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Protocol for a systematic review of outbreak response intervention models of vaccine-preventable diseases in humans, and foot-and-mouth disease in livestock

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ABSTRACT

Introduction: Outbreak response interventions, for example, vaccination, social distancing, and palliative care are usually undertaken to control outbreaks of infectious disease. Since a lot of effort and funding go into these campaigns, their impact and efficiency are key. Mathematical and statistical models are useful for exploring intervention strategies, assessing their impact, and strategizing. The state of the art of the modelling literature, including the best practices and gaps, are currently unclear and there is a need for a systematic review that aims to identify these. Our objective is to examine all the mechanistic models used so far in the literature to examine interventions mounted during outbreaks of human vaccine-preventable diseases and foot-and-mouth disease in livestock. This protocol describes the strategy we will use for the systematic review.

Methods and analysis: We have developed this protocol following the Preferred Reporting Items for Systematic Reviews and Meta- Analyses Protocols (PRISMA-P) guidelines. We will search on PubMed, Scopus, Web of Science, and some preprint and Grey literature sources to identify all mechanistic models describing and assessing interventions organized in response to outbreaks of a list of diseases. Inclusion: studies, published in English, that employed mechanistic models in their approach to evaluating an outbreak intervention. Exclusion: reviews, and studies that do not use mechanistic models, or do not describe an outbreak. We will extract data from the included studies using a pre-designed form and will assess the quality of reporting with a questionnaire, based on a standard reporting guideline.

Ethics and dissemination: This systematic review will not require any ethics approval since it only involves scientific articles. The review will be disseminated in a peer-reviewed journal and at various conferences fitting its scope.

Review registration number: PROSPERO Receipt ID 160803.

Strengths and limitations of the study

- The detailed search strategy used in this systematic review captures all human vaccine-preventable diseases, and foot-and-mouth disease in livestock.
- This review protocol is developed according to the PRISMA guidelines, hence, reported in a standard manner.

- This study will assess the quality of model reporting of each study using a questionnaire, which will be tailored to this study based on The Strengthening of the Reporting of Observation Studies in Epidemiology (STROBE) guidelines.
- This study will only review studies published in English and may miss any studies written in other languages, but initial search results show that this is not substantial to impact on its outcomes.

INTRODUCTION

Great progress has been made globally in reducing the high rates of child mortality and morbidity attributed to vaccine- preventable diseases [1]. However, outbreaks of these diseases continue to threaten global health and well-being. When these outbreaks occur, outbreak response interventions may be organized to control, or halt disease spread. There are numerous interventions for preventing and controlling outbreaks of vaccine-preventable diseases. Immunization is one of the most cost-effective [2]. Additionally, a diversity of other interventions exist for complementing vaccination, but their implementation depends on the disease type, epidemic size, intervention timing, and budget allocation[3]. For instance, during outbreaks of diseases like Smallpox and Ebola, a combination of contact tracing, isolation, quarantine, and vaccination have been employed to effectively control the pathogen[4–6]. More generally, case management and vaccination are used concurrently to reduce transmission and disease-related mortality during outbreaks of vaccine- preventable diseases [7].

Outbreak response interventions have many public health and economic benefits. Vaccination particularly helps increase population-level immunity, preventing illness and death, and reduce productivity losses due to illness [8]. For outbreaks of diseases like measles that are part of the routine immunization schedule, outbreak response vaccination campaigns serve as an opportunity to immunize individuals who were missed by routine vaccination [9].

Many uncertainties surround outbreak response campaigns. For example, how large the target susceptible population is. Accurate knowledge of the susceptible population size is useful for planning in terms of how many vaccines to import, teams to dispatch, and so forth. Unfortunately, this kind of pertinent data is not readily available. Uncertainties about population size before or during an outbreak has been a subject of a few modelling studies[10]. Even though such an uncertainty cannot be eliminated, models can be used to pursue such questions to manage the uncertainty prior to planning a response campaign.

Dynamical models are useful for understanding many aspects of outbreaks[11–13]. Particularly, outbreak response intervention models are an application of dynamical models for studying efficient ways of controlling outbreaks. They have three general applications, namely forecasting of epidemic spread, analysing of disease surveillance, and assessment of intervention impact [14]. They are widely employed for investigating the potential impact of reactive interventions, identifying and assessing strategies that help achieve efficient interventions, and for considering future intervention decisions[13,15]. Over the past few decades, there has been a rise in the use of outbreak response intervention models for informing response strategies, decision-making and policy[12,16]. In fact, a recent theme issue by the Philosophical Transactions of the Royal Society acknowledged this rise in their use and highlighted some current work done for out- breaks of humans, animals and plants[14].

There is a need to review the current state of the approach to outbreak response intervention modelling. This will help us identify best practices, draw parallels in approach, and ascertain gaps in knowledge. A systematic review is one way to achieve these objectives. It is our aim to conduct this systematic review for models of human vaccine-preventable diseases because this study forms part of a larger project, where we are using models to identify efficient strategies for responding to measles outbreaks in hard-to-reach populations. We

believe that some of our findings from this review will be transferable to the animal disease outbreak modelling literature. To ascertain this, we will review the modelling literature on the control of outbreaks of foot-and-mouth disease [17–19] because of the rich lessons we can learn from that literature as well. This systematic review will be useful to disease modelers, both novice and expert, and policymakers who may already be using or considering the use of models for decision-making.

Objectives

1. Our primary objective is to systematically review the literature on models of outbreak response intervention for human vaccine-preventable diseases to:
    a. Summarize similarities and differences in modeling approaches
    b. Identify knowledge gaps
    c. Ascertain best modeling practices
2. The secondary objective is to identify lessons from the foot-and-mouth disease outbreak modeling literature that are applicable to the modeling of human vaccine- preventable disease outbreaks.

METHODS

In conducting this review, we will adhere to the criteria listed in the Preferred Reporting of Items in Systematic Reviews and Meta- Analyses, PRISMA statement[20,21]. A Supplementary file contains the populated checklist for the protocol [see Supplementary file 1].

For this systematic review, we describe as outbreak response intervention models all mechanistic models that have been developed to investigate the impact of any intervention to the outbreak of a vaccine-preventable disease affecting hu- mans. Moreover, following a similar definition of "mechanistic model" [22,23], we will only consider models that describe the disease's individual- or population-level transmission dynamics by incorporating its biological mechanisms or natural history with some form of equation.

Study registration

This study has been submitted for registration on PROSPERO with the receipt ID 160803.

Eligibility criteria

Here, we describe the criteria for article selection.

Type of studies

We will consider studies containing a mechanistic model for assessing interventions mounted during an outbreak of any of the vaccine-preventable diseases listed on the left column of Table 1. This table contains the World Health Organization's (WHO) published list of human vaccine-preventable diseases[24]. Even though Ebola is not on the list provided by the WHO, we will include it in our search because the developmental vaccine has been used for outbreak response in Central, East, and West Africa [25].

Table 1. The World Health Organization (WHO) list of diseases with an available vaccine.

Cholera	Mumps
Dengue	Pertussis
Diphtheria	Pneumococcal disease
Hepatitis A	Poliomyelitis
Hepatitis B	Rabies
Hepatitis E	Rotavirus
Haemophilus influenzae type b (Hib)	Rubella
Human papillomavirus (HPV)	Tetanus
Influenza	Tick-borne encephalitis

Japanese encephalitis	Tuberculosis
Malaria	Typhoid
Measles	Varicella
Meningococcal meningitis	Yellow Fever

We will limit the studies to those published in English. For the search period restriction, the beginning date limit will be based on how far back the database can be searched and the upper limit will be December 15, 2019.

Type of intervention

We will consider reactive interventions, that is, responses mounted because of an outbreak, such as vaccination, quarantine, isolation, palliative care, education, and others indicated in the articles.

Outcomes

The primary outcome will be a summary of the outbreak response modeling landscape. We will obtain this in terms of the diseases and interventions studied, classes of models used, mathematical or statistical approaches for incorporating the intervention(s), and method used to analyze/evaluate the model and intervention. Other outcomes will be the types of equations used, the conclusions drawn from the models, study limitations stated, and recommendations provided.

Information sources

We will search through the following sources:

1. Bibliographic databases: Scopus, PubMed, and Web of Science
2. Preprint: bioRxiv.org, and medRxiv.org
3. Grey literature: Google Scholar

Search strategy

We have developed search strings for the three bibliographic databases. Details of the search strings can be found in the Supplementary file 2. To validate the search string, we used a list of known references from the literature and found that the strings capture all the relevant articles.

Preprint servers do not support Boolean searches, making it difficult to pre-define the exact search procedure. We will, therefore, hand search the Preprint servers with keywords such as ``outbreak response'', “model”, and their synonyms. The final procedure will be reported in the Systematic review.

To identify relevant grey literature, we will search through Google Scholar, which supports Boolean searches, and websites of epidemic response organizations that are known (or likely) to use modelling in understanding outbreaks, for example, the Centers for Disease Control and Prevention (CDC). We will also contact authors from cited unpublished literature in the studies we will identify from the peer reviewed and preprint literature.

STUDY RECORDS

Data management

The initial search results will be imported into EndNote X7.8 (endnote.com) for deduplication. Following that, the Rayyan web-tool (https://rayyan.qcri.org/) will be used for the study selection. The KoboToolbox web-tool (https://www.kobotoolbox.org/) will be used to extract the data from included studies. The extracted data will be exported in a comma-separated values format for further analyses. All post-processing of the exported data, including visualisations will be performed with the R language (https://www.r-project.org/).

Selection process

In the first stage, one reviewer will peruse the preprints and grey literature search results to ascertain whether any have been published as peer-reviewed articles. The reviewer will achieve this using the author names and working titles. If any of such exist, the reviewer will remove the preprint/grey literature version from the search results and record the number of removed records. If any uncertainties arise, the reviewer will consult the other reviewers. Following that, the reviewer will remove the duplicates from the total resulting records, using EndNote X7.8. With the aid of the Rayyan web-tool the three reviewers will screen the titles and abstracts, and if necessary, full text of resulting articles using the inclusion/exclusion criteria listed below.

Inclusion

1. Disease appears in Table 1 or is foot-and-mouth disease
2. Uses a mechanistic model
3. Studies an intervention to an outbreak
4. Uses a mechanistic model for describing the intervention
5. Paper written in English

Exclusion

1. Reviews, whether peer-reviewed or not
2. Not a human vaccine-preventable disease listed in Table 1 or foot-and-mouth disease
3. Not describing an outbreak
4. Does not use a model
5. Model is not mechanistic according to our definition
6. Not written in English
7. Full-text unobtainable after contacting the school librarian, and the corresponding author

Data collection process

We will develop a data extraction form according to the items in Supplementary file 3. We will initially pilot the form to resolve any confusing fields or terminologies. Before the full-blown data extraction, all reviewers will pilot the process with an article on each of the distinct diseases from the included articles. The pilot phase will help ensure we capture any form of non-standard practice across the various disease models. We will split the data collection task among three of the reviewers, who will work independently. We will combine the resulting data after every number of articles, and clarify any confusions encountered, through discussion.

DATA ITEMS

Three reviewers will extract the data from each included article according to the data items outlined in the Supplementary file 3 provided. If any disagreements arise from the data extraction process, we will resolve it through discussions with the other co-authors.

QUALITY ASSESSMENT

The three reviewers undertaking the study appraisal and data extraction will assess each study individually with a quality of model reporting questionnaire we will design based on the STROBE guidelines[26,27]. In case of confusion or disagreement, we will resolve it through discussion, and if need be, confer with the other two reviewers through a piloted version.

DATA

Synthesis

We will report in a narrative style, comparing groups of articles sharing common approaches and themes.

For example, we will discuss which articles employed deterministic models compared to stochastic models, and so forth. These groupings will also be summarized in a citation table. In addition, we will study the included studies from the foot-and-mouth disease, and the human vaccine-preventable disease outbreaks literature to highlight their commonalities and differences with the human disease models. This will help complement any best practices we will provide as an outcome of this review for the human disease modelling community.

PATIENT AND PUBLIC INVOLVEMENT

No patient involved.

CONCLUSION

Outbreak response intervention models are useful for devising effective strategies for responding to outbreaks of vaccine-preventable diseases in humans. They also aid in assessing intervention strategies and decisions and how those influence pathogen transmission during outbreaks. Moreover, responding to new and emerging pathogens requires being able to transfer strategies that have worked for similar pathogens. These decisions can be tested with outbreak response models. To the best of our knowledge, the state of the art of the models and modelling techniques have not yet been systematically reviewed. Consequently, there is need for a systematic review, which provides a summary of all models that have been used to study outbreaks of vaccine-preventable diseases affecting humans. Hence, we aim to achieve this through the systematic review we will conduct with this protocol.

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DECLARATION

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Contributors

JMA is the guarantor of this manuscript. JMA and JRCP first conceived the study. JMA prepared the manuscript with the thorough intellectual feedback from JRCP, MJF, EBA, and XP. All authors read and approved the final copy of the manuscript.

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Competing interests

The authors declare that they have no competing interests.

Ethics approval

Not required.

Amendments

We will report all amendments we make to this protocol in the Systematic Review and the PROSPERO registration.

Availability of data and material

Excel sheets of the extracted data and analysis will be made publicly available as supplementary material.

Provenance and peer review

Not commissioned; externally peer reviewed.

Reporting checklist for protocol of a systematic review.

Based on the PRISMA-P guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the PRISMA-Preporting guidelines, and cite them as:

Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart LA. Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) 2015 statement. Syst Rev. 2015;4(1):1.

		Reporting Item	Page Number
Title			
Identification	#1a	Identify the report as a protocol of a systematic review	1
Update	#1b	If the protocol is for an update of a previous systematic review, identify as such	n/a (no such systematic review exists)

Registration			
	#2	If registered, provide the name of the registry (such as PROSPERO) and registration number	1
Authors			
Contact	#3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author	1
Contribution	#3b	Describe contributions of protocol authors and identify the guarantor of the review	7
Amendments			
	#4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	8
Support			
Sources	#5a	Indicate sources of financial or other support for the review	7
Sponsor	#5b	Provide name for the review funder and / or sponsor	7

Role of sponsor or funder	#5c	Describe roles of funder(s), sponsor(s), and / or institution(s), if any, in developing the protocol	7
Introduction			
Rationale	#6	Describe the rationale for the review in the context of what is already known	1-2
Objectives	#7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	2
Methods			
Eligibility criteria	#8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	3-4
Information sources	#9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	4

Search strategy	#10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	4
Study records - data management	#11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	4
Study records - selection process	#11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)	4
Study records - data collection process	#11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	4-5
Data items	#12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications	5
Outcomes and prioritization	#13	List and define all outcomes for which data will be sought, including prioritization of	4

		main and additional outcomes, with rationale	
Risk of bias in individual studies	#14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	5
Data synthesis	#15a	Describe criteria under which study data will be quantitatively synthesised	5
Data synthesis	#15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I2, Kendall's τ)	n/a (data are mostly qualitative and not appropriate)
Data synthesis	#15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)	n/a (this study is not a meta-analysis)
Data synthesis	#15d	If quantitative synthesis is not appropriate, describe the type of summary planned	5
Meta-bias(es)	#16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)	n/a (it is not the purpose of this study to assess the quality or appropriateness of the approaches used)

Confidence in cumulative evidence	#17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	n/a (the outcome of this review is not of clinical relevance)

Notes:

- 1b: n/a (no such systematic review exists)
- 15b: n/a (data are mostly qualitative and not appropriate)
- 15c: n/a (this study is not a meta-analysis)
- 16: n/a (it is not the purpose of this study to assess the quality or appropriateness of the approaches used)
- 17: n/a (the outcome of this review is not of clinical relevance) The PRISMA-P checklist is distributed under the terms of the Creative Commons Attribution License CC-BY 4.0. This checklist was completed on 03. December 2019 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai

Additional file 2: Search strategy

October 28, 2019

The following are the list of topics we created the search strings for:

1. Epidemic OR Outbreak OR Emergency OR Reactive OR Crisis
2. Respon* OR Manage* OR Control OR Interven* OR Strateg*
3. Vaccination OR Intervention OR Immuni*
4. Stochastic OR Transmission OR Computational OR Mathematical OR Mechanistic OR Statistical OR Simulat* OR "In silico" OR Dynamic*
5. Impact OR Influence
6. model*
7. Cholera OR Dengue OR Diphtheria OR Ebola OR "Foot-and-mouth" OR "foot and mouth" OR FMD OR "Hepatitis A" OR "Hepatitis B" OR "Hepatitis E" OR "Haemophilus influenzae type b" OR Hib OR "Human papillomavirus" OR HPV OR Influenza OR "Japanese encephalitis" OR Malaria OR Measles OR "Meningococcal meningitis" OR Mumps OR Pertussis OR "Whooping cough" OR "Pneumococcal disease" OR Poliomyelitis OR Polio OR Rabies OR Rotavirus OR Rubella OR Tetanus OR "Tick-borne encephalitis" OR Tuberculosis OR Typhoid OR Varicella OR Chickenpox OR "Yellow Fever" OR "vaccine-preventable"

Web of Science (Topic search)

TOPIC: (Epidemic OR Outbreak OR Emergency OR Reactive OR Crisis) AND TOPIC: (Respon* OR Manage* OR Control OR Interven* OR Strateg*)) AND TOPIC: (Stochastic OR Transmission OR Computational OR Mathematical OR Mechanistic OR Statistical OR Simulation OR In silico OR Dynamic*) AND TOPIC: (model*) AND TOPIC: (Cholera OR Dengue OR Diphtheria OR Ebola OR "Foot-and-mouth" OR "foot and mouth" OR FMD OR "Hepatitis A" OR "Hepatitis B" OR "Hepatitis E" OR "Haemophilus influenzae type b" OR Hib OR "Human papillomavirus" OR HPV OR Influenza OR "Japanese encephalitis" OR Malaria OR Measles OR "Meningococcal meningitis" OR Mumps OR Pertussis OR "Whooping cough" OR "Pneumococcal disease" OR Poliomyelitis

OR Polio OR Rabies OR Rotavirus OR Rubella OR Tetanus OR "Tick-borne encephalitis" OR Tuberculosis OR Typhoid OR Varicella OR Chickenpox OR "Yellow Fever" OR "vaccine-preventable")

Scopus (Title, abstract, keywords search)

(TITLE-ABS-KEY (epidemic OR outbreak OR emergency OR reactive OR crisis)) AND (TITLE-ABS-KEY (respon* OR manage* OR control OR interven* OR strateg*)) AND (TITLE-ABS-KEY (stochastic OR transmission OR computational OR mathematical OR mechanistic OR statistical OR simulation OR "In silico" OR dynamic*)) AND (TITLE-ABS-KEY (model*)) AND ((TITLE-ABS-KEY (cholera OR dengue OR diphtheria OR ebola OR "Foot-and-mouth" OR "foot and mouth" OR fmd OR "Hepatitis A" OR "Hepatitis B" OR "Hepatitis E" OR "Haemophilus influenzae type b" OR hib OR "Human papillomavirus" OR hpv OR influenza)) OR (TITLE-ABS-KEY ("Japanese encephalitis" OR malaria OR measles OR "Meningococcal meningitis" OR mumps OR pertussis OR "Whooping cough" OR "Pneumococcal disease" OR poliomyelitis OR polio OR rabies OR rotavirus OR rubella)) OR (TITLE-ABS-KEY (tetanus OR "Tick-borne encephalitis" OR tuberculosis OR typhoid OR varicella OR chickenpox OR "Yellow Fever" OR "vaccine-preventable")))

PubMed (Title and abstract search)

Search ((((((Epidemic OR Outbreak OR Emergency OR Reactive OR Crisis))) AND ((Response OR Management OR Control OR Intervention OR Strategies))) AND ((Stochastic OR Transmission OR Computational OR Mathematical OR Mechanistic OR Statistical OR Simulation OR "In silico" OR Dynamic*))) AND model*) AND ((Cholera OR Dengue OR Diphtheria OR Ebola OR "Foot-and-mouth" OR "foot and mouth" OR FMD OR "Hepatitis A" OR "Hepatitis B" OR "Hepatitis E" OR "Haemophilus influenzae type b" OR Hib OR "Human papillomavirus" OR HPV OR Influenza OR "Japanese encephalitis" OR Malaria OR Measles OR "Meningococcal meningitis" OR Mumps OR Pertussis OR "Whooping cough" OR "Pneumococcal disease" OR Poliomyelitis OR Polio OR Rabies OR Rotavirus OR Rubella OR Tetanus OR "Tick-borne encephalitis" OR Tuberculosis OR Typhoid OR Varicella OR Chickenpox OR "Yellow Fever" OR "vaccine-preventable"))

Google Scholar

(Epidemic OR Outbreak OR Emergency OR Reactive OR Crisis) AND (Respon* OR Manage* OR Control OR Interven* OR Strateg*) AND (Stochastic OR Transmission OR Computational OR Mathematical OR Mechanistic OR Statistical OR Simulation OR In silico OR Dynamic*) AND model* AND

(Cholera OR Dengue OR Diphtheria OR Ebola OR "Foot-and-mouth" OR "foot and mouth" OR FMD OR "Hepatitis A" OR "Hepatitis B" OR "Hepatitis E" OR "Haemophilus influenzae type b" OR Hib OR "Human papillomavirus" OR HPV OR Influenza OR "Japanese encephalitis" OR Malaria OR Measles OR "Meningococcal meningitis" OR Mumps OR Pertussis OR "Whooping cough" OR "Pneumococcal disease" OR Poliomyelitis OR Polio OR Rabies OR Rotavirus OR Rubella OR Tetanus OR "Tick-borne encephalitis" OR Tuberculosis OR Typhoid OR Varicella OR Chickenpox OR "Yellow Fever" OR "vaccine-preventable")

Additional file 3: Data items

October 28, 2019

The following information will be extracted from each of the included studies:

1. Disease(s) modelled
2. Study's main objective(s)
3. Model type: deterministic, stochastic, or a combination
4. Model type: individual-level or population-level
5. Heterogeneity:
   (a) Spatial structure: single population, meta-population, lattice-based, cellula automata, other(s) as indicated,
   (b) Age structure
   (c) Social structure
   (d) Behavioural
6. Model treatment of time: discrete, continuous, other(s) as indicated
7. Type of intervention studied: vaccination (ring, mass, targeted, prophylactic, pulse), movement restrictions, palliative care, quarantine, isolation, treatment, other(s) as indicated
8. Intervention implementation method
9. Model fitting/parametrisation/calibration method. We define model fitting/parametrisation/calibration as the process of obtaining the model's parameter values either from literature or through some kind of mathematical or statistical technique
   (a) A Bayesian approach
   (b) Method of least squares
   (c) Maximum likelihood
   (d) Values obtained from literature
   (e) Values were assumed

10. Method of model validation with some form of data. We define model validation as any procedure used to evaluate the model's suitability for the data and problem being studied.
    (a) Data was independent of that used for calibration
    (b) Model's output was compared to the independently observed data
    (c) Model's output was compared to at least one other model's output
    (d) Model was fitted and validated on the same dataset
    (e) No form of validation was performed
    (f) Validation method was unclear
11. Outcome that was measured:
    (a) Intervention coverage
    (b) Cases averted
    (c) Deaths averted/prevented
    (d) Cost-effectiveness
    (e) Cost-benefit/benefit-cost
    (f) Direct cost
    (g) Others as listed
12. Constraints considered:
    (a) Time
    (b) Budget
    (c) Teams
    (d) Other kinds of logistics, to be indicated
13. Authors' conclusion on the predicted or potential impact of the intervention
14. Timing of modelling practice: retrospective, real-time, other(s) as indicated
15. Location under study and whether the first or last author has an affiliation in the location
16. Type of publication:
    (a) A peer-reviewed research article
    (b) Preprint
    (c) Grey literature
    (d) Other (indicate)

BMJ Open

Protocol for a systematic review of outbreak response intervention models of vaccine-preventable diseases in humans, and foot-and-mouth disease in livestock

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Manuscript ID	bmjopen-2019-036172.R1
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Date Submitted by the Author:	31-Jul-2020
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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Epidemiology, Infectious diseases, Public health
Keywords:	EPIDEMIOLOGY, INFECTIOUS DISEASES, Public health < INFECTIOUS DISEASES

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Protocol for a systematic review of outbreak response intervention models of vaccine-preventable diseases in humans, and foot-and-mouth disease in livestock

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ABSTRACT

Introduction: Outbreaks of vaccine-preventable diseases continue to threaten public health, despite the proven effectiveness of vaccines. Interventions such as vaccination, social distancing, and palliative care are usually implemented, either individually or in combination, to control these outbreaks. Mathematical models are often used to assess the impact of these interventions, and for supporting outbreak response decision-making. The objectives of this systematic review, which covers all human vaccine-preventable diseases, are to determine the relative impact of vaccination compared to other outbreak interventions, and to ascertain the temporal trends in the use of modelling in outbreak response decision-making. We will also identify gaps and opportunities for future research through a comparison with the foot-and-mouth disease (FMD) outbreak response modelling literature, which has good examples of the use of modelling to inform outbreak response intervention decision-making.

Methods and analysis: We searched on PubMed, Scopus, Web of Science, Google Scholar, and some preprint servers from the start of indexing to 15/01/2020. Inclusion: modelling studies, published in English, that use a mechanistic approach to evaluate the impact of an outbreak intervention. Exclusion: reviews, and studies that do not describe or use mechanistic models, or do not describe an outbreak. We will extract data from the included studies such as their objectives, model types and composition, and their conclusions on the impact of the intervention. We will ascertain the impact of models on outbreak response decision-making through visualisation of time trends in the use of the models. We will also present our results in narrative style.

Ethics and dissemination: This systematic review will not require any ethics approval since it only involves scientific articles. The review will be disseminated in a peer-reviewed journal and at various conferences fitting its scope.

Review registration number: PROSPERO CRD42020160803.

Strengths and limitations of the study

- To the best of our knowledge, this is the first systematic review to examine studies that use mechanistic models to assess the relative benefit of vaccination compared to other outbreak interventions, and to ascertain the impact of modelling studies on policy and decision-making.

- The detailed search strategy used in this systematic review captures all human vaccine-preventable diseases.
- This review protocol is developed according to the PRISMA guidelines, hence, reported in a standard manner.
- This study will only review studies published in English and may miss any studies written in other languages, but initial search results show that this is not substantial to impact on its outcomes.

INTRODUCTION

Great progress has been made globally in reducing the high rates of child mortality and morbidity attributed to vaccine-preventable diseases [1]. However, outbreaks of these diseases continue to threaten global health and well-being. When these outbreaks occur, outbreak response interventions may be organized to control, or halt disease spread. There are numerous interventions for preventing and controlling outbreaks of vaccine-preventable diseases. Immunization is one of the most cost-effective [2]. Additionally, a diversity of other interventions exist for complementing vaccination, but their implementation depends on the disease type, epidemic size, intervention timing, and budget allocation[3]. For instance, during outbreaks of diseases like Smallpox and Ebola, a combination of contact tracing, isolation, quarantine, and vaccination have been employed to effectively control the pathogen[4–6]. More generally, case management and vaccination are used concurrently to reduce transmission and disease-related mortality during outbreaks of vaccine-preventable diseases [7].

Outbreak response interventions have many public health and economic benefits. Vaccination particularly helps increase population-level immunity, preventing illness and death, and reduces productivity losses due to illness [8]. For outbreaks of diseases like measles, whose control through vaccination is part of the routine immunization schedule, outbreak response vaccination campaigns serve as an opportunity to immunize individuals who were missed by routine vaccination [9].

Mathematical models are useful for understanding many aspects of outbreaks[10–12]. Particularly, outbreak response intervention models are an application of mathematical models for studying efficient ways of controlling outbreaks. They have three general applications, namely forecasting of epidemic spread, analysing of disease surveillance, and assessment of intervention impact [13]. They are widely employed for investigating the potential impact of reactive interventions, identifying and assessing strategies that help achieve efficient interventions, and for considering future intervention decisions[12,14]. Over the past few decades, there has been a rise in the use of outbreak response intervention models for informing response strategies, decision- and policy-making[11,15]. In fact, a recent theme issue by the Philosophical Transactions of the Royal Society acknowledged this rise in their use and highlighted some current modelling work with regards to our understanding and control of outbreaks of infectious diseases of humans, animals and plants[13]. However, we are unaware of any systematic review that as ascertained this increase in trend for all human-vaccine preventable diseases. Moreover, it is common for models to be described in the literature as being useful for informing outbreak response decision-making[16], but to the best of our knowledge, no systematic review has ascertained the degree to which this assertion is true. Hence, an objective of this review will be to assess whether models are increasingly being used to inform outbreak response decision-making and policymaking.

It is clear in the outbreak response literature that a wealth of policy-relevant models have amassed from previous efforts to control outbreaks of foot and mouth disease[17–19]. In fact, models of foot-and-mouth disease (FMD) were the first to be used for outbreak response decision-making [16,20]. Additionally, FMD outbreak response models are well-studied in epidemiological modelling and are often used to illustrate the usefulness of models in outbreak response decision-making [21]. We will, therefore, include eligible FMD modelling studies

to help us to compare the current practice of outbreak response modelling for impact assessment and decision-making in the human vaccine-preventable diseases literature.

Several systematic reviews have been conducted to describe the use of models to assess the impact of interventions on outbreaks of infectious diseases and to ascertain their impact on policy and decision-making[20,22]. However, these reviews are often focussed on a few diseases. One systematic review, for instance, explored models that assessed the impact of future vaccines on TB infection[23]. Additionally, few reviews have attempted to assess the conclusions of models on the relative benefit of vaccination compared to other outbreak interventions during outbreaks of human vaccine-preventable diseases. For example, a systematic review by Lee et al (2009) [24] compared the effectiveness of combination strategies with single strategies but the baseline intervention was not vaccination and the scope was pandemic influenza. Hence, this systematic review will identify the overall conclusion on the relative impact of vaccination compared to other outbreak interventions, when models are used as the assessment tools. This systematic review will also highlight research gaps and opportunities for future research. The main objectives for this review are informed by that of a larger project, which involves the formulation and use of models to evaluate alternative intervention strategies for responding to measles outbreaks. This review will be useful to infectious disease modelers, both novice and expert, and policymakers who may already be using or considering the use of models for decision-making.

Objectives

Our main objectives are:

1. To assess the relative impact of vaccination compared to other reactive interventions during outbreaks of human vaccine-preventable diseases, and
2. To determine whether mathematical modelling is increasingly impacting on the policy and decision-making process during outbreak response.

Additionally, our secondary objectives are:

1. To summarize similarities and differences in modelling approaches of included studies,
2. To identify knowledge gaps in modelling approaches and opportunities for advancement,
3. To identify and summarise any parallels and contrasts in approaches between the literature on foot-and-mouth disease outbreak response models.

METHODS

In conducting this review, we will adhere to the criteria listed in the Preferred Reporting of Items in Systematic Reviews and Meta-Analyses, PRISMA statement[25,26]. A Supplementary file contains the populated checklist for the protocol [see Supplementary file 1].

For this systematic review, we will consider a model as mechanistic if it describes the disease's individual- or population-level transmission dynamics by capturing its biological mechanisms or natural history with some form of mathematical equation [22,27]. Consequently, we describe as outbreak response intervention models, all mechanistic models that have been developed to investigate the impact of any intervention to the outbreak of a vaccine-preventable disease affecting humans.

Study registration

This study has been registered on PROSPERO with registration ID CRD42020160803.

Patient and Public Involvement

This research will not require the involvement of patients as the review will involve the use of secondary

information collected from modelling studies.

Eligibility criteria

Here, we describe the criteria for article selection.

Type of studies

We will consider studies containing a mathematical model, which is mechanistic based on our earlier definition, and is used for assessing vaccination and/or other interventions mounted during an outbreak of any of the human vaccine-preventable diseases listed in Table 1 below. Table 1 contains the World Health Organization's (WHO) published list of human vaccine-preventable diseases[28]. Even though Ebola is not on the list provided by the WHO, we will include it in our search because there is a vaccine, which has been used for outbreak response in Central, East, and West Africa [29] and has been modelled in the literature.

Table 1. The World Health Organization (WHO) list of diseases with an available vaccine.

Cholera	Mumps
Dengue	Pertussis
Diphtheria	Pneumococcal disease
Hepatitis A	Poliomyelitis
Hepatitis B	Rabies
Hepatitis E	Rotavirus
Haemophilus influenzae type b (Hib)	Rubella
Human papillomavirus (HPV)	Tetanus
Influenza	Tick-borne encephalitis
Japanese encephalitis	Tuberculosis
Malaria	Typhoid
Measles	Varicella
Meningococcal meningitis	Yellow Fever

We will limit the studies to those published in English. For the search period restriction, the beginning date limit will be based on how far back the database can be searched and the upper limit will be January 15, 2020.

Type of intervention

We will consider outbreak response vaccination and other outbreak interventions, that is, any responses mounted because of an outbreak, such as vaccination, social/physical distancing, quarantine, isolation, palliative care, media coverage /information campaigns, education, and others indicated in the articles.

Outcomes

The two main outcomes will be a conclusion on the temporal trends in the use of modelling as a decision-making tool during outbreak response of human vaccine-preventable diseases, and the overall conclusion on the relative benefit of vaccination and non-vaccination interventions mounted in response to outbreaks of human vaccine preventable diseases, with modelling as the tool of assessment. The secondary outcomes will include a summary of the outbreak response modelling landscape. We will obtain this in terms of the diseases and interventions studied, classes of models used, mathematical or statistical approaches for incorporating the intervention(s), and method used to analyse/evaluate the model and intervention. Other outcomes will be the types of equations used, the conclusions drawn from the models, study limitations stated, and recommendations provided.

Information sources

We will search through the following sources:

1. Bibliographic databases: Scopus, PubMed, and Web of Science

2. Preprint: bioRxiv.org, and medRxiv.org
3. Gray literature: Google Scholar

Search strategy

With feedback from the Stellenbosch University Faculty of Science Librarian, we have developed search strings for the three bibliographic databases. Details of the search strings can be found in the Supplementary file 2. To validate the search string, we used a list of known references from the literature and found that the strings capture all the relevant articles.

Preprint servers do not support Boolean searches, making it difficult to pre-define the exact search procedure. We will, therefore, hand search the Preprint servers with keywords such as ``outbreak response'', “model”, and their synonyms. The final procedure will be reported in the Systematic review.

To identify relevant grey literature, we will search through Google Scholar, which supports Boolean searches, and websites of epidemic response organizations that are known (or likely) to use modelling in understanding outbreaks, for example, the Centers for Disease Control and Prevention (CDC). We will also contact authors from cited unpublished literature in the studies we will identify from the peer reviewed and preprint literature.

STUDY RECORDS

Data management

The initial search results will be imported into EndNote X7.8 (endnote.com) for deduplication. Following that, the Rayyan web-tool[30] will be used for the study selection. The KoboToolbox web-tool (https://www.kobotoolbox.org/) will be used to extract the data from included studies. The extracted data will be exported in a comma-separated values format for further analyses. All post-processing of the exported data, including visualisations will be performed with the R language[31].

Selection process

In the first stage, one reviewer will peruse the preprints and gray literature search results to ascertain whether any have been published as peer-reviewed articles. The reviewer will achieve this using the author names and working titles. If any of such exist, the reviewer will remove the preprint/gray literature version from the search results and record the number of removed records. If any uncertainties arise, the reviewer will consult the other reviewers. Following that, the reviewer will remove the duplicates from the total resulting records, using EndNote X7.8. With the aid of the Rayyan web-tool the three reviewers will screen the titles and abstracts, and if necessary, full text of resulting articles in duplicate using the inclusion/exclusion criteria listed below.

Inclusion

1. Diseases are either listed in Table 1, Ebola or foot-and-mouth disease
2. Mathematical modelling studies
3. The mathematical model is mechanistic, that is, its structure is represented with at least one mathematical equation informed by explicit assumptions about the natural history of the disease [22]
4. The modelling study assesses the impact of an intervention during an outbreak of one of the eligible diseases
5. The study is written in English

Exclusion

1. Reviews, whether peer-reviewed or not
2. Not a human vaccine-preventable disease listed in Table 1, Ebola or foot-and-mouth disease
3. Not describing an outbreak
4. Does not formulate or use a model

5. Model is not mechanistic according to our definition above
6. Not written in English
7. Full-text unobtainable after contacting the school librarian, and the corresponding author

Data collection process

We will develop a data extraction form according to the items in Supplementary file 3. Three reviewers will initially pilot the form with an article on each of the distinct diseases from the included articles to resolve any confusion. The pilot phase will help ensure we capture any form of non-standard practice across the various disease models. Following that, the three reviewers will split the data collection task among themselves and work independently. We will combine the resulting data after every number of articles, and clarify any confusions encountered, through discussion.

DATA ITEMS

Three reviewers will independently extract the data from their share of included articles according to the data items outlined in the Supplementary file 3 provided. If any disagreements arise from the data extraction process, we will resolve it through discussions with the other two reviewers.

QUALITY ASSESSMENT

It is not the objective of this systematic review to assess the quality of the included models or to select a best or worst model or model design. We will, therefore, not be assessing the quality of the included modelling studies.

DATA

Synthesis

We will report in a narrative style, comparing groups of articles sharing common approaches and themes. The themes will include diseases modelled, classes of models, categories of objectives, and so forth. For example, we will compare which articles employed deterministic models versus stochastic models. These groupings will also be summarized in a citation table. In addition, we will study the included studies from the foot-and-mouth disease, and the human vaccine-preventable disease outbreaks literature to highlight their commonalities and differences in approach, objectives, and so on. This will help highlight any gaps and opportunities as well as recommendations we will provide as an outcome of this review for the human vaccine-preventable disease outbreak response modelling community.

ETHICS AND DISSEMINATION

This study does not require any ethics approval as we will not be collecting any primary data. We will disseminate our results through a peer-reviewed journal and conferences.

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DECLARATION

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Authors' contributions

JMA is the guarantor of this manuscript. JMA and JRCP conceived the study. JMA prepared the manuscript with the thorough intellectual feedback from JRCP, MJF, XP, and EBA. All authors read and approved the final copy of the manuscript.

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Competing interests

The authors declare no competing interests.

Ethics approval

Not required.

Amendments

We will report all amendments we make to this protocol in the Systematic Review and the PROSPERO registration.

Availability of data and material

Excel sheets of the extracted data and analysis will be made publicly available as supplementary material.

Provenance and peer review

Not commissioned; externally peer reviewed.

Reporting checklist for protocol of a systematic review.

Based on the PRISMA-P guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

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In your methods section, say that you used the PRISMA-Preporting guidelines, and cite them as:

Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart LA. Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) 2015 statement. Syst Rev. 2015;4(1):1.

		Reporting Item	Page Number
Title			
Identification	#1a	Identify the report as a protocol of a systematic review	1
Update	#1b	If the protocol is for an update of a previous systematic review, identify as such	n/a (no such systematic review exists)
Registration			
	#2	If registered, provide the name of the registry (such as PROSPERO) and registration number	1
Authors			
Contact	#3a	Provide name, institutional affiliation, e-mail address of all protocol authors;	1

		provide physical mailing address of corresponding author	
Contribution	#3b	Describe contributions of protocol authors and identify the guarantor of the review	7
Amendments			
	#4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	8
Support			
Sources	#5a	Indicate sources of financial or other support for the review	7
Sponsor	#5b	Provide name for the review funder and / or sponsor	7
Role of sponsor or funder	#5c	Describe roles of funder(s), sponsor(s), and / or institution(s), if any, in developing the protocol	7
Introduction			
Rationale	#6	Describe the rationale for the review in the context of what is already known	1-2
Objectives	#7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	2
Methods			
Eligibility criteria	#8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	3-4

Information sources	#9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	4
Search strategy	#10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	4
Study records - data management	#11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	4
Study records - selection process	#11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)	4
Study records - data collection process	#11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	4-5
Data items	#12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications	5
Outcomes and prioritization	#13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	4
Risk of bias in individual studies	#14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how	5

		this information will be used in data synthesis	
Data synthesis	#15a	Describe criteria under which study data will be quantitatively synthesised	5
Data synthesis	#15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I2, Kendall's τ)	n/a (data are mostly qualitative and not appropriate)
Data synthesis	#15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)	n/a (this study is not a meta-analysis)
Data synthesis	#15d	If quantitative synthesis is not appropriate, describe the type of summary planned	5
Meta-bias(es)	#16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)	n/a (it is not the purpose of this study to assess the quality or appropriateness of the approaches used)
Confidence in cumulative evidence	#17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	n/a (the outcome of this review is not of clinical relevance)

Notes:

- 1b: n/a (no such systematic review exists)
- 15b: n/a (data are mostly qualitative and not appropriate)
- 15c: n/a (this study is not a meta-analysis)
- 16: n/a (it is not the purpose of this study to assess the quality or appropriateness of the approaches used)
- 17: n/a (the outcome of this review is not of clinical relevance) The PRISMA-P checklist is distributed under the terms of the Creative Commons Attribution License CC-BY 4.0. This checklist was completed on 03. December 2019 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai

Supplementary file 2: Search strategy

The following are the list of topics we created the search strings for:

1. Epidemic OR Outbreak OR Emergency OR Reactive OR Crisis
2. Respon* OR Manage* OR Control OR Interven* OR Strateg*
3. Vaccination OR Intervention OR Immuni*
4. Stochastic OR Transmission OR Computational OR Mathematical OR Mechanistic OR Statistical OR Simulat* OR "In silico" OR Dynamic*
5. Impact OR Influence
6. model*
7. Cholera OR Dengue OR Diphtheria OR Ebola OR "Foot-and-mouth" OR "foot and mouth" OR FMD OR "Hepatitis A" OR "Hepatitis B" OR "Hepatitis E" OR "Haemophilus influenzae type b" OR Hib OR "Human papillomavirus" OR HPV OR Influenza OR "Japanese encephalitis" OR Malaria OR Measles OR "Meningococcal meningitis" OR Mumps OR Pertussis OR "Whooping cough" OR "Pneumococcal disease" OR Poliomyelitis OR Polio OR Rabies OR Rotavirus OR Rubella OR Tetanus OR "Tick-borne encephalitis" OR Tuberculosis OR Typhoid OR Varicella OR Chickenpox OR "Yellow Fever" OR "vaccine-preventable"

Web of Science (Topic search)

TOPIC: (Epidemic OR Outbreak OR Emergency OR Reactive OR Crisis) AND TOPIC: (Respon* OR Manage* OR Control OR Interven* OR Strateg*)) AND TOPIC: (Stochastic OR Transmission OR Computational OR Mathematical OR Mechanistic OR Statistical OR Simulation OR In silico OR Dynamic*) AND TOPIC: (model*) AND TOPIC: (Cholera OR Dengue OR Diphtheria OR Ebola OR "Foot-and-mouth" OR "foot and mouth" OR FMD OR "Hepatitis A" OR "Hepatitis B" OR "Hepatitis E" OR "Haemophilus influenzae type b" OR Hib OR "Human papillomavirus" OR HPV OR Influenza OR "Japanese encephalitis" OR Malaria OR Measles OR "Meningococcal meningitis" OR Mumps OR Pertussis OR "Whooping cough" OR "Pneumococcal disease" OR Poliomyelitis OR Polio OR Rabies OR Rotavirus OR Rubella OR Tetanus OR "Tick-borne encephalitis" OR Tuberculosis OR Typhoid OR Varicella OR Chickenpox OR "Yellow Fever" OR "vaccine-preventable")

Scopus (Title, abstract, keywords search)

(TITLE-ABS-KEY (epidemic OR outbreak OR emergency OR reactive OR crisis)) AND (TITLE-ABS-KEY (respon* OR manage* OR control OR interven* OR strateg*)) AND (TITLE-ABS-KEY (stochastic OR transmission OR computational OR mathematical OR mechanistic OR statistical OR simulation OR "In silico" OR dynamic*)) AND (TITLE-ABS-KEY (model*)) AND ((TITLE-ABS-KEY (cholera OR dengue OR diphtheria OR ebola OR "Foot-and-mouth" OR "foot and mouth" OR fmd OR "Hepatitis A" OR "Hepatitis B" OR "Hepatitis E" OR "Haemophilus influenzae type b" OR hib OR "Human papillomavirus" OR hpv OR influenza)) OR (TITLE-ABS-KEY ("Japanese encephalitis" OR malaria OR measles OR "Meningococcal meningitis" OR mumps OR pertussis OR "Whooping cough" OR "Pneumococcal disease" OR poliomyelitis OR polio OR rabies OR rotavirus OR rubella)) OR (TITLE-ABS-KEY (tetanus OR "Tick-borne encephalitis" OR tuberculosis OR typhoid OR varicella OR chickenpox OR "Yellow Fever" OR "vaccine-preventable")))

PubMed (Title and abstract search)

Search ((((((Epidemic OR Outbreak OR Emergency OR Reactive OR Crisis))) AND ((Response OR Management OR Control OR Intervention OR Strategies))) AND ((Stochastic OR Transmission OR Computational OR Mathematical OR Mechanistic OR Statistical OR Simulation OR "In silico" OR Dynamic*))) AND model*) AND ((Cholera OR Dengue OR Diphtheria OR Ebola OR "Foot-and-mouth" OR "foot and mouth" OR FMD OR "Hepatitis A" OR "Hepatitis B" OR "Hepatitis E" OR "Haemophilus influenzae type b" OR Hib OR "Human papillomavirus" OR HPV OR Influenza OR "Japanese encephalitis" OR Malaria OR Measles OR "Meningococcal meningitis" OR Mumps OR Pertussis OR "Whooping cough" OR "Pneumococcal disease" OR Poliomyelitis OR Polio OR Rabies OR Rotavirus OR Rubella OR Tetanus OR "Tick-borne encephalitis" OR Tuberculosis OR Typhoid OR Varicella OR Chickenpox OR "Yellow Fever" OR "vaccine-preventable"))

Google Scholar

(Epidemic OR Outbreak OR Emergency OR Reactive OR Crisis) AND (Respon* OR Manage* OR Control OR Interven* OR Strateg*) AND (Stochastic OR Transmission OR Computational OR Mathematical OR Mechanistic OR Statistical OR Simulation OR In silico OR Dynamic*) AND model* AND (Cholera OR Dengue OR Diphtheria OR Ebola OR "Foot-and-mouth" OR "foot and mouth" OR FMD OR "Hepatitis A" OR "Hepatitis B" OR "Hepatitis E" OR "Haemophilus influenzae type b" OR Hib OR "Human papillomavirus" OR HPV OR Influenza OR "Japanese encephalitis" OR Malaria OR Measles OR "Meningococcal meningitis" OR Mumps OR Pertussis OR "Whooping cough"

OR "Pneumococcal disease" OR Poliomyelitis OR Polio OR Rabies OR Rotavirus OR Rubella OR Tetanus OR "Tick-borne encephalitis" OR Tuberculosis OR Typhoid OR Varicella OR Chickenpox OR "Yellow Fever" OR "vaccine-preventable")

Supplementary file 3: Data items

The following information will be extracted from each of the included studies:

1. Disease(s) modelled
2. Study's main objective(s)
3. Model type: deterministic, stochastic, or a combination
4. Model type: individual-level or population-level
5. Heterogeneity:
   (a) Spatial structure: single population, meta-population, lattice-based, cellula automata, other(s) as indicated,
   (b) Age structure
   (c) Social structure
   (d) Behavioural
6. Model treatment of time: discrete, continuous, other(s) as indicated
7. Type of intervention studied: vaccination (ring, mass, targeted, prophylactic, pulse), movement restrictions, palliative care, quarantine, isolation, treatment, other(s) as indicated
8. Intervention implementation method
9. Model fitting/parametrisation/calibration method. We define model fitting/parametrisation/calibration as the process of obtaining the model's parameter values either from literature or through some kind of mathematical or statistical technique:
   (a) A Bayesian approach
   (b) Method of least squares
   (c) Maximum likelihood
   (d) Values obtained from literature
   (e) Values were assumed

10. Method of model validation with some form of data. We define model validation as any procedure used to evaluate the model's suitability for the data and problem being studied:
    (a) Data independent of that used for calibration
    (b) Model's output was compared to the independently observed data
    (c) Model's output was compared to at least one other model's output
    (d) Model was fitted and validated on the same data set
    (e) No form of validation was performed
    (f) Method was unclear
11. Outcome that was measured:
    (a) Intervention coverage
    (b) Cases averted
    (c) Deaths averted/prevented
    (d) Cost-effectiveness
    (e) Cost-benefit/benefit-cost
    (f) Direct cost
    (g) Others as listed
12. Constraints considered:
    (a) Time
    (b) Budget
    (c) Teams
    (d) Other kinds of logistics, to be indicated
13. Authors' conclusion on the predicted or potential impact of the intervention
14. Timing of modelling practice: retrospective, real-time, other(s) as indicated
15. Location under study and whether the first or last author has an affiliation in the location
16. Type of publication:
    (a) A peer-reviewed research article
    (b) Preprint
    (c) Grey literature
    (d) Other (indicate)