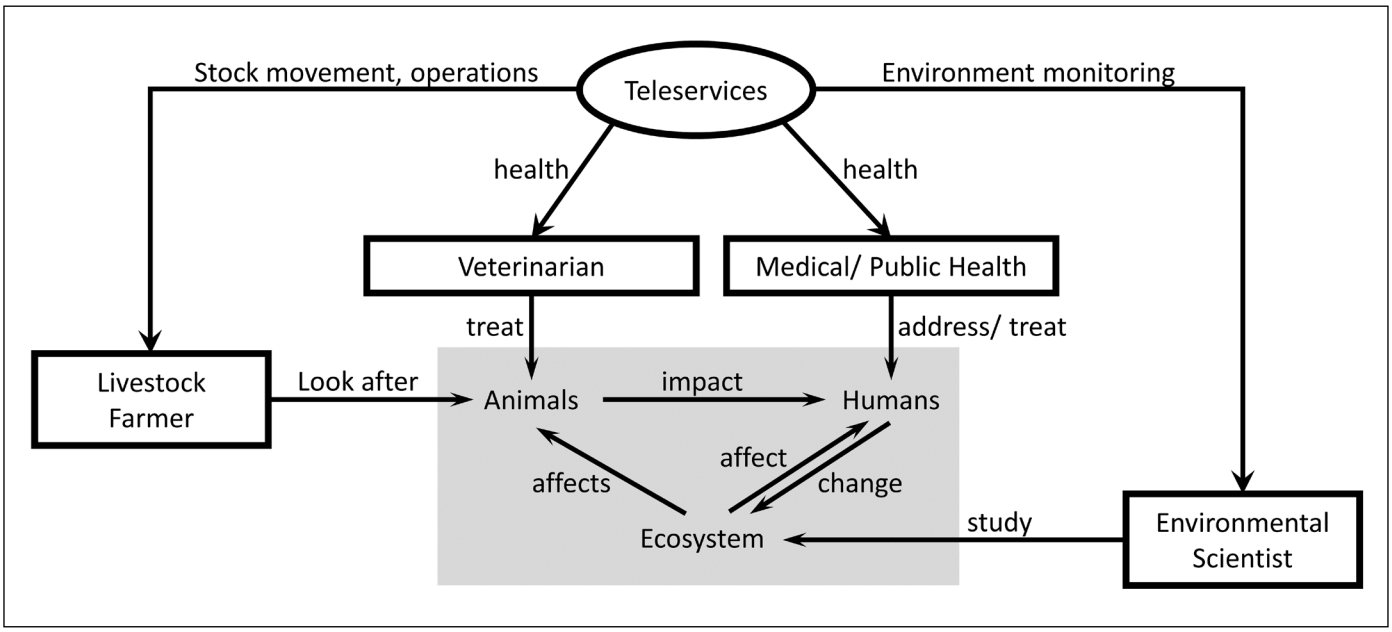

Fig. 2 Model of how Teleservices unite livestock farming, veterinarian services, medical care, public health and ecosystem health in one framework.

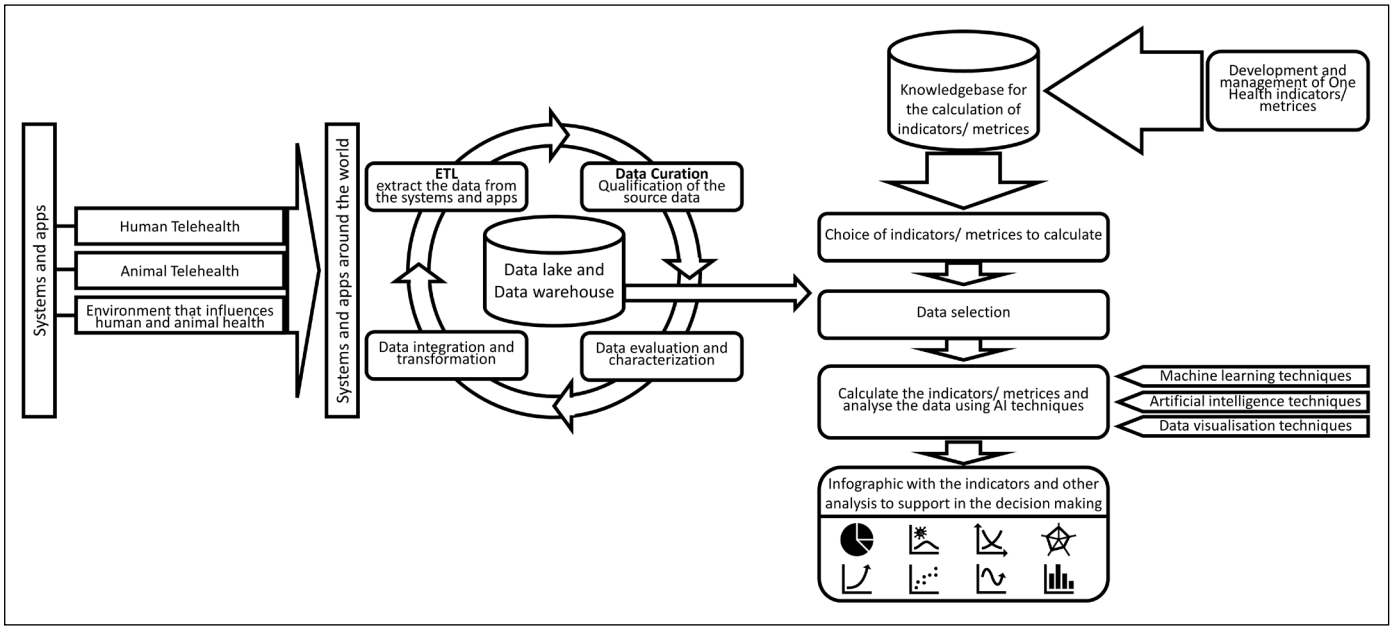

Fig. 3 Information Architecture - Strategic Information Management in the One Health.

We also suggest an information architecture for integrating and processing the data collected by the various teleservices (Figure 3) generating dashboards with indicators and analysis that support managers and experts in decision making.

As the information architecture illustrates, relevant data are abstracted from teleservices, and subsequently processed to be finally integrated and transformed to allow it to be stored in data lakes or data warehouses. These processes would facilitate linkage with indicator data in One Health contexts [33]. Additionally, the stored data can be used to assess and estimate indicators that are defined and managed in the "Management of One Health Indicators" module. AI techniques can add further value. The indicators and analyses would enable the healthcare providers to participate in their decision-making processes. In addition to the estimation of the indicators, such integration would make it possible to use artificial intelligence and machine learning algorithms for model building and prevention or for the prevention of future pandemics. Finally, the result of the analysis and the indicators are presented in information dashboards.

In summary, One Health is an overarching framework to integrate three sectors — the ecosystem health, the animal health, and the population health sectors — with a view to pre-empt future pandemics and address issues around zoonoses and infectious disease epidemics. Telehealth can provide the necessary coordination of the three sectors. The principles and processes supporting such coordination as telehealth are essentially about health systems as is One Health and the success stories of using telehealth in addressing One Health issues such as antimicrobial resistance and stewardship are encouraging. More studies and efforts are needed to integrate telehealth within a One Health framework.

Disclaimer

Views expressed in this article are our own and not an official position of the respective institutions.

Disclosure

None or as explained in the accompanying conflict of interest forms.

References

1. WHO. 2022. One Health. [available from : https://www.who.int/europe/initiatives/one-health].
2. Evans BR., Leighton FA. A history of One Health. Rev Sci Tech 2014, 33(2):413–20.
3. Mackenzie JS, Jeggo M. The One Health Approach—Why Is It So Important? Trop Med Infect Dis 2019; 4(2):88. doi: 10.3390/tropicalmed4020088.
4. Benis A, Tamburis O, Chronaki C, Moen A. One Digital Health: A Unified Framework for Future Health Ecosystems. J Med Internet Res 2021;23(2):e22189. doi: 10.2196/22189.
5. Basu A, Kuziemsky C, de Araújo Novaes M, Kleber A, Sales F, Al-Shorbaji N, et al. Telehealth and the COVID-19 Pandemic: International Perspectives and a Health Systems Framework for Telehealth Implementation to Support Critical Response. Yearb Med Inform 2021;30(01):126–33. doi: 10.1055/s-0041-1726484.
6. Kuziemsky CE, Hunter I, Gogia SB, lyengar S, Kulatunga G, Rajput V, et al. Ethics in Telehealth: Comparison between Guidelines and Practice-based Experience -the Case for Learning Health Systems. Yearb Med Inform 2020;29(01):44–50. doi: 10.1055/s-0040-1701976.
7. Kuziemsky C, Gogia S, Househ M, Petersen C, Basu A. Balancing Health Information Exchange and Privacy Governance from a Patient-Centred Connected Health and Telehealth Perspective. Yearb Med Inform 2018;27(01):48–54. doi: 10.1055/s-0038-1641195.
8. Dorsey ER, Topol EJ. State of Telehealth. N Engl J Med 2016;375(2):154–61. doi: 10.1056/nejmra1601705.
9. Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Robles Aguilar G, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. The Lancet 2022;399(10325):629–55. doi: 10.1016/s0140-6736(21)02724-0.
10. Osei Sekyere J, Reta MA. Genomic and Resistance Epidemiology of Gram-Negative Bacteria in Africa: a Systematic Review and Phylogenomic Analyses from a One Health Perspective. mSystems 2020;5(6). doi: 10.1128/msystems.00897-20.
11. Alemayehu T, Hailemariam M. Prevalence of vancomycin-resistant enterococcus in Africa in one health approach: a systematic review and meta-analysis. Sci Rep 2020;10(1):20542. doi: 10.1038/s41598-020-77696-6.
12. Oliver SP. Foodborne Pathogens and Disease Special Issue on the National and International PulseNet Network. Foodborne Pathog Dis 2019;16(7):439–40. doi: 10.1089/fpd.2019.29012.int.
13. Smith BA, Meadows S, Meyers R, Parmley EJ, Fazil A. Seasonality and zoonotic foodborne pathogens in Canada: relationships between climate and Campylobacter, E. coli and Salmonella in meat products. Epidemiol Infect 2019;147. doi: 10.1017/s0950268819000797.
14. Antunes P, Novais C, Peixe L. Food-to-Humans Bacterial Transmission. Microbiol Spectr 2020;8(1). doi: 10.1128/microbiolspec.mtbp-0019-2016.
15. Tcharaktchiev D, Krastev E, Petrossians P, Abanos S, Kyurkchiev H, Kovatchev P. Cross-Border Exchange of Clinical Data Using Archetype Concepts Compatible with the International Patient Summary. Stud Health Technol Inform 2020;270:552–6. doi: 10.3233/SHTI200221.
16. https://www.pubmed.gov
17. Avent ML, Walker D, Yarwood T, Malacova E, Brown C, Kariyawasam N. et al. Implementation of a novel antimicrobial stewardship strategy for rural facilities utilising telehealth. Int J Antimicrob Agents 2021;57(6):106346. doi: 10.1016/j.ijantimicag.2021.106346.
18. Halpren-Ruder D, Chang AM, Hollander JE, Shah A. Quality Assurance in Telehealth: Adherence to Evidence-Based Indicators. Telemed J E Health 2019; 25(7):599–603. doi: 10.1089/tmj.2018.0149.
19. Gillies MB, Burgner DP, Ivancic L, Nassar N, Miller JE, Sullivan SG, et al. Changes in antibiotic prescribing following COVID19 restrictions: Lessons for postpandemic antibiotic stewardship. Br J Clin Pharmacol 2021;88(3):1143–51. doi: 10.1111/bcp.15000.
20. Pedrotti CHS, Accorsi TAD, De Amicis Lima K, Serpa Neto A, Lira MTSS, Morbeck RA, et al. Antibiotic stewardship in direct-to-consumer telemedicine consultations leads to high adherence to best practice guidelines and a low prescription rate. Int J Infect Dis 2021;105:130–4. doi: 10.1016/j.ijid.2021.02.020.
21. Ceradini J, Tozzi AE, D'Argenio P, Bernaschi P, Manuri L, Brusco C, et al. Telemedicine as an effective intervention to improve antibiotic appropriateness prescription and to reduce costs in pediatrics. Ital J Pediatr 2017;43(1):105. doi: 10.1186/s13052-017-0423-3.
22. van der Giessen J, Vlaanderen F, Kortbeek T, Swaan C, van den Kerkhof H, Broens E, et al. Signalling and responding to zoonotic threats using a One Health approach: a decade of the Zoonoses Structure in the Netherlands, 2011 to 2021. Euro Surveill 2022;27(31):2200039. doi: 10.2807/1560-7917.es.2022.27.31.2200039.
23. Akinsuyi OS, Orababa OQ, Juwon OM, Oladunjoye IO, Akande ET, Ekpueke MM, et al. One Health approach, a solution to reducing the menace of multidrug-resistant bacteria and zoonoses from domesticated animals in Nigeria – A review. Global Biosecurity 2021;3(1). doi: 10.31646/gbio.88.
24. Sanders P, Vanderhaeghen W, Fertner M, Fuchs K, Obritzhauser W, Agunos A, et al. Monitoring of Farm-Level Antimicrobial Use to Guide Stewardship: Overview of Existing Systems and Analysis of Key Components and Processes. Front Vet Sci 2020;7:540. doi: 10.3389/fvets.2020.00540.
25. Carmo LP, Schüpbach-Regula G, Müntener C, Chevance A, Moulin G, Magouras I. Approaches for quantifying antimicrobial consumption per animal species based on national sales data: a Swiss example, 2006 to 2013. Euro Surveill 2017;22(6):30458. doi: 10.2807/1560-7917.es.2017.22.6.30458.
26. Levy S. (2014). Reduced Antibiotic Use in Livestock: How Denmark Tackled Resistance. Environ Health Perspect 2014;122(6):A160-5. doi: 10.1289/ehp.122-a160.

27. Speksnijder DC, Mevius DJ, Bruschke CJM, Wagenaar JA. Reduction of Veterinary Antimicrobial Use in the Netherlands. The Dutch Success Model. Zoonoses Public Health 2014;62:79–87. doi: 10.1111/zph.12167
28. Shanbehzadeh M, Nopour R, Kazemi-Arpanahi H. Designing a standardized framework for data integration between zoonotic diseases systems: Towards one health surveillance. Inform Med Unlocked 2022;30:100893. doi: 10.1016/j.imu.2022.100893.
29. Timme RE, Wolfgang WJ, Balkey M, Venkata SLG, Randolph R, Allard M, et al. Optimizing open data to support one health: best practices to ensure interoperability of genomic data from bacterial pathogens. One Health Outlook 2020;2(1):20. doi: 10.1186/s42522-020-00026-3.
30. [available from: https://www.rcvs.org.uk/document-library/telemedicine-consultation-summary/].
31. Steele SG, Booy R, Manocha R, Mor SM, Toribio JLML. Towards One Health clinical management of zoonoses: A parallel survey of Australian general medical practitioners and veterinarians. Zoonoses Public Health 2020;68(2):88–102. doi: 10.1111/zph.12799.
32. Katapally TR. A Global Digital Citizen Science Policy to Tackle Pandemics Like COVID-19. J Med Internet Res 2020;22(5):e19357. doi: 10.2196/19357.
33. de Moura RR, Chiba de Castro WA, Farinhas JH, Pettan-Brewer C, Kmetiuk LB, et al. One Health Index (OHI) applied to Curitiba, the ninth-largest metropolitan area of Brazil, with concomitant assessment of animal, environmental, and human health indicators. One Health 2022;14:100373. doi: 10.1016/j.onehlt.2022.100373.

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