

Title

Determinants of health and disease dynamics preceding emerging disease at the human-wildlife-livestock interface: a scoping review protocol

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Keywords: emerging infectious diseases, zoonoses, human-wildlife-livestock interface, surveillance, health, disease dynamics

Abstract

Emerging diseases at the human-wildlife-livestock interface are often zoonotic, hold high pandemic potential, and have high current and future risks to global health security. Development of health-based, “upstream” surveillance methods could elucidate patterns and risk factors leading to disease, and inform policy and interventions designed to maintain or improve population health. This protocol outlines a scoping review to investigate determinants of health and emerging disease in the context of the global human-wildlife-livestock interface. Four databases will be searched, including Web of ScienceTM, Medline via OVID, CAB Direct (CABI) and Agricultural and Environmental Sciences. Criteria for eligibility include full text availability in English, focus on emerging disease affecting human, livestock and wildlife at their interface, and incorporation of disease dynamics and/or changes in host, agent or environmental characteristics. Articles that focus on *in vitro* work or that are not peer-reviewed primary literature (including scoping or systematic reviews) will be excluded. Results will be uploaded to Covidence, de-duplicated, then screened by two reviewers. Data charting will include classification and name of disease or topic, classification of livestock and wildlife species, geographic location, risk factors or determinants of health/disease, study design, study focus, and author-reported study limitations and calls to action. These findings will improve understanding of health maintenance at the intersection of wild and domestic species, and will provide sentinel factors which might be used to develop health-based surveillance strategies.

Introduction

Rationale

The rate of emerging infectious disease is climbing exponentially, driven by ecological, socioeconomic and environmental factors; many of these involve zoonotic pathogens, with the majority including a wildlife origin and/or reservoir (Jones *et al.*, 2008). Current surveillance efforts utilize a disease-focused, reactive approach, which presents disadvantages to health, welfare and spread of disease (Federal, Provincial, and Territorial Governments of Canada, 2018).

Health-based surveillance is being used to describe disease trends and health indicators of global wildlife populations (Privot *et al.*, 2023). Generally speaking, its development could allow for surveillance of risk factors at an “upstream” location, at a time when interventions may be applied to mitigate risk of disease (Stephen *et al.*, 2005), which translates to cost savings and resilience to harm (Federal, Provincial, and Territorial Governments of Canada, 2018).

The literature supports the idea that we could identify risk factors associated with emerging disease (Fasina *et al.*, 2015; Mysterud *et al.*, 2019), and if data are available, use them to create signals that could alert health and surveillance personnel to the beginnings of a potential threat. For the purposes of this review, the definition of emerging disease will follow the proposed definition of emerging infectious diseases by Petersen *et al.* (2018): “diseases that are newly recognized, newly introduced or newly evolved, or they are diseases that have recently and rapidly changed in incidence or expansion in geographical, host or vector range” (Petersen *et al.*, 2018).

On September 12, 2023, a preliminary title and abstract search was completed using Web of Science™, Medline via OVID, CAB Direct (CABI), Agricultural and Environmental Sciences and PROSPERO databases, to investigate existing or planned reviews surrounding this topic. Search terms were identical to those found in Table 2, with the addition of one search string including the key terms “scoping review OR systematic review OR meta-analysis OR knowledge synthesis OR qualitative synthesis OR narrative synthesis OR rapid review OR mixed methods review.” A truncated search string consisting of “emerging disease AND wildlife AND livestock” was used to search Open Science Framework. The University of Guelph Atrium was also searched using a truncated search string: “(disease OR pathogen OR zoonosis) AND (emergence OR emerging OR spillover OR incidence) AND (livestock OR farm OR agriculture) AND wildlife AND (signal OR factor OR risk OR determinant) AND (relationship OR proximity OR dynamics) AND (“systematic review” OR “scoping review”).

No scoping or systematic reviews, either published or in progress, were found that focused on factors associated with health and host or pathogen characteristics/dynamics preceding emerging disease at the global human-wildlife-livestock interface. Common themes of existing scoping reviews included characterizing prevalence, epidemiology, risk and prevention of specific diseases such as Rabies (Mshelbwala *et al.*, 2021) and Tuberculosis (Gordon *et al.*, 2022); also, several reviews focused on a factor such as antimicrobial resistance and discussed it in the context of a chosen setting (Medina-Pizzali *et al.*, 2021).

Objectives

This scoping review will identify indicators of changing health status and changes in disease dynamics which precede emerging disease in human, wildlife and livestock populations in a global context.

Broadly, it explores the research question:

“What changes in host, pathogen or disease factors or interactions precede disease emergence at the human-wildlife-livestock interface?”

The objectives for the scoping review are as follows:

1. Identify drivers, or factors associated with changes in health or disease dynamics which precede emerging disease where humans, wildlife and livestock interact.
2. Identify factors which may be used as signals in health-based early warning surveillance efforts.

Methods

Protocol and registration

This protocol was developed using the Preferred Reporting Items for Systematic Reviews and Meta-analysis protocols (PRISMA-Scr) (Moher *et al.*, 2009; Levac *et al.*, 2010). It will be published and made publicly available in The Atrium, the University of Guelph's online reference archive (<https://atrium.lib.uoguelph.ca/>).

Any changes to this scoping review protocol will be published as amendments in the final draft of the scoping review.

Eligibility criteria

Articles eligible for inclusion in this review will meet the following criteria:

1. Available in English. Due to resource constraints, only articles published in English will be included. There will be no geographical or author affiliation limitations placed on articles or study locations.
2. Full text available (>500 words) and able to be downloaded.
3. Peer-reviewed primary journal articles. This may include any descriptive, experimental or qualitative studies, as well as articles presented as opinion papers but which contain primary data or have more than one author.
4. Emerging disease: the article will state a focus on emerging disease, and/or focus on a disease and/or pathogen which, in the context of the study, is newly recognized, introduced or evolved, or is changing in incidence, geographical, host or vector range (Petersen *et al.*, 2018).
5. Interface: study takes place in a location that demonstrates proximity or interaction between humans, wildlife or livestock species.
6. Disease dynamics: article examines changing host, agent or environmental factors preceding emerging disease. May include changes in characteristics of, or interactions between, populations and/or environment.

The following criteria will result in exclusion of articles from the review:

1. Duplicate studies

2. Articles focusing on *in vitro* work will be excluded due to distance from this review’s context. An exception may be studies which utilize genomic or other “-omic” methods to describe host or pathogen characteristics.
3. Book chapters, thesis dissertations, editorials, opinion pieces with one author or not presenting primary data, newspaper or other media articles.

Table 1. Summary of eligibility criteria for inclusion or exclusion from scoping review

	Inclusion criteria
Full text availability	Full text available
Language	English
Article type	Peer-reviewed journal articles including primary research articles, case studies, case series. Opinion articles presenting primary data or with more than one author
Emerging disease	Explicitly describes the study of emerging disease, or a disease which is newly recognized, introduced or evolved, or is changing in incidence, geographical, host or vector range (Petersen <i>et al.</i> , 2018)
Interface	Describes interaction or proximity between humans, domestic livestock and wildlife
Disease dynamics	Describes changes in characteristics of, or interaction between host, agent or environment preceding emerging disease
Study location and data type	Field studies, data from populations/host/agent/environment, including genomic and other -omic studies

	Exclusion criteria
Duplicates	Duplicate studies will be excluded using Covidence
<i>In vitro</i> work	Articles focused primarily <i>in vitro</i>
Article type	Book chapters, thesis dissertations, reviews, editorials, opinion pieces with one author or not presenting primary data, newspaper or other media articles

Information sources

Consultation with a research librarian identified four databases which would encompass the interdisciplinary scope of this review. These include Web of Science™, Medline via OVID, CAB Direct (CABI) and Agricultural and Environmental Sciences. All databases are accessible via the University of Guelph’s McLaughlin library.

Search queries from each database will be as follows:

Web of Science™: topic (includes title, author, keywords, keywords plus)

Medline via OVID: title, abstract, exploded subheading, floating subheading, floating subheading word, keyword heading, MeSH subject heading

CAB Direct (CABI): abstract

Agricultural and Environmental Sciences: NOFT (anywhere except full text)

Search strategy

Search terms including key words and MeSH terms were developed to encompass five categories which defined the scope of disease, population interface and factors associated with host and disease dynamics. AM developed the search terms in consultation with subject matter expert EJP and a University of Guelph Research Librarian. Table 2 lists search terms. Each search string was linked to the rest by the Boolean operator “AND”. The same search string was utilized for each database, with adjustments made for database-specific operators. Example search strings for Web of Science™ and Medline (via OVID) can be found in Appendix 1.

Additionally, ten key articles of interest were identified and inclusion was assessed in results from each database. Table 3 lists key articles and a summary of inclusion in results.

There will be no restrictions on language or time frame during the initial search. Authors of articles will not be contacted for further information or clarification.

Search results will be exported to reference manager Readcube Papers. Results will also be uploaded to Covidence for deduplication and eligibility screening. Covidence and Readcube Papers will be used for data extraction.

Table 2: search string to identify studies on emerging disease at the human/wildlife/livestock interface

Disease	diseas* OR illness* OR pathog* OR viral OR virus OR zoono* OR bacteria* OR fung* OR parasit* OR protozo* OR prion* OR infection*
Emergence	emerg* OR re-emerg* OR spillover OR spillback OR outbreak* OR epidem* or pandem* OR "emerging infectious disease*" OR "EID*" OR "inciden*" OR "hot spot"
Population	(human* OR people* OR public health OR anthro* OR zoono* OR farm* OR agricultur* OR food OR domestic OR trade OR slaughter OR meat OR bushmeat OR hunt* OR fishing OR fisher* OR aquaculture* OR conservation

	OR manage*) AND (wildlife OR fauna OR (wild adj3 (bird* OR avian OR fish*)) OR bat* OR primate* OR rodent* OR ungulate* OR carnivore* OR "marine mammal" OR reptile OR amphibian) AND (livestock OR bovine OR cattle OR goat* OR caprine OR sheep OR ovine OR pig* OR porcine OR poultry)
Signal/factor	risk* OR factor* OR determinant* OR indicat* OR predict* OR characteristic* OR driver OR predispos* OR signal* OR source* OR impact* OR "risk-factors" OR surveillance OR network* OR monitor* OR probability
Interface/disease dynamics	relationship* OR proxim* OR ecol* OR interact* OR susceptib* OR sympatric OR behaviour OR system OR interface* OR vector* OR spread OR transmi* OR exposure OR dynamic* OR reservoir*

Table 3: list of key articles of interest, and summary of inclusion in results from each database

Reference	Web of Science	OVID Medline	CAB Direct	Agricultural and Environmental Sciences
Hassell, J. M. <i>et al.</i> Socio-ecological drivers of vertebrate biodiversity and human-animal interfaces across an urban landscape. <i>Global Change Biology</i> 27 , 781–792 (2021).	X	X	X	X
Herrero-García, G. <i>et al.</i> Tuberculosis Epidemiology and Spatial Ecology at the Cattle-Wild Boar Interface in Northern Spain. <i>Transboundary and Emerging Diseases</i> 2023 , (2023).	X			X
Jones, B. A. <i>et al.</i> Peste des Petits Ruminants Virus Infection at the Wildlife–Livestock Interface in the Greater Serengeti Ecosystem, 2015–2019. <i>Viruses</i> 13 , 838 (2021).	X	X		X
Katani, R. <i>et al.</i> Identification of <i>Bacillus anthracis</i> , <i>Brucella</i> spp., and <i>Coxiella burnetii</i> DNA signatures from bushmeat. <i>Sci. Rep.</i> 11 , 14876 (2021).	X			X
Muloi, D. M. <i>et al.</i> Genomic epidemiology of <i>Escherichia coli</i> : antimicrobial resistance through a One Health lens in sympatric	X	X		

humans, livestock and peri-domestic wildlife in Nairobi, Kenya. <i>BMC Med.</i> 20 , 471 (2022).				
Fürst, M. A., McMahon, D. P., Osborne, J. L., Paxton, R. J. & Brown, M. J. F. Disease associations between honeybees and bumblebees as a threat to wild pollinators. <i>Nature</i> 506 , 364–366 (2014).	X	X	X	X
Cleaveland, S., Laurenson, M. K. & Taylor, L. H. Diseases of humans and their domestic mammals: pathogen characteristics, host range and the risk of emergence. <i>Philos. Trans. R. Soc. Lond. Ser. B: Biol. Sci.</i> 356 , 991–999 (2001).	X	X	X	
Childs, M. L., Nova, N., Colvin, J. & Mordecai, E. A. Mosquito and primate ecology predict human risk of yellow fever virus spillover in Brazil. <i>Philos. Trans. R. Soc. B</i> 374 , 20180335 (2019).	X	X	X	X
Grear, D. A., Hall, J. S., Dusek, R. J. & Ip, H. S. Inferring epidemiologic dynamics from viral evolution: 2014–2015 Eurasian/North American highly pathogenic avian influenza viruses exceed transmission threshold, $R_0 = 1$, in wild birds and poultry in North America. <i>Evol. Appl.</i> 11 , 547–557 (2018).	X	X	X	
VICENTE, J., DELAHAY, R. J., WALKER, N. J. & CHEESEMAN, C. L. Social organization and movement influence the incidence of bovine tuberculosis in an undisturbed high-density badger <i>Meles meles</i> population. <i>J. Anim. Ecol.</i> 76 , 348–360 (2007).	X			X
Total	10/10	7/10	5/10	7/10

Selection of sources of evidence

Level one screening will be performed on title and abstract in Covidence, using two independent reviewers. A form will be created to help guide reviewers through steps of the eligibility screening. Reviewers will meet to discuss eligibility criteria, and will screen a set of 25 training titles/abstracts to assess agreement (Peters *et al.*, 2020). Discrepancies will be discussed between reviewers, and modifications to eligibility criteria made if necessary. Level one screening will commence once agreement greater than 75% is reached during the title/abstract pilot (Peters *et al.*, 2020). During level one screening, reviewers will discuss discrepancies until a consensus is reached, or a third reviewer may be consulted.

Level one screening will comprise the following questions:

1. Is the abstract available in English?

- a) YES/unsure – proceed to question 2
- b) NO – exclude article

2. Based on the title and/or abstract, is the article one of the following: primary research article, case studies, case series, opinion articles presenting primary data or with more than one author?

- a) YES/unsure – proceed to question 3
- b) NO – exclude article

3. Does the title and/or abstract explicitly describe the study of emerging disease, or a disease which is newly recognized, introduced or evolved, or is changing in incidence, geographical, host or vector range (Petersen *et al.*, 2018)?

- a) Yes/unsure – proceed to question 4
- b) No – exclude article

4. Does the title and/or abstract describe interaction or proximity between humans, livestock and wildlife?

- a) Yes/unsure – proceed to question 5
- b) No – exclude article

5. Does the title and/or abstract describe changes in characteristics of, or interaction between host, agent or environment?

- a) Yes/unsure – proceed to question 6
- b) No – exclude article

6. Does the title and/or abstract describe work done primarily *in vitro* (excluding genomic studies)?

- a) No/unsure – include article
- b) Yes – exclude article

Level 2 eligibility screening will be performed on full text in Covidence by two reviewers working independently. Level 2 screening will comprise the same list of questions as level 1.

Data charting

Data charting will be performed independently by two reviewers using Covidence, and will begin with the terms outlined below. The data charting form will be tested on an initial 10 articles and the reviewers will meet to discuss and resolve any discrepancies. Iterative data charting may occur where trends and further topics of interest are collected throughout the review process.

Data items

The following are proposed data items to be extracted. A form combining check boxes and free text entry will be provided to reviewers via Covidence. Data from free text entry may undergo thematic analysis.

1. Classification of disease or topic

- Viral
- Bacterial
- Parasitic
- Protozoa
- Fungal
- Prion
- AMR
- Vector-borne? (tick/mosquito/other)
- Zoonosis? (yes/no/unsure)
- Disease not specifically identified
- Other: free text entry

2. Name of disease or pathogen (or disease, if exact pathogen name not available): free text entry

3. Classification of livestock species

- cattle
- small ruminant (sheep, goat, camelid)
- equine
- avian
- swine
- fish
- other

4. Classification of wildlife species

- avian
- mammal: ungulate
- mammal: rodent

- mammal: bat
- mammal: aquatic
- mammal: carnivore
- mammal: other
- reptile/amphibian
- fish
- other

5. Geographic location (country): free text entry

6. Are there risk factors/drivers/determinants of health or disease named? If so, please list: free text entry

- for each risk factor, is it explicitly described or implied? Checkbox or free text entry: explicit/implicit/unsure

- for each risk factor, was it described as preceding emerging disease? Checkbox or free text entry: yes/no/unsure

7. Are there quantitative results collected by this study (ex. measures of association or effect, prevalence or incidence)? If so, please list the result and associated exposure or risk factors, if applicable: free text entry

8. Study design

- Descriptive (case report, case series, surveys)
- Analytic
 - Observational (cross-sectional, case control, cohort)
 - Experimental (randomized controlled trial, field study)
- Qualitative (focus groups, interviews, etc)
- Other (text entry)

9. Purpose of study: free text entry/copy and paste

10. Calls to action/recommendations: free text entry/copy and paste

11. Self-reported limitations by authors: free text entry/copy and paste

RESULTS

Synthesis of results

A flow chart (Moher *et al.*, 2009) will be generated to demonstrate the results of initial database search, deduplication, eligibility screening, and inclusion of studies into qualitative synthesis. The authors will compile findings in a descriptive report, using a qualitative approach to summarize trends and key findings. Methods of results dissemination may include tables, figures, text, poster and/or oral presentations. Study characteristics and data extraction will be summarized; trends, gaps and future knowledge directions will be explored. A systems map will be generated to display interactions and factors influencing health and disease of populations.

Critical appraisal of individual sources of evidence

Study results will not be extracted and critical appraisal will not be performed, as this is a scoping review which may include articles from varying regions, with different scopes, study designs and aims, thus making comparison difficult. However, a list of self-reported limitations to each study will be collected in order to comment on trends in study limitations and future research directions.

Discussion

The summary of evidence from this review will provide insight into factors which predispose populations to emerging disease at the human-wildlife-livestock interface. These factors may inform policy and animal management and improve upon current disease surveillance measures. These findings will support global efforts in disease prevention, inform health management, and contribute to development of health-based interventions.

Limitations

This review is limited to articles written in the English language, which may exclude some results despite a global focus. Companion animals are not included in this review. Reviews and grey literature are also excluded due to the breadth of articles and challenges in collecting representative grey literature from other countries and regions. A focus on the human-wildlife-livestock interface intends to investigate the effects of changing health and disease in these dynamic and interrelated populations. However, a focus on diseases common to these interfaces may exclude others which occur more in isolation or are less commonly studied.

Funding

No external funding contributed to this protocol. AM is supported by an Ontario Veterinary College PhD Fellowship and CGS-M scholarship.

Contributions and Acknowledgements

AM will develop the search string query, compile results, perform eligibility screening and data extraction, complete the scoping review, summarize results, and draft publication and presentation materials. EJP, LG and CJ will contribute to the methodology, results analysis and dissemination. AM and a second researcher will act as reviewers. All authors will review the final publication. The authors would like to acknowledge University of Guelph librarian Jacqueline Kreller-Vanderkooy for her kind help throughout the process of envisioning and drafting this protocol.

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Petersen, E. *et al.* Emerging infections—an increasingly important topic: review by the Emerging Infections Task Force. *Clin. Microbiol. Infect.* **24**, 369–375 (2018).

Stephen C, Artsob H, Bowie WR, Drebot M, Fraser E, Leighton T, Morshed M, Ong C, Patrick D. Perspectives on emerging zoonotic disease research and capacity building in Canada. *Can Vet J.* 2005 Jan;46(1):65-71. PMID: 15759832; PMCID: PMC2831550.

Appendix 1

Table A.1: search strings and results from database Web of Science™ (“Topic”)

	Search String	Results
1	diseas* OR illness* OR pathog* OR viral OR virus OR zoono* OR bacteria* OR fung* OR parasit* OR protozo* OR prion* OR infection*	9 077 196
2	emerg* OR re-emerg* OR spillover OR spillback OR outbreak* OR epidem* or pandem* OR "emerging infectious disease*" OR "EID*" OR "inciden*" OR "hot spot"	4 038 106
3	(human* OR people* OR public health OR anthro* OR zoono* OR farm* OR agricultur* OR food OR domestic OR trade OR slaughter OR meat OR bushmeat OR hunt* OR fishing OR fisher* OR aquaculture* OR conservation OR manage*) AND (wildlife OR fauna OR (wild NEAR/3 (bird* OR avian OR fish*)) OR bat* OR primate* OR rodent* OR ungulate* OR carnivore* OR "marine mammal" OR reptile OR amphibian) AND (livestock OR bovine OR cattle OR goat* OR caprine OR sheep OR ovine OR pig* OR porcine OR poultry)	32 863
4	risk* OR factor* OR determinant* OR indicat* OR predict* OR characteristic* OR driver OR predispos* OR signal* OR source* OR impact* OR "risk-factors" OR surveillance OR network* OR monitor* OR probability	27 616 529
5	relationship* OR proxim* OR ecol* OR interact* OR susceptib* OR sympatric OR behaviour OR system OR interface* OR vector* OR spread OR transmi* OR exposure OR dynamic* OR reservoir*	25 109 327

	1 AND 2 AND 3 AND 4 AND 5	4009
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Table A.2: search strings and results from database Medline via OVID (title, abstract, exploded subheading, floating subheading, floating subheading word, keyword heading, MeSH subject heading)

	Search String	Results
1	diseas* OR illness* OR pathog* OR viral OR virus OR zoono* OR bacteria* OR fung* OR parasit* OR protozo* OR prion* OR infection*	8 477 439
2	emerg* OR re-emerg* OR spillover OR spillback OR outbreak* OR epidem* or pandem* OR "emerging infectious disease*" OR "EID*" OR "inciden*" OR "hot spot"	4 340 830
3	(human* OR people* OR public health OR anthro* OR zoono* OR farm* OR agricultur* OR food OR domestic OR trade OR slaughter OR meat OR bushmeat OR hunt* OR fishing OR fisher* OR aquaculture* OR conservation OR manage*) AND (wildlife OR fauna OR (wild adj3 (bird* OR avian OR fish*)) OR bat* OR primate* OR rodent* OR ungulate* OR carnivore* OR "marine mammal" OR reptile OR amphibian) AND (livestock OR bovine OR cattle OR goat* OR caprine OR sheep OR ovine OR pig* OR porcine OR poultry)	22 103
5	risk* OR factor* OR determinant* OR indicat* OR predict* OR characteristic* OR driver OR predispos* OR signal* OR source* OR impact* OR "risk-factors" OR surveillance OR network* OR monitor* OR probability	14 419 660
6	relationship* OR proxim* OR ecol* OR interact* OR susceptib* OR sympatric OR behaviour OR system OR interface* OR vector* OR spread OR transmi* OR exposure OR dynamic* OR reservoir*	8 849 354
	1 AND 2 AND 3 AND 4 AND 5	3387