

Research priorities for public health and social measures to manage epidemics: a multi-method consensus study

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Abstract

Background:

Prioritizing research to address uncertainties about the effects of public health and social measures (PHSM) to manage epidemics and pandemics can help to ensure that research addresses important questions and future decisions are better informed.

Methods

We used a multi-method approach to develop a list of PHSM, identify important uncertainties about the effects of those interventions, develop priority criteria, and prioritize research questions. We developed an exhaustive list of PHSM based on a literature review and feedback from stakeholders, shortened that list based on stakeholders' top priorities, and used a nominal group technique (NGT) and methods developed by the James Lind Alliance to identify important uncertainties about the effects of those interventions. We used thematic analysis and member checking to create a list of research questions that captured the questions posed by stakeholders. Concurrently, we developed criteria for prioritising those questions based on a literature review and feedback from stakeholders. Eighteen researchers applied those criteria to prioritise questions and we sought feedback on those priorities from stakeholders. Based on this input, our research centre, the Centre for Epidemic Interventions Research (CEIR) reached a consensus.

Results

The exhaustive list included 173 interventions. This was reduced to 22 interventions based on stakeholders' top priorities. Stakeholders proposed 252 questions regarding those interventions, which we reduced to 76 questions based on a thematic analysis. Thirteen researchers used 12 criteria to prioritize questions from that list. Following feedback from stakeholders and discussion, we reached a consensus on 16 prioritized questions about the effects of PHSM.

Conclusion

The prioritized list of research questions will guide future work of the CEIR and can be used by others to inform research priorities to reduce important uncertainties about the effects of PHSM.

Background

When COVID-19 was characterized as a pandemic by the WHO in March 2020, national and local governments began implementing a variety of public health and social measures (PHSM) to contain the spread of the SARS-CoV-2 virus and its consequences. These measures included testing practices,

contact tracing, social distancing, hand washing, facemasks, travel restrictions, isolation and quarantine, and closing businesses and schools. Attempts to conduct rigorous evaluations of the effect of PHSM were limited by a number of challenges, including, the large number of participants needed,¹ ethical issues,^{1,2} issues related to consent and health research legislation, ascertaining the effects of individual interventions when a large number of interventions were implemented simultaneously,³ and controlling for other confounders in non-randomized studies. As a result, there is low- to very low-certainty evidence regarding the benefits and harms of PHSM.⁴

The Centre for Epidemic Interventions Research (CEIR) at the Norwegian Institute of Public Health has a mandate to produce high quality evidence on the effects of PHSM and non-pharmacological infection control measures to combat and prepare for epidemics and pandemics.⁵

During the COVID-19 pandemic several organizations and research teams developed lists, frameworks, and taxonomies of interventions to control and prevent the pandemic. These included, for example, the European Centre for Disease Control's list of non-pharmaceutical interventions,⁶ the World Health Organization's Global Database of PHSM during COVID-19,⁷ and a framework to classify PHSM.⁸ The interventions included in these lists vary with respect to the included interventions, how they are categorised, targeted populations, settings, and timing. Furthermore, each intervention can be implemented in many ways that are not always well described.

We have very limited knowledge regarding the benefits and harms of PHSM to prevent and control epidemics or pandemics.⁴ This is particularly concerning when interventions are disruptive to individual freedoms and community functioning.⁹ Rigorous studies of prevention and control measures to be used during an epidemic or a pandemic can provide critical evidence to inform policy and practice. Randomized trials are the best method for assessing the benefits and harms of PHSM because no other way of creating comparison groups can ensure that they are similar in terms of factors that can predict outcomes and responsiveness to the intervention, whether or not these factors are known and measured.¹⁰ However, there are few examples of randomized controlled trials studying the effectiveness of PHSM interventions.¹¹ This is especially problematic when decisions need to be made quickly regarding which interventions to implement during times of crisis: "If an encyclopedia of wrong public health decisions and poor evidence could be written for COVID-19, it must include a large share of the tens of thousands of measures taken to try to deal with the pandemic based on no evidence, weak evidence or wrong evidence."¹² It is critical that we not only develop a comprehensive overview of PHSM, but that we also develop an overview of important uncertainties regarding the positive and negative effects of these interventions.

Since the Commission on Health Research for Development published its 1990 report recommending national plans for addressing local and global health issues there has been a gradual but clear emphasis on the importance of priority setting for health research.^{13,14} Increased focus on research waste, effective use of resources, improved collaboration, avoiding duplication has shone focus on the

importance of strategy when setting the research agenda.¹⁵ Different countries or institutions may prioritize research questions based on different criteria, such as the importance of the question, availability of resources (money and people), the feasibility of conducting the research, and the likelihood that the research findings will produce real impact on decision-making processes.

Priority setting in research is a multifaceted process that entails the identification and ranking of research questions or topics based on their relevance, potential impact, and feasibility. A systematic approach to priority setting can help ensure optimal allocation of resources and promote the advancement of knowledge on topics deemed important. In a priority setting process, it is important to consider existing research, involve stakeholders, and consider relevant ethical, economic, and societal implications of establishing research priorities. Once priorities are determined, reassessment and adaptation are necessary in response to new developments and research.

Research priority setting has the potential to improve our efficiency in solving health problems.¹⁶ Various international organizations have developed lists of prioritized research questions.^{17–19} Priorities for evaluating public health and health system interventions for the Covid-19 pandemic have been developed using consensus methods²⁰ and expert consultation.¹⁹ There is not a consensus regarding which criteria should be used to prioritize research on the benefits and harms of interventions. However, while there is no agreement about involving stakeholders,²¹ there is increasing recognition of the importance of involving stakeholders in research priority setting.²² Using explicit criteria to prioritize research can potentially increase transparency and help to ensure a sound basis for priorities.^{23, 24}

Objective

The objective of this study was to prioritize research questions on the effects of PHSM for CEIR or other research groups with a similar mandate.

We addressed the following research questions:

1. What public health and social measures have been or could have been used to control an epidemic or pandemic?
2. What are the important uncertainties about the positive and negative effects of those interventions?
3. What criteria should be used to prioritize PHSM for evaluation?
4. What research questions about the effects of PHSM should CEIR prioritize?

Methods

The methods used throughout this project were informed by the James Lind Alliance Priority Setting Guidebook²⁵ and good practice guidelines for prioritizing health research.²⁰ We used the NGT²⁶ to reach a consensus regarding answers to each of the four questions. The research took place in four stages to

address the four research questions above. See Table 1 for an overview of the stages of this project and activities in each stage.

Table 1
Overview of stages of the project

Stage	Activity
1. Develop a list of public health and social measures	Search for lists of PHSM Develop an exhaustive list of PHSM interventions Gather feedback on list Shorten the list by prioritising interventions
2. Identify important uncertainties about the effects of those interventions	Solicit research questions regarding the prioritized interventions Synthesize the questions using thematic analysis
3. Develop priority criteria	Search for research priority setting criteria Develop a list of priority setting criteria Gather feedback on criteria Pilot the criteria
4. Prioritize research questions	Prioritize the research questions using the priority criteria Discuss and refine the list of questions Gather feedback on the list of questions Reach a consensus on a final list of prioritised questions

Stage 1. Develop a list of public health and social measures

Search strategy

We searched grey literature and websites of relevant national and multinational public health institutions for relevant lists and taxonomies of public health and social measures to control epidemics and pandemics. We also contacted experts to identify existing lists.

Inclusion criteria

We included taxonomies and lists of interventions for propagated, common-source and mixed epidemics, but focused primarily on interventions used to contain the COVID-19 pandemic. We included lists of general infection prevention and control measures (or standard precautions) and PHSM that are relevant only during an epidemic or a pandemic.^{27, 28} We excluded lists that primarily comprised pharmaceutical or biological interventions and excluded pharmacological and biological interventions from lists that included both PHSM and pharmaceutical or biological interventions.

Analysis

We used the WHO taxonomy for PHSM as the starting point for a list of interventions to be used in this priority setting process. This list was revised based on relevance to the Norwegian context. We expanded the list with specific categories and measures implemented in Norway to ensure that all PHSM used in Norway were included in the taxonomy. For example, we included measures to increase compliance and adherence, as well as various ways of surveillance and management of the pandemic response.

Nominal group technique for developing a list of interventions

Stakeholders

We identified 89 stakeholders representing a broad range of backgrounds and geographical settings that could give feedback on the resulting interim list of PHSM (Appendix 1). We selected stakeholders based on their experience with epidemics and pandemics, and with COVID-19 in particular. We defined stakeholders as both decision makers and researchers. The invited stakeholders can broadly be divided into five categories: (1) members of the CEIR team, (2) members of the CEIR advisory group which included researchers and decision makers from across Norway and representing sectors such as business, education, health, etc, (3) members of the Division of Infection Control the Norwegian Institute of Public Health, (4) other relevant Norwegian stakeholders, and (5) international stakeholders working in research or decision making connected to pandemic control measures. It was especially important to involve members of the Infection Control Division given their role during the COVID-19 pandemic monitoring infection rates and advising on infection prevention and control measures.

We developed a Google form to collect feedback and a corresponding set of instructions. We piloted these with relevant colleagues to assess and improve people's ability to understand and carry out the exercise.

We sent stakeholders an email invitation in May 2023 describing the research team and the goal of the project. We invited them to give feedback on the completeness and comprehensiveness of a list of public health and social measures (Appendix 1) by filling out the revised Google form (Appendix 2) and to indicate any missing interventions or where the interventions were grouped inappropriately. Consent

was assumed when the participants clicked on the link to the Google form. We also asked participants to indicate via email if they were interested in participating in subsequent feedback stages of the project.

Based on feedback, the taxonomy of PHSM was deemed too long to use in the subsequent steps of the priority setting process. To shorten the list, we asked stakeholders to indicate the three interventions that they viewed as the most important to research (from the list in Appendix 3). We piloted this exercise in meetings with two groups of colleagues. We then sent stakeholders an email invitation to fill out a Google form (Appendix 4) for assigning points in the following way: most important (3 points), second most important (2 points), and third most important intervention (1 point). We tallied the two groups' scores for each intervention to come up with a final list of interventions.

Stage 2. Identify important uncertainties about the effects of PHSM interventions

We used the NGT²⁹ and methods developed by the James Lind Alliance to guide the work in this stage. NGT is a decision-making process whereby experts can independently and collectively contribute ideas to a process, and is especially suited to processes whereby opinions may be varied and strong.³⁰ The James Lind Alliance priority setting process emphasizes engaging stakeholders in order to identify important uncertainties.²⁵

Using the list of interventions resulting from the work done in Stage 1, we solicited three research questions related to at least three of the interventions from 77 stakeholders (see Stage 1) using a Google form (see Appendix 5). When respondents suggested questions not directly linked to the list of prioritized interventions, we found the closest corresponding category of interventions for their responses.

Using thematic analysis³¹ we synthesized the questions submitted for each intervention to come up with a list of research questions for each of the prioritized interventions. We used member checking methods to ensure that the list of research questions reflected and captured the questions posed by stakeholders.³²

Stage 3. Develop priority criteria

We used a mixed-methods exploratory approach in this stage, including a literature search, brainstorming, and piloting.

Literature search

We searched published and grey literature using Google Scholar for frameworks or lists of criteria for prioritizing research questions in health or for making decisions about health policy and practice using

relevant search terms (e.g., “priority setting criteria research” and “prioritizing research questions” and “decision health framework”). We contacted experts in the field and searched reference lists of relevant reports. We considered frameworks or lists regardless of the study designs they were intended to prioritize (e.g., qualitative, randomized controlled trials, systematic reviews).

Brainstorming

We conducted a stakeholder brainstorming session with a small group of researchers to consider which priority setting criteria are most relevant and important in the context of this project. Based on this discussion and the results of the search above, we developed a list of priority criteria.

Piloting

We invited two groups of stakeholders from Stage 1 (N = 33, including the authors) plus relevant research methodologists and stakeholders with experience related to priority setting processes to give feedback on the priority setting criteria. The resulting interim list of criteria was piloted in meetings with one group of researchers (N = 9) using multiple examples of interventions. We sought feedback on the completeness of the criteria and the wording.

Consensus

Stakeholders were asked to indicate whether each criterion should be included in the final list of priority setting criteria. The outcome of these meetings was a final list of criteria for prioritizing research on the effects of PHSM.

Stage 4. Prioritize research questions

Participants

We undertook this prioritizing with two groups of stakeholders. First, 18 individuals from CEIR (including the authors) were invited to initially apply the priority-setting criteria. Thereafter, we sought feedback on the prioritized list of questions from approximately 50 researchers and stakeholders in three meetings (a mix of hybrid digital and in-person meetings made it difficult to ascertain the exact number of participants). This included individuals with expertise related to infection control in Norway and internationally.

Data collection

A group of researchers individually or in groups of two or three applied the priority-setting criteria to the list of questions identified in stage 2 (Appendix 6). Based on their assessments for each criterion, they determined two overall scores of 1–7 (1-not a priority, 7 – high priority) – one for research during an epidemic or a pandemic and one for research outside of an epidemic or a pandemic.

Data analysis

For each identified research question we calculated the average, maximum, and minimum scores. We used these scores to identify outlier responses (for any question with an average score greater or equal to 5, an outlier was defined as an individual score below 4, for any question that had an average score of 4.9 or below, an outlier was defined as an individual score of 6 or higher).

We discussed the results with the respondents. The discussion was hybrid (digital and in-person) and took place over two two-hour meetings. For each question, we started the discussion by asking respondents with an outlier response to justify their response and argue for changing the ranking of the research question.

Based on the scores and the discussions, we arrived at a list of broad questions which included more than one intervention question (e.g., In daycare and schools, what are the effects of individual and combinations of interventions, including quarantine (of a whole class/group), screening, cohorting, social distancing, hand washing, facemasks), and sub-questions focusing on specific interventions. We did not specify outcomes in the questions.

With the second larger group, participants (50 researchers and stakeholders) were provided with the list of prioritized questions, the criteria we used, and an outline of the process we used. They were asked to comment on the broad questions, to indicate whether there were any questions that did not belong on the list, and to identify any important questions that were missing from the list. They were also encouraged to send feedback following the discussion at the three meetings if they had any comments.

Finally, we invited six key stakeholders from diverse contexts (USA, Canada, Australia, United Kingdom, Ethiopia, Chile and India) to discuss the transferability of the prioritized research questions to their contexts using the TRANSFER approach.³³ We summarized the discussions and explored themes that arose in multiple discussions.

Results

Stage 1

We conducted a targeted search for relevant lists of PHSM. One researcher reviewed all published recommendations for measures to prevent the spread of COVID, as well as overviews and taxonomies of COVID measures published by the following agencies and organizations: European Centre for Disease

Prevention and Control (ECDC), US Centers for Disease Control and Prevention (CDC), World Health Organization (WHO), the Norwegian Institute of Public Health (NIPH) and the Norwegian Government (Regjeringen).

We developed an exhaustive list of 173 PHSM divided into five main categories: (1) individual measures, (2) environmental measures, (3) testing, isolation, contact tracing and quarantine, (4) social and physical distancing measures, adaptation to settings, and (5) international travel measures (Appendix 1). We received feedback from 30 stakeholders on the completeness and comprehensiveness of this list. This is an estimated number of respondents because responses were anonymous in Google forms; however, some stakeholders sent feedback via email and it is unclear if they also submitted via the Google form. We looked for identical answers between email and the Google form to remove any possible duplicate responses. No new interventions were added to the list based on this feedback.

Twenty-one respondents, including Norwegian and international researchers and Norwegian decision makers representing diverse government agencies and departments, provided a list of the three most important interventions to include in a truncated list. Based on this input, we identified 22 prioritized PHSM (Appendix 7).

Stage 2

Fifteen respondents submitted 233 research questions. Each question was categorized by us according to one of the 22 interventions and then broken down into population, intervention, comparison and outcomes. In this way we were able to identify questions with similar populations and interventions. We did not consider outcomes, based on the assumption that research protocols would include all important outcomes for the interventions being compared. Thus, each question was formulated using the following format: "What are the effects (both benefits and harms) of intervention X compared to intervention y (or no intervention) for population Y?".

Questions with similar interventions and populations were grouped together. The result of this content analysis was 76 research questions (see Appendix 8).

Stage 3

We searched for priority criteria using Google Scholar (priority criteria AND research questions) and reference searching identified publications. We identified two key publications (Fadlallah (2022)³⁴ and the GRADE Evidence-to-Decision framework³⁵) which formed the basis for our list of priority criteria.

Thirty-three respondents provided feedback on the list of priority criteria, mostly related to wording. Criteria were revised accordingly. See Table 2 for the final list of priority criteria.

Table 2
List of priority criteria

Criteria	Response option
1. This intervention is relevant in Norway. <i>Consider if this intervention has been implemented, or could it potentially be implemented, in Norway?</i>	Strongly agree Agree I don't know Disagree Strongly disagree
2. This intervention is relevant in other countries. <i>Consider if this intervention has been implemented, or could it potentially be implemented, in other countries?</i>	Strongly agree Agree I don't know Disagree Strongly disagree
3. How important is it to know about the benefits of this intervention?	Very important Important Moderately important Slightly important Not important I don't know
4. How important is it to know about the harms or burden of the intervention? <i>You can consider both the severity of the harms or burden, and how important it is to gain more information on the harms or burden.</i>	Very important Important Moderately important Slightly important Not important I don't know
5. How important is it to know about the economic consequences?	Very important Important

Criteria	Response option
	Moderately important Slightly important Not important I don't know
6. How important is it to research the impacts of this intervention on equity? <i>We are not asking if this intervention will lead to or reduce equity.</i> <i>By equity, we mean considering the possible differential effects of options on disadvantaged populations, and in relation to characteristics that are likely to be associated with disadvantage (Moberg 2018)</i>	Very important Important Moderately important Slightly important Not important I don't know
7. We could conduct a research study on this intervention in Norway during a normal season. <i>Consider both feasibility of conducting research in times of low infection (sample sizes and statistical strength of a study) and acceptability or ethical issues of conducting a study outside of a severe epidemic.</i>	Definitely Very Probably Probably Possibly Probably Not Definitely Not
8. We could conduct a research study on this intervention during a normal season in an international setting. <i>Consider both feasibility of conducting research in times of low infection (sample sizes and statistical strength of a study) and acceptability or ethical issues of conducting a study outside of a severe epidemic.</i>	Definitely Very Probably Probably Possibly Probably Not Definitely Not
9. We could conduct a research study in Norway on this intervention during a severe epidemic. <i>Consider both feasibility of conducting research in times of severe epidemics (sample sizes and statistical strength of a study) and acceptability or ethical issues of conducting a study during a severe epidemic.</i>	Definitely Very Probably Probably Possibly Probably Not

Criteria	Response option
	Definitely Not
10. We could conduct a research study on this intervention during a severe epidemic in an international setting. <i>Consider both feasibility of conducting research in times of a severe epidemic (sample sizes and statistical strength of a study) and acceptability or ethical issues of conducting a study during a severe epidemic.</i>	Definitely Very Probably Probably Possibly Probably Not Definitely Not
Comments regarding feasibility Free text response	
11. The results of feasible research on this intervention could change policies or practice?	Definitely Very Probably Probably Possibly Probably Not Definitely Not
12. Are the potential benefits of feasible research worth the cost of the research?	Definitely Very Probably Probably Possibly Probably Not Definitely Not
13. Based on these criteria, how high a priority is research evaluating the effects of this intervention outside of a pandemic?	7 - very high 6 - 5 - high 4 - 3 - Low 2 1- very low

Criteria	Response option
14. Based on these criteria, how high a priority is research evaluating the effects of this intervention during a pandemic ?	7 - very high 6 - 5 - high 4 - 3 - Low 2 1- very low
13/14a Reflecting on your answer in column P and Q, please specify the study setting you were thinking about for this judgment: - Norway, multi-country or LMICs.	
13/14b Reflecting on your answer to questions 13 and 14, please specify the study setting you were thinking about for this judgment: - population/group.	
13/14c Reflecting on your answer questions 13 and 14, please specify the outcomes that you think are most important to evaluate. Free text response	
15. What type of research should be prioritised? If a non-randomised trial, what study design should be used? Free text response	
Notes about your judgements Free text response	

Stage 4

Thirteen of the 18 invited participants applied the priority criteria to the list of 76 questions. All the respondents were members of the CEIR team. We separated the priority scores for research to be conducted during a pandemic and outside a pandemic. We set a limit of an average score of 5 for a question to be considered prioritized: Twenty questions were prioritized for research during a pandemic and six questions outside a pandemic (see Appendix 9 for an overview of scores). All respondents were invited to a discussion. No questions were promoted or downgraded following this discussion. However, questions were rephrased and combined in some cases. They were then sorted according to the setting (daycare and schools, businesses, social settings & communities) or intervention category (ventilation, communication, public participation, face masks, hand hygiene).

The final list of prioritized research questions comprises 16 broad questions and 46 sub-questions focused on specific interventions. See Table 3 for an overview, as well as an indication as to whether the main research questions could only be conducted during an epidemic or a pandemic or could be conducted outside of an epidemic or a pandemic (note that some sub-questions can be investigated outside a pandemic even where the main question is indicated for during a pandemic). Dividing questions in this way was based on the feasibility and ethics of addressing the questions outside of a pandemic. If it is feasible to address a question outside of a pandemic, we prioritised it in the latter category. The first nine questions in Table 3 address the effects of PHSM in different settings. The other seven address a type or category of interventions. The questions are not ranked or listed in order of how high a priority they are.

Table 3. Overview of prioritized research questions

During this stage, we also identified several issues that should be addressed during the preparatory work for questions that only can be addressed during a pandemic, e.g.:

- The type, degree and format of stakeholder engagement in developing a protocol and conducting a trial
- The type of appropriate study design (e.g., RCT, ITS, online trials using MessageLab – a digital platform for testing the effect of communicating research findings on the public’s understanding of findings and intended behaviour)
- The type, degree and format of communication with decision makers
- Ethical considerations
- Equity, diversity and other inclusion considerations, such as identifying important subgroups and deciding when and why it is important to include them in an analysis
- A system for updating protocols based on new and emerging evidence
- The type, degree and format of international collaboration

Context and the priority process

While we sought feedback from international stakeholders, this priority process was heavily influenced by the Norwegian context in terms of how the COVID-19 pandemic affected Norway, which interventions were feasible and acceptable in this context, and the needs of Norwegian decision makers and the Norwegian public. Using TRANSFER to consider whether the following contextual factors could influence the transferability of our list of research questions to other contexts:

- • Geographical, political and/or economic context
- • Health or welfare systems
- • Community acceptability
- • Compliance

Findings from the discussions with six key stakeholders indicated that the list of prioritized research questions is comprehensive and considered transferable to settings such as Australia, Canada, Chile, UK and USA. The main concerns when considering other transferability to these contexts were related to (1) trust in national/local authorities and (2) identify politics related to physical interventions (e.g., face masks), (3) social structures related to workforce participation and support for young families (e.g., school and daycares) (4) capacity to test (e.g., availability of self-tests), and (5) the ability of a health system to act and implement quickly, including how much preparation and practice they have had with similar situations, and the resources and logistics associated with implementation. There was thus a suggestion that we consider adding “effect of preparedness” to the list of questions. This was deemed to be a potential exploratory question under some of the included questions (e.g., questions related to nursing homes and other healthcare facilities).

For settings that implement PHSMs under resource constraints and weaker public health systems, such as India and Ethiopia, the above factors plus several additional were important to consider regarding transferability. Namely, that nursing home settings are not relevant in many lower and middle-income countries in Africa and India where aging relatives live with their families instead of in care facilities. Additionally, many African settings are often dealing with numerous epidemics simultaneously and lack the health and social structures to implement recommended and/or effective interventions. In India, numerous health care systems co-exist in the same local areas with different payment and delivery mechanisms which can complicate delivery of PHSMs. Finally, in these settings, and in some sub-groups in Chile and other higher income settings, the degree of citizen empowerment may influence the relevance and importance of many of the prioritized research questions.

Finally, a common point of feedback from stakeholders was the importance of considering different types of epidemics (e.g., illnesses that spread via aerosol vs contact) and evidence needs at different points during an epidemic or pandemic.

Discussion

The COVID-19 pandemic was characterized by quick decisions regarding prevention and control in response to a rapidly changing infection landscape. Researchers attempted to respond to decision-makers’ needs and inform policy and practice. However, the result was often ad hoc, poorly coordinated, and in some cases poorly conducted, research, with a lack of data.³⁶ There remains important uncertainty about both the benefits and harms of PHSM.⁴ An informed research agenda is a crucial step toward better preparation for the next pandemic.

This priority setting process aimed to address this issue and inform the research agenda of CEIR and other similar research groups. While research priorities are inevitably influenced by opportunities, prioritizing questions that address decision-makers’ needs can help to reduce research waste and ensure that important research gaps are addressed.

Involving decision makers and people representing different sectors (e.g. education and business) in setting priorities helped to ensure that our research priorities address the needs of people responsible for making decisions and implementing PHSM and the concerns of those affected by PHSMs. Involving people responsible for advising decision makers helped to ensure that we identified important research gaps. Involving other researchers both in Norway and in other countries also helped to ensure that our research priorities address important research gaps and that they are relevant outside of Norway.

Importantly, many PHSMs that may be valuable during an epidemic, especially those that are particularly invasive or limit freedoms, are often difficult to evaluate during pandemic times. For this reason it was important to distinguish questions that can be investigated during non-epidemic times and those that can only be examined during an epidemic.

Important limitations of the methods that we used include not having systematic reviews to inform the judgements that were made in stages 1 and 2 about uncertainties and shortening the list of interventions based on judgements made by 21 stakeholders about what they considered to be the three most important interventions from their perspective. We did not use any explicit criteria to do this, and we did not ensure that the stakeholders were representative. Consequently, some important interventions may have been left off the list of interventions used for which we solicited research questions. Finally, this project was undertaken with respiratory epidemics in mind and the findings may not be applicable to other types of epidemics. Future epidemics may involve microbes with different transmission modes and varying risks of severe illness compared to COVID-19. In contact-driven epidemics, measures like hand hygiene may take priority over airborne interventions like face masks. For other transmission modes, such as vector-borne, assessing measures like mosquito nets may be more crucial. Increased severity might necessitate prioritizing control over mitigation efforts. During high-mortality outbreaks, studies on border control or isolation will be of high demand. Our study outlines how to prioritize research questions in epidemic management, but it is important to adapt research on interventions to new situations, including emerging pathogens with pandemic potential.

Despite these shortcomings, we believe that our research priorities address a broad range of PHSM that are widely relevant, and that the questions that we have prioritized address important uncertainties about the effects of PHSM. Finally, an important limitation for some readers may be that we have focussed on the Norwegian context and needs in this process, and researchers and decision makers in other contexts may have prioritized differently.

Conclusion

The prioritized list of research questions developed in this study will guide the work of our research centre and can inform the work of other researchers and research funders. It can help reduce research waste by focusing research on questions that are important for policy and practice. It also can help to ensure effective pandemic preparedness planning by having protocols prepared in advance of a pandemic for questions about PHSM for which there currently is insufficient research to make well-

informed decisions. By undertaking the preparatory work for research questions that can only be addressed during a major epidemic or a pandemic, it will be possible to prepare protocols for research that is feasible and has a high likelihood of providing useful answers to important questions. For questions that can be addressed outside of a pandemic, we should conduct research to ensure that it will be possible to make better-informed decisions about those interventions.

Declarations

Ethics

No ethical approval was needed to conduct this research.

Conflicts of interest

None of the authors have any financial or other conflicts of interest.

Funding

No funding was received for this work.

Contributions

HMK designed the study, led data collection and analysis and wrote the manuscript. PE, TB, and AO contributed to the study design, data collection and data analysis. MB, IE, SF, AF, UG, CH, AS, SR and RS participated in data collection and analysis. All authors made comments and approved the manuscript.

Reflexivity

The research team is made up of epidemiologists (TB, PE), health services researchers (AO, HMK) and physicians (AO, TB). PE and TB were also involved in informing implementation of PHSM to prevent and control the spread of COVID-19 and monitoring infection in Norway. The researchers will be responsible for conducting some of the research identified and prioritized by this priority setting process.

All participants indicated consent by clicking on a link to the survey, or providing verbal or written consent to interviews or discussions.

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Supplementary Files

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- [Appendix1.Listofepidemicinterventionsforfeedback.xlsx](#)
- [Appendix3.Listofinterventionsfortop3.xlsx](#)
- [Appendix6.Prioritizingresearchquestions.xlsx](#)
- [Appendix7.ListofprioritizedPHSM.docx](#)
- [Appendix2.Feedbackonlistofinterventions.pdf](#)
- [Appendix8.Researchquestionssynthesisedforprioritizing.docx](#)
- [Appendix4.Top3fromlistofinterventions.pdf](#)
- [Appendix9.Researchquestionsprioritizedwithscores.docx](#)
- [Appendix5.Identifyingresearchquestionsfromprioritizedlistofinterventions.pdf](#)
- [Table.docx](#)