Drivers of risk and rapid risk assessment for communicable diseases in complex and traditional humanitarian emergencies

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Abstract

Background: Humanitarian emergencies pose significant risks for human health, especially regarding disease outbreaks. This projects unpacks the risk of outbreaks in humanitarian settings. It seeks to understand and identify outbreak risks and vulnerabilities in humanitarian emergencies, including risk factor cascades and interactions. The main aim of the project is the development of a rapid risk assessment tool for disease outbreaks in humanitarian emergencies that can be used by aid workers with no or limited health protection experience to accurately assess communicable disease risks in humanitarian emergencies.

Methods: This is a mixed-methods study with multiple stages. The first stage was the development of a theoretical model and a qualitative systematic review on communicable disease risk factors in complex emergencies. This was followed with stakeholder-level analysis in the form of a three-stage expert elicitation process on risk factors, thresholds and weights. Finally, the development of a rapid risk assessment tool based on the preliminary results was completed by validation (key-informant interviews) and inter-rater reliability testing.

Results: While humanitarian emergencies differ depending on their type and setting, the key risk factors they pose for disease outbreaks are similar: the main concerns include access to clean water, health care and contextual issues such as humanitarian access and ongoing conflict, some of which can trigger risk factor cascades. Hence, reliable and accessible rapid risk assessment is pivotal. The developed tool is suitable for use by non-expert humanitarian aid workers.

Conclusion: One of the main concerns for disease outbreak risk in humanitarian and disaster settings is that issues such as population displacement trigger risk factor cascades that further compound the disease risk and humanitarian situation. However, aid workers without prior health protection expertise can successfully conduct a rapid risk assessment for disease outbreak risk if they are equipped with a suitable tool.

Table of contents

Abstract **2**

Table of contents **3**

List of tables **5**

List of illustrations **6**

List of accompanying materials **7**

Publications included in this research project **8**

List of abbreviations **9**

Acknowledgements **10**

1. Introduction **11**

1.1. Humanitarian emergencies and humanitarian health **12**

1.1.1. Typology of humanitarian crises 12

1.1.2. Epistemology of humanitarian crises 20

1.1.3. Current humanitarian emergencies and humanitarian response 21

1.2. Humanitarian health **24**

1.2.1. Medical issues in humanitarian emergencies 24

1.2.2. Communicable diseases in humanitarian emergencies 26

1.3. Project overview **27**

1.3.1. Research questions 30

1.3.2. Methodology 32

1.3.3. Ethics 38

2. Drivers of risk and vulnerability towards communicable diseases in humanitarian emergencies – A Pressure and Release Model for outbreak risk in humanitarian emergencies **40**

2.1. Introduction **40**

2.2. Key concepts **43**

2.3. The original PAR Model **46**

2.4. A PAR model for outbreaks in humanitarian crises **47**

2.4.1. Drivers of vulnerability to communicable diseases in humanitarian emergencies . 50

2.4.2. Drivers of risk of communicable diseases in humanitarian emergencies 51

2.5. The Crisis-Outbreak Progression **54**

2.6. Conclusion **58**

3. Study 1: Systematic review of risk factors and risk factor cascades for communicable diseases in complex humanitarian emergencies **60**

3.1. Context **60**

3.2. Risk factors and risk factor cascades for communicable disease outbreaks in complex humanitarian emergencies: a qualitative systematic review **61**

3.2.1. Abstract 61

3.2.2. Introduction 62

3.2.3. Methods 63

3.2.4. Results and discussion 66

3.2.5. Conclusion 82

4. Study 2: Expert elicitation for risk factors for communicable disease outbreaks in humanitarian emergencies 83
4.1. Context 83
4.2. Risk factors for communicable diseases in humanitarian emergencies and disasters: Results from a three-stage expert elicitation 84
4.2.1. Abstract 84
4.2.2. Introduction 85
4.2.3. Methods 86
4.2.4. Results 88
4.2.5. Discussion 102
4.2.6. Conclusion 104

5. Study 3: Rapid risk assessment tool development and validation 106
5.1. Context 106
5.2. Rapid risk assessment for communicable diseases in humanitarian emergencies: validation of a rapid risk assessment tool for communicable disease risk in humanitarian emergencies 107
5.2.1. Abstract 107
5.2.2. Introduction 108
5.2.3. Methods 112
5.2.4. Results 115
5.2.5. Discussion 121
5.2.6. Conclusion 124

6. Discussion 126
6.1. Main findings 126
6.1.1. Summary of main findings 126
6.1.2. Triangulation 128
6.1.3. Answers to research questions 129
6.2. Limitations and weaknesses of the thesis 136
6.3. Wider Discussion: The context of communicable disease outbreaks in humanitarian crises 139

7. Conclusion 150
7.1. Final personal reflections 152
7.2. Recommendations and implications for science and policy 153
7.3. Suggested future research 154

References 157

Appendix A: Publication List 171

Appendix B: Examples of the print and digital versions of the rapid risk assessment tool 173

Appendix C: Tool guide 176

Appendix D: Original versions of published papers included in the thesis 183

List of tables

Table 1: Comparison of emergency types used in this thesis with disaster groups and main types according to EM-DAT: 14
Table 2: Comparison of emergency types in this thesis and types according to other prominent typologies (Checci and Roberts; Utstein): 18
Table 3: Assessment of emergency severity based on mortality according to Redmond:..... 21
Table 4: Most common medical issues in humanitarian emergencies and the impact humanitarian emergencies have on them:..... 25
Table 5: Non-exhaustive, not ranked list of the most common communicable diseases in humanitarian emergencies and their importance in humanitarian emergencies:..... 26
Table 6: Overview of study methods: 32
Table 7: Definitions of key terms for risk: 41
Table 8: List of articles included in the analysis: 69
Table 9: Email Listservs (n=11), with affiliations and characteristics of targeted individuals (n=16): 87
Table 10: List of the selected 20 most critical risk factors irrespective of emergency type and setting:..... 90
Table 11: Weighted averages of the importance of the risk factors in humanitarian emergencies and disasters, irrespective of emergency type and setting:..... 92
Table 12: Summary of yellow and red thresholds for 9 quantifiable risk factors: 95
Table 13: Median values for the weights of the selected risk factors in different types of emergencies: 100
Table 14: Mean values for the weights for the risk factors in different emergency types (standard deviations in brackets): 101
Table 15: Risk factors and sub-factors (items) in tool: 111
Table 16: Main elements of the rapid risk assessment tool:..... 112
Table 17: Completion time for both scenarios:..... 116
Table 18: Item and group validation for scenario 1 (line-by-line and group-by-group comparison of the answers of all four groups for scenario one in comparison with the answer sheet): 118
Table 19: Item and group validation for scenario 2 (line-by-line and group-by-group comparison of the answers of all four groups for scenario two in comparison with the answer sheet): 120
Table 20: Overall weighted risk scores for all groups compared against answer sheet:..... 121

List of illustrations

Figure 1: Overview of the research project. 28
Figure 2: Conceptual steps of the PhD project. 29
Figure 3: Thesis research questions and methods situated on a continuum of research questions and methods of data collection and analysis. 34
Figure 4: Vulnerability-focused outbreak risk model (adapted PAR model for health emergencies). 49
Figure 5: The progression of vulnerability for communicable disease outbreak risk in humanitarian emergencies. 52
Figure 6: The Crisis-Outbreak Progression. 56
Figure 7: Search strategy in Medline. 65
Figure 8: PRISMA diagram. 67
Figure 9: Mass population displacement cascade (blue denoting risk factors that have been identified to directly trigger additional cascades). 76
Figure 10: Insecurity cascade (blue denoting risk factors that have been identified to directly trigger additional cascades). 79
Figure 11: Distribution of mean weights in different emergency types. 99
Figure 12: Tool development process. 110
Figure 13: Risk factor triangulation. 128
Figure 14: Tool content validation and triangulation. 129
Figure 15: Simplified, mono-directional version of the Crisis-Outbreak-Progression without feedback loops 151
Figure 16: Overview of the stages of the PhD project and the possible further research based on them. 155

List of accompanying materials

Accompanying materials submitted in digital format:

1. Original published papers
    a. Theories and Concepts Paper
    b. Systematic Review Paper
    c. Expert Elicitation Paper
    d. Validation Paper

2. Supplementary Files Chapter 4 – Expert Elicitation Paper
    a. SF-1: Survey 1
    b. SF-2: Survey 2
    c. SF-3: Survey 3
    d. SF-4: Correlation table for risk factors across all emergency types

3. Supplementary Files Chapter 5 – Validation Paper
    a. SF-5: Rapid risk assessment tool digital version
    b. SF-6: Rapid risk assessment tool print version
    c. SF-7: Tool guide

Publications included in this research project

Hammer, CC, Brainard, J, Hunter, PR (2019) 'Rapid risk assessment for communicable diseases in humanitarian emergencies: validation of a rapid risk assessment tool for communicable disease risk in humanitarian emergencies', *Global Biosecurity*, 1(2):1-11.

Hammer, CC, Brainard, J, Innes, A, Hunter, PR (2019) '(Re-) Conceptualising vulnerability as a part of risk in global health emergency response: Updating the pressure and release model for global health emergencies', *Emerging Themes in Epidemiology*, 16(2):1-8.

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List of abbreviations

ADF	Allied Democratic Forces
AIDS	Acquired Immune Deficiency Syndrome
CASPER	Community Assessment for Public Health Emergency Response
CDC	Centers for Disease Prevention and Control
CHE	Complex Humanitarian Emergency
CMR	Crude Mortality Rate
DRC	Democratic Republic of the Congo
EM-DAT	International Disaster Database
EVD	Ebola Virus Disease
EWARN	Early Warning and Response Network
HCW	Health Care Worker
HIV	Human Immunodeficiency Virus
IBBS	International Bibliography of the Social Sciences
IDP	Internally Displaced Person
IHA	InterEuropean Human Aid Association
L1	Level 1
L2	Level 2
L3	Level 3
MONUC	Mission de l'Organisation des Nations Unies en République démocratique du Congo/United Nations Mission in the Democratic Republic of Congo
MONUSCO	Mission de l'Organisation des Nations unies pour la stabilisation en République démocratique du Congo/United Nations Organization Stabilization Mission in the Democratic Republic of the Congo
MSF	Médcins Sans Frontièrs (Doctors Without Borders)
NGO	Non-Governmental Organisation
OCHA	Office for the Coordination of Humanitarian Affairs
PAR	Pressure and Release
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
R_0	Basic Reproductive Number
R2P	Responsibility ot Protect
TB	Tuberculosis
UN	United Nations
UNHCR	Office of the United Nations High Commissioner for Refugees
UNICEF	United Nations International Children's Emergency Fund
UNSC	United Nations Security Council
WASH	Water, Sanitation, and Hygiene
WHO	World Health Organization

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1. Introduction

The main aim of this thesis is to unpack how communicable disease risk in humanitarian emergencies is driven by socio-political, contextual and structural vulnerabilities, and to utilise this understanding to develop a rapid risk assessment tool for communicable disease outbreak risk in humanitarian emergencies. In 2000, Whitman wrote: "But so many of the environments in which human populations now find themselves – natural and political – greatly complicate both epidemiological assessment of risk and political responses" (1). This project seeks to address this complication in one of the most complex environments – both natural and political – in which communicable diseases occur: humanitarian emergencies.

Humanitarian emergencies, including both disasters associated with natural hazards and man-made catastrophes, pose significant challenges to public health. While the academic literature on disease risks in disasters and emergencies is ever growing, there is still a gap in our understanding of how assessments of vulnerability can be used to reduce and manage communicable disease risks. There is a strong need for better evidence and conceptualisation of the risk of communicable diseases in humanitarian emergencies to inform control strategies and emergency surveillance. Both of these are based on risk assessments, which currently lack a complex understanding of risk in terms of its drivers and underlying vulnerabilities. Thus, the work presented within this thesis builds on the understanding that communicable disease occurrence and human vulnerability towards communicable diseases are based on social and contextual conditions, which determine the spread of disease and are inherently political in nature.

The thesis builds on previous work that mainly focused on communicable diseases in specific populations, most notably refugees and displaced persons (2-4). Prior work tended to focus on individual crises and settings (5-7), or individual outbreaks of communicable disease in specific emergencies (8-11). My research goes beyond this by providing a wider understanding of the complex nature of communicable disease risk. It is the first-ever systematic review of risk factors and risk factor cascades for communicable diseases in complex humanitarian emergencies (CHEs), and a comprehensive assessment of the most critical risk factors for communicable disease outbreaks in humanitarian emergencies, their thresholds and weights. The results of

this first phase of the research project informed the development of a novel rapid risk assessment tool for communicable disease risks in humanitarian emergencies, which was validated in a two-step process. The project builds on the risk approach pioneered in disaster risk reduction to conceptualise the components of risk, which can be used to measure and reduce the risk of communicable diseases in humanitarian emergencies.

At its most basic level, disaster risk reduction assumes that risk is a function of hazard and vulnerability. For the conceptual discussion, hazard in this case is the disease itself, which is constant but unknown. Therefore, the risk framework will focus on vulnerability towards the hazard. Thus, the result is a vulnerability-based risk framework. While the traditional phrasing of risk assessment and risk factors will be maintained, the factors that will form the core of this project will be those factors on the vulnerability side of risk and the rapid risk assessment tool could equally be called a rapid vulnerability assessment tool. As such, the terms 'risk factors', 'vulnerabilities' and 'drivers of risk' are mostly used interchangeably throughout this thesis. Details on their differences and definitions can be found in Chapter Two. The rapid risk assessment and the tool developed as part of this thesis can be seen as a triage approach that provides a first estimate of the overall risk of communicable disease outbreaks, as well as the most critical risk factors or drivers of such a hypothetical outbreak, thus providing an instrument of prioritisation.

1.1. Humanitarian emergencies and humanitarian health

1.1.1. Typology of humanitarian crises

There are many typologies for humanitarian crises, depending on their focus and aim. The primary divide is usually considered to be man-made versus not man-made (12, 13). The former comprises conflicts, wars, displacement crises and famines, as well as industrial accidents, while the latter refers to disasters associated with natural hazards. However, even this simple division can be contentious, especially in light of arguments that there are no such things as natural disasters, which are increasingly gaining traction (14-16).

From a positivist point of view – which seems to be the most suitable for the context of this thesis, which does not focus on the typology of emergencies and disasters – it is easiest to define emergency types by a combination of their causative mechanism and their consequences. Thus, the typology developed for the research project builds on the general classification currently used in the International Disaster Database (EM-DAT, see Table 1) (17). Sections on man-made disasters were added as they are missing from the EM-DAT database. Additionally, some of the groupings were slightly changed to make the categories more relevant to their impact on communicable disease outbreak risk.

Table 1: Comparison of emergency types used in this thesis with disaster groups and main types according to EM-DAT:

Emergency type (meta-type in brackets)	**Sub-types**	**Disaster sub-group (disaster group in brackets) according to EM-DAT (17)**	**Disaster main type according to EM-DAT (17)**
Hydro-meteorological (disaster associated with a natural hazard)	Tropical storm	Meteorological (Natural)	Storm
	Extreme weather event	Meteorological (Natural)	Storm; Extreme temperature; Fog
	Floods	Hydrological (Natural)	Flood
Geo-disaster (disaster associated with a natural hazard)	Earthquake	Geophysical	Earthquake
	Rockfall	Geophysical	Dry mass movement
	Landslide, mudslide, avalanche	Geophysical & Hydrological	Dry mass movement; Landslide
	Volcanic and limnic eruptions	Geophysical	Volcanic activity
Tsunami (disaster associated with a natural hazard)	Tsunami	Geophysical	Earthquake
Conflict (man-made)	Conflict (inter-/intra-state)	Not included	Not included
	Protracted conflict/crisis	Not included	Not included
	Complex emergency (CHE)	Not included	Not included
Displacement crisis (man-made)	Internal displacement	Not included	Not included
	External displacement	Not included	Not included
Famine (hybrid: man-made & disaster associated with a natural hazard)	Famine	Not included (only causative factors such as drought or insect infestation included)	Not included (only causative factors such as drought or insect infestation included)
Disease outbreak (disaster associated with a natural hazard)	Epidemic	Biological	Epidemic
	Pandemic	Biological	Epidemic

This typology distinguishes between disasters associated with natural hazards and other types of emergencies. Within the category of disasters associated with natural hazards, it is most sensible to distinguish emergency types by their cause, with the main groups being hydro-meteorological disasters (which also include climatological disasters and can in some typologies form between 2 and 3 different categories), geo-disasters and tsunamis. The second macro-group within the typology of humanitarian emergencies applied in this research project is those often termed 'man-made' disasters. Due to the mentioned issues with this term, it will not be used but these disasters will be considered as disasters not associated with a natural hazard. This group is formed of three sub-groups: conflicts, famines and displacement crises.

Hydro-meteorological disasters: This includes hydro-meteorological disasters, such as tropical storms, extreme weather events (usually referring to situations of extreme precipitation) and floods. For this thesis, the category of floods also includes glacial lake outburst floods, which, while being flood events, are often categorised as geo-disasters or climatological disasters because they are triggered by earthquakes and climatological processes in mountainous regions, mainly in the Himalayas but also in other mountainous areas (17, 18).

Geo-disasters: The second large group of disasters associated with natural hazards is geo-disasters, which include earthquakes and dry and wet mass movements such as landslides, mudslides and avalanches, as well as volcanic and limnic eruptions.

Tsunamis: Tsunamis could be counted among geo-disasters as they are usually triggered by underwater landslides or earthquakes (19, 20). Hence, they are often classified together with earthquakes as geo-disasters (17). However, regarding their public health impact they have more in common with floods. Due to this dual nature, tsunamis are considered a distinct category within the disasters associated with natural hazards for the purpose of this thesis.

Conflicts: Conflicts can include a wide range of issues both on a national and on an international level. As such, the conflict category includes both inter- and intra-state warfare in all its forms, including civil war and insurgency, protracted crises – emergencies lasting for ten years or longer, leading to a state of often low-level, continued insecurity – and CHEs. CHEs are defined by the United Nations (UN) as situations of widespread insecurity and conflict leading to a partial or complete

collapse of normal societal order, requiring a multi-facetted, multi-agency, international response (21). They form a distinct sub-category of the conflict category, as they are caused initially by conflict and then develop into situations of increasing complexity.

Displacement crises: Displacement crises describe situations such as refugee or internally displaced person (IDP) camps. They also cover displacement into non-traditional settings, for example urban settings, that have been much less studied to date. While this type of emergency is usually secondary to another emergency, from a public health and especially from a communicable disease control point of view, they are too distinct to be summarised under the causative emergency.

Famines: The final category among the disasters not associated with a natural hazard is famines. However, famines are a hybrid category and are also associated with a natural hazard. This again is an example of how imperfect any such typology is because even though famine itself can occur without a natural hazard and is always a function of human failure it can of course be associated with situations of prolonged drought.

An additional category exists for biohazards/biological disasters, mainly for emergencies caused by a communicable disease outbreak (with minor categories for animal accidents and insect infestations) (17). However, such emergencies are not included in the analysis as this project focuses on communicable disease outbreaks secondary to another type of humanitarian emergency. Other emergency types excluded from the analysis presented in this thesis include extra-terrestrial hazards and industrial hazards such as industrial and transport accidents (17). These were not included as they are unlikely to result in the type of humanitarian crisis discussed here.

Other typologies

Other prominent typologies include those developed by Checci and Roberts, which distinguish between ‘sudden natural disasters’, ‘acute emergencies’ and ‘slowly evolving, chronic, or intermittent emergencies’ (13). This distinction, based along mortality lines, taking into consideration both crude mortality rates and causes, is certainly sensible for the purpose of health assessments and the assignment of timeliness for those assessments, as described by the Evaluation Unit of Doctors

Without Borders/Médecins Sans Frontières (MSF) (22). However, it remains too crude for a detailed assignment of weights of individual risk factors and progressions of vulnerability, as has been done as part of this project. The modified Utstein typology (12) shares many commonalities with the typology used in this thesis, but it lacks details on some of the types of emergencies relevant to rapid risk assessment for communicable disease outbreaks and maintains the problematic natural versus man-made divide (12). Checci and Roberts' and the modified Utstein approaches are, however, mirrored in the typology applied here as most types outlined correspond to one of the categories described by Checci and Roberts and in the modified Utstein typology (see Table 2).

Table 2: Comparison of emergency types in this thesis and types according to other prominent typologies (Checci and Roberts; Utstein):

Emergency pheno-type (meta-type in brackets)	**Sub-types**	**Type according to Checci and Roberts (13)**	**Type according to modified Utstein (12)**
Hydro-meteorological (disaster associated with a natural hazard)	Tropical storm	Sudden natural disaster	Natural: Climatic: Meteorological: High winds
	Extreme weather event	Sudden natural disaster	Natural: Climatic: Meteorological: High winds/Precipitation /Temperature extremes
	Floods (inc. Glacial Lake Outburst Flood)	Sudden natural disaster	Natural: Climatic: Meteorological: Floods & Mixed: Natural + Human-caused: Floods
Geo-disaster (disaster associated with a natural hazard)	Earthquake	Sudden natural disaster	Natural: Seismic: Earthquake
	Rockfall	Sudden natural disaster	Not included as primary form
	Landslide, mudslide, avalanche	Sudden natural disaster	Mixed: Natural + Human-caused: Landslides/ mudslides & Natural: Climatic: Meteorological: Avalanches
	Volcanic and limnic eruptions	Sudden natural disaster	Natural: Seismic: Volcanic eruption
Tsunami (disaster associated with a natural hazard)	Tsunami	Sudden natural disaster	Natural: Seismic: Tsunami
Conflict (man-made)	Conflict (inter-/intra-state)	Acute emergency	Man-made: Conflict (interhuman): Armed Conflict: Conventional War/Armed conflict/Civil strife
	Protracted conflict/crisis	Slowly evolving, chronic, or intermittent emergency	Not included as primary form
	Complex emergency (CHE)	Acute emergency leading to slowly	Man-made: Conflict (interhuman):

		evolving, chronic, or intermittent emergency	Armed Conflict: Complex humanitarian emergency
Displacement crisis (man-made)	Internal displacement	Acute emergency leading to slowly evolving, chronic, or intermittent emergency	Not included as primary form
	External displacement	Acute emergency leading to slowly evolving, chronic or intermittent emergency	Not included as primary form
Famine (hybrid: man-made & disaster associated with a natural hazard)	Famine	Acute emergency	Not included as primary form
Disease outbreak (disaster associated with a natural hazard)	Epidemic	Acute emergency potentially leading to slowly evolving, chronic, or intermittent emergency	Mixed: Natural + Human-Caused: Health-related epidemics
	Pandemic	Acute emergency leading to slowly evolving, chronic, or intermittent emergency	Mixed: Natural + Human-Caused: Health-related epidemics

1.1.2. Epistemology of humanitarian crises

The epistemology of humanitarian crises seeks to answer the question: How do we recognise a humanitarian crisis when we see one? On a philosophical level this is a highly complex question related to visibility that has been explored in philosophical and social science research on 'seeing crisis'. However, from a humanitarian aid and epidemiology point of view, a more rational and tangible answer is needed.

At its core, an emergency – humanitarian or otherwise – can be defined as an out-of-control situation requiring intervention (23). However, this does not answer the question of how to define thresholds and recognise that a situation is out of control and hence an emergency. The main impetus for defining a humanitarian emergency has to be to distinguish it from situations of normalcy, or in epidemiological terms from the baseline. Toole and Waldman's concept of a humanitarian emergency is defined as a particular population experiencing a rise in mortality (measured in Crude Mortality Rate, CMR) to a level of twice or more of the baseline. This provides a first step for a simple quantification of humanitarian emergencies (24-26).

Table 3 gives and overview of the assessment of emergency severity based on mortality according to Redmond (27). Usually, a doubling in the baseline mortality is assumed to be a cause for concern (24-26). When assuming a baseline mortality rate of 0.5 in low-income countries (28), this corresponds to mortality rates of 1 or more per 10,000 persons per day. A further doubling of the mortality would correspond to an out-of-control emergency (27, 29-31) and a mortality rate above 4.0 would correspond to a major catastrophe (27). Estimating mortality can be done either through a retrospective mortality survey or by using an ongoing surveillance system, in cases where a humanitarian response is established (32). Realistically, CMRs will be estimated using a mixture of these two systems as – at least for the early stages of an emergency – a reliable surveillance system will most likely not be available.

Table 3: Assessment of emergency severity based on mortality according to Redmond (27):

Mortality per 10,000 population per day in adults and children of five years and older		**Mortality per 10,000 population per day in adults and children of five years and older**	
1 or less	Under control	1 or less	"Normal" in a developing country
> 1	Serious condition	< 2	Emergency under control
> 2	Out of control	> 2	Emergency in serious trouble
> 4	Major catastrophe	> 4	Emergency out of control

While these definitions do not offer any breakdown of mortality beyond all-cause mortality, research has shown that non-violent death due mainly to infectious diseases can easily outnumber violent deaths, especially in IDPs (33, 34). This has – among others – been demonstrated in the context of the Darfur conflict (34).

1.1.3. Current humanitarian emergencies and humanitarian response

The last decade has seen a high number of humanitarian crises related to conflicts and disasters, including CHEs. The current prevalence of humanitarian emergencies and crises-associated outbreaks of communicable diseases, such as diphtheria among the Rohingya refugee population in Bangladesh or cholera in the context of the Yemeni civil war, demonstrates the importance of rapid risk assessment for communicable disease outbreak risk in humanitarian emergencies. The results of this thesis seek to be applicable to the majority of humanitarian crises – excluding crises caused by a disease outbreaks. Humanitarian emergencies are currently being classified in a three level-system. In 2018, the majority of humanitarian crises and severe humanitarian crises were situated in Saharan and Sub-Saharan Africa. This does, however, not include the two ongoing CHEs in the Syrian Arab Republic and Yemen.

Current Level 1 & Level 2 emergencies (traditional humanitarian emergencies)

Level 1 (L1) crises can be seen as sub-acute crises from an international point of view. L1 emergencies are defined as situations in which the resources available in the affected country (national and/or international) enable a sufficient response (35).

Current L1 emergencies include Sudan, Somalia, Libya and Pakistan (35). Level 2 (L2) emergencies are less severe but still acute crises that require an international response beyond the response that a country office of an UN agency, fund or programme can provide (35, 36). The situation in South Sudan, for example, is currently classified as L2 (35). Together, L1 and L2 emergencies form the group of traditional humanitarian emergencies or in other words those emergencies not classified as CHEs.

The distinction between L1 and L2 emergencies is often more fluid than between L2 and L3 emergencies and many of the current humanitarian crises can be understood to be at the brink between the two levels. Such current humanitarian crises include the displacement of Muslim Rohingya from Myanmar/Burma to Bangladesh, the Ebola outbreak in the Kivu province of the DRC, where a civil war was already ongoing before the outbreak, and the continued serious humanitarian crisis in the Darfur region of Sudan. Regarding disasters associated with natural hazards, the annually recurring severe impact of hurricanes throughout the Caribbean region has had a considerable impact and will most likely continue to do so, with impacts from the 2010 hurricane season still being of importance in Haiti and destruction wrought by hurricane Maria still affecting Puerto Rico.

Current Level 3 emergencies (complex humanitarian emergencies)

Level 3 (L3) emergencies are considered out-of-control, extreme situations that require a multi-facetted international response, in other words L3s correspond to CHEs, as defined by the UN and the United Nations International Children's Emergency Fund (UNICEF) (21, 37). In 2018, the world faced with two L3 emergencies in the Syrian Arab Republic and Yemen (38). The Syria crisis, which currently impacts Syria, Lebanon, Jordan and Turkey, can be traced back to civilian (non-violent) uprisings in 2011, related to the Arab Spring Movement (39). After initially non-violent protests, the situation developed into a serious civil war, with over a quarter of a million deaths by the end of 2015 (39). The Syria crisis has created a situation of considerable internal and external displacement as well as entrapment in siege conditions.

The second L3 emergency of 2018, which continues in 2019, is the conflict in Yemen. Starting in 2014, the conflict intensified in 2015, triggering a civil war throughout the country (40). This civil war is further driven by the involvement of an Arab coalition, led

by Saud Arabia, which supports the Yemeni government with airpower (40). The involvement of a variety of actors on both sides, including secessionary, rebel and terrorist groups, further compounds the issue. Critical problems in the Yemen crisis include the lack of humanitarian access and the ongoing risk to civilians and especially also healthcare staff (40). There has been a breakdown of water, sanitation and hygiene (WASH) services, leading to the largest cholera outbreak ever recorded (41-44). Additionally, the Office for the Coordination of Humanitarian Affairs (OCHA) responded to two Corporate Emergencies in 2018, which are defined as "[w]hen the [under-secretary general/emergency response coordinator] declares a Corporate Emergency Response, all OCHA offices, branches and sections provide their full support to response activities both at [headquarters] and in the field" (38).

Humanitarian response

Some of the most prolific emergencies that have changed the way the humanitarian system operates, however, took place before the current system was instituted. These include most notably the 1994 crisis in Rwanda, which was a turning point for the humanitarian response system and one of the most striking examples of preventable death due to crisis-related communicable disease outbreaks in the refugee camps, leading to up to 41.3 deaths per 10,000 persons per day at the height of the crisis (5, 32).

The Rwanda crisis of 1994 remains one of the most pivotal humanitarian crises of the last 50 years. Not only was the underlying crisis of a devastating nature but the initial response and lack of coordination also led to additional preventable deaths and in turn to an overhaul of the humanitarian system (45). Refugees fleeing from Rwanda towards Zaire – now the Democratic Republic of the Congo (DRC) – experienced extreme rates of mortality during the summer and autumn of 1994. In early July, a cholera outbreak swept through the refugee population and before the end of this outbreak a *shigella dysentery* outbreak compounded the situation (32). Estimates of the CMR vary widely, but it is estimated that at the height of the crisis, the CMR was as high as between 25 and 50 per 10,000 persons per day and that between 58,000 and 80,000 persons died within the span of one month (5, 32, 46). While initially uncoordinated, the considerable international response led to a decrease in mortality

back to ‘normal’ emergency levels (32). Despite this seeming success, the lack of coordination and duplication of response efforts without proper assessment of the needs and risks had a devastating effect (47, 48). The crisis of 1994 and how it illustrated the shortcomings of the humanitarian system played a significant role in the development of the Sphere standards and humanitarian charter. The Sphere standards define the minimum standards and operating procedures for the humanitarian system across all areas of response (29). Additionally, the UN cluster system seeks to coordinate the humanitarian response in order to strengthen it, avoid duplication of efforts and establish clear responsibilities (49)

Any humanitarian response must follow the humanitarian imperative of assisting and relieving suffering based on need alone (50). This means following the basic humanitarian principles of humanity, neutrality, impartiality and operational independence (51). Within this framework, humanitarian assistance seeks to ensure access to five main needs for human survival: WASH, food, health care, protection, and shelter (26, 52-54).

This response is provided by different actors at different levels. The first to react to any sudden-onset disaster or crisis are always spontaneous volunteers from the affected and neighbouring communities. External response actors can be distinguished into three groups: UN and UN-affiliated organisations and actors, such as OCHA, UNICEF, or the World Health Organization (WHO); International Non-Governmental Organisations such as the Federation of the Red Cross and Red Crescent or the International Committee of the Red Cross; and Non-Governmental Organisations (NGOs), which include a multitude of organisations at all levels and of all sizes from well-known examples such as MSF and Save the Children to small, regional, and faith-based organisations, including those staffed entirely by volunteers.

1.2. Humanitarian health

1.2.1. Medical issues in humanitarian emergencies

Humanitarian emergencies can compromise the health of the population profoundly. Table 4 gives a non-exhaustive list of the most common medical issues on which humanitarian emergencies can have a detrimental effect. Medical issues to consider in

the context of a humanitarian emergency are non-communicable diseases, communicable diseases, traumatic injuries, mental health issues and issues related to maternal, women's, and child health (55, 56).

Table 4: Most common medical issues in humanitarian emergencies and the impact humanitarian emergencies have on them:

Medical Issue	**Impact of humanitarian emergency**
Non-communicable diseases	Destruction of health infrastructure, lack of/danger to health care workers, limited access to essential medicines
Communicable diseases	Destruction of health infrastructure, lack of/danger to health care workers, limited access to essential medicines, humanitarian emergencies driving risk factors
Traumatic injury	Destruction of health infrastructure, lack of/danger to health care workers, limited access to essential medicines, humanitarian emergencies driving traumatic injuries (blast injuries, gunshot wounds, injury related to inadequate shelter, etc.)
Maternal, women's, and child health issues	Destruction of health infrastructure, lack of/danger to health care workers, limited access to essential medicines
Mental health issues	Destruction of health infrastructure, lack of/danger to health care workers, limited access to essential medicines, humanitarian emergencies driving mental health issues (particularly post-traumatic stress disorder)

The specific dynamics of each of the issues and the countless conditions they cover can be vastly different. However, the effect that humanitarian emergencies have on these medical issues is similar and the main mechanisms through which humanitarian emergencies have these detrimental effects are the same. One of the key problems that humanitarian emergencies pose is the destruction of health infrastructure, coupled with a lack of health care workers (HCWs) and the potential for increased physical danger to HCWs, as well as limited access to essential medicines (57). Some issues are further exacerbated. Humanitarian emergencies can directly cause both physical and mental injury, such as blast injuries, injuries linked to debris or inadequate shelter, gunshot wounds and post-traumatic stress disorder (55, 56). Additionally,

humanitarian emergencies can trigger risk factors and risk factor cascades that significantly increase the risk of communicable disease outbreaks (58).

1.2.2. Communicable diseases in humanitarian emergencies

Communicable diseases are one of the major causes of preventable deaths in humanitarian emergencies and can account for more deaths than the original underlying emergency (34). Preventive measures to lower the risk of a communicable disease outbreak include provision of adequate shelter, safe WASH, vector control, food and nutrition, vaccination and health education (46, 59-61). Table 5 lists some of the most common and most concerning communicable diseases associated with outbreaks in crisis settings. Table 5 differentiates between the agents of diseases and the causes, as defined by Lewontin (62). This is by no means an exhaustive list. Also, depending on the setting, location and season, other diseases might be equally or even more important.

Table 5: Non-exhaustive, not ranked list of the most common communicable diseases in humanitarian emergencies and their importance in humanitarian emergencies:

Agent(s)	**Disease**	**Main mechanisms in humanitarian emergencies ('causes')**
Various	Acute respiratory infections (other)	Close quarters, inadequate shelter, no access to adequate healthcare
Vibrio cholerae	Cholera	Breakdown of WASH, close quarters
Various	Other diarrhoeal diseases	Breakdown of WASH, close quarters
Measles virus	Measles	Close quarters, breakdown of vaccination services
Mainly *Plasmodium falciparum,* also *Plasmodium vivax*	Malaria	Increased contact with vectors, breakdown of vector control, no access to bed nets
Neisseria meningitidis	Bacterial Meningitis	Close quarters, breakdown of vaccination services
Corynebacterium diphtheriae	Diphtheria	Close quarters, breakdown of vaccination services
Mycobacterium tuberculosis	TB	Close quarters
Rickettsia prowazekii	Typhus	Breakdown of WASH, close quarters
Salmonella typhi	Typhoid fever	Close quarters, breakdown of vaccination services

The two main issues to be concerned about regarding communicable diseases in humanitarian emergencies are diarrhoeal and respiratory infections (46). The most pressing concerns in humanitarian emergencies are diarrhoeal diseases such as shigella dysentery or cholera. They pose an especially high risk to children under the age of five and are closely related to WASH problems (46, 59, 61). Especially, the mixing of drinking water and human waste is a precursor to diarrhoeal disease outbreaks, but also less severe WASH problems can contribute to diarrhoeal disease outbreaks. Acute respiratory infections (which can be due to viruses or bacteria), diphtheria, measles and tuberculosis (TB) are all related to unsuitable shelter conditions (59). Most notably this includes overcrowding, bad ventilation, especially if indoor fires are used, and inadequate heating (59). Other diseases potentially of importance include conjunctivitis, dengue fever, viral hepatitis, human immunodeficiency virus (HIV)/ acquired immune deficiency syndrome (AIDS), Japanese encephalitis, leishmaniasis, louse-borne relapsing fever, scabies, sexually-transmitted infections, human African trypanosomiasis, viral haemorrhagic fevers and yellow fever (59).

1.3. Project overview

As indicated, humanitarian emergencies, including both disasters associated with natural hazards and man-made catastrophes, pose significant challenges to public health. While the academic literature on disease risks in disasters and emergencies is ever growing, there is still a gap in understanding how risk assessments based on drivers of risk, or in other words based on vulnerabilities, can be used to reduce and manage communicable disease risks. This project seeks to develop a vulnerability-based risk framework and rapid risk assessment tool for communicable diseases in humanitarian emergencies and disasters.

My research can be divided into two stages (see Figure 1). The first stage consists of the development of the conceptual and literature-based background on drivers of risk and vulnerability, risk factors and communicable disease outbreak risk in complex and traditional humanitarian emergencies. The second stage of the project sought to bring this knowledge together in the form of a rapid risk assessment tool, which was then face and content validated. Face validation sought to confirm that the tool measures what it is supposed to measure (63). Content validation sought to evaluate the

usefulness, appropriateness, relevance and suitability of the tool (64). Finally, it underwent a reliability test using inter-rater reliability testing across groups of aid workers to determine that it could be used reliably by persons with little or no health protection experience (65).

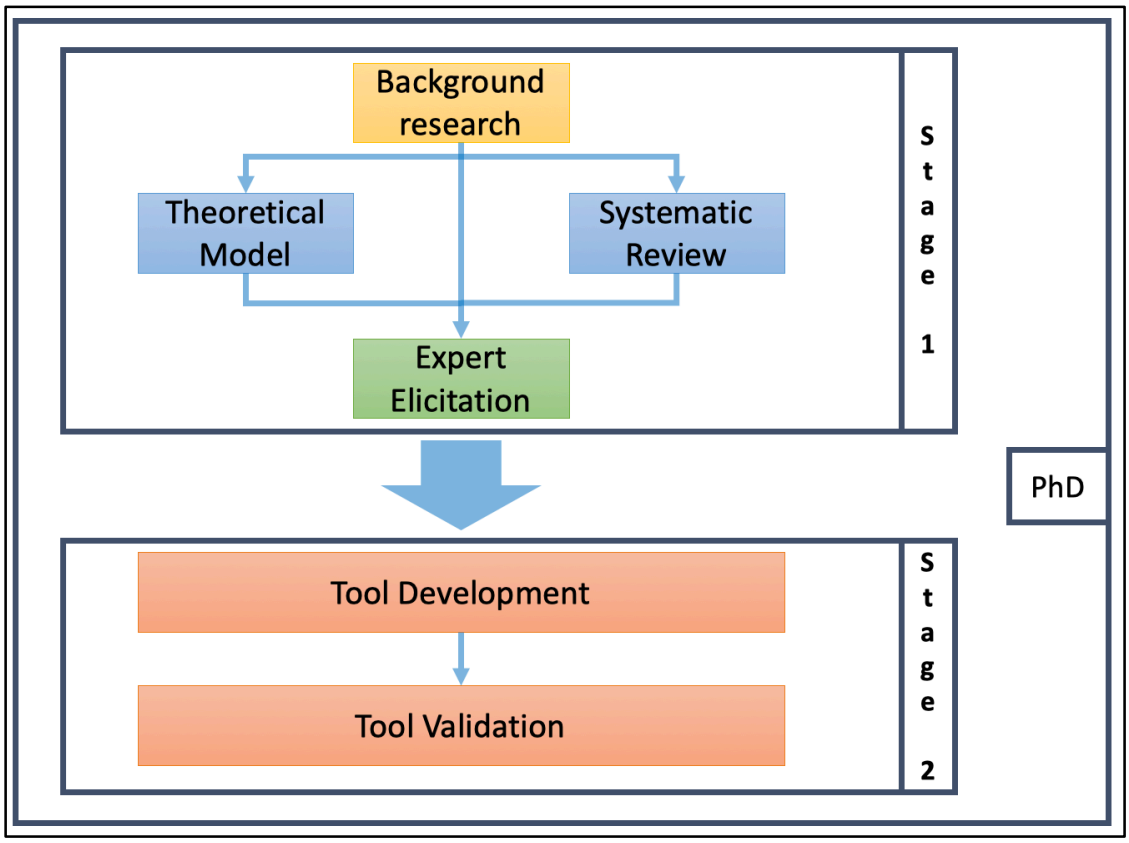

Figure 1: Overview of the research project.

These stages are further broken down into individual steps, leading from the system-wide and stakeholder analysis in stage one to the tool development, modification and validation in stage two (see Figure 2).

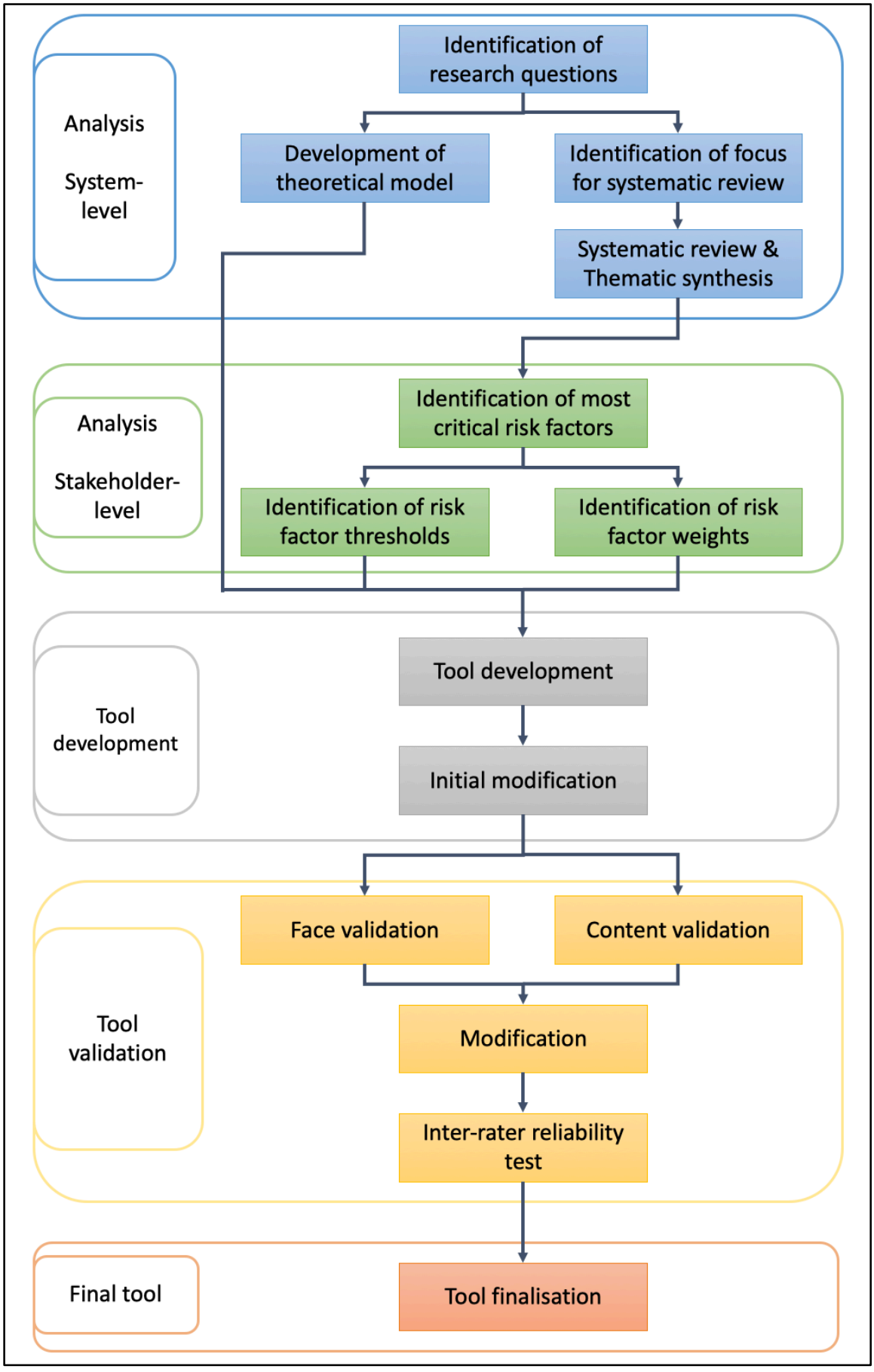

Figure 2: Conceptual steps of the PhD project.

1.3.1. Research questions

The research presented in this thesis follows four main research questions as well as an introductory research question and an additional research question regarding the implications of the answers to the previous questions. Each question is answered in one or several of the presented papers, which form the basis for the main empirical chapters of this thesis.

1. Introductory research question: How can outbreak risk in humanitarian emergencies be conceptualised in the form of drivers of risk or vulnerabilities, in order to better understand its dynamic and contextual nature?

This question regarding the theoretical and conceptual nature of communicable disease risk in humanitarian emergencies can be seen as an underlying or preliminary question, the answer to which influenced the set-up of the thesis and the approach taken to answering the four empirically answered questions. This question, while informing all chapters of this thesis, is specifically addressed in Chapter Two, which outlines the nature of the drivers of risk and vulnerability, their progression towards risk and – in interaction with the presence of a hazard (in this case a disease-causing micro-organism) – towards an outbreak.

2. What are the contextual risk factors (drivers of risk, vulnerabilities) for communicable disease outbreaks in humanitarian emergencies and disasters and how do they interact?

The second research question guiding this project is at the same time the first empirical question and can also be understood as the main research question, which is implicated in all other research questions. As such it is touched upon in all chapters, especially in the systematic review of risk factors and risk factor cascades for communicable disease outbreaks in CHEs, in the expert elicitation on the most critical risk factors in humanitarian emergencies and disasters and to some degree in the content validation of the rapid risk assessment tool. This research question mainly guided the development of the systematic review.

3. Which are the most critical risk factors for communicable disease outbreaks in humanitarian emergencies? What are their thresholds and weights in different emergency types?

Research question three directly builds on the results from research question two and seeks to narrow down these results in order to facilitate research question four. This question guided the expert elicitation on the 20 most critical risk factors for communicable disease outbreaks in humanitarian emergencies and disasters, their critical and highly critical thresholds, and their weights in different emergency types.

4. How can these risk factors be operationalised in the form of a rapid risk assessment tool?

Building on research question three and as such on the expert elicitation, research question four sought to facilitate the development of a rapid risk assessment tool. This tool was built based on the results from Chapters Three (study 1: systematic review) and Four (study 2: expert elicitation). Research question four is mainly addressed in the results of the expert elicitation, especially in the sections on thresholds and weights, as well as in the face and content validation of the tool, which form the first stage of study three, as reported in Chapter Five.

5. Can such a tool be used by aid workers with no or limited health protection experience to accurately assess communicable disease risks in humanitarian emergencies?

As the tool was designed to eliminate most subjectivity from the risk assessment process, it should ideally be suitable for aid workers with no or limited health protection or epidemiology experience. In order to answer research question five, the reliability validation of the tool, which forms the second part of study three (reported in Chapter Five) was done with volunteer aid workers who had no health protection experience.

6. Additional research question: What are the implications of this for medical humanitarianism and outbreak preparedness in humanitarian emergencies?

Research question six is an additional question, which does not form part of the empirical analysis presented in this thesis but was used as a guiding principle for considering the implications of the findings from the three studies both individually and together. Therefore, it is touched upon throughout the thesis in all empirical chapters as well as in the discussion and conclusion.

1.3.2. Methodology

Overview

This project is formed of two main stages and uses mixed methods in order to seek answers to the research questions discussed in the preceding section. This corresponds with the overview of the project presented in Figures 1 and 2. Stage one consists of a systematic review of the literature on risk factors for disease outbreaks in CHEs as well as a three-round expert elicitation. Beyond providing the wider background and the groundwork for understanding the dynamics of communicable disease outbreak risk in complex and traditional humanitarian emergencies, this stage sought to identify the components needed for the rapid risk assessment tool and to collect the data that could then be used in the tool development. Afterwards, the results of stage one have been operationalised into a rapid risk assessment tool in stage two, which has then been content and reliability validated. Thus, the methods have been selected to inform one another in the way that each included study builds on the previous study or studies and prepares for the following study or studies. Table 6 gives an overview of the methods used in each study.

Table 6: Overview of study methods:

Study	Study 1	Study 2	Study 3
Literature review	+	+	+
Systematic literature review	+		
Survey		+	
Semi-structured/key-informant interviews			+
Inter-rater reliability test			+

Rather than considering the methods used in this thesis along the traditional dichotomy of quantitative versus qualitative, which is wrought with difficulties (66, 67), the research was conducted with a methodological continuum in mind, as outlined by Gravlee (67). The research questions outlined in the previous section follow the continuum from exploratory to confirmatory just as the methods outlined below move from unstructured approaches in the thematic synthesis of the systematic review to highly structured approaches in the inter-rated reliability testing (see Figure 3). As such this project employs elements of both positivist-epidemiological and structuralist approaches.

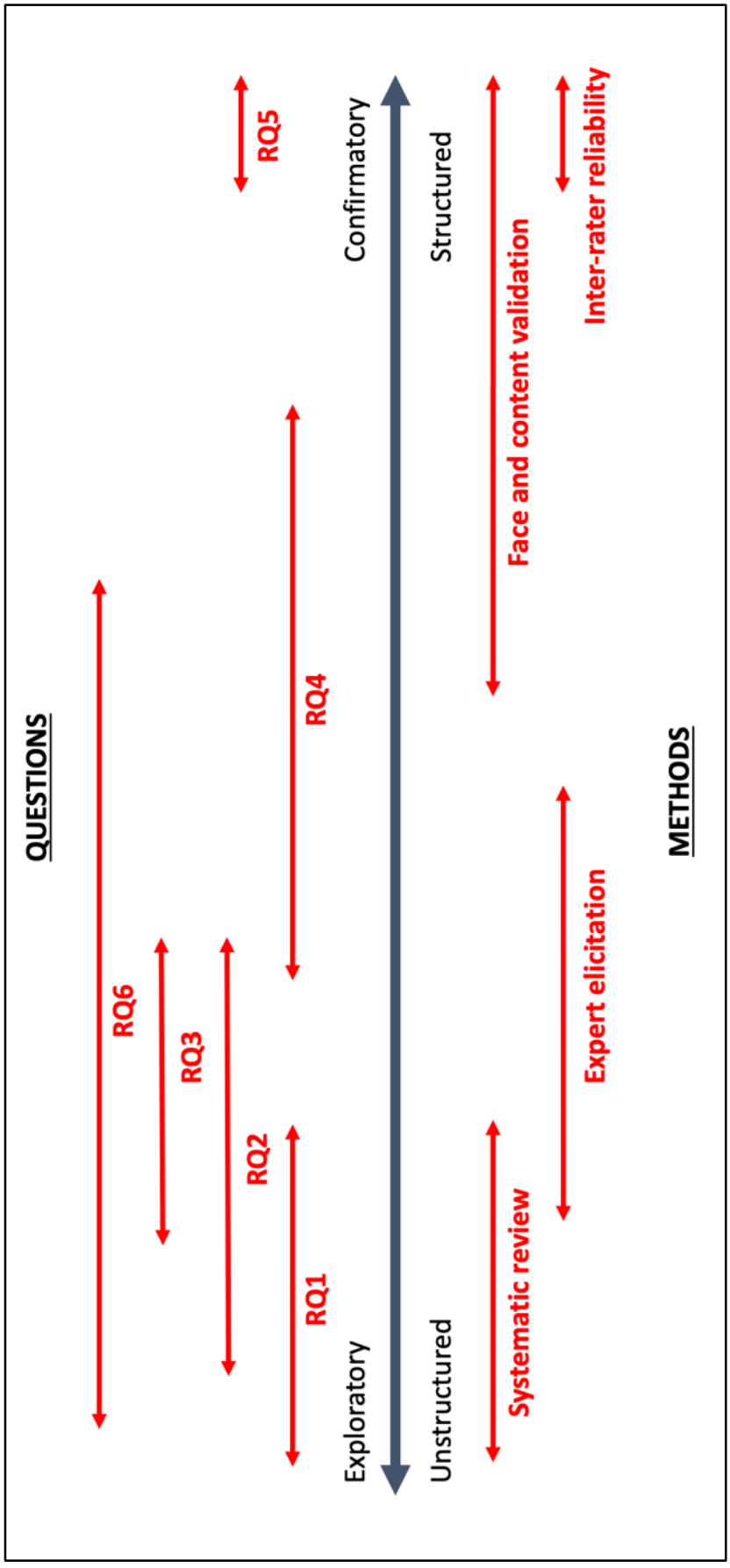

Figure 3: Thesis research questions and methods situated on a continuum of research questions and methods of data collection and analysis.

Systematic review

More detailed information regarding the methods used for the systematic review can be found in chapter 3.2.3. The systematic review of current academic and grey literature presented in Chapter Three (study 1) was conducted by applying a systematic search strategy and a thematic analysis of the results, as a mix of both quantitative and qualitative results was expected. The following databases were searched: Medline, Embase, Scopus and the International Bibliography of the Social Sciences (IBBS). Additionally, the websites of the WHO, MSF and ReliefWeb (OCHA) were also searched to identify appropriate grey literature. The references of included publications were also checked, and reviews were included. Emergencies after 1990 and publications published on or after the 1st of January 1994 were included. The search question for this literature review was: What are the risk factors for communicable diseases in complex humanitarian emergencies? The search comprised of terms for communicable diseases, including specific diseases that have very often occurred in previous CHEs, and terms for CHEs. To capture all risk factors and risk factor mechanisms that might not have been labelled as risk factors or have been mentioned as a side note, no terms for risk factors was included in the search strategy. However, they were applied as an inclusion criterion. 26 articles met the inclusion criteria. Analysis was done through thematic synthesis as relevant articles included qualitative and mixed-methods studies, which cannot be included in a meta-analysis. Thematic synthesis goes beyond mere narrative analysis and allows for the development of themes within the data, thus making the results richer and adding to the knowledge base beyond summarising the included articles.

Expert elicitation

More detailed information regarding the methods used for the expert elicitation can be found in chapter 4.2.3. The results from the literature review formed the basis for an expert elicitation process to develop a risk framework for communicable diseases in humanitarian emergencies; this forms Chapter Four (study 2). The process consisted of three rounds of online surveys asking experts from the fields of humanitarian aid and health protection about their experience and opinions regarding the most pressing risk factors, and their thresholds and weights in different emergency types. Round one of

the process was designed to identify the 20 most critical risk factors across all types of emergencies from a list compiled based on the wider literature as well as the systematic review presented in Chapter Three, based on median ranks. In the second round, the experts were consulted regarding the yellow (critical) and red (highly critical) thresholds for those risk factors that could be measured quantitatively. In the final round, the experts were asked to assign weights (on a scale from 1-5) to all risk factors identified in the first survey as being among the 20 most critical. Individual weights were assigned for different types of emergencies. Thus, the resulting risk assessment can have two scores for each factor, the first indicating which threshold level has been reached (status score) and the second indicating the weighted status as green, yellow or red (risk/priority score). The first questionnaire was completed by 21 participants; the second questionnaire was completed by 24 and the last questionnaire by 25 persons.

Tool development

More detailed information regarding the tool development can found in chapter 5.2.1. The tool development draws on the theoretical-conceptual framework (Chapter Two), the systematic review (Chapter Three) and the expert elicitation process (Chapter Four). The expert elicitation described in Chapter Four gave the main data for the development of the tool. The results from the three expert elicitation surveys were used to program a rapid risk assessment tool for communicable diseases in humanitarian emergencies in the form of an interactive excel table. The tool presents the results of the risk assessment both numerically – in the form of weighted risk scores – and visually – using a traffic light system. An early draft was further refined after reflective practice and deliberations involving the research team prior to the validation and testing process.

Content validation

More detailed information regarding the methods used for the content validation of the rapid risk assessment tool can be found in chapter 5.2.3. Chapter Five consists of the final empirical study, which builds on the results from all previous chapters. The

validation of the rapid risk assessment tool was carried out in two stages. Stage one was a face and content validation that consisted of semi-structured key-informant interviews. A total of 25 experts from humanitarian aid, health protection, medical humanitarianism and similar fields were invited to comment on the content of the tool (64) and on the face validity, which means establishing if the tool measured what it was supposed to measure (63). Participants were asked to comment on the design of the tool, regarding the layout and ease of use, the order and inclusion of risk factors, and the amount of information (i.e. the length of the tool). Additionally, risk factors and their measurements were discussed individually regarding their suitability. Based on the results from this first validation stage, the tool was adapted before the inter-rater reliability test.

Inter-rater reliability test

More detailed information regarding the methods used in the inter-rater reliability test of the rapid risk assessment tool can be found in chapter 5.2.3. In the second stage of the validation process, the inter-rater reliability of the tool was tested. The reliability testing was done in August 2018 in Thessaloniki, Northern Greece in the format of adapted focus groups with four groups of two participants each. The tool was designed so that aid workers with little or no experience in health protection would be able to consistently fill in the tool with the right information. This was tested with two hypothetical scenarios. Participant groups filled in the tool independently form one another for two scenarios – one a displacement crisis with a setting in a refugee camp and the other a response to an earthquake. Inter-rater reliability testing was done based on the filled-in tool documents provided by the participants against an answer sheet. The tool was considered reliable if agreement of 70 or more percent with the answer sheet was reached.

1.3.3. Ethics

Ethical approval was sought for two of the three empirical studies presented in this thesis. The systematic review (Chapter Three) did not deal with any human subjects and hence no ethical approval was sought.

Expert elicitation

The research study has been approved under the regulations of the University of East Anglia's Faculty of Health and Medicine Ethics Committee.

The first page of the survey was used to obtain informed consent, giving participants details about the project, about what data that was required and about the possibility to exit the form at any point. Data was only stored for completed surveys. No personal data was obtained. Once the submit button had been pressed it was no longer possible to withdraw consent as after that point the data could no longer be traced back to the individual. The responses were anonymous as no personal data was stored of any kind. The questions only concerned factual questions and opinions on factual questions, thus confidentiality was guaranteed by the data collection methods.

Tool validation

The research study has been approved under the regulations of the University of East Anglia's Faculty of Health and Medicine Ethics Committee. All participants provided written informed consent prior to participating.

Face and content validation: Participants could choose to withdraw at any point. Written and verbal informed consent was obtained prior to the start of the interview and consent could be withdrawn up until the end of the interview after which the data collected (in the form of notes made by the researcher) was saved anonymously. No questions were asked pertaining to the person of the participants (apart from general questions regarding the experience of the participants) as all questions were about the tool (examples are: Are there any drivers of vulnerability missing? Is the tool easy to use? What would you change?). All results were published open access. Participants were made aware of how they are able to access the final research outputs.

Inter-rater reliability test: The relevant organisation agreed to the cooperation. No formal ethical review exists within their organisation but the consent can be interpreted as implicit ethical clearance. Ethical clearance from Greek authorities was not sought as this is not appropriate for a project that will be conducted within less than two days and does not focus on any issues regarding the country. The NGO expected that several of their volunteers would be interested as this can be seen as a learning experience for them and as a capacity building project for the organisation. However, no pressure was put on volunteers to take part. No personal information of any kind was collected. Written and verbal informed consent was obtained from all participants prior to starting the exercise. Participants were informed about their right to not take part and their right to withdraw consent at any stage during the data collection. Once the data collection was completed the right to withdraw consent lapsed as information was at this stage no longer traceable to individual participants. All results were published open access. Participants were made aware of how they can access the final research outputs.

For both stages, any inconvenience for all participants was minimised as much as possible by reducing the time of interviews/exercises as much as possible and by making sure that the tool and its validation was relevant to their professional interests and that they can access the research outputs which are expected to be relevant to their research and professional practice.

General ethical considerations: No specific ethical issues were expected as this project is mostly technical in nature and the risk to and inconvenience of participants and researchers was minimal. Every measure has been taken for the project to not be disruptive and no personal or confidential information was collected. Working with the mentioned NGO could be considered the use of a gatekeeper, however, their role in the project was more that of a research partner than that of a gatekeeper. It is unlikely that this caused any problems as people accessed will be volunteers within the organisation who were free to participate or not as they like. No pressure was put on any participant to take part. The topics that were discussed are technical in nature and have little to no potential to cause any distress in participants. The researcher herself had previously worked with this NGO in the context that was examined and is familiar with any cultural issues that could arise. Any risks to the researcher were actively minimised and relevant travel and health insurance were in place for the second stage.

2. Drivers of risk and vulnerability towards communicable diseases in humanitarian emergencies – A Pressure and Release Model for outbreak risk in humanitarian emergencies

This chapter forms the theoretical basis for the empirical work presented in Chapters Three to Five. Parts of this chapter have been published in 2019 in *Emerging Themes in Epidemiology* (68).

2.1. Introduction

Communicable disease risk, especially in extreme situations such as humanitarian emergencies, arises from a complex network of socio-economic, structural and contextual vulnerabilities, which are difficult to adequately capture when looking at risk and risk factors in isolation. Underlying these vulnerabilities are structural drivers of vulnerability, which are reinforced by the humanitarian emergency. Conceptually, risk is only a final point in a long progression made up of drivers of vulnerability, vulnerabilities, drivers of risks and risk factors, definitions of which are given in Table 7. Understanding communicable disease risk in humanitarian emergencies has to integrate the contextual conditions – often precipitated by colonial histories – with the proximal risk factors that are traditionally the focus of infectious disease epidemiology and health protection.

Table 7: Definitions of key terms for risk:

Term	Definition (see also figure 4)
Progression of vulnerability	Process of increasing vulnerability made up of drivers of vulnerability and vulnerabilities categorised in the areas of 'Structural Violence', 'Root Causes', 'Dynamic Pressures', and 'Unsafe Conditions'.
Drivers of vulnerability	Drivers of vulnerability describe the most distant end of the progression of vulnerability, they are underlying issues that lead to the development of vulnerabilities.
Vulnerabilities	Vulnerabilities are factors and combinations of factors within the 'Root Causes', 'Dynamic Pressures', and 'Unsafe Conditions' that make a population or system more susceptible or exposed to hazard and hence more at risk.
Drivers of risk	Drivers of risk are the same as vulnerabilities but the different term underlies how they push a population or system to be more at risk. Hence, in some contexts 'rivers of risk' is a more useful term to stress this function.
Risk factors	Risk factors are the same as drivers of risk and as vulnerabilities. However, this is the term most familiar in the biomedical field and in some context – especially when speaking to biomedical audiences – the term 'risk factor' might be more suitable. While often the most proximal ends of the progression of vulnerability are most likely to be noticed as risk factors all vulnerabilities/drivers of risk are risk factors.

Learning from both the conceptual discussions underlying disaster studies and hazard geography perspectives, as well as the political economy and ecology approaches towards structural drivers of vulnerability to diseases, not only lends a new lens to understand risk differently, but such a more comprehensive approach also facilitates risk management and risk reduction in communicable disease outbreaks in humanitarian emergencies. This in turn leads to a more sustainable response. While the immediate response will no doubt be focused on proximal risk factors, a longer-term focus on drivers of vulnerabilities and drivers of risk can help to reduce the recurrence of communicable disease outbreaks and due to the most likely nature of these drivers, also address some of the underlying humanitarian issues, thus integrating the outbreak response with wider humanitarian aims.

Such an approach requires a consideration of the underlying concepts as well as the underlying structural drivers of vulnerability before analysing the communicable disease risk in humanitarian emergencies. This can be done by integrating and

adapting perspectives from a variety of fields and disciplines. While health and medicine use the term "risk" widely, its use usually lacks conceptualisation and it is often defined merely in the sense of probability. This approach may suffice for traditional individual and population health issues. However, in the context of communicable disease outbreak risk in humanitarian crises, it could benefit from a more thoroughly conceptualised addition.

The most suitable model for risk in this context comes from hazard geography and conceptualised risk in terms of its genesis from both vulnerability and hazard. The culmination of this traditional geographic approach lies in the Pressure and Release (PAR) Model (69), which forms part of the basis of the model for communicable disease risk in humanitarian emergencies presented here. The PAR model is arguably the best known and most accepted model for conceptualising risk in the context of disasters and emergencies and it offers a comprehensive and compelling framework for understanding the role of (social) vulnerability to risk. The PAR model, in the tradition of disaster studies, rightly assumes risk to be more than just the possibility of an adverse event taking place and conceptualises risk as a function of hazard and vulnerability. This more complex conceptualisation also facilitates an understanding of resilience beyond that of a 'bounce back (better)' capacity.

Current uses of risk in health and medicine

Despite the mentioned lack of conceptualisation, risk is widely used in health and medicine and is a key element in epidemiology. Examples of the use of risk in health and medicine include risk ratios (70, 71), attributable risks (70, 71), disease risks for individual patients and populations (70, 71) and comparisons of proportions of a population at risk (72). In these contexts, "[r]isk has a very similar meaning in epidemiology as it does in everyday usage – it is about chance. It is defined by Unwin et al. as 'the probability that an event will occur'. It is often used to compare the risk of an event between groups" (73). While this non-conceptual definition has merit, especially in traditional highly quantitative approaches to population health, it also comes with limitations. It omits the role of vulnerability as a key component of risk and as such it impedes risk reduction in less quantitative and data-rich situations. This in no way means that all understandings of risk (or vulnerability) in health and medicine

should be replaced by a new understanding that is more in line with that used in disaster studies. Instead, in the case of communicable disease outbreak risk in humanitarian emergencies, an additional understanding of risk could be helpful both to better identify risks and vulnerabilities and respond to them, as well as to facilitate cooperation with other actors in order to achieve comprehensive mitigation and risk reduction strategies.

2.2. Key concepts

Hazard

Understanding hazard is at the same time the starting point for understanding risk and the least controversial part of risk in the context of the PAR model and conceptualising risk. Hazard in this context is, in most cases, the natural component. Following the debates about the use and suggested discontinuation of the use of the term 'natural disaster' (14-16), hazard can be understood as the only (potentially) natural component of disasters. Hazards exist in nature and society in all forms, including traditional natural hazards such as geo-hazards (e.g. earthquakes or volcanic eruptions), hydro-hazards (e.g. tsunamis or floods), or – in the context of disease outbreak risk in any setting – biohazards (such as all disease-causing micro-organisms). The term and concept 'hazard' does, however, make no comment about the level of risk these hazards pose to humans (or animals, the environment, society, or the economy for that matter). In order to understand the potential risk associated with a hazard, the dimension of vulnerability is necessary.

Vulnerability

In order to delineate the concept of risk and its relationship with drivers of vulnerability and vulnerabilities, the concept of vulnerability needs to be fully understood in the context of the risk equation. Vulnerability lies at the heart of the conceptualisation of risk and the traditional PAR model. Vulnerability is a key component of risk and risk itself does not exist without vulnerability (74). Vulnerability can be roughly defined as a combination of exposure and susceptibility and can be applied to humans, environmental entities, and societal or even technical structures.

Traditionally, most – if not all – elements in the medical, health and epidemiology field termed 'risk factors' fall within the category of vulnerability and can be either on the exposure or on the susceptibility side. "Susceptibility is a capacity characterisable by a set of intrinsic and extrinsic factors that modify the impacts of a specific exposure upon risks/severity of outcomes in an individual or population" (75), while exposure characterises the likelihood of an encounter with the disease-causing organism and the level or strength of this encounter. Vulnerability in this context plays a part in both the likelihood and severity of disease and disease outbreaks for both individual patients and entire populations. The introduction of the concept of vulnerability is not meant to replace the concept of a risk factor but rather to offer a better understanding of why risk factors are risk factors and the underlying mechanisms of these risk factors, as well as to offer approaches to reduce the risk of diseases by reducing (human) vulnerability.

Risk

Risk is a complex concept made up of both hazard and vulnerability, even going beyond its components. Risk assumes that the interaction of hazard and vulnerability leads to disaster risk, or in this case outbreak risk, in a multiplicatory way. Beck defines risk as "the modern approach to foresee and control the future consequences of human action, the various unintended consequences of radicalized modernization. It is an (institutionalized) attempt, a cognitive map, to colonize the future" (76). While such a future-oriented approach to risk is certainly beneficial in the context of resilience and a sustainable disaster and global health emergency response, the core of risk and the need for its conceptualisation in this context lie more within its ability to give different avenues to risk reduction by unpacking the interaction between hazard and vulnerability to form risk. As such, Ewald's conclusion that "[n]othing is a risk in itself; there is no risk in reality" (74) still holds true and forms the very basis of vulnerability and hazard and their distinction from risk. This is also the basis for questioning what a risk factor is. If Ewald's understanding is to be taken seriously, risk factors will have to have a direct and significant link to vulnerabilities. In fact, upon closer inspection – considering risk factors for communicable disease outbreaks not to be features of the diseases encountered in this context – risk factors can be framed as vulnerabilities.

Considering the traditional conceptualisation of risk as a function of both hazard and vulnerability, which also forms the basis of the traditional PAR model, risk is often defined as the following:

Risk = Hazard x Vulnerability

This is not necessarily meant as a quantifiable equation but rather as a conceptual backdrop for understanding risk and its components. However, one fundamental mathematical truth plays a crucial role in this equation. The idea that without hazard or without vulnerability there is no risk is central to both the understanding of risk and the use of the traditional PAR model, as well as any further considerations of the role of vulnerability within disease outbreak risk in humanitarian emergencies and beyond. This does not assume that situations of zero vulnerability are achievable but rather focuses on the possibilities opened by acknowledging that risk reduction is possible even in situations where the hazard is unknown or unknowable. The hazard side of the equation is less of a focus for the PAR model and thus possibilities for hazard reduction are not prioritised. However, within the PAR model, a significant reduction in vulnerability leads to a significant reduction in risk and a (however hypothetical) eradication of vulnerability leads to an eradication of risk. Being able to reduce risk by being able to target multiple different aspects of it provides additional options for risk reduction, mitigation and risk management.

Resilience

While definitions of resilience are highly contested (77) and the benefit and potential harm of the concept of resilience itself has been debated in the context of neoliberal society (78-80), all definitions of resilience carry with them at least some aspects of absorbing, changing and carrying on (81) as well as recovery (82). These ideas are often augmented by conceptualisations about the ability to 'bounce back' (83) or even to emerge stronger. Schoon describes resilience as “a two-dimensional construct defined by the constellations of exposure to adversity and the manifestation of successful adaptation in the face of that risk” (84). As such, a complete conceptual understanding of risk, including its components is, if not necessary, then at least highly beneficial to understanding and thus actively fostering resilience. Active disaster risk reduction enhances resilience. While reducing the hazard (the disease-causing

organisms) is an admirable intention, it is also highly dependent on the specific type of bio-hazard. Focusing on the vulnerability side also has the advantage of offering perspectives for situations of unknown hazards. Thus, there is a need to increase focus on the vulnerability side of the risk – including both susceptibility and exposure to the hazard. This approach holds the greatest promise of producing enduring resilience and therefore a sustainable emergency response.

2.3. The original PAR Model

The original PAR model follows the understanding of risk as a function of hazard and vulnerability. The original PAR model focuses on the vulnerability side of risk and especially on factors related to susceptibility.

Components of the original PAR model

The original or traditional PAR model defines three steps to explain the progression of vulnerability: root causes, dynamic pressures and unsafe conditions (69). Each step in the progression of vulnerability builds on the step(s) before and leads to increasing pressure on the whole system. These steps, combined with the presence of hazard, lead to a risk of disaster and ultimately to disaster (69). Root causes in the original PAR model include limited access to power, limited access to structures, limited access to resources, aspects of the political system(s) and aspects of the economic system(s) (69). Root causes, as such, are at the structural level and often describe underlying situations and power dynamics that are ingrained in a society or group. According to the original PAR model, these root causes can then lead to dynamic pressures, which include lack of training, lack of local investment, lack of press freedom, rapid population change, rapid urbanisation and de-forestation (69). The root causes are mainly static and resistant to change, within the span of an emergency response. The dynamic pressures are evolving systems that can lead to increasing pressure and subsequently to unsafe conditions. Unsafe conditions include the physical environment, the local economy, social relations and public actions (69). They are, in terms of traditional health and medical terminology, the most immediate risk factors.

However, their causes lie in the preceding steps of the progression of vulnerability (69).

Critique of the original PAR model

As mentioned before, the role of exposure is not entirely clear in the original PAR model; however, it is sufficiently clear for its original uses. While the original model also lists 'viruses and pests' as potential hazards, the progression of vulnerability for those is slightly different. Most of the original factors and steps still hold true but they are insufficient to explain the progression of vulnerability towards disaster, which in this case can be defined as the outbreak of a disease, hence making an adaptation sensible for any health-related disaster event, including communicable disease outbreaks in humanitarian settings.

Other critiques of the original PAR model focus mainly on its lack of environmental focus, either expressed as a lack of focus on the role of sustainability (85) or as a lack of focus on human-environment interactions and the vulnerability of the biophysical world (86). However, these issues have since been addressed in the second version of the model. The original PAR model – and the adapted version – certainly still has a decidedly human focus, specifically a focus on human vulnerability with an underlying assumption that socio-economic vulnerability is key to risk. However, this is a suitable approach given the particularities of disease outbreaks in humanitarian crises.

2.4. A PAR model for outbreaks in humanitarian crises

While many of the assumptions made in the context of the original PAR model still hold true for the specific challenges of disease outbreaks in humanitarian emergencies, they need to be critically examined and in some places augmented by root causes, dynamic pressures and unsafe conditions that are more specific to outbreak risk. The improved understanding of the progression of vulnerability in such situations has implications for vulnerability, risk and resilience and their conceptualisation – and lack thereof – in the concept of health emergencies. Figure 4 gives an overview of the PAR model for outbreaks in humanitarian crises.

The model follows the original PAR model in its understanding of (the progression of) vulnerability. As such, vulnerability becomes a progression of root causes, dynamic pressures and unsafe conditions:

Vulnerability = Root Causes -> Dynamic Pressures -> Unsafe Conditions.

The model highlights the interaction and progressive nature of the system. Those components traditionally identified as risk factors for health emergencies are most commonly found in the third category – unsafe conditions. While these are undoubtedly the most direct risk factors, focusing on them alone risks overlooking the complex causes of these unsafe conditions or risk factors. The risk from the original equation in this context is the outbreak of a communicable disease. When considering the original equation of risk as a function of hazard and vulnerability, the model and its components as described cover the vulnerability side, with the hazard being the disease-causing micro-organism. Recall Ewald's conclusion that risk only exists with vulnerability (74). This means that, while it is improbable that all vulnerabilities in situations such as the ones mentioned above can be reduced to zero, the risk can be greatly reduced by reducing the vulnerability towards the said risk. This can be done without always needing a 'toolkit' to reduce hazard.

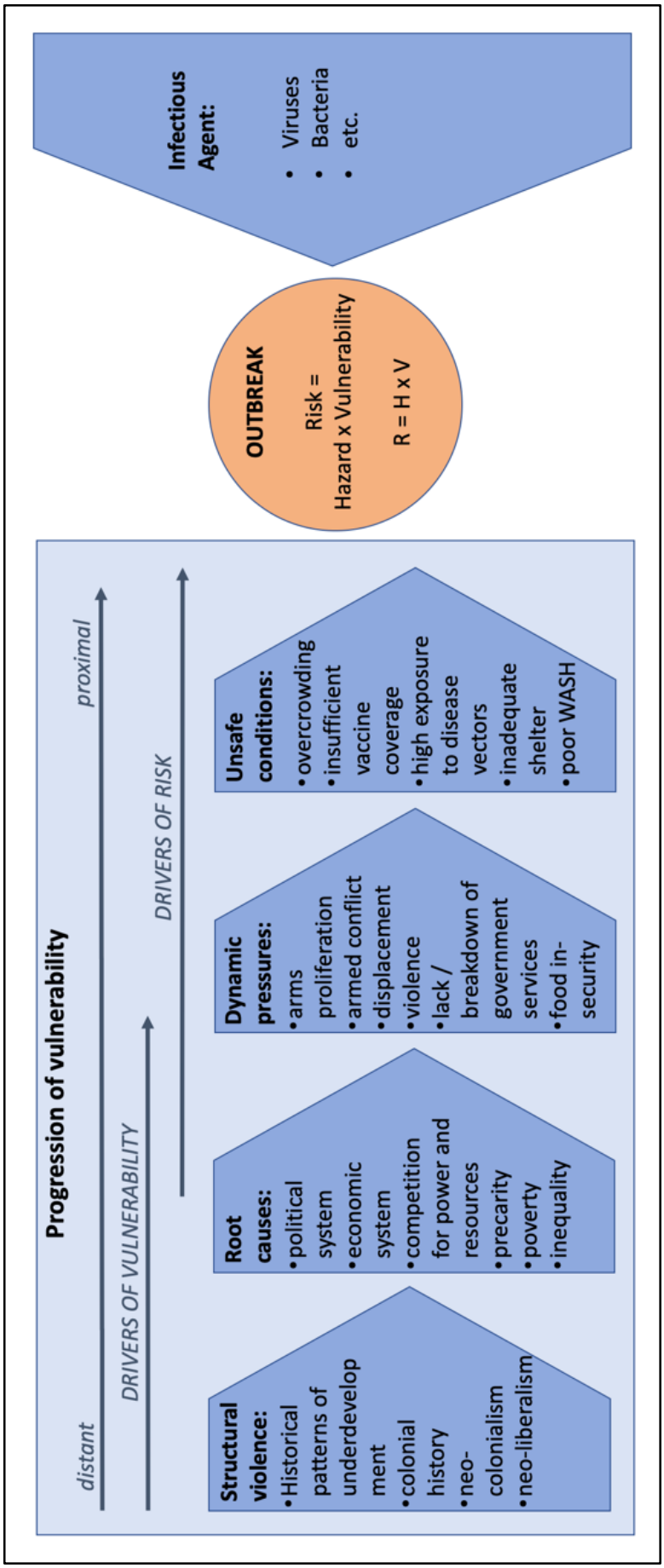

Figure 4: Vulnerability-focused outbreak risk model (adapted PAR model for health emergencies).

2.4.1. Drivers of vulnerability to communicable diseases in humanitarian emergencies

The reasons for communicable disease outbreaks – both in general and especially in humanitarian emergencies – go beyond a mere question of biology and geography. It is not just an individual's or group's characteristics, questions of demography and exposure to disease risk that lead to communicable disease outbreaks in humanitarian emergencies. The reasons why some people, or groups of people, experience disease outbreaks are rooted in a complex system of socio-political, contextual and structural forces. Craddock and Hinchliffe's (87) advice to take into consideration the political economy of vulnerability towards diseases for a One Health approach transfers also to the field of communicable diseases in humanitarian emergencies. Communicable disease outbreak risk in humanitarian emergencies does not exist in a vacuum. It is precipitated by the underlying humanitarian emergency as well as the conditions underlying the emergency itself. The drivers to be taken into consideration for understanding communicable disease vulnerability include political and economic forces (88). Such forces are the key mechanisms of structural systems of power, (in-) equity and societal relationships. These in turn have implications at the socio-cultural level. Dzingirai et al. (88) argue that it is both political economy and political ecology that provide valid lenses for understanding the structural drivers of vulnerability to zoonotic diseases in Africa. The same applies for understanding the structural drivers of vulnerability to communicable diseases in humanitarian emergencies. Political and economic factors create social vulnerabilities and structures of precarity that play important roles in the progression towards communicable disease outbreak risk (89, 90). Many of those structures can be traced back to histories of underdevelopment (91). These histories of underdevelopment can play out along marginalising societal lines as well as being reinforced within the power structures of the respective countries. Beyond this, humanitarian emergencies tend to reinforce such power structures, rooted in underdevelopment and underlying inequity. The underlying structures of those historical patterns of underdevelopment reach further back. They are rooted in colonial systems designed to benefit the colonialists rather than the population, which have reached into the present by shaping development efforts and (re-)producing vulnerabilities in systems of neo-colonialism (88). Such vulnerabilities can linger in a global climate of neo-liberalism and will be increased with any unsuccessful and/or inappropriate development aid. This in turn leads to increased

disease risk, increased risk of humanitarian emergencies occurring, and challenges when responding to such crises (92, 93). 'Structural violence' captures these underlying political economies and ecologies of vulnerability-generating political, economic and security interests and forces at their core. The term, coined by Paul Farmer (94) captures the 'pathologies of power and politics' (95, 96) within which both communicable disease outbreaks and humanitarian emergencies are generated.

Drivers of vulnerability, which can tentatively be understood in terms of 'structural violence' and 'root causes', are at the structural level and often describe underlying situations and power dynamics that are ingrained in a society or group. They are components that are unlikely to change or are even resistant to change. These conditions form the backdrop for both the humanitarian crisis and the disease outbreak, or disease outbreak risk. At the same time they are also the starting points for a progression of increasing vulnerability, which when encountered with a communicable disease leads to an outbreak. Additionally, they also serve as the conditions under which humanitarian aid and outbreak response have to operate and define the challenges encountered in those two fields.

2.4.2. Drivers of risk of communicable diseases in humanitarian emergencies

Based on an understanding of the drivers of vulnerability towards communicable disease outbreaks in humanitarian emergencies, the question arises: which proximal drivers of risk do these drivers of vulnerability influence, and how do these drivers of risk lead to communicable disease outbreaks? The distinction between drivers of vulnerabilities and drivers of risk – or in other words vulnerabilities or risk factors – is certainly a fragile one. There is a fluid progression from underlying drivers of vulnerability towards more proximal drivers of risk. Drivers of risk mostly comprise the dynamic pressures and unsafe conditions depicted in the progression of vulnerability, but they can also be found among the root causes. This can be seen in Figure 5.

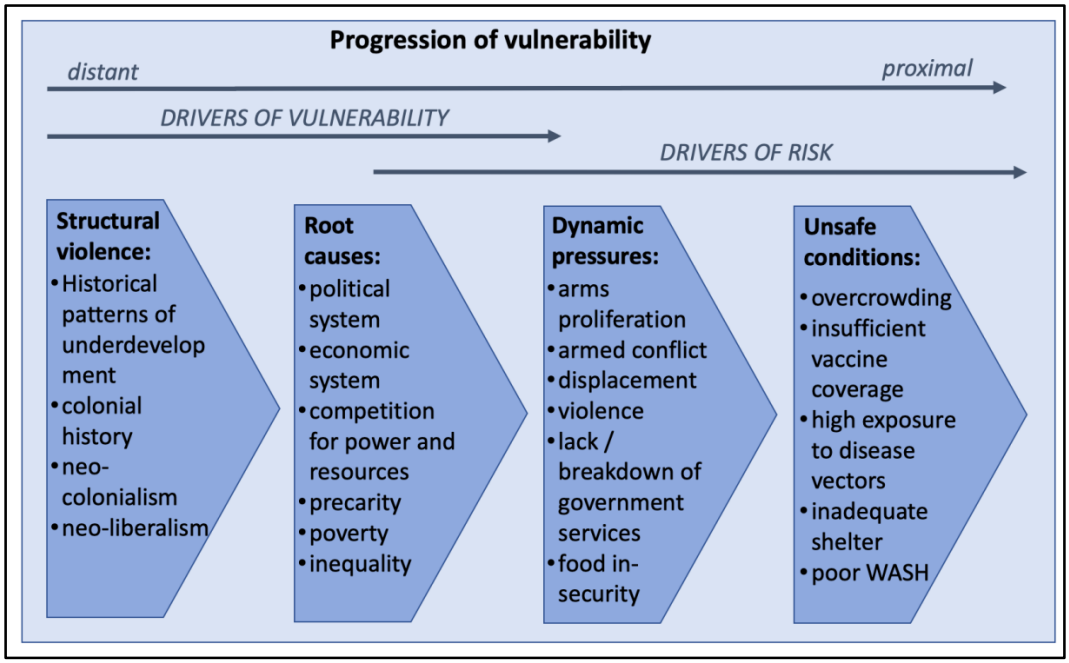

Figure 5: The progression of vulnerability for communicable disease outbreak risk in humanitarian emergencies.

While the traditional root causes – limited access to power, structures and resources, and political and economic systems – certainly hold true in the context of disease outbreaks in humanitarian crises, the related issues of competition for power and resources (69), precarity (88, 90), poverty (88, 94, 95), and inequality (88, 94, 95) warrant further emphasis as root causes that facilitate the development of dynamic pressures. They are on the threshold between drivers of vulnerability and drivers of risk.

Competition for power and resources could be interpreted as a part of limited access to power, structures and resources. However, the level at which those root causes act and interact is different. Limited access to power, structures and resources arises from the lack of an inclusive and democratic society and political system. Competition for power and resources does not necessarily assume widespread access to power and resources. It focuses on those groups and individuals who have access and on how their interaction stabilises or destabilises any given situation. Additionally, we suggest considering environmental and ecological fragility, which describes the resilience or lack thereof of the natural environment and hence plays an important part in characterising the geographical context. While it is not a component of social vulnerability, environmental fragility strongly impacts severity of exposure.

We see all of these root causes as based on conditions of structural violence comprised of historical patterns of underdevelopment, colonial histories, neo-colonialism and neo-liberalism, which act as drivers of vulnerability and form an integral part of the early progression of vulnerability (88). These forms of structural violence and their ingrained stigmatisation and marginalisation of populations along lines of race, ethnicity, religion, gender, sexuality and socio-economic status, lead to historically rooted inequalities, which form the backdrop of many of the root causes, dynamic pressures and unsafe conditions. This climate is a volatile mix that can form part of a progression of vulnerability towards communicable diseases; at the same time it also forms part of a progression of vulnerability towards humanitarian emergencies.

The resulting dynamic pressures include arms proliferation, armed conflict, displacement, violence, lack or breakdown of government services, and food insecurity. Arms proliferation is a direct precursor to armed conflict, which is arguably one of the main drivers of health emergencies that are secondary to a humanitarian crisis. Armed conflict and violence together foster a climate of insecurity that is conducive to disease outbreaks through a variety of mechanisms (31, 97-105). Population displacement leads to a lack of access to health services (55, 98, 100, 106, 107) and generally unsafe living conditions, both in camp and community settings (55, 97-102, 104-116). A lack or breakdown of government services can lead to a breakdown of health-related infrastructure including individual health services and population health services such as vaccination (55, 97-100, 102-106, 108-114, 116-118) as well as a breakdown of other (critical) infrastructure and coordination activities (100, 102, 104, 105, 107, 119). All of the preceding can produce health emergencies. Food insecurity can be seen as a key precursor to malnutrition, which is an important risk factor, both at the level of the population and at the individual level, for communicable diseases (55, 98, 100, 102, 106, 108-111, 118-120) and other health conditions (121-123).

This progression culminates in the most proximal drivers of communicable disease risk in humanitarian emergencies – the unsafe conditions –, which are all highly conducive to ill health and direct or indirect progressions of the aforementioned dynamic pressures: overcrowding, insufficient vaccine coverage, high exposure to disease vectors, inadequate shelter, and poor WASH. Overcrowding, which can result from

both displacement and entrapment, facilitates the spread of diseases from person to person and is thus a key risk factor for communicable disease outbreaks (55, 98, 100, 102, 105-108, 111, 118, 119, 124-136). Insufficient vaccine coverage is produced both by a breakdown of government services, especially population health services, and by unvaccinated persons being displaced into areas with higher disease prevalence. Considering the important role of vaccination as a health protection tool, the importance of its absence as an unsafe condition should be obvious and has been identified as an unsafe condition in the example of the European migration crisis (130, 131, 133, 137-139). Similarly, increases in the presence of disease vectors, such as specific species of mosquitos, increase the likelihood of an outbreak and of the transmission of vector-borne diseases. Inadequate shelter without proper heating, ventilation and cooking facilities has implications both for communicable diseases (100, 102, 105, 108, 110, 125, 129-131, 135, 140) and for non-communicable health problems such as asthma and chronic obstructive pulmonary disorder (COPD) if indoor fires are used (100, 102, 108). Finally, the role of poor WASH as a risk factor and as an adequate unsafe condition for communicable diseases, has been well documented (5, 55, 98-100, 102, 105-108, 110, 118-120, 128, 129, 132, 135, 136, 141-143).

What we traditionally call a risk factor in health, medicine and epidemiology is – according to the model and seen in a more complex picture – in fact a stage in the progression of vulnerability or in other words a component of the overall vulnerability. Vulnerabilities are what might lead to disease in an individual and to an outbreak or epidemic in a population. When considering these drivers of risk, it becomes clear that they are more than just drivers of risk for communicable disease in humanitarian emergencies. They are more generally drivers of communicable disease risk. However, they also represent the drivers of risk that are most likely to lead to an outbreak in humaniatrian emergencies as well as those that are heavily impacted by humanitarian emergencies.

2.5. The Crisis-Outbreak Progression

Drivers, vulnerabilities, and risks interact in a complex and non-linear conglomerate of interdependency. This leads to a Crisis-Outbreak Progression with feedback loops and multi-layered amplifications of vulnerabilities and risks, in which humanitarian crises

precipitate communicable disease outbreak risk and communicable disease outbreaks precipitate humanitarian crisis risk (see Figure 6). The aim of any disease control efforts under such circumstances has to be to interrupt this vicious circle.

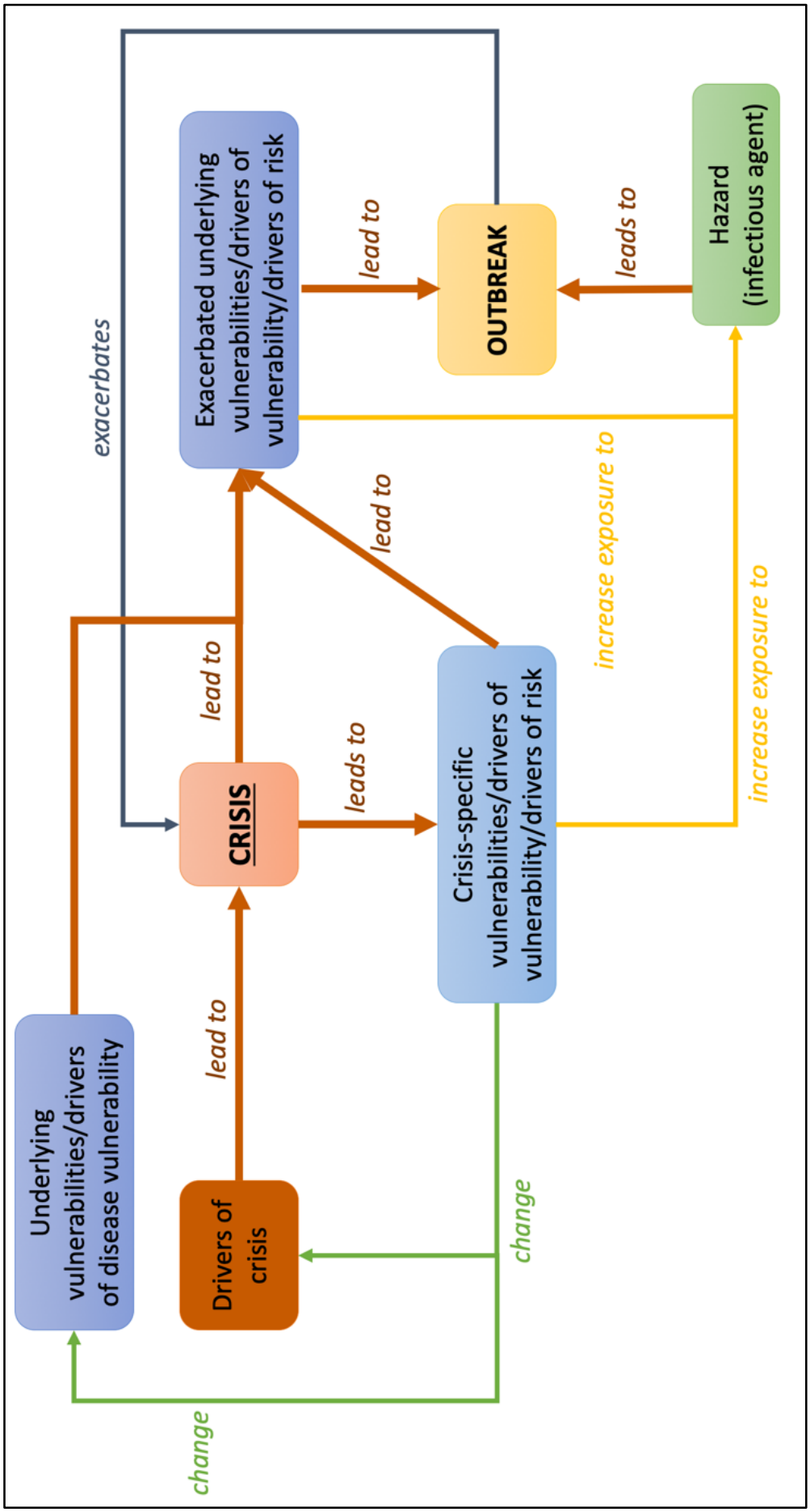

Figure 6: The Crisis-Outbreak Progression.

This conglomerate of interdependency and mutual amplification gains additional layers of complexity when exposed to a humanitarian response. Any humanitarian response can impact the Crisis-Outbreak Progression at various levels and in various directions. Such an impact does not necessarily have to be positive even if the aim of such an intervention is in accordance with the humanitarian imperative and principles. Uncoordinated humanitarian responses in particular can lead to increased rather than decreased risk. An extreme example of the devastating impact of a humanitarian (in this case peacekeeping) intervention on communicable disease risk is the case of Haiti, where sanitation practices in a peacekeeper camp led to an outbreak of cholera along the Artibonite river (144, 145).

Generally speaking, crises tend to not only potentially lead to disease outbreaks but they also exacerbate these outbreaks by impeding humanitarian access and disrupting prevention and control measures. This can be seen in the 2018-2019 outbreak of Ebola Virus Disease (EVD) in the DRC. While a previous outbreak in another part of the DRC was successfully brought under control, the outbreak in the North of the DRC has quickly progressed to become the worst outbreak in the country's history. The disease spread within the DRC and had from early on the possibility to spread to neighbouring countries due to the problems posed by an underlying humanitarian emergency, in this case a conflict between the government and the insurgent Allied Democratic Forces (ADF) (146). The ADF is a militant organisation mainly operating in the Beni region and it has repeatedly disrupted control efforts by the Congolese government and international organisations (146). Thus, the historical drivers of vulnerability might not differ drastically between the two outbreaks but the resulting drivers of risk are considerably changed due to the humanitarian crisis the region is experiencing. These drivers of risk enable a further and longer spread of the disease as well as hindering the disease control efforts.

The conclusion has to be that communicable disease risk in crises is precipitated by socio-political, contextual and structural vulnerabilities, which in turn are created by underlying structural and historical drivers of vulnerability. Combining this with Ewald's conclusion that risk only exists with vulnerability (74), this means that while it is inconceivable that all vulnerabilities in humanitarian emergencies can be lowered to zero, (thereby reducing the risk to zero), the risk can be greatly decreased by

minimising the vulnerability towards the said risk without needing a 'toolkit' for hazard reduction. Such an intervention on the vulnerability side will have to be on the more proximal end of the scale for interventions during humanitarian emergencies. However, ultimately it has to be the aim to reduce the distant side of the progression of vulnerability as this would greatly reduce the risk of both communicable disease outbreaks and underlying humanitarian emergencies. Thus, the disease response along the progression of vulnerability mirrors the integration of development aid with humanitarian aid. While development aid and changes to the drivers of vulnerability or the more distant drivers of risk might not be possible in the early stages of an emergency response, they should be integrated in order to find a longer-term solution and to reduce the risk of the problems recurring.

2.6. Conclusion

Crises heavily impact both drivers of risk and drivers of vulnerability for communicable diseases. Vulnerability is a key part of risk and this should be recognised in all fields that inherently deal with risk. While traditional definitions and terms such as 'risk factor' do not need to be replaced in the context of health and medicine, when dealing with communicable disease outbreaks in humanitarian crises, a more thorough consideration of their components certainly helps to understand mechanisms and pathways of risk beyond probability. The traditional term 'risk factor' mainly describes proximal drivers of risk but generally, drivers of risk and even drivers of vulnerability have been recognised as risk factors. Considering the progression of vulnerability and the complexity of communicable disease outbreak risk in humanitarian emergencies, inclusion of the distant end of this progression is essential in order to understand and interrupt the progression of vulnerability towards communicable disease outbreaks, especially in situations of unknown or unknowable hazards. Hence, vulnerabilities are drivers of risk and what are commonly framed as risk factors are nothing less than vulnerabilities.

The analysis of risk factors, augmented with the conceptual understanding of their place in the progression of vulnerability, is an important part of understanding how disease outbreaks in the context of humanitarian crises evolve. The theoretical backing offered here supports quantitative study of the epidemiological basis for risk factors in

individual emergencies by providing a wider understanding of the role of risk factors as drivers of vulnerabilities and risk. As such, an interdisciplinary approach to global health emergency response and medical humanitarianism – both academically and in practice – is essential. This approach can open new avenues for mutual understanding. Additionally, understanding risk in terms of hazard and vulnerability fosters increased understanding of how to introduce and increase resilience by sustainably reducing vulnerability and therefore risk. Complex understandings of risk are a first step to working towards resilience. However, more than just conceptual insights are needed in order to foster lasting and positive resilience. In the context of outbreak risk in humanitarian emergencies, the insights into vulnerability certainly highlight and reinforce the fact that a focus on strengthening health systems can lead to a reduction of vulnerability and therefore a reduction of risk. The dynamic element of the PAR model allows for the consideration of changing conditions – and the causes of the changes, as traceable through the progression of vulnerability – to be considered in both epidemiology and risk assessment, which allows for both mitigation and preparedness.

Understanding the drivers of vulnerability and risk, updating the original PAR model for communicable disease outbreak risk in humanitarian emergencies, and using it in this context could lead to an improvement of the conceptual and practical understanding of the progression from population-level risk to outbreaks and epidemics in humanitarian contexts and beyond. This prospect has direct and indirect implications for risk assessments, leading to potentially longer lead times between the detection of an increased risk due to increased vulnerability and an actual outbreak or epidemic. Additionally, such a conceptual understanding can be used as a basis for improving targeted risk management and risk reduction interventions by providing action points for intervention and understanding where they lie in the progression of vulnerability. This opens up the possibility of prioritising interventions.

3. Study 1: Systematic review of risk factors and risk factor cascades for communicable diseases in complex humanitarian emergencies

3.1. Context

Based on the theoretical understandings delineated in Chapter Two, this first of three consecutive studies, describes a systematic review of risk factors and risk factor cascades for communicable disease outbreaks in CHEs. Complex humanitarian emergencies were chosen as the archetype of humanitarian crises and it was expected that the review would show that complex emergencies trigger most – if not all – of the risk factors associated with communicable disease outbreaks in disasters and emergencies and compound these. This was confirmed and the review revealed that risk factors for communicable disease outbreaks in CHEs often appear in the form of risk factor cascades, further compounding the risk of a communicable disease outbreak as well as the underlying crisis.

The paper presented in this chapter seeks to address research question two: What are the contextual risk factors (drivers of risk, vulnerabilities) for communicable disease outbreaks in humanitarian emergencies and disasters and how are they interacting? The systematic review was published in the *British Medical Journal Global Health* in 2018 (58). Changes were made to ensure a coherent and standardised referencing style, the labelling of sections as sub-chapters, and the continuous numbering of tables and figures.

3.2. Risk factors and risk factor cascades for communicable disease outbreaks in complex humanitarian emergencies: a qualitative systematic review

3.2.1. Abstract

Background: Communicable diseases are a major concern during CHEs. Descriptions of risk factors for outbreaks are often non-specific and not easily generalisable to similar situations. This review attempts to capture relevant evidence and explore whether it is possible to better generalise the role of risk factors and the risk factor cascades that these factors may form.

Methods: A systematic search of the key databases and websites was conducted. Search terms included terms for CHEs (OCHA definition) and terms for communicable diseases. Due to the types of evidence found, a thematic synthesis was conducted.

Results: 26 articles met the inclusion criteria. Key risk factors include crowded conditions, forced displacement, poor-quality shelter, poor water, sanitation and hygiene, lack of health care facilities and lack of adequate surveillance. Most identified risk factors do not relate to specific diseases, or are specific to a group of diseases such as diarrheal diseases and not to a particular disease within that group. Risk factors are often listed in general terms but are poorly evidenced, not contextualised and not considered with respect to interaction effects in individual publications. The high level of interrelatedness of risk factors became evident, demonstrating risk factor cascades that are triggered by individual risk factors or clusters of risk factors.

Conclusions: CHEs pose a significant threat to public health. More rigorous research on the risk of disease outbreaks in CHEs is needed, from a practitioner and from an academic point of view.

3.2.2. Introduction

CHEs (21) pose a significant threat to public health, often in settings that were already deprived before the disruptive event or events. While CHEs generally affect the health of the affected population negatively, they especially exacerbate the risk of communicable diseases including diarrhoeal diseases, acute respiratory diseases, measles, meningitis, tuberculosis, HIV, viral haemorrhagic fevers, hepatitis E, trypanosomiasis and leishmaniosis (100, 147). Priorities that need to be addressed in a complex emergency include rapid assessment of the health status of the affected population, mass measles vaccination, implementation of water and sanitation measures, food supply and nutrition programmes, site planning, provision of shelter, non-food items and basic medical services, control and prevention of communicable diseases and potential epidemics, surveillance and alert, mobilisation of community health workers, and coordination with national and international agencies (147). Several of these interventions rightly target communicable diseases, as during complex emergencies up to three-quarters of excess deaths are attributable to infections (2). While research in this field is growing, there is inadequate understanding of the risk factors associated with communicable diseases in these situations (148). There is a strong need for better evidence and understanding of the risk of communicable diseases in CHEs, in order to inform control strategies and emergency surveillance, both of which are based on risk assessments that currently lack a common risk framework. We conducted the first (to our knowledge) systematic review on risk factors for communicable diseases in CHEs.

CHEs, for our purposes, are defined as crises in a region or area in which no local coping capacity can handle the situation due to a complete breakdown of state authority. The problems in complex emergencies are diverse and a multi-agency international response is necessary to address the situation. They usually result from extensive inter- or intra-state armed conflict, leading to “[e]xtensive loss of life, massive displacement of population, widespread damage to societies and economies”; “Need for large-scale, multi-faceted humanitarian assistance”; “Hindrance or prevention of humanitarian assistance by political and military constraints”; and “Significant security risks for humanitarian relief workers in some areas” (21). Any such situation requires a multi-faceted international response, usually led by the UN. No CHE would be adequately addressed by the activation of only one of the humanitarian

clusters. In fact, in most complex emergencies, most if not all clusters are activated and many such emergencies happen in situations and countries where multiple clusters are already active due to the underlying conditions, with the complex emergency exacerbating these conditions beyond the scope of an ongoing UN country programme.

3.2.3. Methods

The description of methods follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement as far as is applicable to qualitative systematic reviews (149). No review protocol was published beforehand.

Inclusion criteria

For this review, we had to define three terms on which we could formulate clear inclusion criteria – 1) risk factors; 2) communicable diseases; and 3) complex humanitarian emergencies.

In order to capture all risk factors and risk factor mechanisms that might not have been labelled as risk factors or have been mentioned as a side note, we decided to not include terms for risk factors in our search strategy. However, they were applied as an inclusion criterion. Risk factors for this purpose were anything mentioned as increasing the risk of a communicable disease outbreak happening, or as a reason for an outbreak having happened, or as a mechanism that promoted favourable conditions for communicable disease spread in CHEs. Only those risk factors that apply at the population or setting level were included, as this review does not focus on the individual. Risk factors were eligible for inclusion if they could plausibly apply in CHEs. Communicable diseases were defined as infectious diseases transmissible "by direct contact with an affected individual or the individual's discharges or by indirect means (as by a vector)" (150).

Definitions for CHEs, sometimes also simply called 'complex emergencies', are plentiful; however, as most agencies involved in the management of this type of disaster agree on some key issues, we used the OCHA definition: "[M]ultifaceted humanitarian crisis in a country, region or society where there is a total or considerable breakdown of authority resulting from internal or external conflict and

which requires a multi-sectoral, international response that goes beyond the mandate or capacity of any agency and/or the ongoing United Nations country program"(21). As such, emergencies such as the 2013-2015 West Africa Ebola outbreak, the Plague outbreak in Madagascar, tsunamis (151), tropical storms and other disasters associated with a natural hazard are not classified as CHEs under the OCHA definition and are therefore not eligible for inclusion in this systematic review.

We only included emergencies after 1990 and publications published on or after the 1st of January 1994. These dates were chosen to exclude emergencies before 1990, which were mainly influenced by the Cold War and hence were considerably different in their nature. The first major CHE after the end of the Cold War was Rwanda and with those dates we made sure that we would include research on Rwanda but exclude research on CHEs during the Cold War.

We initially included all languages but if no one in the research team could be found who understood the language an article was published in, we excluded it for practical reasons. Because all articles found were either in English, French or Spanish, no articles were excluded due to language barriers.

Search strategy and data sources

Our search strategy was developed from discussion between the authors and it was based on previous experience and extensive background reading. The search comprised of terms for communicable diseases, including specific diseases that have very often occurred in previous CHEs, and terms for CHEs. We searched the following bibliographic databases: Scopus, Medline, Embase, and IBSS. The search strategy for Medline is presented in Figure 7. Search terms for Medline and Embase included subject headings, which were not available in Scopus and IBSS. The search was conducted in May 2017. Additionally, we searched the relevant websites of MSF, the WHO, the United Nations High Commissioner for Refugees (UNHCR), UNICEF and ReliefWeb (OCHA). The search strategy was adapted for the individual websites according to the technical and search engine capacities provided by the websites. All terms were searched for in abstracts, titles, keywords and relevant subjects where possible. The references of included publications were also checked, and reviews were included.

# ▲	Searches
1	(complex adj emergenc*).ab,hw,kf,ti.
2	(complex adj humanitarian adj emergenc*).ab,hw,kf,ti.
3	(complex adj humanitarian adj cris#s).ab,hw,kf,ti.
4	1 or 2 or 3
5	Disease Outbreaks/
6	Communicable Diseases/
7	(diarrhoeal adj disease*).ab,hw,kf,ti.
8	(respiratory adj disease*).ab,hw,kf,ti.
9	(infectious adj disease*).ab,hw,kf,ti.
10	"vector?borne disease*".ab,hw,kf,ti.
11	malaria.ab,hw,kf,ti.
12	measels.ab,hw,kf,ti.
13	pertussis.ab,hw,kf,ti.
14	Trypanosomiasis.ab,hw,kf,ti.
15	dysentery.ab,hw,kf,ti.
16	meningitis.ab,hw,kf,ti.
17	meningococcal.ab,hw,kf,ti.
18	pneumonia.ab,hw,kf,ti.
19	Leishmaniosis.ab,hw,kf,ti.
20	TB.ab,hw,kf,ti.
21	tuberculosis.ab,hw,kf,ti.
22	5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21
23	4 and 22

Figure 7: Search strategy in Medline.

Study selection

Based on the inclusion criteria, Charlotte C Hammer (CH) and Julii Brainard (JB) screened the titles and abstracts of all the articles identified via bibliographic databases independently. In case of disagreement, the full text was obtained. An article was included for full text review if either screener did not reject it. CH and JB next screened full texts independently and a decision about final inclusion was reached

discursively. We sought access via libraries and contacted authors of conference abstracts directly.

Data analysis and synthesis

Due to the qualitative and heterogeneous nature of the evidence found, this is a qualitative systematic review. The data were analysed using thematic synthesis (152). Primary coding was done by CH, except for one article in Spanish, which was primarily coded by JB. JB or CH confirmed the primary codes and added secondary codes for all articles. Coding was done by hand and codes were transcribed into custom-made coding sheets, recording quotes, codes and sub-codes. Initially, predefined codes such as 'overcrowding' or 'risk factors related to water' were applied to sentences and phrases that corresponded to them. This bank of initial codes was added to every time an author mentioned a potential risk factor that did not correspond with a pre-defined code. If an additional code could be seen as a part of a larger group that code was applied as a sub-code (e.g. 'clean drinking water' as a sub-code for 'risk factors related to water'). Secondary coding checked that the applied codes were accurate and added any additional codes and sub-codes that were overlooked during primary coding. Based on the codes and sub-codes, descriptive and analytical themes were developed. While the clustering of risk factors is the outcome of the analysis and not mere coding, the clusters largely correspond to codes and the individual risk factors within the clusters largely correspond to the sub-codes.

3.2.4. Results and discussion

Our literature search retrieved 153 articles after de-duplication and 8 grey literature documents (as shown in Figure 8). Articles were mainly excluded if they did not focus on CHEs or applied a significantly different definition of CHEs than this review does, if they did not focus on communicable diseases and if they gave no indications of any risk factors. Twenty-two articles were included directly from searches with an additional four retrieved from the reference lists of included articles. Articles were predominantly in English. One article was in Spanish and one in French.

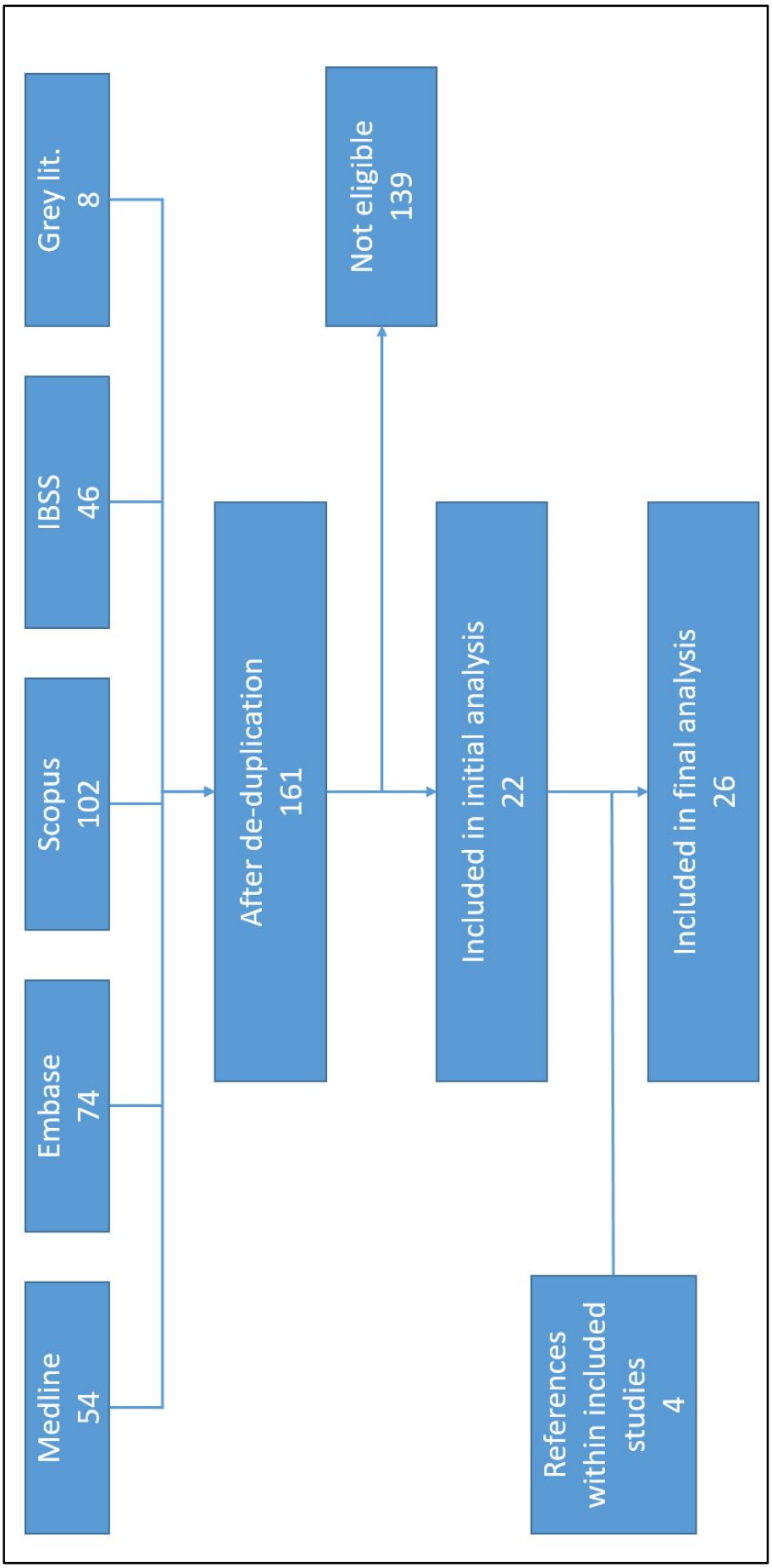

Figure 8: PRISMA diagram.

Twelve main clusters of risk factors were identified that all exhibited a high level of interrelatedness, feedback loops and interaction on various levels. These risk factor clusters provide an analytical lens and many individual risk factors can be grouped into primary and secondary (and sometimes even tertiary) clusters. Table 8 gives an overview of the included articles, the setting they describe and the risk factor clusters identified in them.

Table 8: List of articles included in the analysis:

Article	Setting	Risk factor clusters
Abubakar et al. (2015)	South Sudan; Internally Displaced Persons (IDP) camps	Infrastructure, economy, mass population displacement, nutrition, overcrowding, water, sanitation and hygiene (WASH)
Bompangue et al. (2009)	Democratic Republic Congo (DRC); mainly refugee camps	Humanitarian response, mass population displacement
Brenna et al. (2001)	Complex emergencies	Health and public health services, HIV-specific risk factors, humanitarian response, insecurity, mass population displacement, nutrition, overcrowding, WASH
Burkle (1999)	Complex emergencies	Infrastructure, mass population displacement, overcrowding, living conditions, WASH
Burkle (2001)	Complex emergencies; paediatric populations	Economy, health and public health services, mass population displacement, nutrition, overcrowding, WASH
Chaignat and Monti (2007)	Complex emergencies	Environment, health and public health services, humanitarian response, living conditions, mass displacement, nutrition, WASH
Close et al. (2016)	Complex emergencies	Nutrition, overcrowding, mass population displacement, health and public health services, WASH
Connolly et al. (2004)	Complex emergencies	Economy, environment, health and public health services, HIV-specific risk factors, infrastructure, insecurity, mass displacement, living conditions, overcrowding, nutrition, WASH
Coulombier et al. (2002)	Complex emergencies	Health and public health services, insecurity, mass population displacement, WASH
Cuadrado and Gonzalez (2014)	Complex emergencies	Environment, WASH, insecurity, mass population displacement, nutrition, overcrowding, health and public health services, living conditions, economy, infrastructure
Fisher et al. (2010)	Complex emergencies	Environment, health and public health services, HIV-specific risk factors, mass population displacement, overcrowding,

		living conditions, nutrition, WASH
Goma Epidemiology Group (1995)	Rwanda; refugee camps	Environment, WASH
Guthmann et al. (2006)	Sudan; IDPs	WASH
Howard et al. (2003)	Afghanistan	Economy, mass population displacement, health and public health services
Howard et al. (2010)	Afghanistan	Economy, infrastructure
Khaw et al. (2000)	Complex emergencies	Health and public health services, HIV-specific risk factors, insecurity, mass population displacement
Kolaczinski (2005)	Afghanistan	Health and public health services
Kolaczinski et al. (2005)	Afghanistan	Insecurity, health and public health services
Kolaczinski andWebster (2003)	East Timor	Heath and public health services, mass population displacement, overcrowding, living conditions
Leyenaar (2004)	Complex emergencies	Economy, HIV-specific risk factors, insecurity, mass displacement
Liddle et al. (2013)	Somalia	Economy, infrastructure, health and public health services, insecurity, mass displacement
MMWR (2011)	Horn of Africa	Mass population displacement, health and public health services
Salama and Dondero (2001)	Complex emergencies	HIV-specific risk factors, insecurity, mass population displacement, health and public health services
Toole and Waldman (1997)	Complex emergencies and displacement crises	Health and public health services, mass population displacement, overcrowding, living conditions, nutrition, WASH
WHO (2000)	Complex emergencies	Environment, health and public health services, humanitarian response, mass population displacement, nutrition
WHO (2001)	Afghanistan and neighbours	Environment, health and public health services, living conditions, mass displacement, overcrowding, nutrition, WASH

WHO (2004)	Liberia	Economy, environment, health and public health services, HIV-specific risk factors, infrastructure, WASH, insecurity, living conditions, mass population displacement, overcrowding, nutrition

Main risk factor clusters

1. *WASH (5, 55, 98-100, 102, 105-108, 110, 118-120, 141):* WASH is a central element to limit the risk of communicable diseases in populations experiencing an emergency. As such it is also central to CHEs and often in a more precarious state than in other emergencies. WASH risk factors include issues such as lack of safe drinking water (5, 55, 98-100, 102, 106, 108, 110, 141), lack of hygiene (55, 98, 102, 119), hygiene behaviour (5, 107, 119), lack of soap (5, 100, 102, 108, 111), lack of bed nets (153) (as vector control is usually seen as a part of WASH in humanitarian response) and general water scarcity (5, 55, 98-100, 102, 106, 108, 110, 141), as well as lack of adequate sanitation and latrines. These factors considerably increase the risk for diarrhoeal diseases and they compound risks for other types of communicable diseases, especially if they are coupled with other risk factor categories such as overcrowding and mass population displacement.
2. *Overcrowding (55, 98, 100, 102, 105-108, 111, 118, 119):* Overcrowding in CHEs is usually a function of either mass population displacement or entrapment. While overcrowding can also be an issue in ad hoc shelters after the widespread destruction of homes and infrastructure, it is more prevalent if populations are forced to become refugees or IDPs and are forced into camps. Overcrowding affects hygiene-related diseases, such as diarrhoeal diseases, but it also increases the transmission rate of diseases such as measles and other infections that spread from person to person.
3. *Mass population displacement (55, 97-102, 104-116):* Mass population displacement is a trigger for most risk factor categories and as such is possibly the main risk factor in CHEs. Mass population displacement is usually associated with large numbers of people moving into camp settings, and is often associated with overcrowding, inadequate shelter, and poor WASH

conditions (55, 98, 100, 102, 106-108, 114). Additionally, populations are displaced into regions and areas with insufficient resources and services, and with potentially increased contact of naive populations with new disease vectors. Early camp structures (such as layout of tents and siting of toileting areas) can lead to further complications. Early layout often develops as an ad hoc response to mass population displacement but may prove completely unsuitable as the camp expands.

4. *Nutrition (55, 98, 100, 102, 105, 106, 108-111, 118, 119):* While nutrition factors, such as malnutrition (55, 98, 100, 102, 106, 108, 109, 111, 118, 119), food shortages (98, 100, 102, 106, 110, 120) and exposure to contaminated food (102, 108) are mainly risk factors at the individual level, they also pose an increased risk to populations as a whole if a sufficient percentage of the population is exposed. Nutrition factors are related to increased susceptibility to communicable diseases, resulting in greater shedding and transmission to others. At the population level, nutritional factors can exacerbate other risk factors and risk factor clusters, for example by increasing the risk of violence and social unrest. Root causes for nutrition risk factors lie mainly in other risk factor clusters, such as insecurity and armed conflict, or mass displacement and inadequate humanitarian response.
5. *Living conditions (100, 102, 105, 108, 110):* Poor living conditions are a combination of inadequate shelter, overcrowding and other individual factors in the immediate surroundings of an individual or group of individuals. A key risk for people uprooted from their normal lives in CHEs and subject to inadequate resources and shelter is indoor air pollution (100, 102, 108). This is due to indoor fires, both for cooking purposes and for heating (100, 102, 108).
6. *Insecurity (97-105, 112):* Insecurity is a multi-faceted bundle of risk factors that is one of the main root causes for increased mortality (all causes) in CHEs. Insecurity is composed of factors such as armed conflict (98), social disruption (98, 101, 102, 112) and political instability (100). The specific nature of insecurity differs from complex emergency to complex emergency. However, by our (OCHA) definition, most, if not all, complex emergencies experience a high level of severe violence either from inter- or intra-state conflict. Insecurity triggers other factors such as the lack of an adequate humanitarian response as

it poses risks to aid workers and inhibits access to beneficiaries. Additionally, it also inhibits access for the population to health services and has a high potential to disrupt all other services.

7. *Infrastructure (100, 102, 104, 105, 107, 119):* Due to insecurity and also in some cases long-term neglect and lack of funding, infrastructure in CHEs is often inadequate, especially in response to a mass influx of people, either in camps or in the community. Lack of infrastructure also often comes with a lack of domestic coordination (100, 102, 104), which additionally inhibits efficient coordination with an international response. A lack of resources (100, 104), water (5, 55, 98-100, 102, 106, 108, 110, 141), electricity (102), funding (119) and staff (119) makes the affected population more dependent on an international response.
8. *Humanitarian response (98, 109, 110, 115):* By (our, OCHA) definition, a complex emergency demands a multi-faceted, multi-agency international humanitarian response. However, poor response can itself become a risk for the spread of communicable diseases. Problems can lie with the response itself, due to a lack of international commitment or a lack of professionalism among the responding agencies and organisations (110). Problems can also arise domestically, due to restrictions by governments or warring parties, unsafe conditions in which aid workers cannot properly work without unacceptable levels of risk for themselves, or lack of access for various reasons (98, 109). This also includes lack of organisational motivation (119), poor institutional support (98) and complex international issues such as the lack of a binding legal framework for the protection of internally displaced populations (111).
9. *Environment (5, 55, 100, 102, 105, 108-110):* Environmental factors can increase the likelihood of communicable disease outbreaks, and this is true beyond the context of CHEs. However, many environmental factors, which would not have mattered otherwise, can be triggered by mass population displacement, especially if populations are displaced into areas with a higher prevalence of environmental risk factors. Environmental risk factors include weather and climate factors, such as cold and dust storms (100, 108), but also vector habitats (102, 108, 109), increased contact with animals (102, 108) and endemic diseases (100, 102, 110). Mass population displacement not only

potentially puts people at risk from these factors; it also exacerbates the factors themselves due to the additional stress placed on the local environment by camps and by an influx of large numbers of people, often accompanied with significant land use changes (102).

10. *Economy (100-102, 104, 105, 113, 153):* While economic factors such as poverty and lack of resources are certainly issues that are important in humanitarian emergencies, they are not of the highest importance in CHEs. Poverty and economic degradation have the ability to further exacerbate the root causes of the underlying conflict but they only indirectly increase the likelihood of communicable disease outbreaks.
11. *Health and public health services (55, 97-100, 102-106, 108-114, 116-118):* Breakdown of health and public health services is probably one of the main risk factors for communicable diseases in CHEs both for individuals and for populations. Lack of access to health and medical care is a key risk factor for severe progressions of most communicable diseases for the individual (55, 97, 98, 100, 102, 104, 106, 108-110, 112, 114). It also facilitates the further spread of communicable diseases such as TB and makes detection of cases and outbreaks harder. Additionally, in complex emergencies, public health services including vaccination, communicable disease prevention and control measures, and surveillance are no longer available, making disease outbreaks more likely, harder to detect, and harder to control (55, 98, 100, 102-104, 106, 108, 110-113, 116, 118). This breakdown of services can be seen as a function of the underlying conflict but is further compounded if there is not enough political will to provide adequate health protection (100).
12. *HIV-specific risk factors (55, 97, 98, 100-102, 112):* HIV is a unique and often overlooked concern in CHEs. While many of the above-mentioned risk factors also apply to HIV, there are some very specific additional risk factors that are associated with an increase in the incidence of HIV in complex emergencies. Key risk factors for an increased transmission of HIV include sexual and gender-based violence (55, 97, 98, 100-102, 112), increased rate of sex work (97, 98, 100-102, 112), use of unsafe blood products and conflict-related increased demand for (potentially unsafe) blood products (97, 100, 102), lack of infection control in health care facilities (97, 100, 102), lack of condoms (97, 100) and an

increased use of illicit drugs (97, 102, 112). A high STI prevalence can be linked to an increased risk of contracting HIV (55). Lack of health care access and lack of anti-retroviral therapy increase the likelihood of vertical transmission (101), and mass population displacement can lead to increased contact (sexual and otherwise) with populations with a higher prevalence (97, 98, 112).

Risk factor cascades

The risk factor clusters as well as individual risk factors often interact and exacerbate one another. Some risk factors and risk factor cluster are particularly likely to start risk cascades, especially mass population displacement (as illustrated in Figure 9) and insecurity (as illustrated in Figure 10). All parts of each cascade can potentially trigger further cascades, depending on the circumstances. The pathways shown in these cascades only describe the most direct dynamics clearly identified from the analysis.

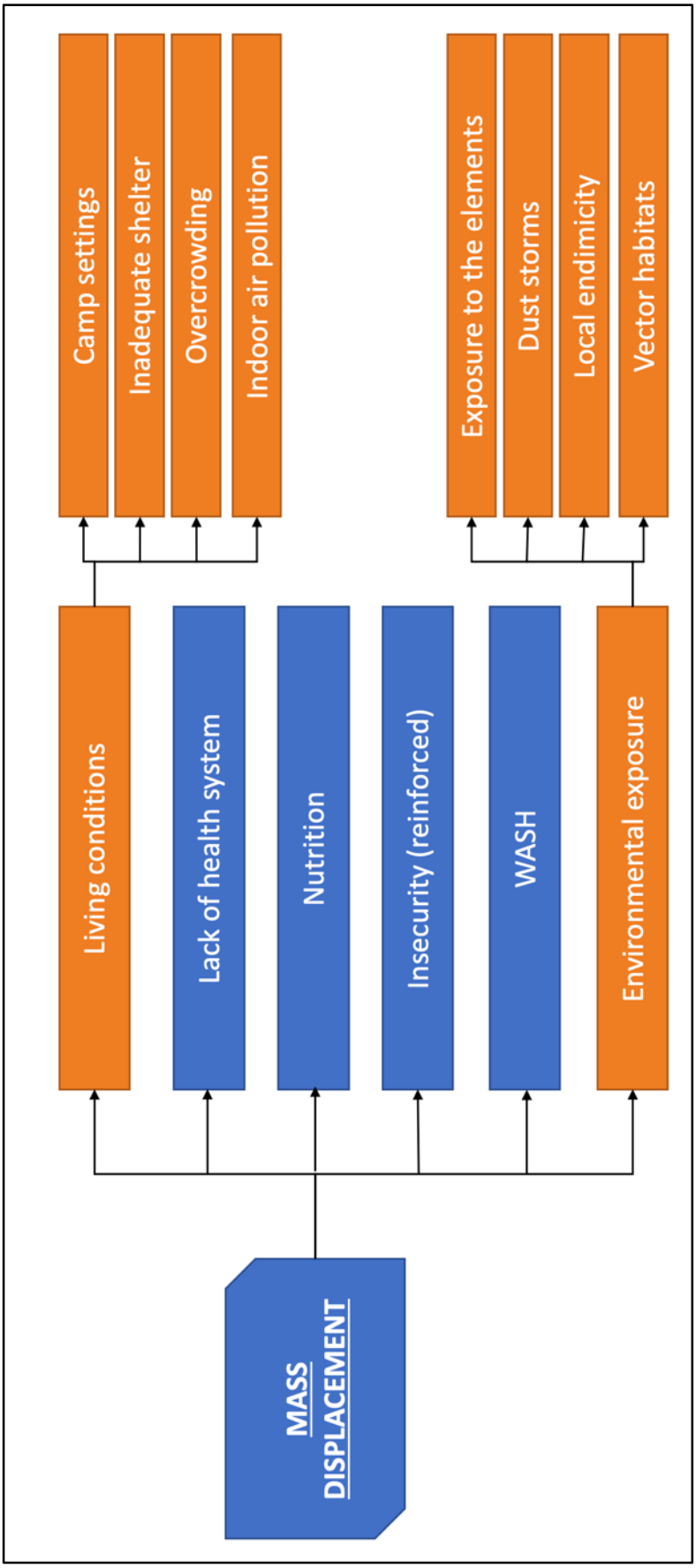

Figure 9: Mass population displacement cascade (blue denoting risk factors that have been identified to directly trigger additional cascades).

One of the key mechanisms for driving risk factors for communicable diseases in complex emergencies is mass displacement (as shown in Figure 9), especially mass displacement into camp settings (102, 107, 108). Camp settings enforce a high dependence on outside support for the residents. This makes residents more at risk for other risk factors. Mass displacement can reduce access to health care and even if access to health care is maintained, the level and quality might be poor (55, 98, 100, 106, 107). Mass displacement thus tends to trigger all risk factors associated with lack of access to health care and it increases the risks for communicable diseases both at individual and community levels. This is often coupled with living conditions that are conducive to increased transmission of communicable diseases and put the individual more at risk (100, 102, 108, 110). This includes the lack of adequate shelter, which makes people especially prone to vector-borne diseases and respiratory diseases, especially in areas with cold temperatures (55, 98, 100, 102, 106, 108, 111, 114). Overcrowding – often together with inadequate shelter and lack of sufficient WASH – increases not only the likelihood of triggering hygiene factors but also the transmission rate of respiratory infections and diseases such as measles. For respiratory infections, this is further exacerbated by conditions that lead to the use of indoor fires and subsequent indoor air pollution (100, 102, 108).

Additionally, as human populations become more overcrowded, the transmission of infections becomes more efficient, i.e., the reproductive ratio (R_0) of the infection increases (154). As R_0 increases, the threshold immunisation coverage needed to achieve herd immunity also increases (155). Consequently, immunisation coverage that was previously sufficient is inadequate to prevent outbreaks. One of the main problems, especially in overcrowded camps, is the provision of safe water and adequate hygiene. If WASH conditions deteriorate, diarrhoeal disease risk in particular increases considerably. Any insufficiency in WASH is more pronounced when coupled with high population density, as experienced in camp situations. However, mass displacement, even when not coupled with displacement into camps, also triggers additional risk factors. Displacement can be into areas with endemic diseases to which the displaced population has no immunity (110). Additionally, mass displacement makes populations vulnerable to environmental factors as well as reinforcing these (5, 110). Mass displacement can exacerbate insecurity and therefore reignite a vicious

circle leading to further displacement and breakdown of health care, services and infrastructure.

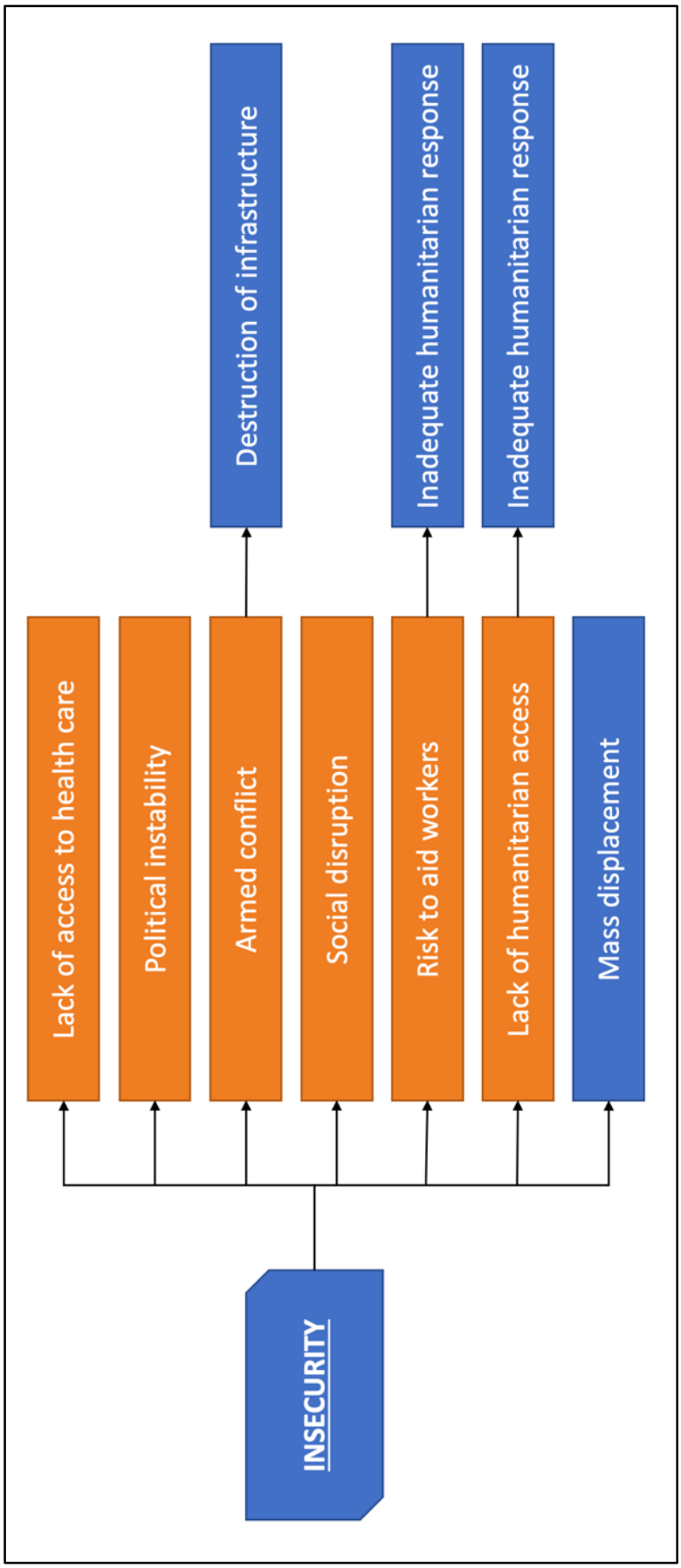

Figure 10: Insecurity cascade (blue denoting risk factors that have been identified to directly trigger additional cascades).

Insecurity itself, whether exacerbated by mass displacement or not, is an important triggering mechanism for communicable disease risk factors in CHEs (as shown in Figure 10). Insecurity, including political instability, armed conflict and social disruption, destroys services that previously prevented the spread of communicable diseases or disallows access to these services by making accessing them unsafe (97-102, 104, 112, 117, 156, 157). This is particularly important for health care services, which in the last few years have increasingly become a target of armed conflict and attacks, decreasing the safety of both staff and patients (158-160). Additionally, disease prevention programmes are likely to be disrupted and infrastructure destroyed (55, 106, 108, 117). With regard to the humanitarian response, which can under certain circumstance take the place of previously government-provided services, insecurity makes an adequate humanitarian response difficult (98, 109). Not only will access to affected populations be difficult, especially in situations where insecurity and active fighting lead to entrapment or even to siege situation, as recently seen in Syria and Iraq, but insecurity will also pose risks to aid workers' security, both for domestic/national and international/expatriate staff (98, 109). Aid organisations are – understandably – increasingly reluctant to accept very high risks to their personnel, leading to gaps in provision of services, which would otherwise have been filled by a humanitarian response. Insecurity also increases the risk of the loss of domestic experts in disease prevention due to injury, death and flight (159).

These are only some aspects of two of the many mechanisms by which CHEs drive risks for communicable diseases. We identified further cascades triggered by economics and infrastructure and risk factor cluster interaction for WASH and health system risk factors. However, the level of complexity in these types of emergencies makes it impossible to capture all levels of interaction adequately. It is not so much that CHEs create different risk factors than other humanitarian crises but they exacerbate any individual risk factors and compound interaction effects. Levels of risk factors will invariably be higher in a CHE and the amount of interacting risk factors creates a "perfect storm" (161) where a multi-faceted, well-funded and logistically and politically highly integrated humanitarian response is not possible due to political, financial or security reasons. These conditions make the danger of one or more outbreaks of communicable diseases extremely high.

While CHEs do not trigger risk factors that are unknown in other types of emergencies and disasters, they produce much higher levels of risk and often tend to trigger more of the known risk factors as well as risk factor cascades. Risk factors related to poor sanitation and hygiene (129, 132, 136, 162-166), nutrition (136, 167-169) and mass population displacement and overcrowding (60, 163, 167, 170-173) have been discussed extensively in the academic literature as being important in most types of emergencies. On the other hand, risk factors resulting from an inadequate humanitarian response, armed conflict and a breakdown in government services are generally more associated with complex emergencies and other situations linked to failing statehood, such as civil war.

The question remains of how to make the best use of this information on risk factors and their interactions. While many of the risk factors and even starting points of risk factor cascades are addressable, the context of a CHE often prevents any such interventions. A key first step in any attempt to address these issues in a given CHE is a rapid but thorough initial needs assessment (31, 147, 174, 175), including an assessment of the most critical risk factors present in that specific CHE in order to develop an evidence-based intervention strategy. However, it is unclear how to best undertake such a needs assessment. Moreover, beyond the development of an evidence-based risk assessment and management methods, there is a need for more rigorous research into the operational and structural barriers that make it difficult to address risk factors in CHEs.

Limitations

This systematic review included subjective interpretation as risk factors were rarely the main focus of the included articles. Authors do not always clearly describe the risk factors and their mechanisms. This introduced an interpretative and subjective element within the included articles, which became more subjective due to the level of interpretation required to complete the thematic synthesis. However, the authors maintained constant feedback to one another and discussed challenges, interpretations, and limitations to ensure the reliability and validity of the findings to the degree that a qualitative analysis allows. We are therefore confident that our interpretation properly reflects the data, albeit agreeing that other interpretations are possible and may be equally valid. This review was necessarily a qualitative synthesis

as the evidence base (heterogeneous and qualitative in nature) did not support quantitative analysis.

3.2.5. Conclusion

CHEs pose a significant threat to public health. The described cascades, interactions and feedback loops are only some of the most striking examples. The increased exposure to the very many interacting risk factors and the resulting risk factor cascades created by a CHE encourage a perfect storm of communicable disease risk. However, despite these extremely increased risks and the exceptional situation that CHEs pose, we did not find a correspondingly high level of academic engagement with the issue. Most of the included articles discussed situations of mass displacement into camps, which is arguably the best studied situation concerning complex emergencies. However, conflicts like Syria and Yemen demonstrate that this might not be the most important situation in the 21st century. Syria and Yemen feature high levels of entrapment (176-179), as they are characterised by limited or no displacement due to a lack of safe humanitarian corridors. This situation coincides with a high level of most other risk factors, especially lack of access to health care, lack of humanitarian response, lack of WASH and other services, food insecurity and high levels of insecurity. We conclude that more rigorous research on the risk of communicable disease outbreaks in CHEs could elucidate opportunities to either prevent or better manage such events. Such research should be undertaken in collaboration between practitioners and academics. More research on entrapment situations is especially desirable, in response to the nature of recent conflicts.

4. Study 2: Expert elicitation for risk factors for communicable disease outbreaks in humanitarian emergencies

4.1. Context

In order to develop a rapid risk assessment mechanism for communicable disease outbreaks, which is described in detail in Chapter Five, experts from the fields of health protection and humanitarian aid were invited to take part in a three-stage elicitation process. This process had the objective of finding the 20 most critical risk factors identified and described in previous chapters of this thesis, and developing options for operationalising these risk factors in a framework that could be used to assess risk in a timely manner in the field. This includes not only the selection of risk factors but also the determination of critical and highly critical threshold levels for those risk factors that can be measured quantitatively, as well as their respective weights in different emergency types. The factors chosen by the experts who took part in the exercise were consistent with previous research, both reported in previous chapters of this thesis and in the wider literature.

The paper presented in this chapter seeks to address research questions two and three, and lays the foundations for addressing question four in a later chapter. The questions are as follows: 2) What are the contextual risk factors (drivers of risk, vulnerabilities) for communicable disease outbreaks in humanitarian emergencies and disasters and how are they interacting? 3) Which are the most critical risk factors for communicable disease outbreaks in humanitarian emergencies? What are their thresholds and weights in different emergency types? 4) How can these risk factors be operationalised in the form of a rapid risk assessment tool?

The results of this expert elicitation process were published in *Global Biosecurity* in 2019 (180).

Changes were made to ensure a coherent and standardised referencing style, labelling of sections as sub-chapters, and continuous numbering of tables and figures.

4.2. Risk factors for communicable diseases in humanitarian emergencies and disasters: Results from a three-stage expert elicitation

4.2.1. Abstract

Background: Humanitarian emergencies, including disasters associated with natural hazards, conflict, complex emergencies and famines, can pose significant risks to public health, especially when they lead to population displacement into inadequate conditions. To reduce the risk of communicable disease outbreaks in such situations it is necessary to know the key risk factors, their thresholds (quantitative risk factors only) and their relative importance in different types of emergencies.

Methods: We conducted a three-stage structured expert elicitation. Experts from the fields of health protection and humanitarian assistance were invited to complete three successive online questionnaires. Experts were asked to choose the 20 most critical risk factors and, in subsequent rounds, to determine thresholds for urgent (yellow threshold level) and critical action (red threshold level). Additionally, experts were asked to assign weights for the risk factors in different emergency types.

Results: We identified 20 key risk factors, which include factors related to WASH, access to health care, vaccination, nutrition, political will and others. Nine out of the 20 risk factors were quantifiable, and for those risk factors, yellow and red thresholds are given. Eleven risk factors were qualitative. All risk factors scored highly when weighted in different emergency types. Differences between risk factor weights in different types of emergencies were limited.

Conclusion: Communicable disease risks in humanitarian emergencies are a nexus of complex and often interrelated individual issues. Knowing key risk factors and their thresholds and weights in different types of emergencies can help to guide emergency response and risk reduction efforts.

4.2.2. Introduction

Communicable diseases are one of the primary concerns in humanitarian emergencies and disasters (2-11, 100, 163, 167, 181-187). Humanitarian emergencies include disasters associated with natural hazards such as earthquakes, floods and tsunamis, as well as man-made disasters such as famine, conflict and complex emergencies. These emergencies usually require a large-scale international response and affect large proportions of a community, country or region. The importance and overall risk of communicable diseases and communicable disease outbreaks differ between different disaster types. It is particularly low in geo-disasters such as earthquakes or volcanic eruptions (188), higher for flooding (163, 182-187), and much worse again in refugee crises (3-7, 9-11, 172, 181) or CHEs (58, 100).

While the problem of a potentially increased risk of communicable diseases in humanitarian emergencies is well documented, information on specific risk factors and the levels at which these risk factors become critical is lacking. Yet, the identification of risk factors and their interaction is crucial for risk management. Knowing the overall risk profiles can help identify those sites where proactive interventions may reduce the impact of communicable diseases. Key risk factors for communicable diseases identified in the academic literature can be broadly grouped into categories such as WASH, health and public health systems, the environment, humanitarian response, infrastructure, insecurity, living conditions, nutrition, mass population displacement, and the economy (58). Within those broader categories, individual risk factors are defined more specifically, although the categories themselves serve as general risk factors as well (5, 55, 58, 98-100, 105, 115, 132, 134-136, 139). While similar groups of risk factors have been identified as significant for all emergency types, their weights can differ depending on the individual setting, as does the overall risk of a communicable disease outbreak. For example, as Floret et al. (188) noted, the risk of communicable disease outbreak is almost negligible in geo-disasters that do not trigger a secondary disaster such as a displacement crisis. For each site, it is also important to know which risk factors are of the most pressing concern in order to allocate resources correctly and prioritise interventions.

In this paper, we summarise the results from three stages of structured online expert consultations that we performed in order to determine the 20 most critical risk factors

(across all types of humanitarian emergencies), the thresholds for those factors that could be assessed by a quantitative indicator, and their weights in different types of emergencies. These data were later used in the development of a rapid risk assessment tool to be used by non-experts to assess needs and priorities in humanitarian emergencies. The factors selected to be the 20 most critical were included in the tool and the thresholds and weights for each factor were used as the basis for a risk score for each factor and a combined overall risk score. The risk factors identified, their weights and thresholds, and especially the rapid risk assessment tool, do not substitute detailed needs assessments and are designed to rapidly assess communicable disease outbreak risk and, as such, are not a suitable basis for humanitarian programming.

4.2.3. Methods

We conducted a three-stage structured expert elicitation.

Recruitment and participants: Participants who self-identified as having experience in health protection and/or humanitarian assistance were invited to take part. Participants were recruited by email through dedicated Listservs that cover areas such as health protection, public health intelligence, humanitarian assistance and disaster studies, as well as through the personal and professional contacts of the research team. Participants were then guided to an online questionnaire.

Recruitment included personalised emails to 16 individuals we knew professionally, and via dedicated relevant Listservs. Recipients were encouraged to share the invitation with interested colleagues. Most of the targeted individual recipients had recent field experience supporting response to humanitarian disasters. Table 9 lists the affiliations of the targeted individuals and the specific Listservs; most affiliations were with public health agencies, charitable aid organisations and/or research institutions. Many targeted respondents had multiple relevant affiliations. To help assure confidentiality we did not ask during the survey for identifying information such as current employer, job title or years of experience. The specific email Listservs we used and the characteristics of the individuals we personally asked to fill in the survey are listed in Table 9.

Table 9: Email Listservs (n=11), with affiliations and characteristics of targeted individuals (n=16):

Public Health Agencies:
Philippine Ministry of Health, Public Health England, World Health Organization, UNICEF, UNESCO, UNRWA
NGOs involved with Humanitarian response:
Global Student Embassy, MSF, Mercy Corps Indonesia
Universities or Research Institutions:
Adnan Menderes Üniversitesi, Institute of Tropical Medicine in Antwerp, Northumbria University, Tufts University, University of East Anglia, Würzburg University
Job titles of targeted individuals:
Associate Professor, Consultant for WHO, Consultant in Global Disaster Risk Reduction, Director of Health programme, Director of Operations Research, Geostatistical Modeller, Operations Researcher, Professor, Research Fellow, Researcher, Senior Fellow, WASH cluster coordinator, Water Coordinator, Water Hygiene and Sanitation Officer
Email List servers

German Disaster Research Listserv	JISCMAIL Health Geography Listserv
Healthcare Information for All listserv	JISCMAIL Public Health Listserv
JISCMAIL Medical Sociology Listserv	JISCMAIL Disaster Research Listserv
JISCMAIL Disaster Research Listserv	JISCMAIL Global Health Listserv
JISCMAIL Public Health Listserv	Humanitarian Listserv
Society of Apothecaries	Healthcare Information for All listserv

Questionnaires are included in the supplementary files SF1-3[1]. Participants could fill out one or more of the three stages of online questionnaires. Participation in a previous questionnaire was not required to take part in the second and/or third stages. The first questionnaire asked the participants to identify the 20 most critical risk factors from a list compiled based on the wider literature and a recent literature review by the research team (58). The first questionnaire also asked the participants to assign weights (on a scale from 0-5) to each risk factor to allow the calculation of a weighted average for each factor. The weighted average was calculated from the mean score of level of importance (on a scale from 0-5) times the number of participants selecting this weight for this factor. Weighted averages were calculated in case the initial mechanism for the selection of the 20 most critical factors, based on how many participants considered them to be in the top 20, proved to be inconclusive. In the second questionnaire, the participants were invited to assign yellow (urgent, action

[1] Supplementary files can be found in a digital version in the accompanying materials.

required) and red (critical, action required immediately) thresholds for all quantifiable risk factors.

The third and final questionnaire sought to identify the respective weights (on a scale from 1-5) of the 20 most critical risk factors in nine different types of emergencies, as broadly described by Spens and Kovács (189). The types of crises were: famine (F), complex emergency (CHE), conflict (C), refugee and IDP camp (RC), flooding (FL), geo-disaster (GD), protracted crisis (PC), tropical storm (TC) and tsunami (T). CHEs describe situations in which widespread internal or external conflict has led to a complete breakdown of authority and widespread damage to society. They are defined by requiring a multi-facetted, multi-agency international response (21, 58). Conflicts include inter- and intra-state warfare, civil war and insurgency. Geo-disasters include earthquakes, landslides, volcanic eruptions and other disasters caused by geological hazards. Flooding refers to fresh water flooding. Tropic storms include hurricanes, typhoons, cyclones and similar hydro-meteorological hazards. This list of types of emergencies was not meant to be complete or to comprise mutually exclusive types of crises. Displacement crises are usually an additional humanitarian emergency secondary to conflicts, complex emergencies, or disasters associated with a natural hazard. However, we believe the risks for communicable disease outbreaks differ significantly enough for these to form distinct categories.

Analysis: Answers were collected online and analysed in Microsoft Excel. Weighted averages, median and mean scores were calculated where appropriate. Additionally, correlations were done in SPSS version 23 using Pearson correlation.

4.2.4. Results

Responses

The first questionnaire was completed by 21 participants; the second questionnaire was completed by 24 and the last questionnaire by 25 persons. We only stored, recorded and analysed fully completed questionnaires, in order to comply with the possibility for participants to withdraw consent to partake in the survey. Given that the surveys were advertised widely, this represents a relatively small proportion of

possible respondents. However, it is not possible to characterise the actual response rate.

Risk factors

The first questionnaire sought to identify the 20 most critical risk factors, irrespective of the emergency type and their relative importance. The 20 risk factors chosen by the most respondents (see column 'Selected (n)' in Table 10) were inputted to the Stage 2 and 3 surveys. 19/20 of these also had the overall highest weighted average scores (see Table 11).

Table 10: List of the selected 20 most critical risk factors irrespective of emergency type and setting. Participants (n=21) were asked to select 20 factors out of the given 59 options:

Risk factor	Selected (%)	Selected (n)	Included in stage 2-3 surveys
No access to clean water	90.48	19	Yes
Lack of functioning toilets	90.48	19	Yes
Exposure to disease vectors	80.95	17	Yes
Lack of waste management	80.95	17	Yes
Lack of health facilities	76.19	16	Yes
Lack of health professionals (doctors, nurses, community health workers)	76.19	16	Yes
Insufficient vaccination coverage	71.43	15	Yes
Poor health status of the population	71.43	15	Yes
Extreme poverty	71.43	15	Yes
Overcrowding	66.67	14	Yes
Lack of medicines	57.14	12	Yes
Insufficient nutrient intake	52.38	11	Yes
Lack of health education	52.38	11	Yes
Inadequate distance between housing etc. and human waste disposal	52.38	11	Yes
Ongoing conflict	52.38	11	Yes
Population displacement	52.38	11	Yes
Lack of organisational and political will to address public health problems	52.38	11	Yes
Flooding (waste water)	47.62	10	Yes
Breakdown of government services	47.62	10	Yes
Reluctance to follow recommended procedures to limit disease spread	47.62	10	Yes
Lack of disease surveillance	42.86	9	No
Inadequate shelter	42.86	9	No
No soap	38.10	8	No
Local endemicity of key communicable diseases	38.10	8	No
Lack of trust in health care provided	33.33	7	No
Flooding (fresh water)	33.33	7	No
Environmental vulnerability	33.33	7	No
Local endemicity of disease vectors	33.33	7	No
Inequalities	33.33	7	No
Political instability	33.33	7	No
Lack of electricity	28.57	6	No
Illiteracy (among target recipients of aid)	28.57	6	No
Unsafe burial rites	23.81	5	No
Breakdown of authority	23.81	5	No
Displacement into camp(s)	23.81	5	No
Low levels of education (among target population)	23.81	5	No

Indoor fires/air pollution	19.05	4	No
Sexual and Gender-Based Violence	19.05	4	No
Increased contact with domestic animals	14.29	3	No
Flooding (sea water)	14.29	3	No
Very high temperatures	14.29	3	No
Lack of belief in germ model – preference for other explanations of diseases	14.29	3	No
Ethnic rivalry	9.52	2	No
Seismic risk (dry mass displacement)	9.52	2	No
Landslide risk (wet mass displacement)	9.52	2	No
High precipitation	9.52	2	No
Very low temperatures	9.52	2	No
Violence	9.52	2	No
Increased contact with wildlife	4.76	1	No
Temporary housing (not tents)	4.76	1	No
Drought	4.76	1	No
Dust storms	4.76	1	No
De-forestation	4.76	1	No
Economic stagnation	4.76	1	No
Competition for resources	4.76	1	No
Arms proliferation	4.76	1	No
Lack of fuel for cooking or heating	4.76	1	No
Housing in tents	0	0	No
Volcanic risk	0	0	No

Table 11: Weighted averages of the importance of the risk factors in humanitarian emergencies and disasters, irrespective of emergency type and setting. 0= Not selected/not important; 1= A little important; 2= Important; 3= Quite important; 4= Very important; 5= Extremely important. Green indicates those factors included in stages 2 and 3 while the factors marked in red were discarded after stage 1:

Risk factor	**0**	**1**	**2**	**3**	**4**	**5**	**Weighted Average**	**Included**
No access to clean water	2	0	0	0	3	15	4.35	Yes
Lack of functioning toilets	2	0	2	1	8	7	3.7	Yes
Lack of health facilities	5	0	1	0	7	7	3.25	Yes
Lack of health professionals (doctors, nurses, community health workers)	5	0	1	2	3	9	3.25	Yes
Extreme poverty	5	0	1	3	4	7	3.1	Yes
Insufficient vaccination coverage	6	0	1	3	3	7	2.9	Yes
Exposure to disease vectors	4	0	4	3	4	5	2.9	Yes
Lack of waste management	4	0	1	6	7	2	2.9	Yes
Poor health status of the population	6	0	0	4	8	2	2.7	Yes
Lack of medicines	9	0	0	2	4	5	2.35	Yes
Overcrowding	7	0	2	4	7	0	2.2	Yes
Ongoing conflict	10	0	0	3	3	4	2.05	Yes
Lack of organisational or political will to address public health problems	9	0	2	3	2	4	2.05	Yes
Insufficient nutrient intake	9	0	2	2	5	2	2	Yes
Inadequate distance between housing, etc. and human waste disposal	9	0	1	3	7	0	1.95	Yes
Flooding (waste-water)	11	0	0	1	5	3	1.9	Yes
Lack of health education	9	0	1	6	3	1	1.85	Yes
Population displacement	10	0	2	0	7	1	1.85	Yes
Breakdown of government services	10	1	2	2	2	3	1.7	Yes
Inadequate shelter	11	0	2	3	1	3	1.6	No
Inequalities	13	0	0	0	5	2	1.5	No
No soap	13	0	1	0	3	3	1.45	No
Lack of disease surveillance	12	0	1	3	3	1	1.4	No
Reluctance to follow recommended procedures to limit disease spread	11	0	2	4	3	0	1.4	Yes
Political instability	13	0	1	1	3	2	1.35	No
Local endemicity of key communicable diseases	13	0	1	2	3	1	1.25	No
Flooding (fresh water)	13	0	1	2	4	0	1.2	No
Local endemicity of disease vectors	14	0	1	1	1	3	1.2	No
Environmental vulnerability	13	0	2	2	2	1	1.15	No
Lack of electricity	14	0	1	2	2	1	1.05	No
Breakdown of authority	15	0	0	1	2	2	1.05	No
Lack of trust in health care provided	14	0	0	4	2	0	1	No

Illiteracy (among target recipients of aid)	14	0	1	3	1	1	1	No
Displacement into camp	5	0	1	1	2	1	0.9	No
Low levels of education (among target persons)	15	0	0	3	1	1	0.9	No
Sexual and Gender-Based Violence	16	0	0	1	2	1	0.8	No
Indoor fires/indoor air pollution	16	0	0	2	1	1	0.75	No
Increased contact with domestic animals	17	0	0	1	2	0	0.55	No
Unsafe burial rites	16	0	2	1	1	0	0.55	No
Ethnic rivalry	18	0	0	0	1	1	0.45	No
Flooding (salt-water)	17	0	1	1	1	0	0.45	No
Very high temperatures	17	0	0	3	0	0	0.45	No
Lack of belief in germ model – preference for other explanations for disease causes	17	0	1	1	1	0	0.45	No
Violence	18	0	0	1	0	1	0.4	No
Seismic risk (dry mass displacement)	18	0	1	0	0	1	0.35	No
Very low temperatures	18	0	0	1	1	0	0.35	No
Increased contact with wildlife	19	0	0	0	0	1	0.25	No
Landslide risk (wet mass displacement)	18	0	1	1	0	0	0.25	No
High precipitation	18	0	1	1	0	0	0.25	No
Drought	19	0	0	0	0	1	0.25	No
Economic stagnation	19	0	0	0	0	1	0.25	No
Arms proliferation	19	0	0	0	0	1	0.25	No
Dust storms	19	0	0	0	1	0	0.2	No
De-forestation	19	0	0	0	1	0	0.2	No
Lack of fuel for cooking or heating	19	0	0	0	1	0	0.2	No
Temporary housing (not tents)	19	0	1	0	0	0	0.1	No
Competition for resources	19	0	1	0	0	0	0.1	No
Housing in tents	20	0	0	0	0	0	0	No
Volcanic risk	20	0	0	0	0	0	0	No

Thresholds

Table 12 shows the expert-identified yellow and red thresholds for the nine quantifiable risk factors. A yellow threshold indicated a situation of concern that should be addressed as soon as possible while a red threshold indicated a highly critical situation that needed to be a top priority. These thresholds are described individually below.

Table 12: Summary of yellow and red thresholds for 9 quantifiable risk factors:

		MIN	MAX	MEDIAN	MEAN	SD	n
Clean water in litres per person per day	*Yellow*	*0.00*	*30.00*	*6.50*	*10.50*	*8.92*	*16*
	Red	*0.00*	*15.00*	*2.00*	*5.25*	*5.01*	*20*
Hospital beds per 10 000 persons	*Yellow*	*5.00*	*200.00*	*20.00*	*45.00*	*54.70*	*13*
	Red	*1.00*	*100.00*	*5.00*	*18.77*	*27.28*	*13*
Functioning toilets per 100 persons	*Yellow*	*1.00*	*50.00*	*9.00*	*10.86*	*11.74*	*14*
	Red	*1.00*	*20.00*	*4.00*	*4.92*	*4.95*	*13*
Doctors per 10 000 persons	*Yellow*	*1.00*	*200.00*	*5.00*	*27.31*	*55.97*	*13*
	Red	*0.00*	*100.00*	*1.50*	*19.21*	*35.24*	*14*
Nurses per 10 000 persons	*Yellow*	*1.00*	*400.00*	*10.00*	*63.00*	*111.29*	*13*
	Red	*0.00*	*1000.00*	*6.00*	*96.79*	*256.24*	*14*
CHW per 10 000 persons	*Yellow*	*1.00*	*200.00*	*20.00*	*42.46*	*55.51*	*13*
	Red	*0.00*	*100.00*	*8.50*	*15.86*	*26.18*	*14*
Measles vaccination percentage	*Yellow*	*40.00*	*95.00*	*90.00*	*81.92*	*14.88*	*13*
	Red	*1.00*	*90.00*	*75.00*	*67.21*	*23.46*	*14*
Meningitis vaccination percentage	*Yellow*	*10.00*	*90.00*	*80.00*	*73.08*	*21.53*	*13*
	Red	*1.00*	*85.00*	*72.50*	*62.21*	*23.92*	*14*
Polio vaccination percentage	*Yellow*	*45.00*	*95.00*	*87.50*	*83.33*	*12.80*	*12*
	Red	*1.00*	*90.00*	*75.00*	*64.31*	*25.89*	*13*
Hepatitis B vaccination percentage	*Yellow*	*20.00*	*90.00*	*72.50*	*70.83*	*17.42*	*12*
	Red	*1.00*	*90.00*	*50.00*	*52.00*	*23.90*	*13*
Persons living under 1 US$ percentage	*Yellow*	*1.00*	*60.00*	*20.00*	*28.27*	*22.88*	*11*
	Red	*1.00*	*80.00*	*20.00*	*29.07*	*25.70*	*14*
Persons per 100 square metres	*Yellow*	*1.00*	*50.00*	*5.00*	*13.09*	*14.53*	*11*
	Red	*1.00*	*75.00*	*10.00*	*20.58*	*22.28*	*12*
Kcal per adult per day	*Yellow*	*800.00*	*3500.00*	*1750.00*	*1716.67*	*692.62*	*12*
	Red	*1.00*	*2500.00*	*1000.00*	*1009.30*	*742.52*	*13*
Distance housing and human waste disposal (metres)	*Yellow*	*10.00*	*300.00*	*50.00*	*79.00*	*89.60*	*10*
	Red	*1.00*	*500.00*	*20.00*	*71.00*	*138.53*	*11*

Access to clean water: Access to clean water was measured in litres per person per day. The median red threshold was 2 (mean 5.25, SD 5.01) litres and the median yellow threshold 6.5 (mean 10.5, SD 8.92) litres.

Health care facilities: The available number of hospital beds per 10,000 persons was used as a proxy indicator for the risk factor health care facilities. The median red threshold was 5 beds (mean 18.77, SD 27.28) per 10,000 persons and the median yellow threshold was 20 beds (mean 45, SD 54.70) per 10,000 persons.

Functioning toilets: The median red threshold for functioning toilets was 4 (mean 4.92, SD 4.95) toilets per 100 persons and the median yellow threshold was 9 (mean 10.86, SD 11.74) toilets per 100 persons.

Health professionals: The number of health professionals per 10,000 persons was measured in three categories. The median red threshold for doctors per 10,000 persons was 1.5 (mean 19.21, SD 35.24) and the median yellow threshold was 5 (mean 27.31, SD 55.91) doctors per 10,000 persons. The median red threshold for nurses was 6 (mean 96.79, SD 256.24) per 10,000 persons and the median yellow threshold 10 (mean 63, SD 111.29) nurses per 10,000 persons. The median red threshold for community health care workers was 8.5 (mean 15.86, SD 26.18) per 10,000 persons and the median yellow threshold was 20 (mean 42.46, SD 55.51) community health care workers per 10,000 persons.

Vaccination coverage: Vaccination coverage was measured for the following four diseases: measles, meningococcal meningitis, polio and hepatitis B. The median red threshold for measles vaccination coverage was 75% (mean 67.21, SD 23.46) and the median yellow threshold was 90% (mean 81.92, SD 14.88). The median red threshold for meningococcal meningitis vaccination coverage was 72.5% (mean 62.21, SD 23.92) with a median yellow threshold at 80% (mean 73.08, SD 21.53). The median red threshold for polio vaccination coverage was 75% (mean 64.31, SD 25.89) with a median yellow threshold of 87.5% (mean 83.33, SD 12.80). The median red threshold for Hepatitis B vaccination coverage was 50% (mean 52.00, SD 23.90) with a median yellow threshold of 72.5% (mean 70.83, SD 17.42).

Poverty: Poverty was measured in percentage of the population living on below 1 US$ per person per day. The median red threshold was 20% (mean 29.07, SD 25.70) and the median yellow threshold was also 20% (mean 28.27, SD 22.88).

Overcrowding: Overcrowding was measured in the number of persons living per 100 square metres (m^2). The median red threshold was 10 (mean 20.58, SD 22.28) persons per 100 m^2 and the median yellow threshold was 5 (mean 13.09, SD 14.53) persons per 100 m^2.

Nutrition: Nutrition was measured in kcal per adult per day. The median red threshold was 1,000 (mean 1009.30, SD 742.52) and the median yellow threshold was 1,750 (mean 1716.67, SD 692.62) kcal per adult per day. These figures – especially the seemingly 'high' figure for the yellow threshold – must be understood in the context of the impact of mal- and undernutrition for the severity of communicable disease outbreaks through mechanisms such as increased susceptibility and greater shedding and transmission. Poor nutritional status is a common attribute of affected populations in many humanitarian emergencies, and is known to exacerbate the size and severity of communicable disease outbreaks (53, 98, 100, 105, 111).

Distance between human waste disposal and housing: The median red threshold for the distance between human waste disposal and housing was 20 metres (mean 71.00, SD 138.53) and the median yellow threshold was 50 metres (mean 79, SD 89.60).

Weights in different emergency types

Weights for the different risk factors were similar for different types of emergencies, with only minor differences (see Figure 11 and Tables 13 and 14). On a scale from 1 (not important) to 5 (very important), all of the included risk factors scored above 4 (both mean and median) when combining all emergencies. The only two risk factors with a median of 3 were 'insufficient nutrient intake' and 'lack of health education' in the context of a tropical storm. Mean values for all risk factors in all different emergency types (not combined) remained above 3.4, except for 'lack of health education' in the context of flooding (mean 3.29, SD 1.14, median 4) and 'lack of health education' in the context of a tropical storm (mean 3.22, SD 1.28, median 3). This suggests a reinforcement of the importance of these risk factors across different humanitarian emergency types.

There was considerable correlation between risk factors, demonstrating the highly interactive nature of risk and risk factors in humanitarian emergencies, as well as the complexity of such situations (see Supplementary File SF-4[2]).

[2] Supplementary files can be found in a digital version in the accompanying materials.

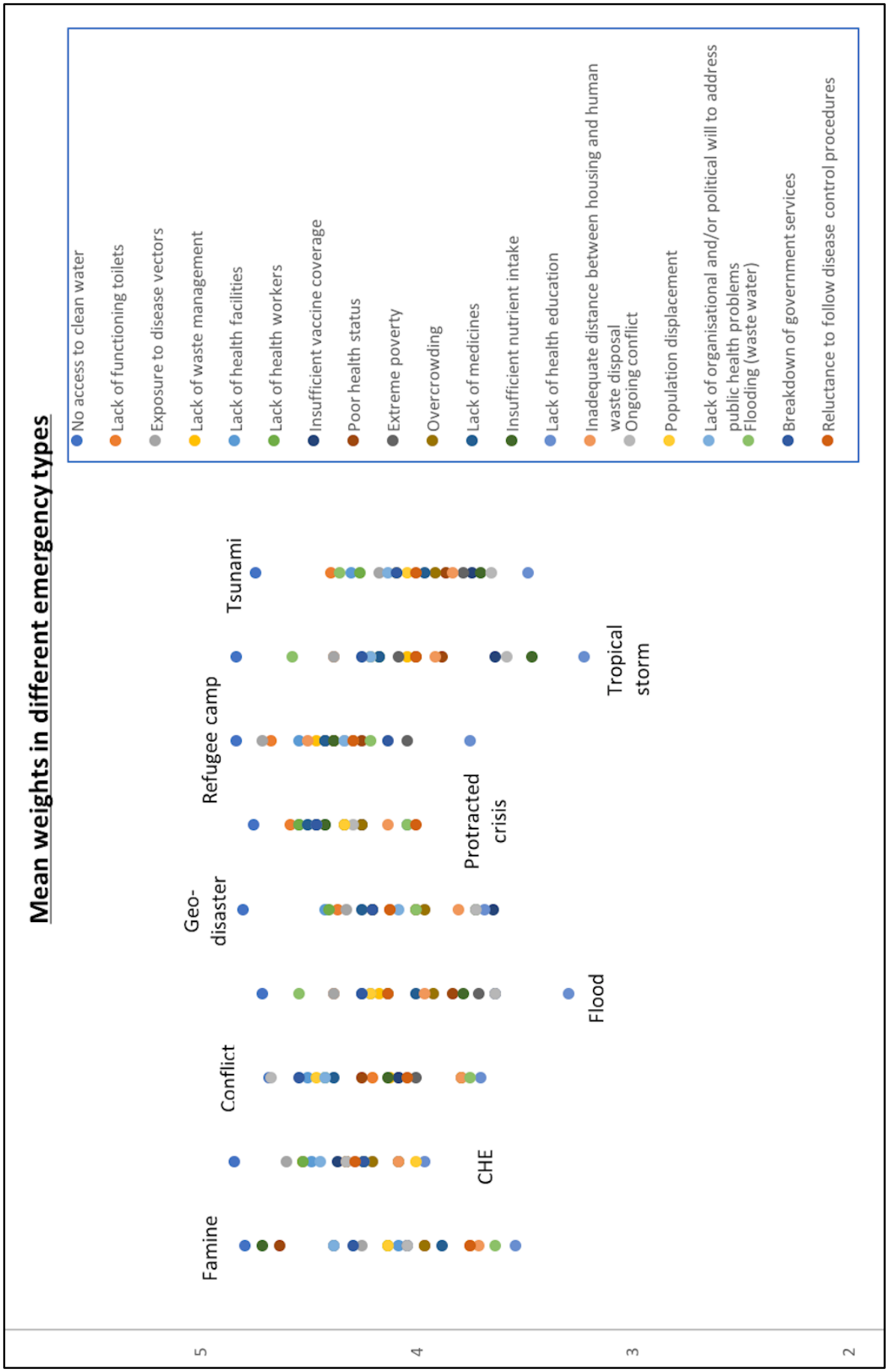

Figure 11: Distribution of mean weights in different emergency types.

Table 13: Median values for the weights of the selected risk factors in different types of emergencies:

	F	CHE	C	F	GD	PC	RC	TS	T
No access to clean water	5	5	5	5	5	5	5	5	5
Lack of functioning toilets	4	5	5	5	5	5	5	5	5
Exposure to disease vectors	4.5	5	4	5	5	5	5	5	5
Lack of waste management	4	4	4	4.5	4	5	5	4	4
Lack of health facilities	4.5	5	5	4.5	5	5	5	5	5
Lack of health workers	4	5	5	4	5	5	5	4	4
Insufficient vaccine coverage	4.5	4	4	4	4	4.5	5	4	4
Poor health status	5	5	4.5	4	4	5	4.5	4	4
Extreme poverty	4.5	4	4	4	4	5	4.5	4.5	4
Overcrowding	4	4	4	4	4	4	5	4	4
Lack of medicines	4	5	5	4	5	5	5	4	4
Insufficient nutrient intake	5	4	4	4	4	5	5	3	4
Lack of health education	4	4	4	4	4	4	4	3	4
Inadequate distance between housing and human waste disposal	4	4	4	4	4	5	5	4	4
Ongoing conflict	5	5	5	4	4	5	5	4	4
Population displacement	4.5	4	5	4.5	4	5	5	4.5	4
Lack of organisational and/or political will to address public health problems	5	5	5	5	4	5	5	4	5
Flooding (waste water)	4	4	4	5	4	4.5	4	5	5
Breakdown of government services	5	4	5	4.5	4	5	4.5	4	4
Reluctance to follow disease control procedures	4	4	4	4	4	4	4.5	4	4

Table 14: Mean values for the weights for the risk factors in different emergency types (standard deviations in brackets):

	F	CHE	C	FL	GD	PC	RC	TS	T
No access to clean water	4.79 (0.41)	4.84 (0.46)	4.68 (0.55)	4.71 (0.54)	4.80 (0.40)	4.75 (0.43)	4.83 (0.47)	4.83 (0.37)	4.74 (0.44)
Lack of functioning toilets	3.96 (1.27)	4.52 (0.90)	4.20 (1.10)	4.38 (1.03)	4.36 (1.02)	4.58 (0.76)	4.67 (0.80)	4.38 (1.03)	4.39 (1.05)
Exposure to disease vectors	4.25 (0.83)	4.60 (0.57)	4.08 (0.89)	4.38 (0.90)	4.32 (0.84)	4.42 (0.76)	4.71 (0.54)	4.38 (1.07)	4.17 (1.20)
Lack of waste management	3.75 (1.33)	4.32 (0.79)	4.12 (1.07)	4.17 (1.07)	4.20 (0.80)	4.46 (0.82)	4.46 (0.87)	4.04 (1.10)	4.09 (0.93)
Lack of health facilities	4.08 (1.11)	4.48 (0.70)	4.50 (0.76)	4.21 (1.00)	4.42 (0.81)	4.54 (0.76)	4.54 (0.71)	4.21 (1.04)	4.30 (0.95)
Lack of health workers	4.13 (1.05)	4.52 (0.70)	4.42 (0.70)	4.13 (1.01)	4.40 (0.75)	4.54 (0.71)	4.38 (0.86)	4.17 (0.99)	4.26 (0.94)
Insufficient vaccine coverage	4.04 (1.24)	4.36 (0.69)	4.08 (0.95)	3.63 (1.15)	3.64 (1.05)	4.25 (0.92)	4.42 (0.86)	3.63 (1.18)	3.74 (1.03)
Poor health status	4.63 (0.56)	4.32 (0.93)	4.25 (0.88)	3.83 (1.25)	4.00 (0.98)	4.46 (0.76)	4.25 (0.92)	3.88 (1.05)	3.86 (1.22)
Extreme poverty	4.38 (0.70)	4.24 (0.81)	4.00 (1.04)	3.71 (1.21)	4.20 (0.89)	4.33 (0.90)	4.04 (1.21)	4.08 (1.15)	3.78 (1.21)
Overcrowding	3.96 (1.21)	4.20 (0.69)	3.79 (1.04)	3.92 (0.95)	3.96 (1.00)	4.25 (0.83)	4.38 (0.81)	4.00 (1.08)	3.91 (0.93)
Lack of medicines	3.88 (1.17)	4.24 (0.86)	4.38 (0.81)	4.00 (1.22)	4.25 (0.88)	4.50 (0.71)	4.42 (0.81)	4.17 (0.94)	3.96 (1.16)
Insufficient nutrient intake	4.71 (0.61)	4.08 (0.93)	4.13 (0.97)	3.78 (1.06)	3.72 (1.08)	4.42 (0.81)	4.38 (0.81)	3.46 (1.08)	3.70 (1.08)
Lack of health education	3.54 (1.22)	3.96 (0.82)	3.70 (1.20)	3.29 (1.14)	3.68 (1.05)	4.04 (0.84)	3.75 (1.09)	3.22 (1.28)	3.48 (1.02)
Inadequate distance between housing and human waste disposal	3.71 (1.24)	4.08 (0.93)	3.79 (1.26)	3.96 (1.14)	3.80 (0.94)	4.13 (1.09)	4.50 (0.87)	3.91 (1.10)	3.83 (1.01)
Ongoing conflict	4.04 (1.31)	4.32 (0.88)	4.67 (0.75)	3.63 (1.41)	3.72 (1.15)	4.29 (1.06)	4.33 (0.94)	3.58 (1.41)	3.65 (1.34)
Population displacement	4.13 (1.13)	4.00 (0.94)	4.46 (0.64)	4.21 (0.96)	4.12 (0.82)	4.33 (0.85)	4.29 (1.10)	4.21 (0.96)	4.04 (1.12)
Lack of organisational and/or political will to address public health problems	4.38 (0.99)	4.44 (0.70)	4.42 (0.76)	4.25 (1.01)	4.08 (0.84)	4.46 (0.71)	4.33 (0.99)	4.21 (0.91)	4.13 (1.15)
Flooding (waste water)	3.63 (1.41)	4.24 (0.76)	3.75 (1.20)	4.54 (0.82)	4.00 (1.06)	4.04 (1.10)	4.21 (0.91)	4.57 (0.71)	4.35 (0.91)
Breakdown of government services	4.29 (1.02)	4.24 (0.65)	4.54 (0.71)	4.25 (0.92)	4.20 (0.75)	4.46 (0.71)	4.13 (1.09)	4.25 (0.83)	4.09 (0.97)
Reluctance to follow disease control procedures	3.75 (1.23)	4.28 (0.78)	4.04 (0.93)	4.13 (0.93)	4.12 (0.86)	4.00 (1.04)	4.29 (0.84)	4.00 (1.04)	4.00 (0.98)

4.2.5. Discussion

The results from the first questionnaire, regarding the selection of risk factors, confirm that, as suggested in the wider literature, WASH (190-193), health care (53, 118), nutrition (53, 100, 105) and emergency-specific risk factors such as poverty (104, 113, 153), displacement and overcrowding (98, 100, 107, 115), and (ongoing) armed conflict or war (156), are among the primary factors influencing communicable disease outbreaks in humanitarian emergencies and disasters. These results are further confirmed by the outcomes of the third questionnaire, which indicate the high importance of the selected risk factors across all types of humanitarian emergencies. While some of the risk factors identified in this research were – deliberately – broad, additional discussion with humanitarian aid providers (which were not strictly speaking part of this research) revealed some of the most common interpretations of these risk factors and showed that, while encompassing a range of issues, they were interpreted similarly by all people we spoke to. For example, 'breakdown of government services' was generally interpreted as encompassing wider infrastructure issues such as transportation and roads, telecommunications, safety and security, and sometimes education. Many of these have complex interaction pathways (58).

For some of the risk factors, the responses included seemingly extreme values. Due to this we suggest, for any use of the data, to rely on median values rather than means to make sure that extremes have little effect. However, we are not confident enough that they are simply mistakes to omit them from the analysis. Extremes of 1 or 0 could also mean that the responder didn't think this was a relevant factor. We cannot know why such a value was selected. If such values had been mentioned in interviews, it would have been highly interesting to know if this was a mistake or an intentional way to signify that a risk factor or threshold would – in the responder's opinion – not have a significant effect on communicable disease outbreak risk.

While we focused on the 20 most critical risk factors, this does not mean that other factors are not important when assessing the risk of communicable disease outbreaks in such situations. However, our aim was to establish which factors needed to be priority concerns. We were interested in identifying quantitative thresholds for the risk factors that could support quick assessment using minimal resources and man-power by not requiring professional judgements.

The argument could be raised that thresholds for many of these factors can be as easily obtained from the Sphere standards (29). However, the thresholds listed in the Sphere standards have important limitations if used for the purpose of assessing the risk of communicable disease outbreaks in humanitarian emergencies. The Sphere standards were developed to assess the adequacy of overall humanitarian response and provide general minimum standards. Thus, the Sphere standards are neither intended as a risk assessment nor are they specific to communicable diseases. Secondly, the Sphere standards have a normative component, as they indicate standards that should be reached based on ethical considerations rather than those that empirically relate to changes in the level of risk experience. While this makes the Sphere standards an unsuitable comparison, it might be interesting to see how this difference in approach shapes the suggested thresholds. Sphere standards indicate a minimum of 15 litres of water per person per day (29). Our survey found a yellow threshold for clean water availability at 6.5 litres per person per day. This difference is explained by the fact that the thresholds we sought to identify are only thresholds for increases in disease outbreak risk. A yellow threshold for clean water at 6.5 litres per person per day does not suggest that a person does not need more that 6.5 litres of water per day but rather that below that the risk for a communicable disease outbreak critically increases. Additionally, some of the risk factors and especially their measurements are simply proxies. This becomes clear when looking at vaccination coverage. The selected vaccines are not meant to be the main, the only, or even vaccination priorities at all in all emergencies but rather they are used as proxies to estimate the reach of vaccination programmes.

Keeping this in mind, the measures and risk factors identified are entirely unsuitable as a basis for humanitarian programming. This should follow a suitable method for needs assessment – which obviously a communicable disease outbreak risk assessment, which the factors suggested here are meant for, is not – and an estimation of minimum standards based on internationally accepted levels such as the Sphere standards.

In contrast, the thresholds identified by our surveys indicate precise and transferable tipping points for levels of risk. They are the first step towards developing a rapid risk assessment mechanism for communicable disease outbreaks in humanitarian

emergencies that, rather than asking the person or persons completing it for qualitative and personal assessments of the severity (without any indicators of what this should be based on), uses pre-defined thresholds and risk levels against which a situation can be judged. Hence our thresholds are hopefully useful in real-world risk assessment, because they identify specific risk thresholds using simple quantitative indicators.

Limitations

While we made every attempt to maximise participation, the main limitation of this work is the small number of respondents. However, it can be argued that the field of experts suitable for participation is not large. Our experts' opinions are in line with assessments in the scientific literature of the relative importance of different risk factors. Expert elicitations have their limits and are subject to biases (194, 195). Overconfidence in the results of expert elicitations should be avoided (195). Hence, we do not recommend accepting the results without further inquiry, even if they are mostly in line with the literature.

Additionally, the above-mentioned lack of specification and possibly blurred and broad definitions of some of the risk factors is a potential limitation. That would certainly be the case if the results from this research would be used uncritically to make decisions in the field, even if they were used just for risk assessment without further additional investigation. However, considering that we do not recommend using these results beyond the realm of risk assessment and that for risk assessment we considered this research to be a first stage within a larger research project, the results form a good starting point to understand expert opinion on some of the most critical risk factors for communicable disease outbreaks in humanitarian emergencies.

4.2.6. Conclusion

Communicable disease outbreaks remain a significant concern in the aftermath of emergencies and disasters, especially in low- and middle-income countries. Broadly, expert consensus seems to be that WASH, access to healthcare, nutrition and wider societal and emergency-specific factors are among the most important indicators and

risk factors for communicable disease outbreaks in such situations. These factors remain important across different types of humanitarian emergencies. Beyond establishing current expert opinion, this research also serves as a starting point to assess and improve risk assessment tools, methods and protocols for communicable disease risks in humanitarian emergencies and disasters. Current risk assessment tools, such as the WHO tool used in the context of the Early Warning and Response Network (EWARN) system (196, 197), also use individual risk factors. However, there is a strong need to make risk assessments clearer and more explicit by using, where possible, previously determined risk factor thresholds that can be assessed without expert knowledge in each domain. Ideally, this risk summary would be based on an independent needs assessment and require minimal additional primary data collection in the field. The expert consultation described in this article, combined with a systematic review performed in parallel (58) and additional research by the research team, seeks to be the basis for such a pragmatic, easy-to-use and novel risk assessment tool. No system captures the complexity and diversity of humanitarian emergency settings perfectly and even accepted international standard such as Sphere are under constant revision and do not cover all aspects of humanitarian response. However, such a risk assessment tool can be seen as an attempt to capture some of the main risk factors for communicable disease outbreaks in such settings. This is especially true as it does not assume considerable expert knowledge from the person or persons using it, like the WHO's risk assessment tool for communicable diseases in humanitarian emergencies does (196, 197).

5. Study 3: Rapid risk assessment tool development and validation

5.1. Context

Consolidating the theoretical understandings outlined in Chapter Two, the insights gained from the analysis of communicable disease risk factors in the archetype of crises – CHEs – as outlined in Chapter Three, the most critical risk factors and their dynamics based on expert knowledge as described in Chapter Four, and additional background information on risk factor and disease dynamics in different emergency types, this chapter constitutes the culmination of the research done for this thesis. The aim of studies 1 and 2 was to provide background and content for the development of a rapid risk assessment tool for communicable disease outbreaks in humanitarian emergencies of various types that takes into consideration data from all relevant humanitarian sectors. This chapter details the validation of the tool using a two-stage approach.

The paper presented in this chapter seeks to answer research questions four and five: 4) How can these risk factors be operationalised in the form of a rapid risk assessment tool? 5) Can such a tool be used by aid workers with no or limited health protection experience to accurately assess communicable disease risks in humanitarian emergencies? It also provides further confirmation of the previous results in relation to research question three: Which are the most critical risk factors for communicable disease outbreaks in humanitarian emergencies? What are their thresholds and weights in different emergency types?

The results of the tool development and validation process was published in 2019 in *Global Biosecurity* (198).

Changes were made to ensure a coherent and standardised referencing style, labelling of sections as sub-chapters, and continuous numbering of tables and figures.

5.2. Rapid risk assessment for communicable diseases in humanitarian emergencies: validation of a rapid risk assessment tool for communicable disease risk in humanitarian emergencies

5.2.1. Abstract

Background: Communicable diseases pose a significant risk in humanitarian emergencies. This paper reports on the development and validation of a rapid risk assessment tool for communicable diseases in humanitarian emergencies.

Methods: We developed a tool assessing the 20 most critical risk factors for disease outbreaks in humanitarian emergencies. This paper reports on the development and validation of the tool consisting of face and content validation with key-informant interviews (n=25) and a reliability validation (inter-rater reliability test) with groups of volunteer aid workers (n=4 groups).

Findings: Face and content validation confirmed the importance of rapid risk assessment methods and the suitability and usefulness of the developed tool. Participants without prior health protection experience were able to fill in the tool with an accuracy of 81.25% (SD 4.08) across both scenarios (82.35% and 80.15% for scenarios 1 and 2 respectively). Errors primarily occurred when judging the severity of risk factors that could not be captured quantitatively. Revisions of the tool have been made based on the validation process.

Conclusion: The tool was successfully validated for use in different humanitarian emergency settings and is suitable for users with and without experience in health protection.

5.2.2. Introduction

Humanitarian emergencies pose a significant risk to human health. One of the primary health concerns in humanitarian emergencies is communicable diseases (3-9, 11, 24, 31, 60, 100, 167, 172, 181-183, 199). The outbreaks of Diphtheria and Measles among the Rohingya refugees are striking examples of this (200-203).

Early identification of at risk populations is an important step towards not only a better response but also preparedness and the prevention of outbreaks or at least the more serious outbreaks. Rapid risk assessment is therefore a priority research area. The aim of this study was to develop and validate an easy-to-use rapid risk assessment tool for communicable diseases in humanitarian emergencies. The tool was designed as part of a larger project to understand vulnerabilities towards communicable disease outbreaks in humanitarian emergencies other than a disease outbreak.

Tool development

The tool development draws on a systematic review of the literature on communicable disease risk factors in CHEs (58), theoretical-conceptual framework development (68), expert elicitation (180) and the validation phase. The results were used to develop a rapid risk assessment tool for communicable diseases in humanitarian emergencies. The tool was developed in Microsoft Excel. The expert elicitation described in Chapter Four gave the main data for the development of the tool. Results from the first survey were used to populate the section of the tool regarding the most critical risk factors. The next column was left blank as a field in which the user can input the relevant data. Based on the second survey of the expert elicitation the tool then matches that input with one of three thresholds (green, yellow and red risk levels) and the next column builds on the final expert elicitation survey and assigns weights to the risk factor based on the type of emergency selected by the user. The final column provides a calculation of the weighed risk score based on the weight in this type of emergency and the threshold reached. An early draft was further refined after reflective practice and deliberations involving the research team prior to the validation and testing process described in this paper (see Figure 12). This was done mainly in the form of informally reviewing the tool within the research team and with close colleagues and making changes to the layout and the underlying programming to make sure the tool shared

with participants of the validation was functional and fully reflected the results of the expert elicitation. The tool captures data on the 20 most critical risk factors that indicate a heightened risk for communicable disease outbreaks in humanitarian emergencies, which fall into three categories: WASH, health and socio-political. Table 15 gives an overview of the risk factors and their sub-factors. Table 16 gives definitions of the main elements of the tool. The tool is accompanied by a guide. The tool presents the results of the risk assessment both numerically – in the form of weighted risk scores – and visually – using a traffic light system. Ideally, the risk assessment should be completed immediately following the onset of an emergency or the set-up of a response operation, within the first 72 hours to 14 days. Subsequent iterations of the assessment should be repeated at regular intervals throughout the response and recovery phases. The tool included as Supplementary Files SF-5 (digital) and SF-6 (print). The guide is available as SF-7[3]. The not filled in tool and the guide are also available in the appendices.

The tool differs considerably from previous tools such as the risk assessment matrix described as part of the WHO EWARN system (196, 197). Our tool does not draw on a qualitative assessment of the riskiness of the individual factors with regard to outbreak risk, nor does it provide an overall risk assessment of that. Rather, this tool enables responders with little or no health protection experience to input secondary or primary data and obtain an evidence-based and objective assessment based on those data. Subjectivity is thereby eliminated from the risk assessment process and the only level of subjectivity remains in the data collection and evaluation thereof, not in the assessment of the consequences of the factors related to outbreak risk. This should also reduce the cognitive bias often inherent in risk assessment processes. As such this tool serves a different purpose than the WHO EWARN risk assessment matrix.

The aim of the research described in this paper – the validation phase – was to test the validity of the content of the tool and its reliability. This was done in a structured process with tiered changes to the tool based on the results of previous work.

[3] Supplementary files can be found in a digital version in the accompanying materials.

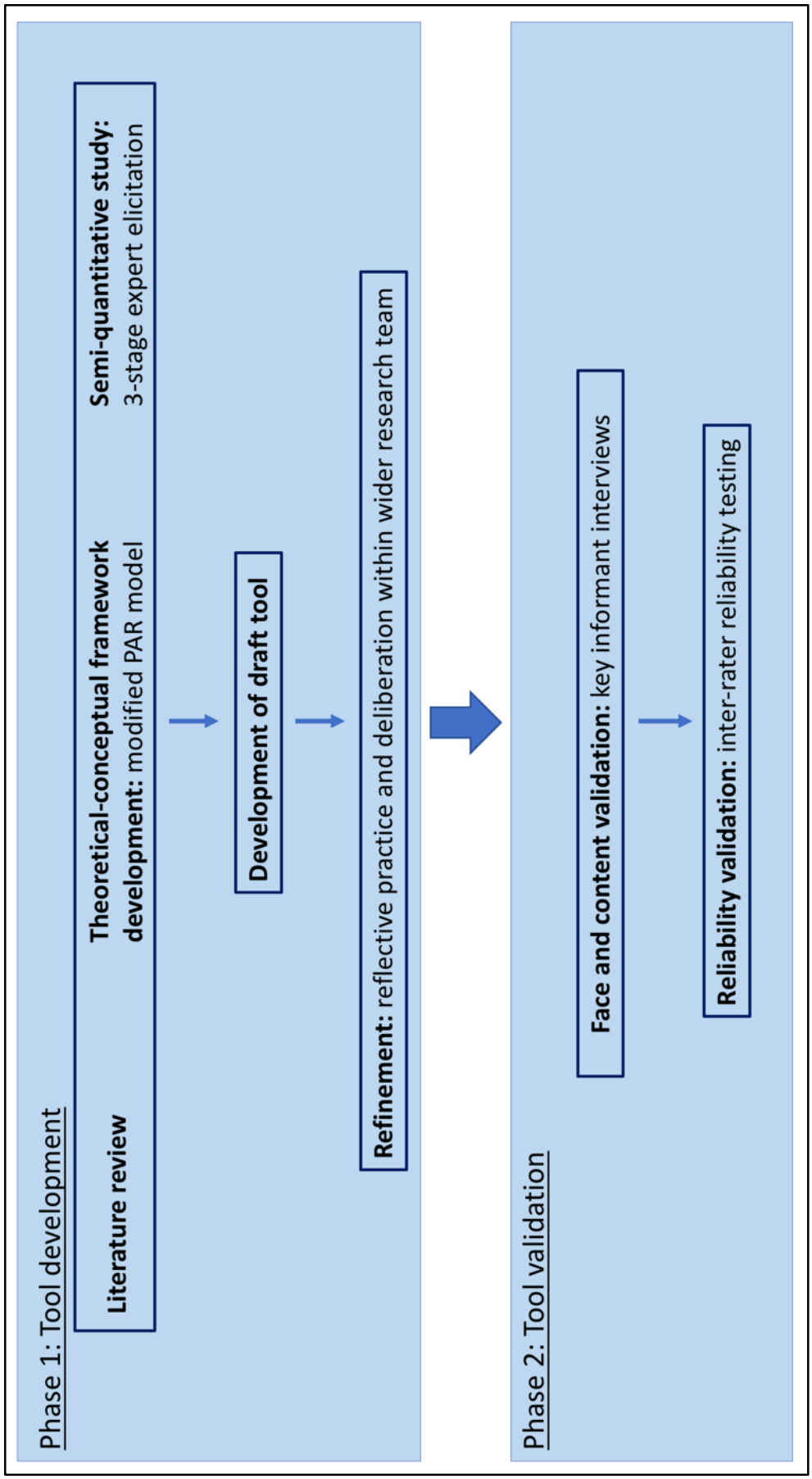

Figure 12: Tool development process.

Table 15: Risk factors and sub-factors (items) in tool:

Category	Risk Factors	Sub-factor
WASH	Lack of clean water	N/A
WASH	Lack of toilets	N/A
WASH	Inadequate distance between housing and human waste disposal	Average distance between housing and human waste disposal
		Shortest distance between housing and human waste disposal
WASH	Flooding (waste water)	N/A
WASH	Lack of waste management	N/A
WASH	Exposure to disease vectors	N/A
Health	Lack of health facilities	Access to health facilities
		Availability of clinics and/or health posts (or other primary care facilities)
		Disease surveillance
		Hospital beds
Health	Lack of health workers	Doctors
		Nurses
		Community health care workers
Health	Insufficient vaccine coverage	Measles
		Meningococcal disease
		Polio
		Hepatitis B
Health	Poor health status of the population	N/A
Health	Lack of medicines	N/A
Health	Reluctance to follow disease prevention measures	Local health professionals
		General population
Health	Insufficient nutrient intake	N/A
Health	Lack of health and hygiene education	N/A
Socio-political	Extreme poverty and food insecurity	N/A
Socio-political	Overcrowding	N/A
Socio-political	Ongoing conflict	N/A
Socio-political	Population displacement	N/A
Socio-political	Lack of organisational and political will to address public health issues	(I)NGOs and donors
		Local and national government
Socio-political	Breakdown of government and infrastructure services	Transport
		Communications
		Education
		Electricity

Table 16: Main elements of the rapid risk assessment tool (for more detailed descriptions refer to the tool guide – SF-6 – in the supplementary files[4]):

Element	Description
Category	Category describes the sphere of the risk factor in question.
Risk Factor	The risk factor is the factor being measured; it can have multiple sub-factors.
Measure	The measure defines how this risk factor is measured. Measures can be quantitative or qualitative.
Answer	The answer is the observed situation, measured either quantitatively or via a selection of options for qualitative factors.
Score (0-2)	The score is the quantification and standardisation of the answer (with pre-defined categories for scores of 0; 1; and 2).
Weight in this type of emergency (0-4)	The weight is pre-determined by the selection of the emergency type.
Weighted Risk Score (0-8)	The weighted risk score is derived from the score reached and the weight of the risk factor in the emergency type (multiplicatory).
Overall weighted risk score (0-8)	The overall weighted risk score combines the weighted risk scores for all included risk factors. It works on the same scale as the weighted risk scores.

5.2.3. Methods

The first part of this study was performed remotely with experts from the fields of humanitarian aid and health protection and the second part of the study was performed in the field with volunteer aid workers. The tool tested was in English. The aims of this research were to determine the validity of the content of the tool and its inter-rater reliability when used by aid workers with no or limited expertise in health protection. We used mixed methods to ensure robust testing and optimal fulfilment of the aims.

Study site, partners and participants

Validity testing was done with key-informant interviews. This was done remotely to include a wide variety of participants from different backgrounds and geographic locations, including persons currently deployed in the field. The reliability testing was

[4] Supplementary files can be found in a digital form in the accompanying materials.

done in August 2018 in Thessaloniki, Northern Greece. Thessaloniki remains a hotspot for the response efforts to the European migration crisis and hosts many of the smaller and volunteer-based organisations. We partnered with the InterEuropean Human Aid Association (IHA). IHA started as an entirely volunteer-based organisation in 2015 and has since developed professional recognition. The organisation works with Greek and international partners and provides services to refugees in camps in Northern Greece. However, the reliability testing was not done specifically in the context of the migration crisis as the response effort in Greece is considerably different from other humanitarian emergencies. Rather, volunteers from IHA were involved to test whether the tool was reliable for volunteers with a background in humanitarian aid but not necessarily in medicine or health protection.

Study population: For the first part of the study, we invited participants with backgrounds in humanitarian medicine, health protection, disaster and humanitarian studies and humanitarian aid. We interviewed 25 people. We did not determine the study size a priori as we agree with Sim et al. (204) that a priori determination of the sample size for qualitative key-informant interviews is wrought with problematic issues due to the underlying "questionable philosophical and/or methodological assumptions". We reached saturation after 20 interviews and conducted another five interviews to confirm. We interviewed 17 people with a health background, five academics and three humanitarian generalists (these represent the primary backgrounds of the participants, several participants fell into multiple groups). Specific practitioner backgrounds included expertise in water, sanitation and hygiene, epidemiology, microbiology, health protection, logistics, clinical medicine and nursing. Apart from academics from institutions in Europe and North America, we interviewed participants from Public Health England, the WHO, MSF, the UK Public Health Rapid Support Team, the United Nations Relief and Works Agency in Jordan and several other organisations. Participants were from Europe, Asia, Africa and North America. Participants were mainly recruited through personal contacts of the research team as well as their contacts. In addition, some of the listservs used to recruit for the expert elicitation were also used. However, there was very little overlap between participants of the expert elicitation and the face and content validation (2/25). Participants who had previously taken part in the expert elicitation did not comment on the inclusion of risk factors or the weights and thresholds but rather on the tool design, the traffic light

system and the general usefulness of such a tool. Hence, no adjustment of results was necessary.

For the reliability testing we invited volunteers from IHA and partner organisations to take part. We conducted an exercise in the format of adapted focus groups with four groups of two participants each. Participants were from various countries in Europe and all had a background in humanities aid, specifically in response in formal and informal refugee camps with varying experience. Participants had no prior training in health protection, epidemiology or risk assessment. None of the participants of the reliability test had previously participated in the expert elicitation.

Validity testing

Validity testing covered both content validity testing, defined as the usefulness, appropriateness, relevance and suitability of the tool (64), as well as face validity, defined by the level to which the tool actually measures communicable disease risk and hence a measure of accuracy (63). Participants were given access to the tool. They were asked to comment on the design of the tool, regarding the layout and ease of use, the order and inclusion of risk factors, and the amount of information (i.e. the length of the tool). Additionally, risk factors and their measurements were discussed individually regarding their suitability. The interview concluded with a discussion of the colour-coding system and the interpretation of the results given by the tool. The interviews used a mix of open-ended introductory questions and more detailed further queries. If the participants desired, they were provided with details on the development of the tool and the data sources used. Interviews were performed using an open-ended interview guide and responses were recorded on standardised response sheets. Response sheets were reviewed after each interview and key themes and repeated suggestions for improvement were recorded on a running document.

Reliability testing

The tool was designed so that aid workers with little or no experience in health protection would be able to consistently fill in the tool with the right information. This was tested with two fictitious scenarios in the form of a reliability testing (65).

Participants filled in the tool for both scenarios – one a displacement crisis with a setting in a refugee camp and the other a response to an earthquake. They had access to the tool, the tool guide and a scenario description. The tool was completed in pairs and inter-rater reliability testing was done based on the filled-in tool documents provided by the participants. Scenarios were modelled after real emergencies (mainly by combining aspects of different past emergencies) and authentically reflected situations with incomplete information. Scenarios were provided in written form. There was no time limit for participants to complete the tool but times to completion were recorded for each group and scenario. Analysis was done against an answer sheet and agreement with the answer sheet was recorded for the overall weighted risk score as well as line-by-line for each individual risk factor and sub-factor. After completion of the two scenarios, all groups came together as one focus group to discuss the ease of use of the tool. Results of this discussion were recorded in the form of field notes and considered in the final changes made to the tool.

Changes to the tool were made after each phase of the testing. After analysis of the reliability testing, the tool was finalised and is included as Supplementary Files SF-5 (digital) and SF-6 (print). The guide is available as SF-7[5].

5.2.4. Results

Validity testing

Participants generally found the tool useful, comprehensible and accurate (24/25). Positive feedback was given for the inclusion of both a print and a digital version of the tool. Those who suggested the inclusion of other risk factors agreed that the 20 included were suitable, after discussion of the data sources and evidence upon which the design of the tool was based. Suggestions for changes made by the participants included issues regarding the layout and design of the tool, the measurement of qualitative risk factors and the breakdown of risk factors into sub-factors. Changes were incorporated in subsequent iterations of the tool. Specific changes were made based on the face and content validation. The risk factor health facilities, which initially only included hospital beds, was extended to include primary care facilities, and access

[5] Supplementary files can be found in a digital version in the accompanying materials.

to health care and disease surveillance. For several risk factors, responses were broken down by groups; for example 'Lack of political and organisational will to address public health issues' was split into the groups 'local and national government' and 'non-governmental organisations and donors'. A risk factor concerning government services was clarified into government and infrastructure services and broken down into roads/transport, communications, electricity and education. Minor changes were made to the wording of some risk factors. Additionally, for the digital version a tab with a mock filled-in version was added to give users a visual example and risk factors were sorted according to clusters based on suggestions from participants. Participants also provided detailed input into issues to be included in the accompanying guide, including the use of a smaller spatial scale where possible and the need to re-do the assessment if significant changes to the situation have occurred.

Reliability testing

Inter-rater reliability testing was done based on the completed tools provided by all groups for both scenarios (n=8). The time that the participants needed to complete the tool decreased with the second scenario, with the average time for completion for scenario 1 being 33 minutes and 1 second and for scenario 2, 13 minutes and 15 seconds (see Table 17). This leads to the assumption that the tool is easier to use once participants have some experience with it. Discussions with the participants confirmed this assumption.

Table 17: Completion time for both scenarios:

Group	Scenario 1	Scenario 2
1	39 min 14 sec	14 min 48 sec
2	38 min 20 sec	12 min 51 sec
3	27 min 15 sec	12 min 30 sec
4	27 min 15 sec	15 min 11 sec
Average	33 min 01 sec	13 min 50 sec

The aim of the analysis of the completed tools was to test whether participants with little or no experience with health protection could fill in the tool and reach accuracy levels of 70% or greater. Accuracy was determined as inter-rater reliability when tested against an answer sheet. Any answer that was not in line with the answer sheet

was considered a mistake, even if it consisted of a blank. We recognise that there are some answers that could be contested, hence our aim for 70% agreement with the answer sheet and not higher. Potentially contestable answers were those that required a qualitative judgement of the situation. These were also the most likely to be answered wrongly. Participants without prior health protection experience were able to fill in the tool with an accuracy of 81.25% (SD 4.08) across both scenarios (82.35% and 80.15% for scenarios 1 and 2 respectively).

Scenario 1 (see Table 18): For 50% of the items, 100% of the groups gave the correct answers. For another 11 items (out of 34 items in total) three groups gave the correct answer (75%). A final six items were correctly completed by less than three groups (50% or lower). Quantitative items were generally more likely to have been identified correctly (8 completely correct answers out of 14 quantitative items versus 11 completely correct answers out of 20 qualitative items).

Table 18: Item and group validation for scenario 1 (line-by-line and group-by-group comparison of the answers of all four groups for scenario one in comparison with the answer sheet):

Risk Factor	Type	Answer Sheet	Group 1	Group 2	Group 3	Group 4	Correct	% Correct
1	quant	0	0	0	0	0	4	100
2	quant	2	2	2	2	2	4	100
3a	quant	1	1	1	N/A	1	3	75
3b	quant	1	1	1	1	1	4	100
4	qual	0	0	0	0	0	4	100
5	qual	1	1	1	1	1	4	100
6	qual	1	2	1	1	1	3	75
7a	qual	0	2	1	1	0	1	25
7b	qual	0	2	0	1	0	2	50
7c	qual	N/A	N/A	N/A	1	1	2	50
7d	quant	1	1	1	1	2	3	75
8a	quant	0	0	0	0	1	3	75
8b	quant	0	0	0	0	2	3	75
8c	quant	1	1	1	1	2	3	75
9a	quant	0	0	0	0	0	4	100
9b	quant	N/A	N/A	N/A	N/A	N/A	4	100
9c	quant	N/A	N/A	N/A	N/A	N/A	4	100
9d	quant	N/A	N/A	N/A	N/A	N/A	4	100
10	qual	1	1	1	N/A	1	3	75
11	qual	1	1	1	1	1	4	100
12a	qual	N/A	N/A	N/A	N/A	N/A	4	100
12b	qual	N/A	N/A	N/A	N/A	N/A	4	100
13	qual	0	0	0	0	0	4	100
14	qual	0	2	N/A	1	1	0	0
15	quant	N/A	N/A	N/A	N/A	N/A	4	100
16	quant	0	0	1	0	0	3	75
17	qual	1	1	1	1	1	4	100
18	qual	2	2	N/A	N/A	2	2	50
19a	qual	1	1	0	1	1	3	75
19b	qual	1	1	0	0	0	3	75
20a	qual	0	0	0	0	0	4	100
20b	qual	1	1	1	2	1	3	75
20c	qual	N/A	N/A	N/A	N/A	N/A	4	100
20d	qual	1	1	1	1	1	4	100
Correct:	N/A	34	29	29	26	28	N/A	N/A
% Correct:	N/A	100	85.29	85.29	76.47	82.35	N/A	82.35

Scenario 2 (see Table 19): 58.82% of items were completely correctly answered (100% of participants giving the correct answer). Another 17.65% were correctly answered by three groups. Half the groups or less answered the remaining 23.53% (eight items) correctly. As in scenario 1, quantitative items were more likely to be answered correctly (92.86% of quantitative items answered correctly by all groups versus 35% of qualitative items answered correctly by all groups).

Table 19: Item and group validation for scenario 2 (line-by-line and group-by-group comparison of the answers of all four groups for scenario two in comparison with the answer sheet):

Risk Factor	Type	Answer Sheet	Group 1	Group 2	Group 3	Group 4	Correct	% Correct
1	quant	1	1	1	1	1	4	100
2	quant	2	2	2	2	2	4	100
3a	quant	N/A	N/A	N/A	N/A	N/A	4	100
3b	quant	N/A	N/A	N/A	N/A	N/A	4	100
4	qual	N/A	N/A	N/A	N/A	N/A	4	100
5	qual	2	2	2	N/A	2	3	75
6	qual	N/A	N/A	N/A	N/A	N/A	4	100
7a	qual	2	2	1	2	1	2	50
7b	qual	N/A	N/A	2	2	1	1	25
7c	qual	2	2	N/A	2	2	3	75
7d	quant	2	2	2	2	2	4	100
8a	quant	2	2	2	2	2	4	100
8b	quant	2	2	2	2	2	4	100
8c	quant	N/A	N/A	N/A	N/A	N/A	4	100
9a	quant	0	0	0	0	0	4	100
9b	quant	N/A	N/A	N/A	N/A	N/A	4	100
9c	quant	0	0	0	0	0	4	100
9d	quant	N/A	N/A	N/A	N/A	N/A	4	100
10	qual	0	0	0	2	1	2	50
11	qual	N/A	N/A	2	2	1	1	25
12a	qual	N/A	N/A	N/A	N/A	N/A	4	100
12b	qual	N/A	N/A	N/A	N/A	N/A	4	100
13	qual	N/A	N/A	N/A	2	N/A	3	75
14	qual	2	N/A	0	2	N/A	1	25
15	quant	2	N/A	N/A	2	N/A	1	25
16	quant	N/A	N/A	N/A	N/A	N/A	4	100
17	qual	0	N/A	0	2	N/A	1	25
18	qual	N/A	N/A	N/A	N/A	2	3	75
19a	qual	N/A	N/A	N/A	N/A	N/A	4	100
19b	qual	N/A	N/A	N/A	N/A	N/A	4	100
20a	qual	2	2	2	2	2	4	100
20b	qual	2	2	N/A	2	2	3	75
20c	qual	0	0	2	0	N/A	2	50
20d	qual	2	2	N/A	2	2	3	75
Correct:	N/A	34	31	25	28	25	N/A	N/A
% Correct:	N/A	100	91.18	73.53	82.35	73.53	N/A	80.15

Additional to the line-by-line and group-by-group analysis, the overall risk scores were compared with the overall risk score ascertained with the answer sheets (see Table 20).

Table 20: Overall weighted risk scores for all groups compared against answer sheet:

Group	Scenario 1	Scenario 2
1	3.67	5.00
2	2.75	4.36
3	2.69	6.00
4	3.50	5.30
Mean	3.14	5.19
SD	0.44	0.59
Answer Sheet	2.89	4.73

5.2.5. Discussion

This study successfully validated a newly developed tool to rapidly assess communicable disease risks in humanitarian emergencies. The results of the validity and reliability testing suggest that the tool is useful and appropriate for aid workers with and without training in health protection for the rapid assessment of the risk that communicable diseases pose in the context of their field deployment. While reliability testing was done in Greece, no part of the study was specific to one singular context and the tool is suitable for all types of humanitarian emergencies that are not caused by the outbreak of a communicable disease. This tool can be used in the following settings: conflicts and war zones, floods, tropical storms and other hydro-metrological disasters, geo-disasters such as earthquakes, complex emergencies, famines, tsunamis, protracted crises and displacement crises with displacement into refugee and similar camps.

The participants' feedback on the tool was positive and reflected both face and content validity. They determined the tool easy to use, and remarked that for those risk factors that are not quantitative, an element of subjectivity remains, but that this is limited with the detailed descriptions in the tool guide. Based on the feedback from the participants, the tool was modified.

This tool can always only be as reliable as the data that is used to fill it in. If data is missing the tool can be used with an incomplete data set; however, that potentially can lead to an untrue representation of the actual risk. Alternatively, additional data can be collected on the missing factors and sub-factors. While the tool is mainly designed to draw on already existing data, a suitable method for additional data collection would be cross-sectional surveys with random or cluster random sampling.

The results from the evaluation of the completed tools for the two scenarios show that aid workers with little or no experience in health protection, risk assessment or epidemiology can successfully and adequately use this tool to assess the risk of a communicable disease outbreak in different types of emergencies. We agreed prior to field validation that a reliability of 70% or greater was suitable for considering the tool reliable in the field, especially if the main source of error was to be qualitative assessments. We acknowledge that some of the qualitative items are open for debate and as such the answer sheet is not as directive for them as it is for the quantitative items. Hence, we consider these results to show the adequateness of the tool.

While the overall weighted risk scores that the participants calculated were higher than those from the answer sheet, they were close enough to consider the tool adequate. In relation to the overall weighted risk scores we considered adequateness to be achieved if the overall weighted risk score of the answer sheet lay within one standard deviation of the mean overall weighted risk score achieved by the participants. This was the case for both scenarios (see Table 20). Additionally, the scores achieved by the participants were generally higher than the overall weighted risk score assumed based on the answer sheet and, as we consider erring on the side of caution to be advisable, any discrepancies between the answer sheet and the participants' answers are particularly unproblematic is in this context.

Based on the reduction in time for completion from scenario 1 to scenario 2, we assume that repeatedly working with the tool will increase the ease of use and the time needed to complete it. Familiarity with the tool does not seem to increase the accuracy. However, we assume that two scenarios is too little to make any substantial comments on the likelihood that repeated use of the tool makes an individual or group more accurate when using it.

Limitations

There are several limitations to this study as well as to the tool itself. The tool is only suitable for certain emergency types. Due to the conceptual basis of the tool, it is not suitable for any emergency in which an outbreak of an infectious disease constitutes the humanitarian emergency, such as the 2014 West Africa Ebola outbreak. Additionally, the tool does not have a specific emergency type for entrapment crises or displacement crises where the majority of the displaced population(s) is displaced into urban and non-camp settings. Should such emergencies occur in a situation where one of the other emergency types – most likely conflict – also apply, this is the emergency type that is the most suitable, which will be the case for most if not all entrapment crises. However, should urban/non-camp displacement be too far removed from the original cause of the displacement, this tool is not suitable. The decision to not include such situations was made based on the comparably limited evidence base for such situations and the authors' call for more primary research into health needs and communicable diseases in both entrapment crises and displacements into urban/non-camp settings.

As this tool focuses on the 20 most critical risk factors for communicable disease outbreaks in humanitarian emergencies, we expect that some users will feel that important issues are missing. Risk factors were selected based solely on their ability to be a reliable indicator of risk and not on any other considerations. Issues like sexual and reproductive health, as well as the protection of vulnerable groups, are extremely important in humanitarian emergencies. They are not included in this tool because they are not among the best indicators of disease outbreak risk – not because they are not important.

The scores calculated by the tool will be less reliable in situations of considerable inequity. In such situations, smaller spatial units should be attempted to be used. If measures are not distributed equitably, their reliability and the reliability of the overall score is questionable.

While the study included comprehensive validity and reliability testing, the results and hence the suitability and value-added of the tool will only be entirely clear after the tool has been used in the field for a longer time and in multiple occasions. Such a test was not within the scope of this study. We hope that over the next months and years

organisations and individuals involved in the response to humanities emergencies will make use of the tool either on its own or alongside other risk assessment procedures and we would welcome any feedback any organisations using the tool would be willing to provide.

5.2.6. Conclusion

We attempted to develop a rapid risk assessment tool for communicable diseases in humanitarian emergencies that gave both quantitative and qualitative indications of risk level and could be used by aid workers with little or no training in health protection. The tool works as an initial assessment tool and is applicable across a large range of different settings. In some cases, specialised organisations might want to have a more focused risk assessment only looking at their own area. Thus, one hurdle is that the tool is interdisciplinary and it may be difficult to convince organisations that the tool is also suitable and useful at first instance for highly specialised organisations, before they do their own more detailed and subject-specific assessments. However, one of the main groups this tool is aimed at are smaller organisations that do not have extensive health protection portfolios. For those organisations, this tool can be empowering when used together with an initial needs assessment to understand priority areas for action both within and beyond their own scope.

In the context of larger – especially country-level – responses, we do not see this tool as a substitute or in competition with well-established mechanisms such as the WHO EWARN system (196, 197). Rather it is a companion that seeks to quantify (to a degree) and make the rapid risk assessment of communicable diseases in humanitarian emergencies possible without the expert knowledge necessary to complete qualitative risk assessments.

In addition to the digital and print versions of the tool it is possible to develop the tool into an app for mobile devices such as tablets and smartphones. The tool can be used as it is as a general rapid risk assessment tool that users can become highly familiar with across different deployments, as well as being adapted for specific circumstances and settings. The tool and the accompanying guide are available in the public domain and the authors are available for any questions regarding the use and adaptation of

the tool. We would also welcome any feedback from organisations adopting the tool as part of their rapid risk assessment.

6. Discussion

One of the main aims of this chapter is to bring the results from the theoretical considerations and the three empirical studies together and put them in the wider context of humanitarian crises. Drawing on the results of the three empirical studies, the first part of this chapter delineates the main findings of the research project and shows how, through triangulation, conclusions can be drawn that go beyond the individual studies. Thus, the overall results of the project are both broader and more robust than those of the individual studies. This is contrasted with the project's limitations and weaknesses and how the triangulation was used to counter the weaknesses of the individual studies. The final part of this chapter puts the above into the wider context of communicable disease outbreaks in humanitarian emergencies and explores the issues of geopolitics, epidemiological no-mans-lands, and outbreaks as drivers of crises and crises as drivers of outbreaks.

6.1. Main findings

6.1.1. Summary of main findings

This project has followed a step-by-step approach with the theoretical model (Chapter Two) forming the backdrop of the formulation of specific research questions for the empirical work. The systematic review (Chapter Three) together with the wider literature gave the foundation upon which the questions for the expert elicitation (Chapter Four) were based. While the expert elicitation is an empirical study in its own right, it was also designed as an initial data collection method to develop the rapid risk assessment tool. The final study – the tool development and validation (Chapter Five) – brings all of those components together.

CHEs pose significant threats to human health through a variety of mechanisms. While only one of several health concerns, communicable diseases are possibly the most pressing concern during a CHE and they have the potential to cause more excess mortality than the emergency itself. The reason for this is that CHEs not only considerably exacerbate risk factors for outbreaks of communicable diseases but also trigger a large number of risk factor cascades with interactive feedback loops, providing a conducive environment for communicable disease outbreaks. The

individual risk factors encountered in a CHE might not differ greatly from those of highest relevance in other types of emergencies but their magnitude and interaction make CHEs unique from a communicable disease outbreak risk point of view.

The three-stage expert elicitation sought to identify the key elements needed to develop the rapid risk assessment tool, which was validated in the tool validation paper. The high scores of all the included risk factors in the section of the survey on weights suggest that the initial selection of risk factors was indeed valid. While communicable disease outbreak risk in humanitarian emergencies is a complex aggregation of interrelated risk factors, knowing the key risk factors, their weights, and – qualitative or quantitative – their critical or highly critical thresholds can help guide rapid risk assessment and therefore improve emergency response and risk reduction.

The key informants participating in the face and content validation phase showed a high level of agreement with the content of the tool, indicating that the content of the tool is suitable for assessing the risk that communicable diseases pose in a humanitarian emergency. This agreement also indirectly validates the results of the expert elicitation as the tool content is a direct application of the results of the three stages of expert elicitation. This gives confidence in the selection of the 20 most critical risk factors, especially the relevance of safe water and sanitation as the most critical risk factors. Additionally, it also confirms the yellow and red thresholds assigned to the quantitative risk factors and the weights in different emergency types.

The inter-rater reliability testing revealed higher levels of compliance of participants' answers with the pre-written answer sheet than expected. A significant number of the included risk factors were qualitative and as such required personal interpretation and an assessment of the severity of the situations. In line with making the scenarios more realistic, the information provided to the participants was limited. Hence, it was deemed appropriate that the tool should be considered valid if participants with no or limited health protection or epidemiology knowledge reached 70% compliance with the answer sheet. However, the answer sheet itself was open to interpretation due to the above-mentioned issues – across all participant groups and in both scenarios. The observed results were above 80%.

6.1.2. Triangulation

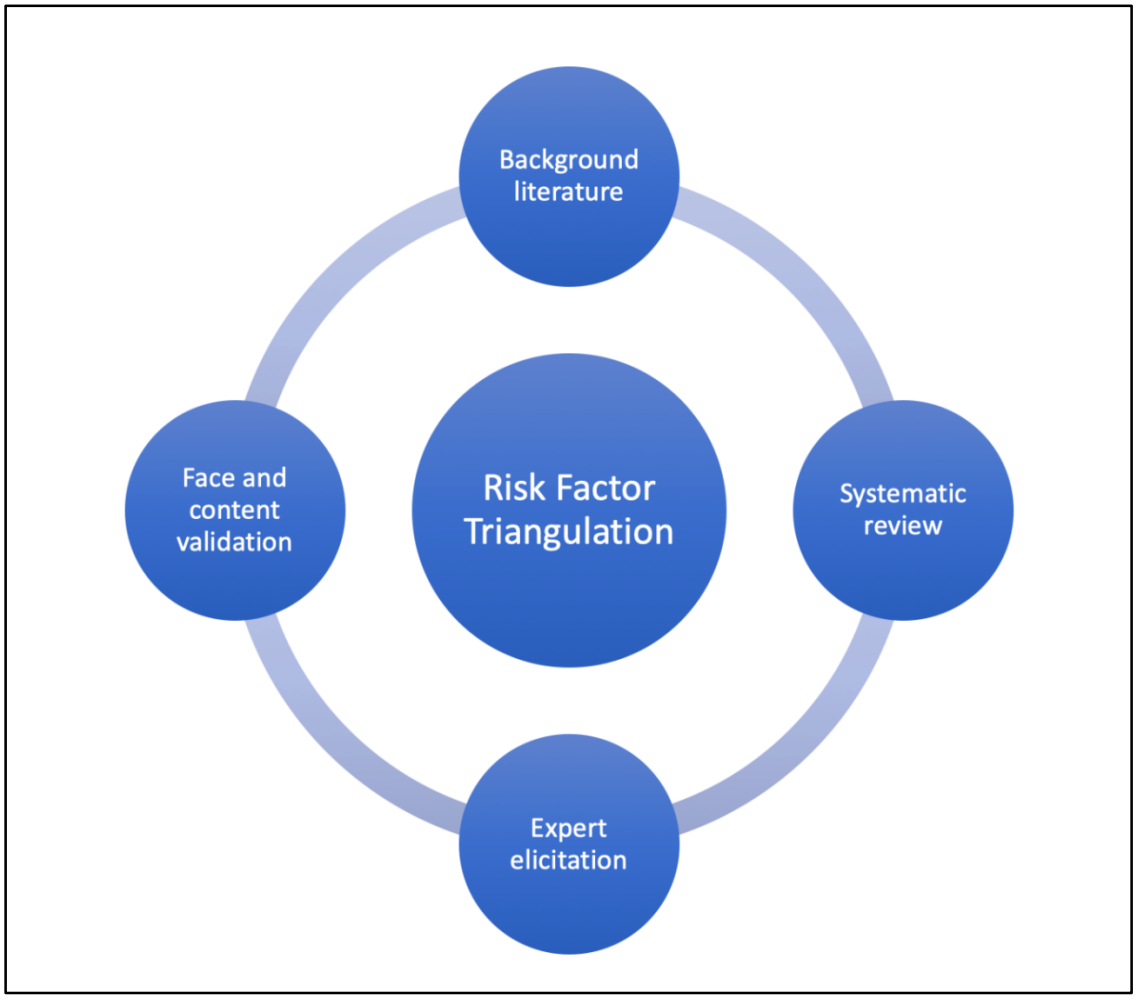

Figure 13: Risk factor triangulation.

Beyond the mere summary and discussion of the main findings of the individual studies that make up the empirical part of this thesis, it is possible to use the study results to confirm wider results and conclusions across all three studies (see Figure 13). This is particularly possible for the most critical risk factors for communicable disease outbreaks in humanitarian emergencies. When combining the insights from all three studies, the role of WASH as the most critical risk factor for communicable disease outbreaks in humanitarian emergencies is strongly confirmed. Additionally, all three studies agree on the importance of the public health system, overcrowding, nutrition, mass population displacement, and the wider socio-political and socio-economic environment. Regarding the content and the design of the tool, the results from the expert elicitation, the key-informant interviews conducted in stage one of the validation study, and the results from the reliability validation in concert with

discussions with the participants of the latter, all confirmed the importance of the content of the tool and its suitable design (see Figure 14).

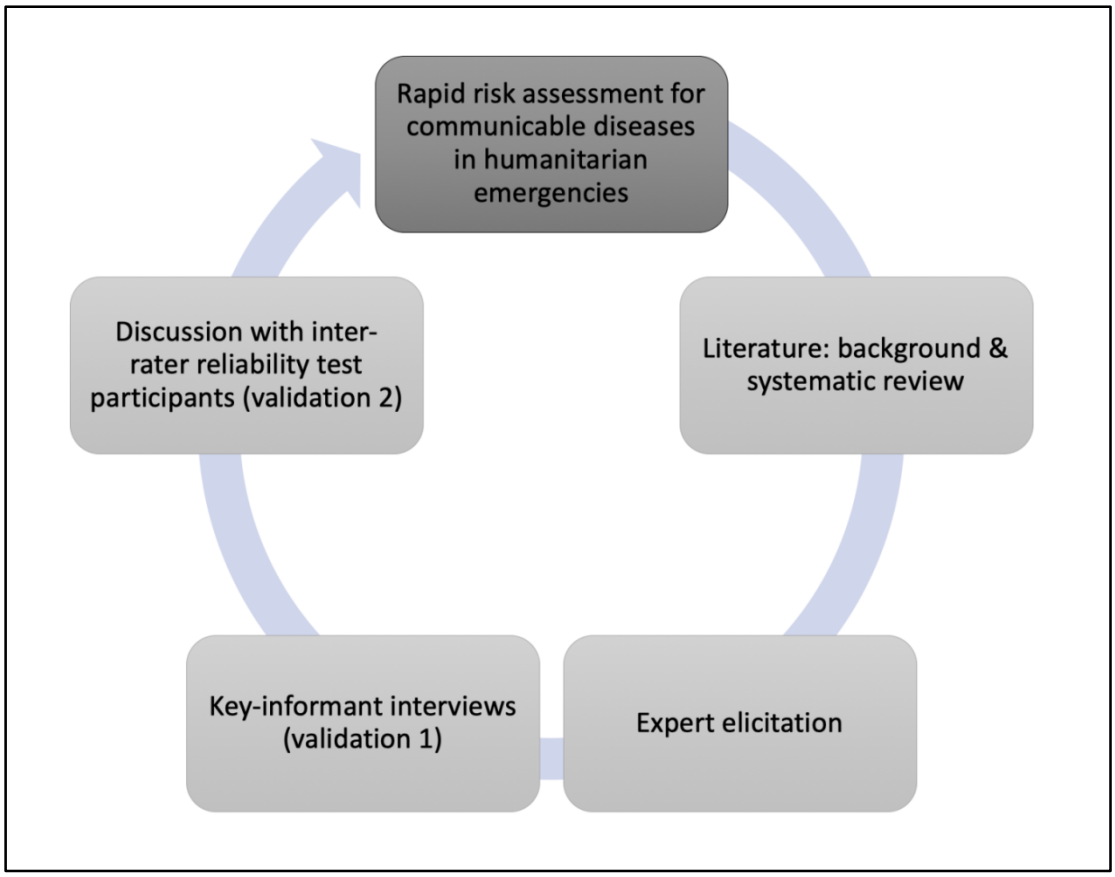

Figure 14: Tool content validation and triangulation.

6.1.3. Answers to research questions

The main answers and discussion of the research questions posed in Chapter One are given in Chapters Two to Five and in the 'Wider discussion' section of this chapter. However, it is useful to recall those answers in the context of the entire project, especially regarding research questions one through five before tackling research question six in the later parts of this chapter. The research presented in this thesis followed four main research questions as well as an introductory research question and an additional research question regarding the implications of the answers to the previous questions.

1. Introductory research question: How can outbreak risk in humanitarian emergencies be conceptualised in the form of drivers of risk or vulnerabilities in order to better understand its dynamic and contextual nature?

This question, while being referred to in all chapters of this thesis, is specifically addressed in Chapter Two, which outlines the nature of the drivers of risk and vulnerability, their progression towards risk and – in interaction with the presence of a hazard (in this case a disease-causing micro-organism) – towards an outbreak.

Communicable disease risk, especially in extreme situations such as humanitarian emergencies, arises from a complex network of socio-economic, structural and contextual vulnerabilities. Underlying these vulnerabilities are structural drivers of vulnerability, which are reinforced by the humanitarian emergency. Especially, political and economic factors create social vulnerabilities and structures of precarity that play important roles in the progression towards communicable disease outbreak risk (89, 90). Many of those structures can be traced back to histories of underdevelopment (91). Beyond this, humanitarian emergencies tend to reinforce such power structures, rooted in underdevelopment and underlying inequity. A suitable model for conceptualising outbreak risk has to include the progression of vulnerability towards actual risk and subsequently towards an outbreak. The PAR model (69) provides a starting point for this if adequately modified. Learning from both the conceptual discussions underlying disaster studies and hazard geography perspectives, as well as the political economy and ecology approaches towards structural drivers of vulnerability to diseases, not only lends a new lens to understand risk differently, but such a more comprehensive approach also facilitates risk management and risk reduction in communicable disease outbreaks in humanitarian emergencies. A key insight here is that vulnerability is a key part of risk and this should be recognised in all fields that inherently deal with risk. This shows how disease outbreaks in humanitarian emergencies are driven by contextual factors and a wide range of vulnerabilities which compound one another and interact in a complex and non-linear conglomerate of interdependency (68). This leads to a Crisis-Outbreak Progression with feedback loops and multi-layered amplifications of vulnerabilities and risks, in which humanitarian crises precipitate communicable disease outbreak risk and communicable disease outbreaks precipitate humanitarian crisis risk. Understanding the earlier stages of the progression of vulnerability – as discussed in detail in Chapter Two – allows for early outbreak prevention and preparedness.

2. What are the contextual risk factors (drivers of risk, vulnerabilities) for communicable disease outbreaks in humanitarian emergencies and disasters and how do they interact?

As this research question can be seen as the central research question guiding the project it is touched upon in all chapters, especially in the systematic review of risk factors and risk factor cascades for communicable disease outbreaks in CHEs (Chapter Three), in the expert elicitation on the most critical risk factors in humanitarian emergencies and disasters (Chapter Four) and to some degree in the content validation of the rapid risk assessment tool (Chapter Five).

Risk factors become more outbreak specific the further along the progression of vulnerability they are situated (68). The most direct risk factors include those associated with WASH and access to healthcare (58, 180). However, issues such as ongoing conflict, arms proliferation, insecurity and (lack of) humanitarian access play vital roles in propagating the more direct risk factors (58, 180). Key risk factors identified in the systematic review (Chapter Three) and the expert elicitation (Chapter Four) include crowded conditions, forced displacement, poor-quality shelter, poor water, sanitation and hygiene, lack of health care facilities and lack of adequate surveillance. While, risk factors related to poor sanitation and hygiene (129, 132, 136, 162-166), nutrition (136, 167-169) and mass population displacement and overcrowding (60, 163, 167, 170-173) have been discussed extensively in the academic literature as being important in most types of emergencies, risk factors resulting from an inadequate humanitarian response, armed conflict and a breakdown in government services are generally more associated with complex emergencies during which up to three-quarters of excess deaths are attributable to infections (2) as well as other situations linked to failing statehood, such as civil war (156). The risk factor clusters as well as individual risk factors often interact and exacerbate one another. Some risk factors and risk factor cluster are particularly likely to start risk cascades, especially mass population displacement and insecurity (58). All parts of each cascade can potentially trigger further cascades, depending on the circumstances. Beyond forming risk factor cascades, the most critical risk factors are also highly correlated (180).

3. Which are the most critical risk factors for communicable disease outbreaks in humanitarian emergencies? What are their thresholds and weights in different emergency types?

Research question three sought to narrow down the results generated in answer to research question two in order to facilitate research question four. This question guided the expert elicitation on the 20 most critical risk factors for communicable disease outbreaks in humanitarian emergencies and disasters, their critical and highly critical thresholds, and their weights in different emergency types as discussed in Chapter Four.

All participants of the studies agreed that the most critical risk factors for communicable disease outbreaks in humanitarian emergencies are those associated with WASH (180, 198). Out of the other factors identified in the systematic review (Chapter Three), the wider literature, the expert elicitation (Chapter Four) and the validation (Chapter Five), the 20 most critical risk factors that were included in the tool could be grouped together into three categories: WASH, health and socio-political risk factors (198). Specifically, the 20 most critical risk factors were: lack of clean water, lack of toilets, inadequate distance between housing and human waste disposal, flooding (waste water), lack of waste management, exposure to disease vectors, lack of health facilities, lack of health workers, insufficient vaccine coverage, poor health status of the population, lack of medicines, reluctance to follow disease prevention measures, insufficient nutrient intake, lack of health and hygiene education, extreme poverty and food insecurity, overcrowding, ongoing conflict, population displacement, lack of organisational and political will to address public health issues, breakdown of government and infrastructure services. Chapter Four gives details regarding specific weights and thresholds of the included 20 most critical risk factors, which were the basis for the development of the rapid risk assessment tool presented in Chapter Five. Definitive yellow and red thresholds could only be established for nine out of the 20 risk factors, as the other 11 could not be measured quantitatively. While the weights of the individual risk factors differ slightly by emergency type, overall they are in a similar range across emergency types, with access to clean water generally scoring among the highest in all emergency types (180, 198).

4. How can these risk factors be operationalised in the form of a rapid risk assessment tool?

Research question four sought to facilitate the development of a rapid risk assessment tool. This tool was built based on the results from the systematic review (Chapters Three) and the expert elicitation (Chapter Four). Research question four is mainly addressed in the results of the expert elicitation, especially in the sections on thresholds and weights as discussed in Chapter Four, as well as in the face and content validation of the tool, which form the first stage of study three, as reported in Chapter Five.

Operationalisation into a rapid risk assessment tool was possible by combining the risk factors, their thresholds and their weights. The tool draws on all previous research presented in this thesis, particularly on the data generated by the expert elicitation process (Chapter Four). Results from the first survey were used to decide which risk factors were to be included in the tool. The tool captures data on the 20 most critical risk factors that indicate a heightened risk for communicable disease outbreaks in humanitarian emergencies, which fall into three categories: WASH, health and socio-political. Based on the second survey of the expert elicitation (Chapter Four) the tool then matches inputs provided by the user (e.g. answers to questions such as 'How many litres per clean water are available per person per day?') with green, yellow and red risk levels. For each included risk factor the tool provides a calculation of the weighed risk score based on the weight in this type of emergency and the threshold reached. The tool presents the results of the risk assessment both numerically – in the form of weighted risk scores – and visually – using a traffic light system. The tool gives a weighted risk score for each individual risk factor as well as an overall weighted risk score for the situation as a whole (198). Specific attention had to be paid to the 11 risk factors that could not be assessed quantitatively and for which the tool has to rely on professional judgement of their severity. However, even those 11 qualitative factors can be broken down into manageable sub-factors with clear indicators for levels of severity. The face and content validation, in the form of key-informant interviews, confirmed that the set-up of the tool and the way it measured disease outbreak risk was appropriate and useful (198). The tool is designed to be used immediately following the onset of an emergency or the set-up of a response operation with

repeated assessment at regular intervals throughout the response and recovery phases.

5. Can such a tool be used by aid workers with no or limited health protection experience to accurately assess communicable disease risks in humanitarian emergencies?

Research question five is mainly addressed in Chapter Five. In order to answer research question five, the reliability validation of the tool, which forms the second part of study three (reported in Chapter Five) was done with volunteer aid workers who had no health protection experience.

The results of the tool development and validation indicate that it is possible to develop a rapid risk assessment tool that is suitable for aid workers with limited or no health protection and epidemiology experience to use accurately. Particularly, the inter-rater reliability testing confirmed that the tool can be used by aid workers with no or very limited health protection and/or epidemiology training with a high degree of accuracy (198). Therein, this tool differs considerably from previous tools such as the risk assessment matrix described as part of the WHO EWARN system (196, 197) as well as tools such as the Centers for Disease Prevention and Control's (CDC) Community Assessment for Public Health Emergency Response (CASPER) system (205). While well regarded, both of those tools – which only serve here as examples of typical assessment tools – rely on expert knowledge when using the tool and are therefore not suitable for users with little or no health protection and epidemiology experience. The tool developed as part of this project does not draw on a qualitative assessment of the riskiness of the individual factors with regard to outbreak risk, nor does it provide an overall risk assessment of that. Instead, it enables responders with little or no health protection experience to input secondary or primary data and obtain an evidence-based and objective assessment based on those data. Subjectivity is thereby eliminated from the risk assessment process and the only level of subjectivity remains in the data collection and evaluation thereof, not in the assessment of the consequences of the factors related to outbreak risk. This should also reduce the cognitive bias often inherent in risk assessment processes. As such this tool serves a different purpose than the WHO EWARN risk assessment matrix or the CDC CASPER

system. One of the main groups this tool is aimed at are smaller organisations that do not have extensive health protection portfolios. For those organisations, this tool can be empowering when used together with an initial needs assessment to understand priority areas for action both within and beyond their own scope. In the context of larger – especially country-level – responses, we do not see this tool as a substitute or in competition with well-established mechanisms such as the WHO EWARN system (196, 197). Rather it is a companion that seeks to quantify (to a degree) and make the rapid risk assessment of communicable diseases in humanitarian emergencies possible without the expert knowledge necessary to complete qualitative risk assessments.

6. Additional research question: What are the implications of this for medical humanitarianism and outbreak preparedness in humanitarian emergencies?

Research question six is an additional question, which does not form part of the empirical analysis presented in this thesis but was used as a guiding principle for considering the implications of the findings from the three studies both individually and together. Therefore, it is touched upon throughout the thesis in all empirical chapters as well as in the discussion and conclusion. The main discussion of the implications of the results from the research project presented in this thesis for medical humanitarianism and outbreak preparedness in humanitarian emergencies can be found in the 'Wider discussion' section of Chapter Six.

Looking back at the progression of vulnerability, this offers a range of intervention possibilities for preparedness and prevention at early stages. Additionally – as discussed in more detail in the following sections of Chapter Six – tier one and two outbreak prevention are more holistic; they are not health-specific issues but are related to conflict prevention and resolution for those humanitarian emergencies caused by any type of conflict. This means that the best way to avoid communicable disease outbreaks in humanitarian settings is to prevent the escalation of the emergency itself where possible because the cumulative effect of vulnerabilities not only becomes deeper but also becomes multi-directional in an entanglement of vulnerabilities, interests and influences when looking at the wider geopolitics. While these second- and third-degree associations are mainly in the sphere of drivers of vulnerability and hence not part of the rapid risk assessment tool developed in the

course of this research project, they are an integral part of the wider context in which communicable disease outbreak risk in humanitarian emergencies unfolds. Operationally, the tool offers a rapid mechanism for assessing disease outbreak risk in humanitarian settings and it does not rely on expert input. This allows smaller organisations to develop a reliable understanding of the (changing) risks. However, this project does not provide tangible solutions for addressing the critical thresholds of each risk factor. Information regarding these issues is available within the humanitarian community, especially within organisations specialising in programming in the cluster that the individual risk factor falls under (e.g. UNICEF for WASH-associated risk factors).

6.2. Limitations and weaknesses of the thesis

Some of the limitations mentioned in relation to individual papers upon which this thesis is built translate to the larger scale of the entire thesis, while some are at least partially alleviated by the triangulations that were possible due to the multitude of data sources and methods involved in this project. Most of the shortcomings demanded by the context of this project have been addressed methodologically or otherwise and their impact has been minimised as completely as possible.

Emergency types: The first major limitation of the tool and thesis relates to the emergency types covered. Some important types of humanitarian emergencies are notably absent from the analysis and tool development, either due to conceptual issues or a lack of applicable data. The first type of emergency that is not covered is crises generated by communicable disease outbreaks, such as the 2014-2016 Ebola epidemic in West Africa. This is due to the conceptual nature of the research project focus. The aim of the project has been to identify drivers of risk and develop a rapid risk assessment tool for secondary disease outbreaks in humanitarian emergencies. While this does not actively preclude primary disease outbreaks, it makes this type of emergency decidedly less important as the main types of emergencies for which the risk of a secondary disease outbreak is a concern are conflicts and all their sub-types, complex emergencies, displacement crises, and disasters associated with a natural hazard. For the last category, the argument might even be made that only those disasters associated with a hydro-meteorological hazard are truly relevant as there is

limited evidence of geo-hazards posing an increased communicable disease risk (188). Of course, this changes if other factors become involved such as after the 2010 earthquake in Haiti, which together with the sanitation practices and the Nepalese origin of the peacekeepers on the UN base led to a perfect storm (144, 145, 206). The other omission in emergency types is more severe as the tool would be highly suitable for these two types: entrapment crises and situations of urban or non-camp displacement. These types of emergency are potentially different in their communicable disease dynamics than all the other emergency types covered. This omission is an acknowledgement of the current data and research gap regarding these two emergency types. One of the conclusions to be drawn from this project, as well as one of the recommendations for further research, is that more academic and field research should be done on these two emergency types, especially regarding their increasing importance with the changing nature of conflict (176, 178, 207-211). For urban displacement, extrapolations could possibly be made from the communicable disease burden of the host community. However, the influence of an influx of refugees or IDPs on this burden needs to be studied in more detail to confirm that this would be a suitable approach. For entrapment crises, the lack of data and research is even more severe and the communicable disease dynamics in entrapment crises need to be a research focus in the future.

Recruitment: Another obvious limitation of this project is the small number of individual data points for each study. Allowances have been made in the study design as this was expected, mainly due to the small number of academics and practitioners working on health protection in humanitarian emergencies and an expected low survey participation rate. Triangulation – especially regarding the identification of the most important drivers of risk – has been a suitable method to counter this. The latter was also used to address the possibility of people with not enough expertise taking part in the expert elicitation. Due to its anonymous online nature, it was theoretically possible that participants could just pretend to be suitably qualified. The surveys did ask the participants to confirm that they had professional expertise and experience with health protection in humanitarian emergencies, and invites were sent via channels that targeted suitably qualified candidates (see section 4.3 for details). However, this was not independently verified. The second option of making both the quantitative and the qualitative risk factor thresholds more reliable seems to be more

suitable. This second option would have been an expansion of the expert elicitation. Feedback loops for all risk factors would certainly have made the results more robust and methodologically there are no substantial counter-arguments for such an approach. In this case, the difficulties lie more within the practical sphere. This design would have allowed for a structured expert elicitation in the form of a Delphi process. Ideally, such an approach would have included between two and three additional rounds with – ideally – the same participants. This approach was deemed beneficial but ultimately unfeasible due to recruitment difficulties. However, adjustments were made in order to counter the limitations in reliability. For the analysis of the quantitative data from the expert elicitation it was decided to use the median values rather than the means to reduce the impact of outliers. On the qualitative side, adjustments were made initially by keeping broad categories and generalisable ideas, which were further specified over the course of the key-informant interviews until saturation was reached. Overall, the key-informant interviews were able to counter-balance many of the shortcomings of the expert elicitation.

Tool limitations: The final two limitations relate to the rapid risk assessment tool. The tool uses the data best suited to make rapid and at the same time reliable assertions about the levels of risk and the risk factors most likely to lead to a communicable disease outbreak in a situation. However, this means that the tool has shortcomings for the desk review of a past or current situation based on openly available records. Data from donor reports are unlikely to be in a suitable format, as the tool cannot compute risk scores from information in the form of percentage of population. Initially, it was planned to follow the validation of the tool with a desk review of one or more past emergencies based on publicly available needs assessment data, as a full field test – even in just one emergency – was out of the question for logistical and ethical reasons as well as being out of the scope of the project. However, the design of the tool made this impossible. To function as it should, the tool needs data at a relatively small spatial scale, especially if there is inequity present in the distribution of the risk factors and their thresholds. Publicly available needs assessments serve a different purpose than risk assessment data. The majority of them stem from donor reports or humanitarian needs overviews and they focus on the percentage of a population reached by humanitarian programming and the absolute number of people in need (212-216). Taking the example of clean water, classical donor-focused needs

assessments, such as the Humanitarian Needs Overview (example from 2016 on the situation in Sudan) (216) tend to specify what percentage of the population (or less likely how many persons) have been reached with clean water and WASH initiatives at Sphere standard. This figure is not suitable for use in the rapid risk assessment tool as it does not correspond to any threshold level. Not only are Sphere standards for clean water – set at 15.0 litres per person per day (29) – not strictly speaking evidence based, they are also not meant as an indicator for communicable disease risk. Hence, such a figure makes it impossible to determine the average threshold (as defined by the tool at 6.5 litres per person per day for the yellow threshold and 2.0 litres per person per day for the red threshold) reached for the population or any part of the population.

Finally, due to the limited scope of the project, an implementation study or field test at a suitably large scale (both in terms of emergencies and organisations studied as well as in terms of time frame) was not possible. However, the validation study was a suitable method to prove that the tool is valid and suitable for the main potential users. That a field test was beyond the scope of the project should not be seen as a limitation but rather as an avenue for future research as discussed in the next chapter, especially since doing the field test as a complex study of its own allows for a longer term and comparative assessment of the tool, which will be both more useful to practitioners and methodologically more robust.

6.3. Wider Discussion: The context of communicable disease outbreaks in humanitarian crises

The aim of the wider discussion is to further explore the research of this thesis in its context. The research project focused on the risks that sudden-impact or long-lasting humanitarian crises pose in terms of communicable disease outbreaks. As such the tool was developed because part of the project measures excess risks beyond local baseline and regional seasonality. For the risk assessment process, that obviously means that these additional factors outside the rapid risk assessment need to be taken into consideration as well. Measuring excess risk serves some of the same purposes as measuring excess mortality. Excess mortality associated with a disaster or conflict can be seen as a measure of the impact of such a crisis (13, 217, 218). Similarly, measuring

excess risk can also be a form of measuring the impact of the crisis rather than the absolute risk. That this excess risk is driven by socio-political, socio-economic, contextual and structural vulnerabilities is a clear finding from this research. As such, humanitarian emergencies are spaces of exception and are uniquely posed to create these vulnerabilities. In the context of the 2004 Boxing Day tsunami, Findlay postulates that vulnerability is a cumulative effect (219). This research project has shown this to be true and even goes so far as to suggest that in fact the drivers of risk – communicable disease or otherwise – are a product of many vulnerabilities, all of which are cumulative effects based on a multitude of drivers of vulnerabilities.

The geopolitics of crisis-associated outbreak risk

As spaces – both in the literal and the figurative sense – of exception, humanitarian emergencies that are associated with either natural hazards and/or with conflict tend to create vulnerable spatialities. These vulnerable spatialities are a complex mixture of physical and social geographies and power relations often embedded in 'imaginary geographies', based on artificial social and physical boundaries (219). Such imaginaries are built on a variety of scales, from local to international. This becomes clear especially in the context of conflict and the changing nature of conflict. Conflict in the 21st century increasingly focuses on the purposeful destruction and destabilisation of civil society, making non-combatants a main target. There is disregard for the rules of war, international humanitarian law and human rights (220). Both the causes of such conflicts and the (international) response to them tend to create narratives of 'us' and 'them' – imaginary boundaries both in social and physical terms. Geopolitical considerations in such systems of failed or failing states can be highly complex with divided international loyalties.

The current humanitarian emergency in Yemen is a prime example of this. The context is highly complex, due to the intricacies of international relations at play in the Yemeni crisis. Yemen is currently experiencing the largest cholera outbreak in recorded history (41-43, 221). The outbreak is primarily associated with a widespread breakdown in WASH infrastructure with the first cases arising within days of the breakdown of the sanitation system (41, 42). Additionally, local environmental characteristics further compound the hazards (42). While cholera is one of the main communicable disease

concerns in humanitarian emergencies, it is also a disease that is treatable. However, the situation in Yemen, possibly the largest entrapment crisis to date, makes disease control difficult. The conflict in Yemen is, on the surface, an intra-state conflict with militia groups fighting the Yemeni government (222). However, looking at the international scale, the picture becomes more complex. The Yemeni government is aided by an Arab coalition under the leadership of Saudi Arabia. Saudi Arabia provides airpower and has been implicated in abuses of international law in the Yemeni conflict (222, 223). Through the proxy of Saudi Arabia, the Yemeni government is also tied to several Western nations, including the United Kingdom (222, 224). The anti-government militias and rebels are supported by Iran (222, 225, 226). Thus, the conflict in Yemen is a modern proxy war. The presence of international interests beyond the humanitarian imperative makes an international intervention in Yemen exceptionally difficult and unlikely. Thus, even communicable disease risks that could normally be minimised or controlled have become drivers of considerable excess mortality in this context. This example illustrates how the geopolitics of the underlying crisis – especially in cases of conflict – act as a driver of communicable disease vulnerability. The reason for excess mortality in humanitarian emergencies is not the type of disease but rather the circumstances that impede or even prohibit successful disease control measures.

When considering the geopolitics of conflict, disaster and humanitarian response, the cumulative effect of vulnerabilities not only becomes deeper but it also becomes multi-directional in an entanglement of vulnerabilities, interests and influences. While these second- and third-degree associations are mainly in the sphere of drivers of vulnerability and hence not part of the rapid risk assessment tool developed in the course of this research project, they are an integral part of the wider context in which communicable disease outbreak risk in humanitarian emergencies unfolds. This entanglement of vulnerabilities rooted in the underlying geopolitics creates inaccessible spatialities that are both geographic and political.

Epidemiological No-Mans-Land

It is through these geopolitical complications and entanglements that a lack of humanitarian access can lead to humanitarian emergencies becoming what can

adequately be termed ‘Epidemiological No-Man’s-Land’. Such inaccessible spatialities develop in the context of entrapment crises, blockades and sieges, such as in Yemen or Syria (207, 208). However, they also occur increasingly in areas where humanitarian aid workers and medical personnel are being targeted. As a consequence, security concerns may prohibit or impede a meaningful humanitarian response (45, 159, 227-230). Throughout the research presented in this thesis, the importance of adequate humanitarian access for the prevention and control of communicable disease outbreaks has emerged as a driving background factor for the development of outbreak risk in humanitarian emergencies, which has led to the development of the term Epidemiological No-Man’s-Land. Access complications lead to situations of Epidemiological No-Mans-Land as they seriously disrupt the outbreak response, surveillance, and disease control efforts. Thus, Epidemiological No-Man’s-Land can be defined as situations in which inaccessible spatialities prevent or seriously impede disease prevention and control efforts or even the generation of information about the (potential) outbreak risk.

One striking example of this is the outbreak of EVD in the North Kivu province of the DRC, beginning in August 2018. North Kivu is made up of six territories: Beni, Lubero, Masisi, Nyiragongo, Rutshuru and Walikale. By the end of 2018, Beni had become a veritable Epidemiological No-Mans-Land. The Grande Nord (Great North), of which Beni is a part, is an area that poses a variety of access and security challenges to national and international responders. The political opposition as well as the Allied Democratic Forces (ADF) and other armed groups have a strong base in this region and there is an ongoing risk of armed attacks and kidnappings (146). Violence in the region – much of which lies within the Virunga National Park – has increased since 2013, leading to civilian deaths and displacement (231). This displacement in turn has led to both large numbers of IDPs within the DRC and refugees in Uganda (232, 233). One of the main risks for humanitarian aid workers – including any international responders to the EVD outbreak – stems from the ADF. The ADF is an Islamist group, which has made a tentative attempt to align itself with other jihadist groups (234). Its leadership is mainly Ugandan but it seeks wider support across East Africa (234). It is not the only violent actor in Beni but it remains one of the most important ones, especially with regard to the threat to the EVD response in the area. Due to historical conflict, the DRC has been host to a UN peacekeeping force since 1999. The operation, originally named

MONUC (Mission de l'Organisation des Nations Unies en République Démocratique du Congo) was in 2010 relabelled as Mission de l'Organisation des Nations Unies pour la stabilisation en République Démocratique du Congo (MONUSCO) as a UN stabilisation mission. In November 2018, clashes between the ADF and MONUSCO in Beni led to the death of seven peacekeepers and the injury of ten others (235-237). During the same burst of violence, a shell hit the hotel that hosted the WHO EVD response staff without exploding (238, 239). Following this altercation, response activities were briefly interrupted (239, 240). This security situation has posed significant dangers to WHO and NGO staff responding to the disease outbreak. While Bedford (146) recommends that the Ebola response effort should take action to differentiate itself from MONUSCO, there has in fact been a deep entanglement between the two. Bedford's recommendations come from a point of safeguarding the Ebola response from attacks against MONUSCO. However, the practical policy of MONUSCO to accompany the (WHO) response to the Ebola outbreak stems from the same desire to ensure a secure and therefore more effective response to the outbreak. Beyond the obvious implications for the local spread of the disease and the treatment of infected persons, this Epidemiological No-Mans-Land has also led to concerns regarding a spread of EVD beyond the borders of the DRC.

The borders of the Grande Nord are already porous with movement of goods and people across the borders, mainly into neighbouring Uganda (146). With the nature of the security situation, this makes the borders of this part of the DRC effectively non-enforceable. By late 2018, the WHO considered the risk of EVD spreading to countries sharing a border with the DRC as well as to other parts of the DRC very high, even though EVD could be ruled out for all suspected cases reported in Uganda and Zambia in November 2018 (240) and as of March 2019 no international spread has been reported. Of particular concern is the possibility of a further spread to South Sudan (241, 242). The country is already experiencing its own humanitarian crisis and an additional spread of EVD would put both excessive strain on the national and international response as well as it being yet another location with impeded humanitarian access.

In such situations, be they in North Kivu or South Sudan for this EVD outbreak, or in other parts of the world where humanitarian access is difficult or impossible – due to

either security concerns in conflict regions or physical access impediments in disaster zones – all stages of the outbreak detection and response are endangered. Not only do humanitarian crises trigger risk factors and risk factor cascades that make communicable disease outbreaks more likely, but they also make the detection and successful early halt of an outbreak less likely. In the case of the August 2018 EVD outbreak in DRC, the WHO mentions the main disease detection and prevention activities, which apply to all outbreaks (243). In order to maintain an accurate tally of the outbreak – as well as to first notice it – accurate and reliable surveillance is necessary. This requires both laboratory and clinical surveillance (243). In an acute outbreak this should be further augmented by contact tracing. Humanitarian emergencies impact all of these activities. Without a functioning health service that includes both clinical health services and public health laboratories, surveillance becomes increasingly difficult. As shown throughout the research presented here, humanitarian emergencies have the ability to disrupt and destroy health services. Contact tracing becomes more difficult with limited humanitarian access and increased risk to those members of staff conducting the contact tracing. Mass population displacement further aggravates these problems. Case management is mentioned as the second main activity of disease prevention and detection (243), which is endangered by the surrounding conditions. For case management the same applies as to surveillance: in a destroyed health system, case management will be near impossible and while international actors can provide clinical competence, they are subject to humanitarian access considerations. Similarly, humanitarian emergencies impact infectious prevention and control and WASH. Sanitary control at Points of Entry is especially important in cases like the 2018-2019 EVD outbreak with its potential to spread to neighbouring countries and provinces (243). However, if access is limited and borders are porous this becomes difficult. Points of Entry in this outbreak region are hard to control, making containment of the outbreak in North Kivu a challenge. The final key actions found to be effective controls in previous EVD outbreaks, i.e. (ring) vaccination, safe and dignified burials, risk communication, social mobilisations and community engagement, are wrought with additional challenges in a situation that is rife with armed conflict and difficult to access for responders. Not only do these activities rely on humanitarian access, but they also require trust.

Thus, humanitarian emergencies – especially conflict situations but also disasters associated with natural hazards – erode the system in which communicable disease prevention and control take place. They create an Epidemiological No-Man's-Land. This further complication adds to the need for easy-to-use tools to evaluate outbreak risks and highlight priority actions that do not need high-level expert input for their use. Not only has this project helped understand the intricacies of outbreak risk in highly complex humanitarian crises but it has also produced a rapid risk assessment tool that fulfils this need.

Early intervention to address both the communicable disease outbreak risk and the underlying conflict or disaster is imperative as the crises and outbreaks have a mutually reinforcing nature. This means that as well as crises driving outbreak risk, as demonstrated throughout this thesis, outbreaks also drive crises, especially in the context of conflicts.

Crises driving outbreaks, outbreaks driving crises

The crisis in Yemen and the EVD outbreak in August 2018 in North Kivu are just two examples that show the different yet similar dynamics that are driving communicable diseases in humanitarian emergencies. While the cholera outbreak in Yemen is undoubtedly a result of the underlying humanitarian emergency and as such falls perfectly within the model presented in this thesis, the situation in North Kivu is more complex. How much the underlying humanitarian crisis in North Kivu has impacted the occurrence of the outbreak of EVD in summer 2018 is probably impossible to tell. Given the geographic location and ecological conditions, a large EVD outbreak in the Congo is not necessarily massively surprising. Since the discovery of EVD in the DRC in the 1970s, it has been endemic in wildlife, and outbreaks there are not entirely unusual. This type of large and rapidly spreading one is, however, a very novel development. The humanitarian crisis has definitely impacted the spread and the challenges in containing the outbreak through the above-mentioned dynamics. Many of the same drivers of risk still apply to outbreaks of endemic diseases in humanitarian emergencies, even if the rapid risk assessment tool is less suitable to predict these as it focuses on crisis-driven outbreak occurrence.

Humanitarian emergencies pose unique challenges to communicable disease prevention and control. They provide a breeding ground for communicable disease outbreaks, as shown in the three studies and the theoretical model, but they also significantly impact the response to such an outbreak. Disasters and emergencies have the capacity to prevent an adequate response even to outbreaks of otherwise easily controllable diseases. This is due to their capacity to impede humanitarian access, either physically or by putting responders at risk, and to erode systems for disease detection, prevention and control. Additionally, crises put disease prevention and control in direct competition for resources from a whole host of other humanitarian concerns. In the case of communicable diseases in humanitarian emergencies, understanding and responding to the underlying humanitarian emergency can be as important to preventing and controlling disease outbreaks as are traditional biomedical interventions, ranging from field epidemiology to clinical case management. This is especially true in situations where disease outbreaks are at risk of occurring in failed or failing states.

Therefore, prevention in the context of communicable diseases in humanitarian emergencies is not limited to the traditional epidemiological and disease control concept of prevention but has to be seen as a more holistic and transdisciplinary activity that promotes conditions that are less advantageous to communicable disease outbreaks. The results presented in this thesis further substantiate Toole's primary, secondary and tertiary prevention for disease outbreaks in refugee and migrant populations (46). Furthering Toole's idea by building on the contextual drivers of communicable disease outbreak risk (58, 68, 180, 198) leads to the conclusion that preventing outbreaks in humanitarian settings, not just in refugee and migrant populations, can be understood as a three tier approach. Especially for those humanitarian emergencies that are primarily human-driven, such as conflicts and complex emergencies, such a prevention concept would have the following three tiers: conflict resolution and prevention (tier 1, crisis prevention); preparedness and emergency planning (tier 2, crisis impact reduction); and communicable-disease-specific preparedness and prevention (tier 3, disease prevention). Disasters associated with a natural hazard function along similar if slightly different lines, with a slight blurring between tiers 1 and 2, depending on whether tier 1 is understood as in this case as natural hazard prevention or as disaster prevention.

While using similar vocabulary to the traditional concepts of primary, secondary and tertiary prevention used in biomedical and epidemiological research and intervention, this concept should not be confused with traditional primary, secondary and tertiary prevention which focuses on preventing the diseases (primary prevention), reducing the impact of disease that has happened (secondary prevention) and long-term management (tertiary prevention) (244-247) out of which really primary prevention is the only 'real' prevention, with secondary and tertiary prevention being forms of disease management. The underlying logic of Toole's (46) three-tier prevention that can be substantiated from the results presented in this thesis, particularly from the modified PAR model (68) is, however, similar: tier 1 focuses on preventing an emergency from happening, tier 2 reduces the impact of an emergency that has happened and tier 3 reduces the likelihood of that impact leading to an outbreak if tiers 1 and 2 did not yield sufficient outcomes to prevent or limit the humanitarian emergency. However, only tier 3 focuses directly on diseases or health, following the logic of the progression of vulnerability presented in Chapter Two.

Tier 1 or primary outbreak prevention (for conflicts, CHEs and disasters associated with a natural hazard that happen in a conflict zone) includes conflict resolution and conflict prevention at the regional and international level (46). This means intervening early to avoid civilian casualties from direct military action, communicable diseases, famine and other sources of excess mortality in conflicts (248-250). This requires early warning and response systems. While Article Five of the UN Charter (251) and the Responsibility to Protect (R2P) technically provides measures for such a system, even to the extent of military intervention, the current system is clearly inadequate and subject to controversy (252-256). Conflicting and entangled interests such as the ones described for the conflict in Yemen, which are also present in the Syria crisis, regularly lead to stalemates in the security council (UNSC) (252, 255, 257, 258). While the UNSC and the R2P are established mechanisms, they often tend to not take effect, therefore it might be time to explore new routes. Ideally such routes would be civilian in nature and would seek to peacefully end conflict or prevent it. However, the current climate of international relations does not seem conducive to such an internationally focused approach, which would be in direct contradiction to increasing nationalism (259-261). Currently, interventions tend to be tied to state interests and the structures in place are inadequate to compel intervention. As they rely on state willingness, any new

routes would have to be tied to real incentives for intervention in humanitarian emergencies in order to overcome this problem. For disasters associated with a natural hazard outbreak prevention starts with a blurring between tiers 1 and 2 depending on whether tier 1 is understood as in this case as natural hazard prevention or as disaster prevention. While preventing the context, that is in this case the natural hazard, might not be possible depending on the type of natural hazard it can be argued that disaster prevention could be the equivalent to conflict prevention as described above, especially if one argues that there is no such thing as a natural disaster. Therefore, it can be argued that broader initiatives to prevent disasters and crises related to natural hazards fall under tier 1 while what is traditionally considered disaster risk reduction (DRR) and mitigation in the more technocratic sense fall under tier 2.

Tier 2 or secondary outbreak prevention includes preparedness and emergency planning at the national and international level (46). This requires less political idealism and, as a technocratic approach to prevention, applies to all types of emergencies. Such an approach would for example include capacity building, establishment of early warning systems, training, emergency supplies and logistics (46, 189, 262-268). In addition to providing vital on-the-ground resources, this second tier of prevention allows for prevention activities even if the first tier fails or is never realised.

Finally, *tier 3 or tertiary outbreak prevention* is the first level that actively interacts with communicable diseases. While tier 1 and tier 2 outbreak prevention focus on the drivers of vulnerability and the underlying humanitarian emergency, tier 3 outbreak prevention focuses on interventions that are specific to communicable diseases. Truly preventive measures, such as immunisation and surveillance (136, 180, 197, 243) fall under this category but also curative programmes as well as the availability of appropriately trained and capable health workers (46, 136, 180) as well as all other main activities of disease prevention and detection, such as availability of contact tracing and case management should an outbreak occur (136, 197, 243).

All these intersecting layers of outbreak prevention acknowledge that communicable disease risk in humanitarian emergencies goes beyond the mere biomedical. They are capable of interrupting the Crisis-Outbreak Progression, as well as preventing the

opposite effect of a disease outbreak, further compounding a humanitarian emergency.

Finally, it would be remiss to just look at the interaction between communicable diseases and humanitarian emergencies one-directionally. Communicable diseases and humanitarian emergencies have a vicious circle dynamic of mutual encouragement and reinforcement. While communicable disease risk in humanitarian emergencies is driven by socio-political, structural and contextual vulnerabilities, it is also true that communicable disease outbreaks in humanitarian crises drive socio-political, structural and contextual vulnerabilities, which in turn have the potential to aggravate the underlying humanitarian emergency.

7. Conclusion

Communicable disease risk is driven by socio-political, contextual and structural vulnerabilities. This applies in general but nowhere more so than in humanitarian emergencies. Humanitarian emergencies are spaces of exception for communicable diseases as well as for their control and prevention. They drive communicable disease outbreak risk and compound challenges for response efforts. Risk factors, vulnerabilities or drivers of risk do not occur in a vacuum. They interact and form cascades and the underlying drivers of vulnerability – both those associated with the crisis and those independent of the crisis – form chains, leading to drivers of risk (vulnerabilities or risk factors), which in turn trigger other risk factors in the form of risk factor cascades as described in the simplified Crisis-Outbreak-Progression (see Figure 15).

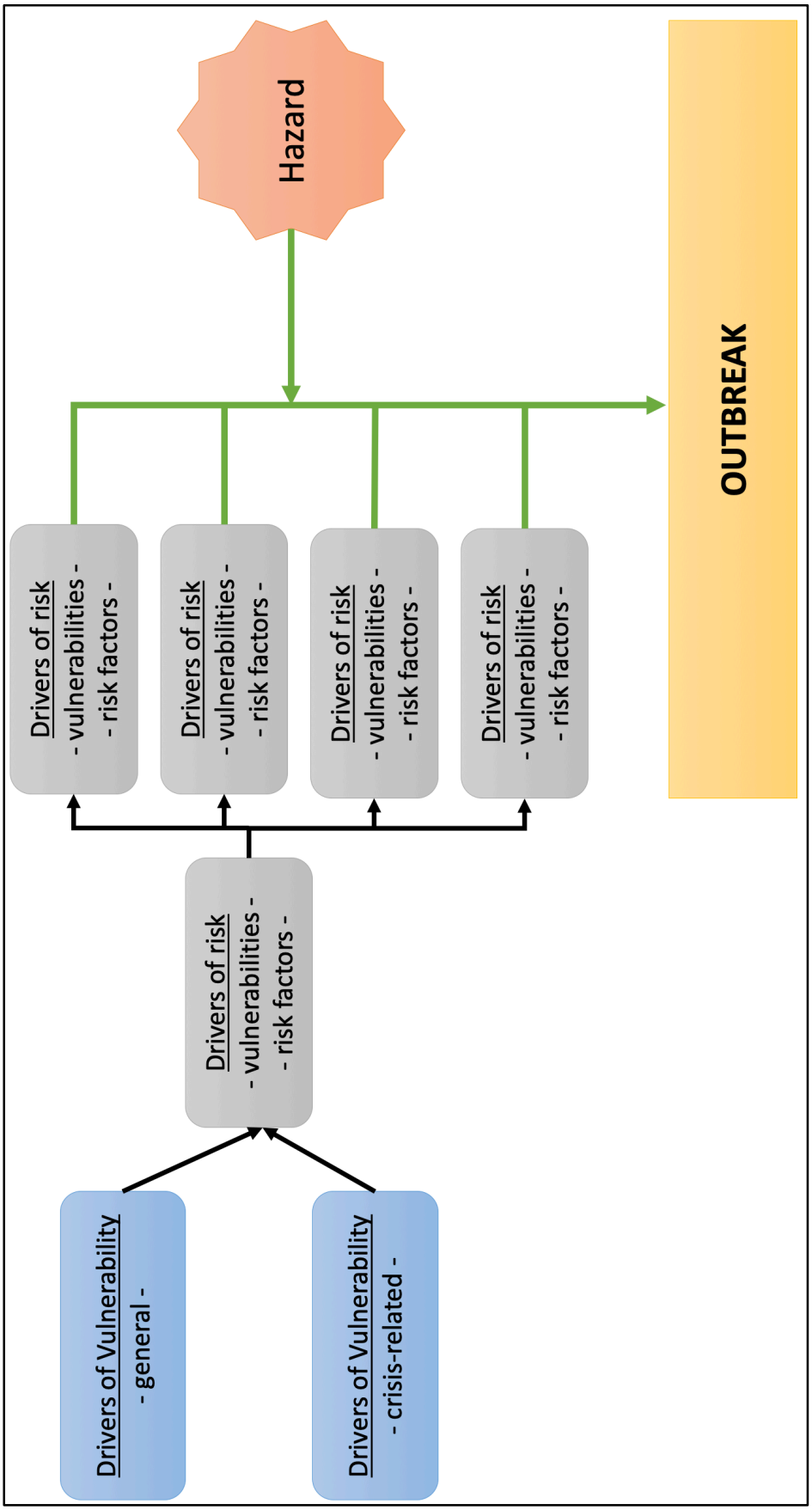

Figure 15: Simplified, mono-directional version of the Crisis-Outbreak-Progression without feedback loops.

Communicable diseases are a serious and continued concern in humanitarian emergencies, especially in CHEs due to the widespread breakdown of normal civil society and the associated triggering of risk factors and risk factor cascades for outbreaks. This is particularly true when widespread population displacement is prevalent. While the importance and weight of risk factors differ with the type of emergency, WASH remains of the highest importance and is associated with the high and highest weights in all emergency types included in the tool. However, this is an operational conclusion as the weights were only determined in relation to a single risk factor and not in relation to their importance for triggering risk factor cascades. For rapid risk assessment, this operational approach is appropriate and relevant, while academically it is important to note that population displacement is possibly the most impactful risk factor due to its capacity to trigger most or all other risk factors, especially in CHEs. The tool itself has been proven to be a solid starting point for rapid risk assessments in the field, especially as it manages to eliminate subjectivity from the risk assessment process and is suitable for practitioners with no or limited health protection or epidemiology experience, thus potentially empowering smaller NGOs to conduct their own rapid risk assessments.

7.1. Final personal reflections

While research on humanitarian emergencies is necessary from an academic point of view, as well as to make the profession more evidence based, it is challenging. Overcoming these challenges – some of which are described in Chapter Six and some of which are of a more personal nature – has been one of the greatest accomplishments of doing this project.

It is often a question of being creative enough to undertake research that initially seems impossible. Researching in an active conflict zone, especially in a CHE such as in the Syrian Arab Republic or in Yemen, was impossible, yet it is those settings that are most in need of additional scientific evidence to inform humanitarian practice. The ongoing situation in Greece provided a backdrop to undertake some of the research required for the validation of the rapid risk assessment tool, possible within the constraints of university research. While the crisis in Greece is unlike other humanitarian settings, some of the actors are the same. Although logistically

inherently different, the situation there provided insights that will no doubt carry forth into more 'traditional' humanitarian settings.

On the other hand, as I am considering this no longer a challenge but an advantage, this project has shown me a truth that I have believed in since my undergraduate education, often despite vehement opposition from senior academics. While being grounded in a discipline can give a sense of academic security, it is important not to be tied down in a single field. Interdisciplinarity and transdisciplinarity, not only within a wider research team but also in the sense of an open mind and the ability to embrace other disciplines, are paramount to successful projects in the area of humanitarian health. This can be daunting at times but will in the end be worthwhile. This project would not have been possible without insights from a large range of fields including epidemiology, public health, medical anthropology, international relations, hazard geography and many others, some of which are already inherently interdisciplinary in themselves.

7.2. Recommendations and implications for science and policy

General: The results of this project lead directly to some general recommendations related to communicable disease risk in humanitarian settings. While it is advisable to maintain attention to WASH issues, risk assessments should be carried out as appropriate to the setting encountered because different types of emergencies pose different risks. Crises with large population displacement should be considered to be potentially high risk, with diverging risk subject to the different conditions encountered along the routes of displacement and in host countries, making individual risk assessments necessary. The same applies to any circumstances of vast inequity as risks might be distributed unevenly. From a research point of view, the main recommendation has to be to not only work interdisciplinarily but transdisciplinarily, with practitioners working alongside academics and researchers. Additionally, both research and practice need to be aware of the changing nature of risk. This refers mainly to the consequences of the changing nature of conflict, particularly the increase in entrapment crises and those that are defined by displacement into non-camp settings – mainly in an urban context. While some similar risks and vulnerabilities are easily imaginable in such situations they are currently understudied and need special

attention as they pose particular challenges not only from a communicable disease risk point of view but also with regard to humanitarian access.

Use of the rapid risk assessment tool for outbreak risk: The tool will invariably appeal to different organisations at different levels. It was designed with small NGOs with limited health protection expertise in mind. For those organisations, it can be a sensible addition to complement already existing risk assessment procedures, either to prioritise their own programming or to enhance awareness of the risks to both recipients and staff. As such, the tool should be empowering because previously small organisations had to rely mainly on risk assessments by major actors for their planning and programming. However, the tool does not preclude use by larger and/or more specialised organisations. As a rapid risk assessment tool, it can be used to prioritise risks and intervention needs before more detailed and sector-specific risk assessments are conducted, thus helping to allocate finite resources to the most pressing concerns. Additionally, the tool is also useful to validate existing risk assessment mechanisms, especially those relying (strongly) on subjective expert knowledge and assessment such as traditional risk matrixes.

7.3. Suggested future research

Even the most comprehensive research project is bound to end with more questions. This project is no exception to this rule. The above-mentioned recommendations and implications already hint at both research gaps identified through the project and future research on the rapid risk assessment tool (see Figure 16). While stage one of the project led to the development and validation of the rapid risk assessment tool (Chapter Five), the project also led to new questions regarding the tool and questions of a more general nature. Within the course of the project, two main areas for future research presented themselves: 1) a logical next step regarding the rapid risk assessment tool would be research accompanying the use of the tool in practice; and 2) several stages of the research have shown that there are considerable gaps in knowledge regarding two types of emergencies: entrapment crises and situations of urban or other non-camp displacement.

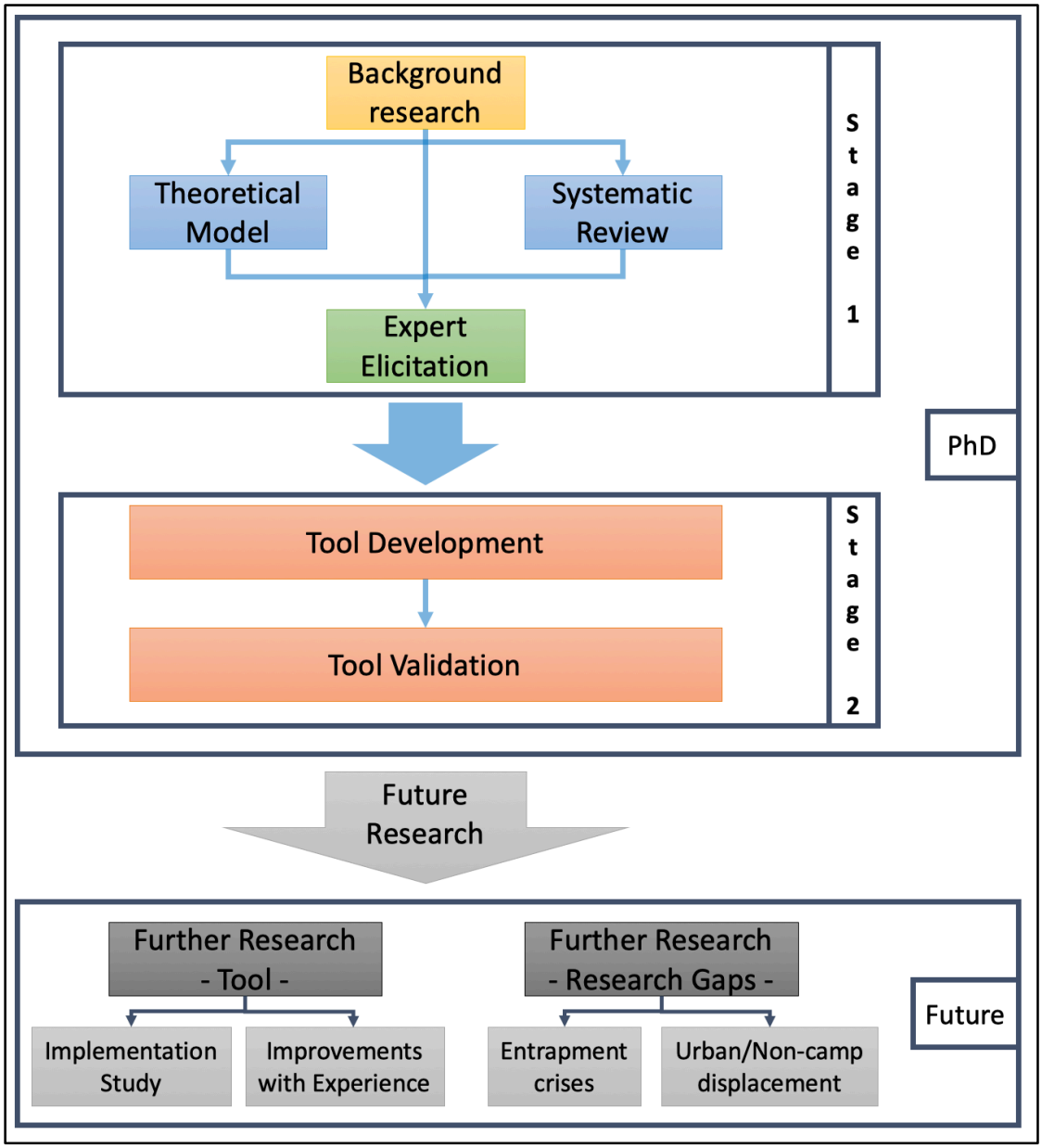

Figure 16: Overview of the stages of the PhD project and the possible further research based on them.

Suggested future research 1 – tool implementation: While validation was within the scope of the PhD, a rigorous full-scale implementation study was not. Such a study, done either retrospectively after the adaptation of the tool or ideally prospectively, should include the use of the tool by one or more organisations in a range of settings. Additionally, the validation phase posed the question whether repeated use of the tool might improve the time-to-completion and accuracy of the results. This would have to be done with a suitably large group of practitioners.

Suggested future research 2 – research gaps on entrapment and non-camp displacement crises: Stage one identified some additional questions that were beyond the scope of this project. Mainly, this refers to disease risks in two understudied types of emergencies that are gaining importance due to the nature of warfare in the 21st century. The first of these are entrapment crises such as the current Level 3 emergency in Yemen, which unlike displacement crises are not very well understood to date. The second are situations of urban and non-camp displacement. There are currently multiple researcher and practitioner groups trying to better understand this emerging type of crisis but so far, communicable diseases in such settings have not been adequately addressed. As mentioned in Chapter Six, the research needs in these two emergency types differ slightly, with the focus for urban and non-camp displacement leaning more towards the effect that the influx of displaced populations has on the burden of communicable diseases in the host community – which the refugees or IDPs become part of in such a displacement situation. For entrapment crises there is no situation to extrapolate from. The increasing importance of communicable disease dynamics in entrapment crises must become a focus of academic and applied research.

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Appendix A: Publication List

Publications included in this research project

Hammer, CC, Brainard, J, Hunter, PR (2019) 'Rapid risk assessment for communicable diseases in humanitarian emergencies: validation of a rapid risk assessment tool for communicable disease risk in humanitarian emergencies', *Global Biosecurity*, 1(2):1-11.

Hammer, CC, Brainard, J, Innes, A, Hunter, PR (2019) '(Re-) Conceptualising vulnerability as a part of risk in global health emergency response: Updating the pressure and release model for global health emergencies', *Emerging Themes in Epidemiology*, 16(2):1-8.

Hammer, CC, Brainard, J, Hunter, PR (2019) 'Risk factors for communicable diseases in humanitarian emergencies and disasters: Results from a three-stage expert elicitation', *Global Biosecurity*, 1(1):1-14.

Hammer, CC, Brainard, J, Hunter, PR (2018) 'Risk Factors for Communicable Disease Outbreaks in Complex Humanitarian Emergencies: A Qualitative Systematic Review', *BMJ Global Health*, 2018;3:e000647.

Other publications completed during the time as a PhD students

Setty, K, Loret, JF, Courtois, S, **Hammer, CC**, Hartemann, P, Lafforgue, M, Manasfi, T, Litrico, X, Medema, G, Shaheen, M, Tesson, V, Bartram, J (2019) 'Faster and Safer: Research Priorities in Water and Health', *International Journal of Hygiene and Environmental Health*, 222(4): 593-606.

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Brainard, J, Al Assaf, E, Omasete, J, Leach, S, **Hammer, CC**, Hunter, PR (2017) 'Forced migrants involved in setting the agenda and designing research to reduce impacts of complex emergencies: combining Swarm with patient and public involvement', *Research Involvement and Engagement*, 3:23.

Appendix B: Examples of the print and digital versions of the rapid risk assessment tool

Rapid Risk Assessment for Communicable Diseases in Humanitarian Emergencies

This tool gives a rapid assessment on the level of risk posed by communicable diseases in a humanitarian emergency. It can also be used to prioritise areas of action in order to reduce the overall risk. The tool is based on an extensive review of the current best evidence and primary collection of additional data. Please refer to the instructions manual for detailed guidance on how to use the tool.

Type of emergency:

Category	Risk Factors	Measure	Answer	Score (0-2)	Weight in this type of emergency (0-4)	Weighted Risk Score (0-8)
WASH	Lack of clean water	Clean water in litre per person per day				
WASH	Lack of toilets	Number of functioning toilets per 100 persons				
WASH	Inadequate distance between housing and human waste disposal	Average distance in meters between housing and human waste disposal				
		Shortest distance in meters between housing and human waste disposal				
WASH	Flooding (waste water)	Professional judgement				
WASH	Lack of waste management	Professional judgement				
WASH	Exposure to disease vectors	Professional judgement				
Health	Lack of health facilities	Professional judgement of access to health facilities				
		Professional judgement of availability of clinics and/or health posts (or other primary care facilities)				
		Professional judgement of disease surveillance				
		Number of hospital beds per 10000 persons				
Health	Lack of health workers	Number of doctors per 10000 persons				
		Number of nurses per 10000 persons				
		Number of community health care workers per 10000				
Health	Insufficient vaccine coverage	Measles vaccination coverage in percent				
		Menigococcal disease vaccination coverage in percent				
		Polio vaccination coverage in percent				
		Hepatitis B vaccination coverage in percent				
Health	Poor health status of the population	Professional judgement				
Health	Lack of medicines	Professional judgement				
Health	Reluctance to follow disease prevention measures	Professional judgement of willingness and ability of local health prefessionals to follow disease prevention measures and access health facilities				
		Professional judgement of willingness of the general population to follow disease prevention measures				
Health	Insufficient nutrient intake	Kcal per adult per day				
Health	Lack of health and hygiene education	Professional judgement of health and hygiene education				
Socio-political	Extreme poverty and food insecurity	Percentage of population living below 1 $ US per person per day AND/OR in food insecurity				
Socio-political	Overcrowding	Population density in persons per 100 square meters (10m x10m)				
Socio-political	Ongoing conflict	Professional judgement				
Socio-political	Population displacement	Professional judgement				
Socio-political	Lack of organisational and political will to address public health issues	Professional judgement of organisational and political will of (I)NGOs and donors				
		Professional judgement of organisational and political will of local and national government				
Socio-political	Breakdown of government and infrastructure services	Professional judgement of transport				
		Professional judgement of communciations				
		Professional judgement of general education				
		Professional judgement of electricity				

Overall Weighted Risk Score (0-8): **TOO FEW DATA**

Rapid Risk Assessment for Communicable Diseases in Humanitarian Emergencies - *print version*

This tool gives a rapid assessment on the level of risk posed by communicable diseases in a humanitarian emergency. It can also be used to prioritise areas of action in order to reduce the overall risk. The tool is based on an extensive review of the current best evidence and primary collection of additional data. Please refer to the insturctions manual for detailed guidance on how to use the tool.

Type of emergency:

Category	Risk Factors	Measure	Score (circle/tick) Score	Average score	Result	Weight in this type of emergency (0-4)	Weighted Risk Score (Score times weight; 0-8)
		8 or more	0				
		Between 7 and 3	1				
WASH	Lack of clean water: Clean water in litre per person per day	Less than 3	2				
		9 or more	0				
		Between 8 and 5	1				
WASH	Lack of toilets: Number of functioning toilets per 100 persons	Less than 5	2				
		More than 50	0				
	Inadequate distance between housing and human waste disposal: Average	Between 50 and 21	1	Less than 0.3	0		
	distance in meters between housing and human waste disposal	Less than 21	2				
	Inadequate distance between housing and human waste disposal: Average	More than 50	0	0.3 to 1.3	1		
	distance in meters between housing and human waste disposal: Shortest	Between 50 and 21	1				
WASH	distance in meters between housing and human waste disposal	Less than 21	2	More than 1.3	2		
		No waste water flooding	0				
		Some waste water flooding	1				
WASH	Flooding (waste water)	Extensive waste water flooding	2				
		Good waste management	0				
		Some waste management	1				
WASH	Lack of waste management	No or non-functional waste management	2				
		Limited exposure to disease vectors	0				
		Medium exposure to disease vectors	1				
WASH	Exposure to disease vectors	Extensive exposure to disease vectors	2				
		Good access to health facilities	0				
		Limited access to health facilities	1				
	Lack of health facilities: Access to health facilities	No or highly limited access to health facilities	2				
		Enough primary care facilities	0	Less than 0.3	0		
		Few primary care facilities	1				
	Lack of health facilities: Availability of clinics or health posts	No or almost no primary care facilities	2				
		Good and reliable disease surveillance	0				
		Some disease surveillance	1	0.3 to 1.4**	1		
	Lack of health facilities: Disease surveillance	No, not utilised or non-functioning	2				
		More than 20	0				
		6 to 20	1				
Health	Lack of health facilities: Hospital beds per 10000	Less than 6	2	More than 1.4	2		
		5 or more	0				
		Between 4 and 2	1	Same as score*			
	Lack of health workers: Doctors per 10000 persons	Less than 2	2		Less than 0.3	0	
		10 or more	0	Less than 0.9*			
		Between 9 and 6	1				
	Lack of health care workers: Nurses per 10000 persons	Less than 6	2	0.9 to 1.3*	0.3 to 1.3	1	
		More than 20	0				
		Between 20 and 10	1	More than 1.3*			
Health	Lack of health care workers: community health care workers per 10000	Less than 10	2		More than 1.3	2	
		More than 90	0				
		Between 90 and 76	1				
	Insufficient vaccine coverage: measles in percent	75 or less	2				
		More than 80	0	Less than 0.3	0		
		Between 74 and 80	1				
	Insufficient vaccine coverage: meningococcal disease in percent	Less than 74	2				
		More than 88	0				
		Between 88 and 76	1	0.3 to 1.4	1		
	Insufficient vaccine coverage: polio in percent	75 or less	2				
		More than 73	0				
		Between 73 and 51	1				
Health	Insufficient vaccine coverage: hepatitis B in percent	50 or less	2	More than 1.4	2		
		Good health status	0				
		Medium health status	1				
Health	Poor health status of the population	Poor health status	2				
		Sufficient access	0				
		Some access	1				
Health	Lack of medicines: access to essential medicines	No or almost no access	2				
		Protocols mostly followed	0				
		Protocols somewhat followed	1	Less than 0.3	0		
	Reluctance to follow disease prevention measures: population	Protocols not or almost not followed	2				
		Protocols mostly followed	0	0.3 to 1.3	1		
	Reluctance to follow disease prevention measures: local health	Protocols somewhat followed	1				
Health	professionals	Protocols not or almost not followed	2	More than 1.3	2		
		More than 1750	0				
		Between 1001 and 1750	1				
Health	Insufficient nutrient intake: Kcal per adult per day	1000 or less	2				
		Good and utilised	0				
		Some health and hygiene education	1				
Health	Lack of health and hygiene education	No or not utilised health and hygiene education	2				
	Extreme poverty and food insecurity: percentage of population living	Less than 20	0				
Socio-political	below 1 $ US per person per day AND/OR in food insecurity	20 or more	2				
		Less than 5	0				
	Overcrowding: population density in persons per 100 square meters (10m	Between 5 and 9	1				
Socio-political	x10m)	10 or more	2				
		No ongoing conlfict	0				
		Some ongoing conflict	1				
Socio-political	Ongoing conflict	Extensive ongoing conflict	2				
		No or limited displacement	0				
		Some displacement	1				
Socio-political	Population displacement	Extensive displacement	2				
		Present	0				
	Lack of organisational and political will to address public health issues:	Some present	1	Less than 0.3	0		
	(I)NGOs and donors	Not present	2				
		Present	0	0.3 to 1.3	1		
	Lack of organisational and political will to address public health issues:	Some present	1				
Socio-political	local and national government	Not present	2	More than 1.3	2		
		Limited or no damage to roads and transport	0				
		Some damage	1				
	Breakdown of government and infrastructure services: transport	Widespread damge	2				
		Functioning communciations infrastructure	0	Less than 0.3	0		
		Some/spotty communciations infrastructure	1				
	Breakdown of government and infrastructure services: communications	No or almost no communcaitions infrastructure	2				
		High standard	0				
		Medium standard	1	0.3 to 1.4	1		
	Breakdown of government and infrastructure services: education	Low standard or no general education	2				
		Sufficient and reliable access to electricity	0				
		Some access to electricity	1				
Socio-political	Breakdown of government and infrastructure services: electricity	No or almost no electricity	2	More than 1.4	2		

Overall Weighted Risk Score (Average of weighted risk scores; 0-8):	
medium risk (YELLOW); scores between 4 and 6 denote a high risk (ORANGE); and scores of 6 and above denote a very high risk (RED).	

Footnotes:

* The additional step for health care workers ensures that nurses and community health care workers can substitute one another and together build one subcategory of health care workers. Please first calculate the average of nurses and CHW and then the average between this new score and the score for doctors.

**The difference in averages for the cutoffs (1.3 versus 1.4) between factors composed of 2 versus 4 sub-factors is due to the distribution of scores if only 3 sub-factors for the 4 sub-factor composites are provided.

Appendix C: Tool guide

Rapid Risk Assessment for Communicable Diseases in Humanitarian Emergencies

Print and digital version V6d and V6p

– Tool Guide –

1. Introduction

Humanitarian emergencies pose a significant risk to human health. One of the primary health concerns in humanitarian emergencies are communicable diseases. This tool was designed based on a review of the current best evidence as well as extensive primary data collection and expert consultation to facilitate rapid risk assessment for communicable diseases in humanitarian emergencies.

When to use this tool?

This tool can be used in most types of emergencies (see selection of emergencies in chapter 2.1.). This tool is not suitable for situations where a disease outbreak or an epidemic constitutes the emergency (e.g. the 2014 West Africa Ebola outbreak).
Ideally, the tool should be done immediately following the onset of an emergency, within the first 72 hours to 14 days, based on initial needs assessment data. Subsequent iterations of the assessment should be repeated at regular intervals throughout the response and recover phases. Suggested intervals are initially every two weeks in the immediate response phase, every month in the medium-term response phase and every two months in the recovery phase.

Who should use this tool?

This tool was designed for responders to humanitarian emergencies. For organisations not involved in health protection the overall weighted risk score can be used to support their overall risk assessment. For organisations involved in health protection or coordination the individual weighted risk scores can be used to prioritise response, as can the overall weighted risk score if the tool is done for multiple spatial units (e.g. sections of a refugee camp).
The tool has three sections (WASH, health, socio-political factors) and each section can ideally be filled in by the responsible programme officer. However, any member of a response organisation with sufficient experience should be able to fill in the tool based on needs assessment data.

How to use this guide?

This guide provides additional information that should make using the tool easier. Before using the tool for the first time it should be read carefully. Chapter 2.1. gives guidance on how to select the right emergency type. Chapter 2.2. gives information on how to fill in the

tool, especially regarding the correct interpretation of the answer choices for non-numerical factors. Chapter 2.3. supports the interpretation of the results.

Additional considerations

Missing issues. This tool focuses on the 20 most critical risk factors for communicable disease outbreaks in humanitarian emergencies. Risk factors were selected solely based on their ability to be a reliable indicator of risk and not on any other considerations. Issues like sexual and reproductive health as well as the protection of vulnerable groups are extremely important in humanitarian emergencies. They are not included in this tool because they are not among the best indicators of disease outbreak risk and not because they are not important.
Sphere standards: The thresholds used in this tool are based solely on current best evidence and expert consultation. The tool does not use Sphere standards (for those indicators for which they exist) as these are not sufficiently evidence based. Sphere standards are normative and important guidelines for a humanitarian response with human dignity at its core but they are not the best indicators for communicable disease risk.
Equity: In situations of (vast) inequity smaller spatial units should be attempted to be used. If measures are not distributed equitably their reliability and the reliability of the overall score is questionable. The tool should be used for the smallest practicable spatial unit, especially if there is inequity between spatial (or social) units.

2. User guide

2.1. Emergency Type Selection

The emergency type can be selected from the dropdown menu. It determines the weights of the individual risk factors. For the print version please select the emergency type before printing.

Emergency Types
Complex emergency: extensive inter- or intra-state armed conflict with significant loss of life, population displacement and damage to society under conditions of severe insecurity needing a large-scale, multi-cluster international response
Geo-disaster: Earthquakes, volcanic eruptions, landslides without extensive flooding, limnic eruptions
Conflict: Inter- and intra-state warfare, civil conflict, insurgency
Protracted crisis: Conflict with or without population displacement lasting more than 10 years
Refugee camp: Refugee camps, Internally Displaced Persons (IDP) camps, mixed camps
Famine: Famine and draughts with potential for famine
Tropic storm: Typhoons, Hurricanes, Cyclones, Tropical Depressions
Flood: Fresh-water flooding, extreme weather events with flooding, landslides with extensive flooding, glacial lake outburst flood
Tsunami: Tsunamis, sea water flooding

If the emergency you are seeking to assess is not listed, please select the one it resembles most. Always select the most immediate emergency type (e.g. for refugee camps within a protracted crisis the correct selection would be 'refugee camp').

2.2. Data Input

Digital version: Please insert your answer in the appropriate field. In cases where the measure is 'Professional judgement' the answer-field will offer you a selection of answers as a dropdown menu.

Print version: Please circle or tick the appropriate answer (or answers for composite factors), calculate the weighted risk score by multiplying the score associated with your answer with the weight. Determine the overall weighted risk score by calculating the average of the weighted risk scores. The tool is not suitable if data exists for less than seven risk factors.

Data sources

This tool can always only be as reliable as the data that is used to fill it in. Ideally, most the data used to fill in the tool should be taken from (initial) needs assessments. If data is missing the tool can either be used with an incomplete data set (if seven or more factors are considered). If mechanisms for additional primary data collection are in place primary data can be used. Methods suitable for primary data collection include cross sectional surveys with random or cluster random sampling. However, extensive and time-consuming primary data collection should be avoided and the aim of the tool is rapid risk assessment based on existing needs assessment data. Primary data collection would be more suitable at a later stage for a comprehensive risk assessment.

Further information on individual factors

This section gives additional guidance on the correct selection of the answers by providing definitions and additional information on individual risk factors and measurements.

1. **Lack of clean water** (in liter per person per day): refers to the amount of water available that is suitable for drinking. Water that is available but unsafe and could potentially be treated (e.g. chlorination) is not to be included.
2. **Lack of toilets** (in functioning toilets per 100 persons): refers to all types of toilets, latrines and privies. Any sanitation facilities that are not broken or overflowing can be included in this figure.
3. **Inadequate distance between housing and human waste disposal**: refers to both the average and the shortest distance.
4. **Waste water flooding**: refers mainly to flooded toilets, latrines and privies. Flooding in areas where open defecation is practiced also constitutes waste water flooding.
5. **Lack of waste management**: refers to systems for disposing rubbish. These can be formal or informal systems.

6. **Exposure to disease vectors**: refers to all types of disease vectors, such as arthropods (mosquitos, ticks, lice, flea, etc.), rats and mice.
7. **Lack of health facilities**:
    a. Access: refers to both physical access (by foot, by car, not at all), financial access (free to use, pay at point of contact, and other models) and other factors impacting access (e.g. safety and security). All of those issues should be taken into consideration when selecting an answer.
    b. Availability of clinics and health posts: refers to all types of clinics, health posts and other primary care facilities.
    c. Disease surveillance: refers to all types of surveillance (e.g. syndromic, sentinel, etc.) and assesses both their existence as well as if they are used and in a suitable state (physical infrastructure such as computers and phone lines, training of staff, etc.) to report potential outbreaks and baseline data timely and accurately.
    d. Hospital beds per 10000 persons: refers to all secondary and tertiary care facilities with stationary care options. Hospital beds include both standard and ICU beds.
8. **Lack of health care workers**:
    a. Doctors per 10000: refers to both practicing local doctors and (international) responders working in a clinical capacity.
    b. Nurses per 10000: refers to both local and international clinicians.
    c. Community health care workers per 10000: refers to trained community health care workers.
    d. Nurses and community health care workers form one sub-category as they can – to some extent – substitute one another.
9. **Insufficient vaccine coverage in percentage of population**: these four diseases were chosen as proxy diseases to assess the overall vaccination status of the population. Other vaccinations (e.g Cholera) might be important in specific settings.
10. **Poor health status of the population**: refers to the general health of the population. Issues to consider for this factor are nutrition status, under-5 mortality, maternal mortality, levels of AMR, prevalence of NCDs, incidence of communicable diseases, access to health care prior to the onset of the emergency and other issues. It might be prudent to look up relevant routinely collected country level data (e.g. WHO health indices).
11. **Lack of medicines**: refers to the WHO list of essential medicines. Lack of medicines also include provisions for cold chain for example for vaccines.
12. **Reluctance to follow disease prevention procedures**: refers to both the general population and the local health care workers. This includes compliance with quarantines, trust in medicine (and use of health facilities), compliance with hand washing and other hygiene protocols.
13. **Insufficient nutrient intake** (in kcal per adult per day): refers to adults only. They are used as a proxy for children of all age groups. If there is considerable inequity (e.g. children not getting enough kcal, families without males not being included in food distributions, etc.) this factor becomes unreliable and should not be used.
14. **Lack of health and hygiene education**: refers to any previous or ongoing health and hygiene education campaigns on which additional disease prevention campaigns could ‘piggy-back’.

15. **Extreme poverty and food insecurity** (in percentage of the population living below 1 $ US per day per person and/or in food insecurity): refers – for sudden onset disasters, such as earthquakes – to the situation before the emergency, for longer-term emergencies, such as protracted crises, it refers to the situation on the day of the assessment.
16. **Overcrowding** (in population density per 100 square meters): refers to density over land and not in an individual household.
17. **Ongoing conflict**: refers only to conflict(s) with spatial relevance to the assess emergency. Ongoing conflict(s) further afield can only be included if it is likely to lead to a significant influx of refugees/IDPs.
18. **Population displacement**: refers to both population displacement towards the place that is being assessed and population movement. No or limited population displacement means up to 5 % of the population, some means up to 25 % and extensive means anything above 25 %.
19. **Lack of organisational and political will to address public health issues**: refers to both (I)NGOs and donors as well as to the local and national government. It includes both general lack of will (including pre-emergency) and lack of will to address public health issues as part of the emergency response.
20. **Breakdown of government and infrastructure services**: refers to the breakdown and functionality of the following services:
    a. Transport: refers to road networks and other transport infrastructure, such as the availability of cars, public transport, airports, ports, railways, and others.
    b. Communications: refers to both the availability of communications (such as telephone and internet but also news and media) as well as their reliability (for telephone and internet stability and issues such as power cuts and for news and media issues such as freedom of the press).
    c. Electricity: refers to all forms of electricity, both centrally managed and via generators, if electricity is provided via generators the saturation with generators needs to be taken into consideration.
    d. Education: refers to general education, with the lowest possibility being no school education and the highest referring to good access to secondary education and universities.

2.3. Interpretation of Results

The weighted risk scores and the overall weighted risk score are displayed on a scale from 0 to 8 with 8 being the highest risk. Additionally, a traffic light system indicates levels of risk visually, with red indicating high risk and green low risk.

Low risk: 0-2
Medium risk: 2-4
High risk: 4-6
Very high risk: 6-8

After assessing the overall risk of communicable disease outbreaks, it is advisable to refer to the individual weighted risk scores in order to identify areas of immediate concern. Recommended actions based on the overall score and the individual weighted risk scores vary by setting and circumstances as well as operational capability and organisational scope. Previous communicable diseases outbreaks and a high local baseline or regional seasonal risk further increase the risk as presented in the overall weighted risk score. This tool is designed to assess excess risk beyond local baseline and regional seasonal risk.

3. Disclaimer

This tool is based on expert opinion and best evidence. It is not a model and cannot predict communicable disease outbreaks. Any decisions made with the help of this tool should always also be supported by the professional opinion of the experts in the field. No liability is accepted for any adverse outcomes associated with the use of the tool.

Appendix D: Original versions of published papers included in the thesis

Emerging Themes in Epidemiology

DEBATE

Open Access

(Re-) conceptualising vulnerability as a part of risk in global health emergency response: updating the pressure and release model for global health emergencies

Charlotte Christiane Hammer[1*], Julii Brainard[1], Alexandria Innes[2] and Paul R. Hunter[1]

Abstract

Vulnerability has become a key concept in emergency response research and is being critically discussed across several disciplines. While the concept has been adopted into global health, its conceptualisation and especially its role in the conceptualisation of risk and therefore in risk assessments is still lacking. This paper uses the risk concept pioneered in hazard research that assumes that risk is a function of the interaction between hazard and vulnerability rather than the neo-liberal conceptualisation of vulnerability and vulnerable groups and communities. By seeking to modify the original pressure and release model, the paper unpacks the representation or lack of representation of vulnerability in risk assessments in global health emergency response and discusses what benefits can be gained from making the underlying assumptions about vulnerability, which are present whether vulnerability is sufficiently conceptualised and consciously included or not, explicit. The paper argues that discussions about risk in global health emergencies should be better grounded in a theoretical understanding of the concept of vulnerability and that this theoretical understanding needs to inform risk assessments which implicitly used the concept of vulnerability. By using the hazard research approach to vulnerability, it offers an alternative narrative with new perspectives on the value and limits of vulnerability as a concept and a tool.

Keywords: Vulnerability, Risk, Emergency response, Communicable diseases, PAR model

Introduction

While health and medicine use the term "risk" widely, its use usually lacks conceptualisation and is often defined merely in the sense of probability. This approach may suffice for traditional individual and population health issues. However, in the context of health emergencies and disaster health, it could benefit from a more thoroughly conceptualized addition.

Global health emergency response operates along similar lines as global disaster and humanitarian response and often in concert with actors from these fields. Learning from the conceptual discussions underlying disaster studies and hazard geography perspectives does not only lend a new lens to understand risk differently but this more comprehensive approach would also facilitate risk management and risk reduction in global health emergency response and thus lead to a more sustainable response. This paper provides a possible pathway for answering the question how can disaster studies and hazard geography help us develop a (social) vulnerability theory for global health emergencies.

Therefore, this paper seeks to bridge the gap between the disaster studies literature and the medical understanding of risk and suggests the adaptation of a classic model for understanding risk from the disaster studies, the Pressure and Release (PAR) model [1] for global health emergencies. The PAR model is arguably the best known and most accepted model for conceptualizing risk in the context of disaster and emergency and offers a comprehensive and compelling framework for

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understanding the role of (social) vulnerability in risk. As such, this paper focuses mainly on the role of vulnerability, currently an under-conceptualized component of risk in health emergencies.

Current uses of risk in health and medicine

Despite the mentioned lack of conceptualisation, risk is widely used in health and medicine and is a key element in epidemiology. Examples for the use of risk in health and medicine include risk ratios [2, 3], attributable risks [2, 3], diseases risks for individual patients and populations [2, 3], and comparisons of proportions of a population at risk [4]. In these contexts, "[r]isk has a very similar meaning in epidemiology as it does in everyday usage—it is about chance. It is defined by Unwin et al., as 'the probability that an event will occur'. It is often used to compare the risk of an event between groups" [5]. While this non-conceptual definition has merit, especially in traditional highly quantitative approaches to population health, it also comes with limitations. It omits the role of vulnerability as a key component of risk and as such, impedes risk reduction in less quantitative and data-rich situations. This paper does in no way argue that all understandings of risk (or vulnerability) in health and medicine should be replaced by a new understanding, which is closer in line with that from disaster studies. Instead we argue that, in the case of global health emergency response, an additional understanding of risk could be helpful both to better identify risks and vulnerabilities and respond to them as well as to facilitate cooperation with other actors in order to achieve comprehensive mitigation and risk reduction strategies.

Key concepts

While it goes beyond the scope of this article to give detailed definitions of all key concepts underlying both the original PAR model and the updated version, a short introduction to some of those concepts—namely hazard, vulnerability, risk and resilience—and their implication for the PAR model and its update is appropriate. The PAR model, in the tradition of disaster studies, rightly assumes risk to be more than just the possibility of an adverse event taking place and conceptualises risk as a function of hazard and vulnerability. This more complex conceptualisation also facilitates an understanding of resilience beyond that of a 'bounce back (better)' capacity.

Hazard

Understanding hazard is at the same time the starting point for understanding risk and the least controversial part of risk in the context of the PAR model and of conceptualising risk. Hazard in this context is, in most cases, the natural component. Following the debates about the use and discontinuation of the use of 'natural disaster' [6–8], hazard can be understood as the only (potentially) natural component of disasters. Hazards exist in nature and society in all forms, including traditional natural hazards such as geo-hazards (e.g. earthquakes or volcanic eruptions), hydro-hazards (e.g. tsunamis or floods), or—in the context of this paper most important—biohazards (such as all disease-causing micro-organisms). A separate category in this context is technological hazards, which are not per se natural but driven by human action. The term and concept hazard does, however, make no comment about the level of risk these hazards pose to humans (or animals, the environment, society, or the economy for that matter). In order to understand the potential risk associated with a hazard the dimension of vulnerability is necessary.

Vulnerability

Vulnerability lies at the heart of the conceptualisation of risk and of the traditional PAR model. Vulnerability is key component of risk and risk itself does not exist without vulnerability [9]. Vulnerability can be roughly defined as a function of exposure and susceptibility and can be applied to humans, environmental entities or societal or even technical structures.

$$\text{Vulnerability} = \text{Exposure} \times \text{Susceptibility}$$

Most—if not all—elements traditionally in the medical, health and epidemiology field termed 'risk factors' fall within the category of vulnerability and can be either on the exposure or on the susceptibility side. "Susceptibility is a capacity characterizable by a set of intrinsic and extrinsic factors that modify the impacts of a specific exposure upon risks/severity of outcomes in an individual or population" [10] while exposure characterises the likelihood of an encounter with the disease-causing organism and the level or strength of this encounter.

Vulnerability in this context plays a part in both likelihood and severity of disease and disease outbreaks for both individual patients and entire populations. The introduction of the concept of vulnerability is not meant to replace the concept of a risk factor but rather to offer a better understanding of why risk factors are risk factors and the underlying mechanisms of these risk factors, as well as to offer approaches to reduce the risk of diseases by reducing (human) vulnerability.

Risk

Risk is a complex concept made up of both hazard and vulnerability, even going beyond its components. Beck defines risk as "the modern approach to foresee and control the future consequences of human action, the various unintended consequences of radicalized modernization.

It is an (institutionalized) attempt, a cognitive map, to colonize the future" [11]. While such a future oriented approach to risk is certainly beneficial in the context of resilience and of sustainable disaster and global health emergency response, the core of risk and the need for its conceptualisation in this context lies more within its ability to give different avenues to risk reduction by unpacking the interaction between hazard and vulnerability to form risk. As such, Ewald's conclusion that "[n]othing is a risk in itself; there is no risk in reality" [9] still holds true and forms the very basis of vulnerability and hazard and their distinction from risk.

Considering the traditional conceptualisation of risk as a function of both hazard and vulnerability, which also forms the basis of the traditional PAR model [1] risk is often defined as the following:

$$\text{Risk} = \text{Hazard} \times \text{Vulnerability}$$

Combining this equation with the above introduced equation for vulnerability leads to a complex understanding of risk:

$$\text{Risk} = \text{Hazard} \times \text{Exposure} \times \text{Susceptibility}$$

This is not necessarily meant as a quantifiable equation but rather as a conceptual backdrop for understanding risk and its components. However, one fundamental mathematical truth plays a crucial role in this equation. The idea that without hazard or without vulnerability there is no risk is central to both the understanding of risk and the use of the traditional PAR model as well as any adaptation for global health emergency response. The hazard side of the equation is less of a focus for the PAR model and thus possibilities for hazard reduction are not prioritized. However, within the PAR model, a significant reduction in vulnerability leads to a significant reduction in risk and a (however hypothetical) eradication of vulnerability leads to an eradication of risk. Being able to reduce risk by being able to target multiple different aspects of it gives additional options for risk reduction, mitigation and risk management.

Resilience

While definitions of resilience are highly contested [12] and the benefit and potential harm of the concept of resilience itself has been debated in the context of neoliberal society [13–15], all definitions of resilience carry with them at least some aspects of absorbing, changing and carrying on [16] as well as of recovery [17]. These ideas are often augmented by conceptualisations about resistance, absorption and restoration [6] and the ability to 'bounce back' [18] or even to emerge stronger. Schoon describes resilience as "a two-dimensional construct defined by the constellations of exposure to adversity and the manifestation of successful adaptation in the face of that risk" [19]. As such, a complete conceptual understanding of risk, including its components is, if not necessary, then at least highly beneficial to understanding and thus actively fostering resilience. Active disaster risk reduction enhances resilience. This holds true for global health emergencies as much as for other disasters. While reducing the hazard (the disease-causing organisms) is an admirable intention, it is also highly dependent on the specific type of bio-hazard. Focusing on the vulnerability side has the advantage of also offering perspectives for situations of unknown hazards. Thus, there is a need to increase focus on the vulnerability side of the risk—including both susceptibility and exposure to the hazard. This approach holds the greatest promise of producing enduring resilience and therefore to a sustainable global health emergency response.

The original pressure and release (PAR) model

The original PAR model follows the understanding of risk as a function of hazard and vulnerability and focuses on the vulnerability side of risk and especially on factors related to susceptibility. While not clearly conceptualised, the original PAR model does include aspects of exposure but it does not directly associate these with susceptibility as a part of vulnerability. This could be seen as a critique of the original model. Due to the slight differences of global health emergencies to disasters associated with natural hazards, our adapted version explicitly includes aspects of heightened exposure in the progression of vulnerability.

Components of the original PAR model

The original or traditional PAR model defines three steps to explain the progression of vulnerability: root causes, dynamic pressures and unsafe conditions [1]. Each step in the progression of vulnerability builds on the step(s) before and leads to increasing pressure on the whole system. These steps, combined with the presence of hazard, lead to risk of disaster and ultimately to disaster [1]. Root causes in the original PAR model include limited access to power, limited access to structures, limited access to resources, aspects of the political system(s) and aspects of the economic system(s) [1]. Root causes as such, are at the structural level and often describe underlying situations and power dynamics that are ingrained in a society or group. According to the original PAR model, these root causes can then lead to dynamic pressures, which include lack of training, lack of local investment, lack of press freedom, rapid population change, rapid urbanisation, and deforestation [1]. Root causes are mainly static and resistant to change within the span of an emergency response. Dynamic pressures are evolving systems that

can lead to increasing pressure and subsequently to unsafe conditions. Unsafe conditions include the physical environment, the local economy, social relations and public actions [1]. They are, in terms of traditional health and medical terminology, the most immediate risk factors. However, their causes lie in the preceding steps of the progression of vulnerability [1].

Critique of the original PAR model

As mentioned before, the role of exposure is not entirely clear in the original PAR model, however, it is sufficiently clear for the original uses. While the original model also lists 'viruses and pests' as potential hazards, the progression of vulnerability for those is slightly different. Most of the original factors and steps still hold true but they are insufficient to explain the progression of vulnerability towards disaster, which in this case can be defined as the outbreak of a disease, hence making an adaptation especially for global health emergencies sensible.

Other critiques of the original PAR model focus mainly on its lack of environmental focus, either expressed as a lack of focus on the role of sustainability [20] or as a lack of focus on human–environment interactions and the vulnerability of the biophysical world [21]. However, these issues have since been addressed in the second version of the model. We acknowledge that the original PAR model—and the adapted version presented in this paper as well—certainly still has a decidedly human focus, specifically a focus on human vulnerability with an underlying assumption that socio-economic vulnerability is key to risk. It is our aim to broaden the perspective on global health emergency response and a broader, adapted PAR model is one component of this.

The updated PAR model for health emergencies

While many of the assumptions made in the context of the original PAR model still hold true for a health specific update, they need to be critically examined and in some places augmented by root causes, dynamic pressures, and unsafe conditions that are more specific to health risk. The improved understanding of the progression of vulnerability in health emergencies has implications for vulnerability, risk and resilience and their conceptualisation—and lack thereof—in the concept of health emergencies (Fig. 1).

Components

While the traditional root causes (limited access to power, structures and resources, and political and economic systems) certainly hold true in the context of health emergencies the related issues of competition for power and resources [1], precarity [22, 23], poverty [22, 24, 25], and inequality [22, 24, 25] warrant further emphasis as root causes that facilitate the development of dynamic pressures. Competition for power and resources could be interpreted as a part of limited access to power, structures and resources. However, the level at which those root causes act and interact is different. Limited access to power, structures and resources arises from lack of an inclusive and democratic society and political system. Competition for power and resources does not necessarily assume widespread access to power and resources. It focuses on those groups and individuals who have access and on how their interaction stabilises or destabilises any given situation. Additionally, we suggest considering environmental and ecological fragility. Environmental and ecological fragility describes the resilience

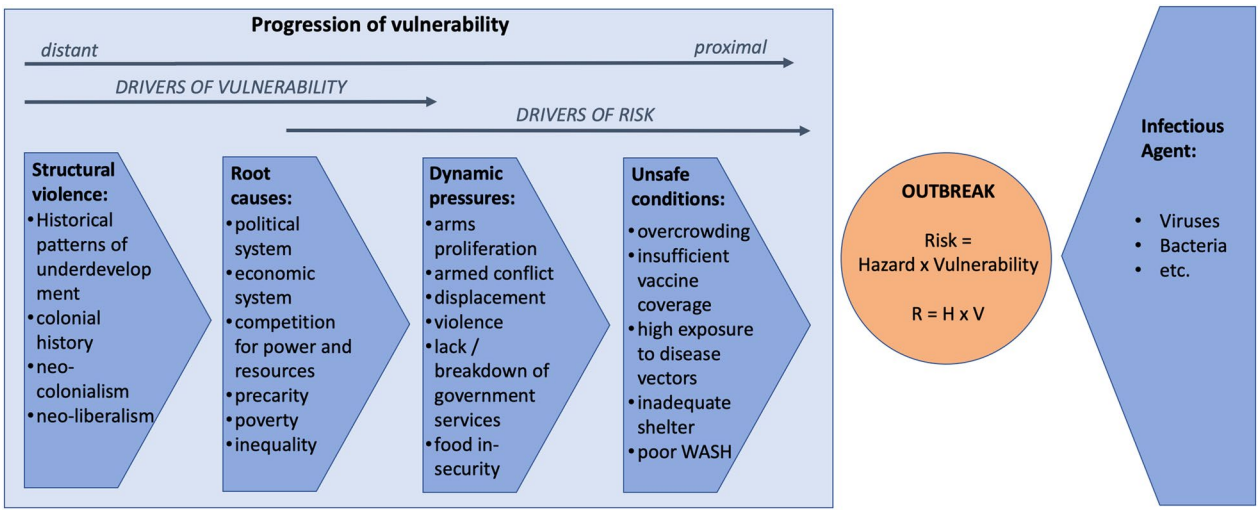

Fig. 1 Adapted PAR model for health emergencies

or lack thereof of the natural environment and hence plays an important part in characterizing the geographical context. While it is not a component of social vulnerability, environmental fragility strongly impacts severity of exposure.

We see all of these root causes as based on conditions of structural violence comprised of historical patterns of underdevelopment, colonial histories, neo-colonialism, and neo-liberalism, which act as drivers of vulnerability and form an integral part of the early progression of vulnerability [22]. These forms of structural violence and their ingrained stigmatization and marginalization of populations along lines of race, ethnicity, religion, gender, sexuality, and socioeconomic status, lead to historically-rooted inequalities, which form the backdrop of many of the root causes, dynamic pressures, and unsafe conditions.

For dynamic pressure, the updated PAR model for health emergencies does not negate the importance of the originally stipulated dynamic pressures (lack of training, lack of local investment, lack of press freedom, rapid population change, rapid urbanisation and deforestation). However, if the risk that is being examined is that of a health crisis more suitable dynamic pressures can be found and substantiated by the evidence. We suggest the following dynamic pressures: arms proliferation, armed conflict, displacement, violence, lack or breakdown of government services, lack of access to health care, and food insecurity. Arms proliferation is a direct precursor to armed conflict, which is arguably one of the main drivers for health emergencies that are secondary to a humanitarian crisis. Armed conflict and violence together foster a climate of insecurity which is conducive to disease outbreaks through a variety of mechanisms [26–35]. Population displacement leads to a lack of access to health services [27, 30, 36–38] and generally unsafe living conditions, both in camp and community settings [26, 27, 29–32, 34–47]. A lack or breakdown of government services can lead to a breakdown of health related infrastructure including individual health services and population health services such as vaccination [26, 27, 29, 30, 32–36, 38–45, 47–49] as well as a breakdown of other (critical) infrastructure and coordination [30, 32, 34, 35, 37, 50]. All of the preceding can produce health emergencies. Food insecurity can be seen as a key precursor to malnutrition which is an important risk factor, both at the level of population and at the individual level, for communicable diseases [27, 30, 32, 36, 38–42, 49–51] and other health conditions [52–54].

In terms of unsafe conditions, we propose inclusion of the following, which are all highly conducive to ill health and direct or indirect progressions of the aforementioned dynamic pressures: overcrowding, insufficient vaccine coverage, high exposure to disease vectors, inadequate shelter, and poor water, sanitation and hygiene (WASH). Overcrowding, which can result from both displacement and entrapment, facilitates the spread of diseases from person to person and is thus a key risk factor for communicable disease outbreaks [27, 30, 32, 35–39, 42, 49, 50, 55–67]. Insufficient vaccine coverage is produced both by a breakdown of government services, especially population health services, and by unvaccinated persons being displaced into areas with higher disease prevalence. Absence of vaccination has for example been identified as an unsafe condition in the example of the European migration crisis [61, 62, 64, 68–70]. Similarly, increases in the presence of disease vectors, such as specific species of mosquitos the likelihood of an outbreak and of the transmission of vector-borne diseases [29, 61] have significant consequences. Inadequate shelter without proper heating, ventilation and cooking facilities has implications both for communicable diseases [30, 32, 35, 39, 41, 56, 60–62, 66, 71] and for non-communicable health such as asthma and COPD especially if indoor fires are used [30, 32, 39]. Finally, the role of poor WASH as a risk factor and as such, as an adequate unsafe condition for communicable diseases, has been well documented [27, 29, 30, 32, 35–39, 41, 49–51, 59, 60, 63, 66, 67, 72–75].

What we traditionally call a risk factor in health, medicine and epidemiology is - according to the model and seen in a more complex picture—in fact a stage in the progression of vulnerability or in other words a component of the overall vulnerability. Vulnerabilities are what might lead to disease in an individual and to an outbreak or epidemic in a population.

Implications for the understanding of vulnerability and risk in health emergencies

This model follows the original PAR model [1] in its understanding of (the progression of) vulnerability. As such, vulnerability becomes a function of root causes, dynamic pressures and unsafe conditions:

$$\text{Vulnerability} = \text{Root Causes} \times \text{Dynamic Pressures} \times \text{Unsafe Conditions}.$$

Vulnerability and its progression stem from these multiplicatory components. The model highlights the interaction and progressive nature of the system. Those components traditionally identified as risk factors for health emergencies are most commonly found in the third category, unsafe conditions. While these are undoubtable the most direct risk factors, focusing only on them risks overlooking the complex causes of these unsafe conditions or risk factors.

The risk from the original equation in this context is the health emergency. That means, in many cases, an outbreak of a communicable disease, either as a stand-alone event such as the 2014 West Africa Ebola outbreak, or a larger humanitarian crisis, such as in ongoing Cholera epidemic in Yemen. When considering the original equation of risk being a function of hazard and vulnerability, the model and its components as described cover the vulnerability side, with the hazard being the disease-causing micro-organism. Recall Ewald's conclusion that risk only exists with vulnerability [9]. This means that, while it is improbable that all vulnerabilities in situations such as the ones mentioned above can be reduced to zero, the risk can be greatly reduced by reducing the vulnerability towards said risk. This can be done without always needing a 'toolkit' to reduce hazard. Hazard reduction is a suitable method in some circumstances but it is not the only or necessarily most productive approach in all situations.

Implications for the understanding of resilience in health emergencies

Understanding risk in terms of hazard and vulnerability fosters increased understanding of how to introduce and increase resilience by sustainably reducing vulnerability and therefore risk. Complex understandings of risk are a first step to work towards resilience, therefore our model may offer benefits. Our new concept of risk and vulnerability may highlight pathways to the ability to absorb, change, carry on [16], recover [17], resist, or absorb [12]. It is worthwhile to explore if the reconceptualisation can help lead to an increased capacity to 'bounce back' [18] or even bounce back better. However, more than just conceptual insights are needed in order to foster lasting and positive resilience. In the context of global health emergencies, the insights into vulnerability certainly highlight and reinforce that a focus on strengthening health systems can lead to a reduction of vulnerability and therefore a reduction of risk. Additionally, we believe that the dynamic element of the PAR model allows for the consideration of changing conditions—and the causes of the changes, as traceable through the progression of vulnerability—to be considered in both epidemiology and risk assessment, which allows for both mitigation and preparedness.

Possible uses and advantages of the updated PAR model for health emergencies

Updating the original PAR model for health emergencies and using it in this context could lead to an improvement of the conceptual and practical understanding for the progression from population-level risk to outbreaks and epidemics. It could become easier to understand how a situation progresses to become an emergency. This prospect has direct and indirect implications for risk assessments, leading to potentially longer lead times between the detection of an increased risk due to increased vulnerability and an actual outbreak or epidemic.

Additionally, such a conceptual understanding can be used as a basis for improving targeted risk management and risk reduction interventions by providing action points for intervention and understanding where they lie in the progression of vulnerability. This opens the possibility to prioritise interventions.

Combining these two approaches leads to a potential use of the adapted PAR model for estimating risk and vulnerability under alternative management approaches. These could include scenario planning or forecasting as well as post hoc analysis in order to better understand the value and reasoning for decisions made. This is particularly relevant in contexts where situations are changing rapidly and creating considerable uncertainty. Thus, the adapted PAR model offers insights to facilitate *adaptive management:* adaptive strategies that develop in response to uncertain and changing circumstances.

Finally, harmonising the language of health emergency response with the language of disaster response can help foster a common understanding of concepts and facilitate better communication across sectors and clusters.

Limitations

Different thinking and practical implications of reconceptualising vulnerability and risk in the context of health emergencies are difficult because risk is an ingrained concept in health and medicine. Moreover, the model does not offer automatic solutions or risk reduction measures. Instead, it seeks to contribute to a discussion on terminology and the implications of terminology for understanding, analysis, and action.

As it is currently built, the updated PAR model might be most suited to situations where general context and vulnerability progression are the focus rather than development of the hazard. Hence, the model might be more immediately and obviously suitable to explain the development of risk in cases of secondary health emergencies rather than emerging disease threats. It might be more suitable as an explanatory model for disease outbreaks in existing humanitarian crises such as the Cholera outbreak in Yemen rather than situations in which the disease outbreak constitutes the humanitarian crisis, such as the 2014 West Africa Ebola epidemic. We hope that use of our model will improve understanding of outcomes and add perspectives that acknowledge that underlying social complexity. The progression of vulnerability remains a pivotal aspect in both types of events. With regard to emerging disease threats, the model would

explain only part of the problem and need to be augmented by understanding other concurrent processes regarding the evolution and progression of the hazard.

Conclusion

Vulnerability is a key part in risk and this should be recognised in all fields that inherently deal with risk. While traditional definitions and terms such as 'risk factor' do not need to be replaced in the context of health and medicine, in global health emergency response, a more thorough consideration of their components certainly helps to understand mechanisms and pathways of risk beyond probability. This paper offers a theoretical model for renewed thinking about the meaning of risk and resilience and at the same time seeks to reconcile the language of health and medicine with the language of disaster studies and disaster response. The analysis of risk factors, augmented with the conceptual understanding of their place in the progression of vulnerability, is an important part of understanding how global health emergencies evolve. The theoretical backing tentatively offered in this paper supports quantitative study of the epidemiological basis for risk factors in individual emergencies by providing a wider understanding of the role of risk factors. We also argue strongly for an interdisciplinary approach to global health emergency response. This approach can open new avenues for mutual understanding.

Abbreviation

PAR: pressure and release.

Authors' contributions

CH developed the model and wrote the first draft under supervision from JB, AI and PH. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

Not applicable.

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Risk factors and risk factor cascades for communicable disease outbreaks in complex humanitarian emergencies: a qualitative systematic review

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ABSTRACT

Background Communicable diseases are a major concern during complex humanitarian emergencies (CHEs). Descriptions of risk factors for outbreaks are often non-specific and not easily generalisable to similar situations. This review attempts to capture relevant evidence and explore whether it is possible to better generalise the role of risk factors and risk factor cascades these factors may form.

Methods A systematic search of the key databases and websites was conducted. Search terms included terms for CHEs (United Nations Office for the Coordination of Humanitarian Affairs definition) and terms for communicable diseases. Due to the types of evidence found, a thematic synthesis was conducted.

Results 26 articles met inclusion criteria. Key risk factors include crowded conditions, forced displacement, poor quality shelter, poor water, sanitation and hygiene, lack of healthcare facilities and lack of adequate surveillance. Most identified risk factors do not relate to specific diseases, or are specific to a group of diseases such as diarrhoeal diseases and not to a particular disease within that group. Risk factors are often listed in general terms but are poorly evidenced, not contextualised and not considered with respect to interaction effects in individual publications. The high level of the inter-relatedness of risk factors became evident, demonstrating risk factor cascades that are triggered by individual risk factors or clusters of risk factors.

Conclusions CHEs pose a significant threat to public health. More rigorous research on the risk of disease outbreaks in CHEs is needed, from a practitioner and from an academic point of view.

Key questions

What is already known?

- Complex humanitarian emergencies pose significant risks to human health and communicable diseases are one of the most pressing concerns during a complex humanitarian emergency.
- Complex humanitarian emergencies exacerbate many important risk factors for outbreaks of communicable diseases.

What are the new findings?

- While not necessarily triggering different risk factors than other emergencies, complex humanitarian emergencies trigger more risk factor cascades with interactive feedback loops and provide a conductive environment for communicable diseases.

What do the new findings imply?

- Humanitarian interventions need to be aware of a wide variety of possible risk factors and to identify those most likely to trigger risk factor cascades.
- While mass population displacement triggers most other risk factors in complex humanitarian emergencies, more research is also needed on entrapment crises, which become more likely with the changing nature of conflict.

INTRODUCTION

Complex humanitarian emergencies (CHEs[1]) pose a significant threat to public health, often in settings that were already deprived before the disruptive event or events. While CHEs generally affect the health of the affected population negatively, they especially exacerbate the risk of communicable diseases including diarrhoeal diseases, acute respiratory diseases, measles, meningitis, tuberculosis, HIV, viral haemorrhagic fevers, hepatitis E, trypanosomiasis and leishmaniosis.[2 3] Priorities that need to be addressed in a complex emergency include rapid assessment of the health status of the affected population, mass measles vaccination, implementation of water and sanitation measures, food supply and nutrition programmes, site planning, provision of shelter, non-food items and basic medical services, control and prevention of communicable diseases and potential epidemics, surveillance and alert, mobilisation of community health workers, and coordination with national and international agencies.[3] Several of these interventions rightly target communicable diseases,

as during complex emergencies up to three quarters of excess deaths are attributable to infections.[4]

While research in this field is growing, there is inadequate understanding of the risk factors associated with communicable diseases in these situations.[5] There is a strong need for a better evidence and understanding of the risk of communicable diseases in CHEs to inform control strategies and emergency surveillance, both of which are based on risk assessments that currently lack a common risk framework. We conducted the first (to our knowledge) systematic review on risk factors for communicable diseases in complex humanitarian emergencies.

CHEs, for our purposes, are defined as crises in a region or area in which no local coping capacity can handle the situation due to a complete breakdown of state authority. The problems in complex emergencies are diverse and a multiagency international response is necessary to address the situation. They usually result from extensive inter-state or intra-state armed conflict, leading to '(e)xtensive loss of life, massive displacement of population, widespread damage to societies and economies'; 'Need for large-scale, multi-faceted humanitarian assistance'; 'Hindrance or prevention of humanitarian assistance by political and military constraints'; 'Significant security risks for humanitarian relief workers in some areas'.[1] Any such situation requires a multifaceted international response, usually led by the United Nations (UN). No complex emergency would be adequately addressed by the activation of only one of the humanitarian clusters. In fact, in most complex emergencies, most if not all clusters would be activated and many such emergencies will happen in situations and countries where multiple clusters are already active due to the underlying conditions with the complex emergency exacerbating these conditions beyond the scope of an ongoing UN country programme.

METHODS

The description of methods follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement as far as applicable to qualitative systematic reviews.[6] No review protocol was published beforehand.

Inclusion criteria

For this review, we had to define three terms on which we could formulate clear inclusion criteria: (1) risk factors, (2) communicable diseases and (3) CHEs.

In order to capture all risk factors and risk factor mechanisms that might not have been labelled risk factors or been mentioned as a side note, we decided to not include terms for risk factors in our search strategy. However, they were applied as an inclusion criterion. Risk factors for this purpose were anything mentioned as increasing the risk of a communicable disease outbreak happening or as a reason for an outbreak having happened or as a mechanism that promoted favourable conditions for communicable disease spread in CHEs. Only those risk factors that apply at the population or setting level were included, as this review does not focus on the individual. Risk factors were eligible for inclusion if they could plausibly apply in CHEs.

Communicable diseases were defined as infectious diseases transmissible 'by direct contact with an affected individual or the individual's discharges or by indirect means (as by a vector)'.[7]

Definitions for CHEs, sometimes also simply called complex emergencies, are plentiful; however, as most agencies involved in the management of this type of disaster agree on some key issues, we used the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) definition: "(M)ultifaceted humanitarian crisis in a country, region or society where there is a total or considerable breakdown of authority resulting from internal or external conflict and which requires a multi-sectoral, international response that goes beyond the mandate or capacity of any agency and/or the ongoing United Nations country programme".[1] As such, emergencies such as the 2013–2015 West Africa Ebola outbreak, the Plague outbreak in Madagascar, tsunamis,[8] tropical storms and other disasters associated with a natural hazard are not classified as CHEs under the UNOCHA definition and therefore not eligible for inclusion in this systematic review.

We only included emergencies after 1990 and publications published on or after 1 January 1994. These dates were chosen to exclude emergencies before 1990, which were mainly influenced by the Cold War and hence considerably different in their nature. The first major CHE after the end of the Cold War was Rwanda and with those dates we made sure to include research on Rwanda but exclude research on CHEs during the Cold War.

We initially included all languages, but if no one in the research team could be found who understood the language an article was published in, we would have excluded that article for practical reasons. Because all articles found were either in English, French or Spanish, no articles were excluded due to language barriers.

Search strategy and data sources

Our search strategy was developed in discussion between the authors and based on previous experience and extensive background reading. The search was composed of terms for communicable diseases, including specific diseases that have very often occurred in previous CHEs and terms for CHEs. We searched the following bibliographic databases: Scopus, Medline, Embase and International Bibliography of Social Sciences (IBSS). The search strategy for Medline is presented in figure 1. Search terms for Medline and Embase included subject headings that were not available in Scopus and IBSS. The search was conducted in May 2017. Additionally, we searched the relevant websites of Medecins Sans Frontièrs, WHO and the United Nations High Commissioner for Refugees, the United Nations Children and Education Fund and ReliefWeb (UNOCHA). The search strategy was adapted

# ▲	Searches
1	(complex adj emergenc*).ab,hw,kf,ti.
2	(complex adj humanitarian adj emergenc*).ab,hw,kf,ti.
3	(complex adj humanitarian adj cris#s).ab,hw,kf,ti.
4	1 or 2 or 3
5	Disease Outbreaks/
6	Communicable Diseases/
7	(diarrhoeal adj disease*).ab,hw,kf,ti.
8	(respiratory adj disease*).ab,hw,kf,ti.
9	(infectious adj disease*).ab,hw,kf,ti.
10	"vector?borne disease*".ab,hw,kf,ti.
11	malaria.ab,hw,kf,ti.
12	measels.ab,hw,kf,ti.
13	pertussis.ab,hw,kf,ti.
14	Trypanosomiasis.ab,hw,kf,ti.
15	dysentery.ab,hw,kf,ti.
16	meningitis.ab,hw,kf,ti.
17	meningococcal.ab,hw,kf,ti.
18	pneumonia.ab,hw,kf,ti.
19	Leishmaniosis.ab,hw,kf,ti.
20	TB.ab,hw,kf,ti.
21	tuberculosis.ab,hw,kf,ti.
22	5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21
23	4 and 22

Figure 1 Search strategy in Medline.

for the individual websites according to the technical and search engine capacities provided by the websites. All terms were searched in abstracts and titles, keywords and relevant subject where possible. References of included publications were also checked. Reviews were included.

Study selection

Based on the inclusion criteria, CCH and JB screened titles and abstracts of all articles identified via bibliographic databases independently. In case of disagreement, full text was obtained. An article was included for full-text review if either screener did not reject it. CCH and JB next screened full texts independently and decision about final inclusion was reached discursively. We sought access via libraries and contacted authors of conference abstracts directly.

Data analysis and synthesis

Due to the qualitative and heterogeneous nature of the evidence found, this is a qualitative systematic review. The data were analysed using thematic synthesis.[9] Primary coding was done by CCH, except for one article in Spanish, which was primary coded by JB. JB or CCH confirmed the primary codes and added secondary codes for all articles. Coding was done by hand and codes were transcribed into custom-made coding sheets, recording quotes, codes and subcodes. Based on the codes and subcodes, descriptive and analytical themes were developed.

RESULTS AND DISCUSSION

Our literature search retrieved 153 articles after de-duplication and eight grey-literature documents (as shown in figure 2). Articles were mainly excluded if they did not focus on CHEs or applied a significantly different definition of CHEs than this review does, if they did not focus on communicable diseases and if they gave no indications of any risk factors. Twenty-two articles were included directly from searches with an additional four articles retrieved from the reference lists of included

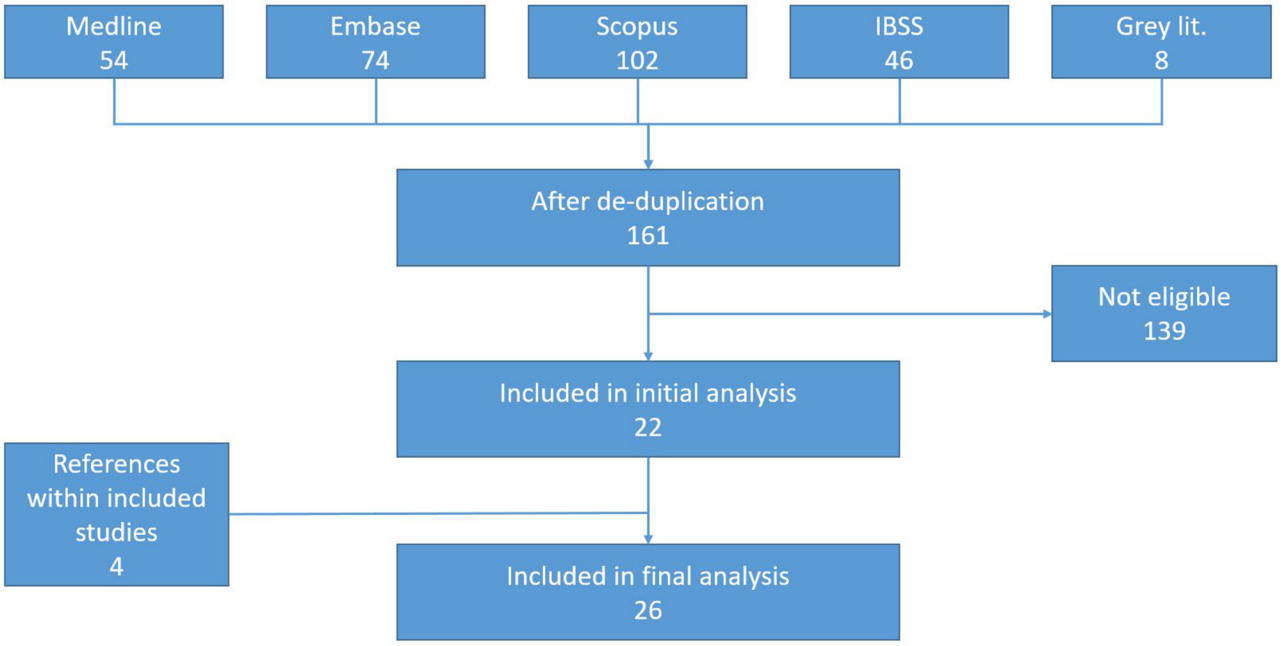

Figure 2 Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagram. IBSS, International Bibliography of Social Sciences.

articles. Articles were predominantly in English. One article was in Spanish and one in French.

Twelve main clusters of risk factors were identified that all exhibit a high level of inter-relatedness, feedback loops and interaction on various levels. These risk factor clusters provide an analytical lens and many individual risk factors can be grouped into primary and secondary (and sometimes even tertiary) clusters. Table 1 gives an overview of the included articles, the setting they describe and the risk factor clusters identified in them.

Main risk factor clusters

- *WASH*[2 10–23]: Water, sanitation and hygiene are central elements to limit the risk of communicable diseases in populations experiencing an emergency. As such, they are also central to CHEs and often in a more precarious state than in other emergencies. WASH risk factors include issues such as lack of safe drinking water,[2 10 12 14–17 19–21] lack of hygiene,[10 15 19 22] hygiene behaviour,[18 21 22] lack of soap,[2 19–21 24] lack of bed nets[25 20] (as vector control is usually seen as a part of WASH in humanitarian response) and general water scarcity,[2 10 12 14–17 19–21] as well as lack of adequate sanitation and latrines. These factors considerably increase the risk for diarrhoeal diseases and compound risks for other types of communicable diseases especially if they are coupled with other risk factor categories such as overcrowding and mass population displacement.
- *Overcrowding*[2 10 13 15 17–20 22–24]: Overcrowding in CHEs is usually a function of either mass population displacement or entrapment. While overcrowding can also be an issue in ad hoc shelters after the widespread destruction of homes and infrastructure, it is more prevalent if populations are forced to become refugees or internally displaced persons and are forced into camps. Overcrowding affects both hygiene-related diseases, such as diarrhoeal diseases, but also increases the transmission rate of diseases such as measles and other infections that spread from person to person.
- *Mass population displacement*[2 10 12 14 15 17–20 23 24 26–34]: Mass population displacement is a trigger for most risk factor categories and as such possibly the main risk factor in CHEs. Mass population displacement is usually associated with large numbers of people moving into camp settings, often associated with overcrowding, inadequate shelter and poor WASH conditions.[2 10 15 17–20 29] Additionally, populations are displaced into regions and areas with insufficient resources and services and with potentially increased contact of naive populations with new disease vectors. Early camp structures (such as layout of tents and siting of toileting areas) can lead to further complications. Early layout often develops as an ad hoc response to mass population displacement but may prove completely unsuitable as the camp expands.
- *Nutrition*[2 10 12 13 15 17 19 20 22–24 34]: While nutrition factors such as malnutrition,[2 10 13 15 17 19 20 22 24 34] food shortages[2 10–12 17 19] and exposure to contaminated food[19 20] are mainly risk factors at the individual level, they also pose increased risk to populations as a whole if a sufficient percentage of the population is exposed. Nutrition factors are related to increased susceptibility to communicable diseases with resulting greater shedding and transmission to others. At the population level, nutritional factors can exacerbate other risk factors and risk factor clusters, for example by

Table 1 List of articles included in the analysis

Article	Setting	Risk factor clusters
Abubakar *et al*[22]	South Sudan; Internally Displaced Persons (IDPs) camps	Infrastructure, economy, mass population displacement, nutrition, overcrowding, water, sanitation and hygiene (WASH)
Bompangue *et al*[26]	Democratic Republic of Congo; mainly refugee camps	Humanitarian response, mass population displacement
Brennan and Nandy[10]	Complex emergencies	Health and public health services, HIV-specific risk factors, humanitarian response, insecurity, mass population displacement, nutrition, overcrowding, WASH
Burkle[18]	Complex emergencies	Infrastructure, mass population displacement, overcrowding, living conditions, WASH
Burkle[24]	Complex emergencies; paediatric populations	Economy, health and public health services, mass population displacement, nutrition, overcrowding, WASH
Chaignat and Monti[12]	Complex emergencies	Environment, health and public health services, humanitarian response, living conditions, mass displacement, nutrition, WASH
Close *et al*[13]	Complex emergencies	Nutrition, overcrowding, mass population displacement, health and public health services, WASH
Connolly *et al*[2]	Complex emergencies	Economy, environment, health and public health services, HIV-specific risk factors, infrastructure, insecurity, mass displacement, living conditions, overcrowding, nutrition, WASH
Coulombier *et al*[14]	Complex emergencies	Health and public health services, insecurity, mass population displacement, WASH
Cuadrado and Gonzalez[23]	Complex emergencies	Environment, WASH, insecurity, mass population displacement, nutrition, overcrowding, health and public health services, living conditions, economy, infrastructure
Fisher *et al*[15]	Complex emergencies	Environment, health and public health services, HIV-specific risk factors, mass population displacement, overcrowding, living conditions, nutrition, WASH
Goma Epidemiology Group (1995)	Rwanda; refugee camps	Environment, WASH
Guthmann *et al*[16]	Sudan; IDPs	WASH
Howard *et al*[27]	Afghanistan	Economy, mass population displacement, health and public health services
Howard *et al*[25]	Afghanistan	Economy, infrastructure
Khaw *et al*[28]	Complex emergencies	Health and public health services, HIV-specific risk factors, insecurity, mass population displacement
Kolaczinski (2005)	Afghanistan	Health and public health services
Kolaczinski *et al* (2005)	Afghanistan	Insecurity, health and public health services
Kolaczinski and Webster (2003)	East Timor	Health and public health services, mass population displacement, overcrowding, living conditions
Leyenaar[30]	Complex emergencies	Economy, HIV-specific risk factors, insecurity, mass displacement
Liddle *et al*[31]	Somalia	Economy, infrastructure, health and public health services, insecurity, mass displacement
MMWR (2011)	Horn of Africa	Mass population displacement, health and public health services

Continued

Table 1 Continued

Article	Setting	Risk factor clusters
Salama and Dondero[33]	Complex emergencies	HIV-specific risk factors, insecurity, mass population displacement, health and public health services
Toole and Waldman[17]	Complex emergencies and displacement crises	Health and public health services, mass population displacement, overcrowding, living conditions, nutrition, WASH
WHO[34]	Complex emergencies	Environment, health and public health services, humanitarian response, mass population displacement, nutrition
WHO[20]	Afghanistan and neighbours	Environment, health and public health services, living conditions, mass displacement, overcrowding, nutrition, WASH
WHO[19]	Liberia	Economy, environment, health and public health services, HIV-specific risk factors, infrastructure, WASH, insecurity, living conditions, mass population displacement, overcrowding, nutrition

increasing the risk of violence and social unrest. Root causes for nutrition risk factors lie mainly in other risk factor clusters such as insecurity and armed conflict or mass displacement and inadequate humanitarian response.

- *Living conditions*[2 12 19 20 23]: Poor living conditions are a combination of inadequate shelter, overcrowding and other individual factors in the immediate surroundings of an individual or group of individuals. A key risk for people uprooted from their normal lives in CHEs and subject to inadequate resources and shelter is indoor air pollution.[2 19 20] This is due to indoor fires, both for cooking purposes and for heating.[2 19 20]
- *Insecurity*[2 10 14 19 23 28 30 31 33 35]: Insecurity is a multifaceted bundle of risk factors that is one of the main root causes for increased mortality (all causes) in complex humanitarian emergencies. Insecurity is composed of factors such as armed conflict,[10] social disruption[10 19 30 33] and political instability.[2] The specific nature of insecurity differs from complex emergency to complex emergency. However, by our (UNOCHA) definition, most, if not all, complex emergencies experience a high level of severe violence either from inter-state or from intra-state conflict. Insecurity triggers other factors such as a lack of an adequate humanitarian response as it poses risks to aid workers and inhibits access to beneficiaries. Additionally, it also inhibits access for the population to health services and has a high potential to disrupt all other services.
- *Infrastructure*[2 18 19 22 23 31]: Due to insecurity and also in some cases long-term neglect and lack of funding, infrastructure in CHEs is often inadequate, especially in response to mass influx of people either in camps or in the community. Lack of infrastructure also often comes with a lack of domestic coordination,[2 19 31] which additionally inhibits efficient coordination with international response. A lack of resources,[2 31] water,[2 10 12 14–17 19–21] electricity,[19] funding[22] and staff[22] makes the affected population more dependent on an international response.
- *Humanitarian response*[10 12 26 34]: By our (UNOCHA) definition, a complex emergency demands a multifaceted, multiagency international humanitarian response. However, poor response can itself become a risk for the spread of communicable diseases. Problems can lie with the response itself, due to a lack of international commitment or a lack of professionalism of the responding agencies and organisations.[12] Problems can also arise domestically due to restrictions by governments or warring parties, unsafe conditions in which aid workers cannot properly work without unacceptable levels of risk for themselves or lack of access for various reasons.[10 34] This also includes lack of organisational motivation[22] and poor institutional support[10] and complex international issues such as the lack of a binding legal framework for the protection of internally displaced populations.[24]
- *Environment*[2 12 15 19–21 23 34]: Environmental factors can increase the likelihood of communicable diseases outbreaks, and this is true beyond the context of CHEs. However, many environmental factors, which would not have mattered otherwise, can be triggered by mass population displacement, especially if populations are displaced into areas with a higher prevalence of environmental risk factors. Environmental risk factors include weather and climate factors, such as cold and dust storms,[2 20] but also vector habitats,[19 20 34] increased contact with animals[19 20] and endemic diseases.[2 12 19] Mass population displacement potentially puts people at risk from these factors and also exacerbates the factors themselves due to the additional stress placed on the local environment by camps and by an influx of large numbers of people, often accompanied with significant land use changes.[19]

- *Economy*[2 19 23 25 27 30 31]: While economic factors such as poverty and lack of resource are certainly issues that are important in humanitarian emergencies, they are not of the highest importance in CHEs. Poverty and economic degradation have the ability to further exacerbate the root causes of the underlying conflict but only indirectly increase the likelihood of communicable disease outbreaks.
- *Health and public health services*[2 10 12–15 17 19 20 23 24 27–29 31–36]: Breakdown of health and public health services is probably one of the main risk factors for communicable diseases in CHEs both for individuals and for populations. Lack of access to health and medical care is a key risk factor for severe progressions of most communicable diseases for the individual.[2 10 12 15 17 19 20 28 29 31 33 34] It also facilitates the further spread of communicable diseases such as tuberculosis and makes detection of cases and outbreaks harder. Additionally, in complex emergencies, public health services including vaccination, communicable disease prevention and control measures, and surveillance are no longer available making disease outbreaks more likely, harder to detect and harder to control.[2 10 12 13 15 17 19 20 24 27 31–33 35] This breakdown of services can be seen as a function of the underlying conflict but is further compounded if there is not enough political will to provide adequate health protection.[2]
- *HIV-specific risk factors*[2 10 15 19 28 30 33]: HIV is a unique and often overlooked concern in CHEs. While many of the aforementioned risk factors also apply to HIV, there are some very specific additional risk factors that are associated with an increase in the incidence of HIV in complex emergencies. Key risk factors for an increased transmission of HIV include sexual and gender-based violence,[2 10 15 19 28 30 33] increased rates of sex work,[2 10 19 28 30 33] use of unsafe blood products and conflict-related increased demand for (potentially unsafe) blood products,[2 19 28] lack of infection control in healthcare facilities,[2 19 28] lack of condoms[2 28] and an increased use of illicit drugs.[19 28 33] A high sexually transmitted infection prevalence can be linked to an increased risk of contracting HIV.[15] Lack of healthcare access and lack of antiretroviral therapy increase the likelihood of vertical transmission,[30] and mass population displacement can lead to increased contact (sexual and otherwise) with populations with a higher prevalence.[10 28 33]

Risk factor cascades

The risk factor clusters as well as individual risk factors often interact and exacerbate one another. Some risk factors and risk factor cluster are particularly likely to start risk cascades, especially mass population displacement (as illustrated in figure 3) and insecurity (as illustrated in figure 4).

One of the key mechanisms for driving risk factors for communicable diseases in complex emergencies is mass displacement (as shown in figure 3), especially mass displacement into camp settings.[18–20] Camp settings enforce a high dependence on outside support for the residents. This makes residents more at risk for other risk factors. Mass displacement can reduce access to healthcare and even if access to healthcare is maintained the level and quality might be poor.[2 10 15 17 18] Mass displacement thus tends to trigger all risk factors associated with lack of access to healthcare and increases the risks for communicable diseases both at individual and community levels. This is often coupled with living conditions that are conducive to increased transmission of communicable diseases and put the individual more at risk.[2 12 19 20] This includes the lack of adequate shelter, which is especially prone to increase vector-borne diseases and respiratory diseases, especially in areas with cold temperatures.[2 10 15 17 19 20 24 29] Overcrowding—often together with inadequate shelter and lack of sufficient

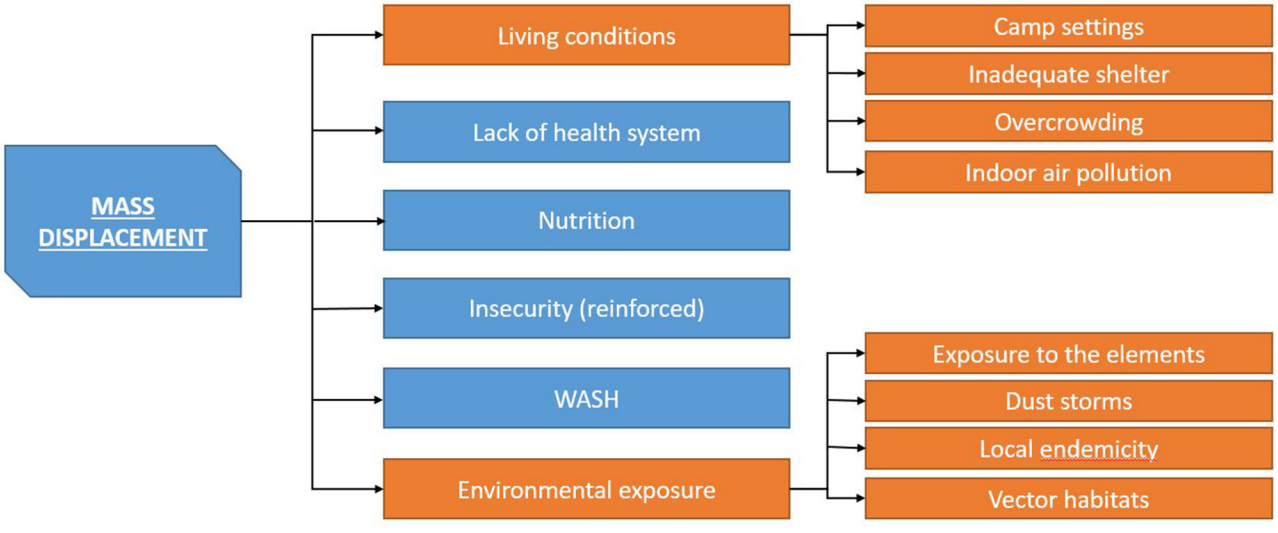

Figure 3 Mass population displacement cascade. WASH, water, sanitation and hygiene .

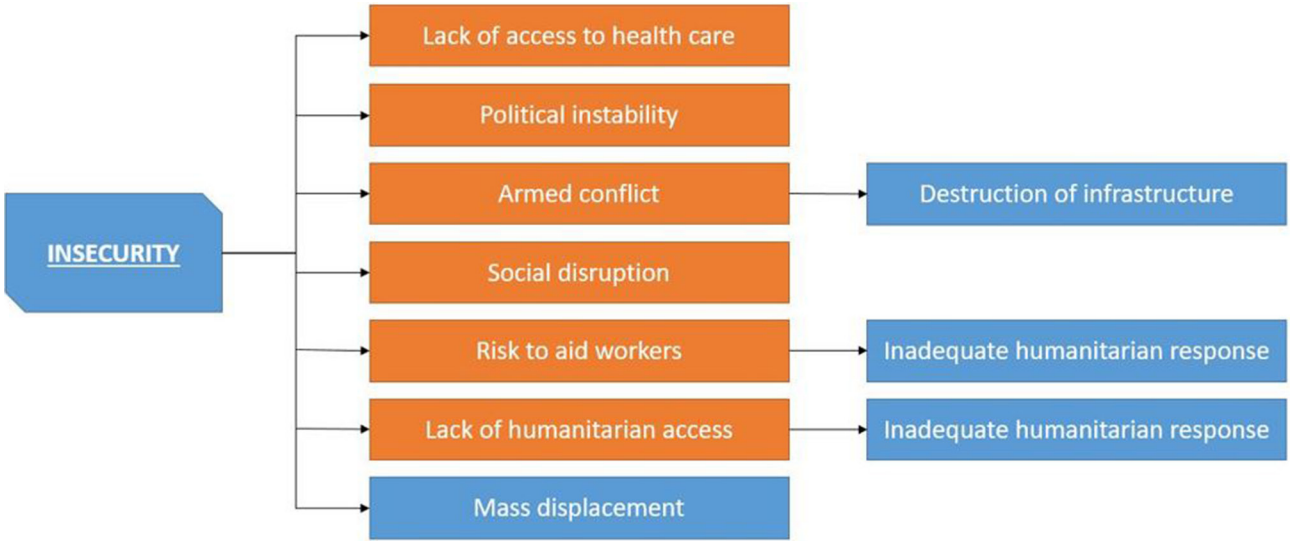

Figure 4 Insecurity cascade.

WASH—increases the likelihood of triggering hygiene risk factors and also the transmission rate of respiratory infections and diseases such as measles. For respiratory infections, this is further exacerbated by conditions that lead to the use of indoor fires and subsequent indoor air pollution.[2 19 20]

Additionally, as human populations become more overcrowded, transmission of infections becomes more efficient, that is, the reproductive ratio (R_0) of the infection increases.[37] As R_0 increases, the threshold immunisation coverage needed to achieve herd immunity also increases.[38] Consequently, immunisation coverage that was previously sufficient is inadequate to prevent outbreaks. One of the main problems, especially in overcrowded camps, is the provision of safe water and adequate hygiene. If WASH conditions deteriorate, especially diarrhoeal disease risk increases considerably. Any insufficiency in WASH is more pronounced when coupled with high population density, as experienced in camp situations. However, mass displacement, even when not coupled with displacement into camps, also triggers additional risk factors. Displacement can be into areas with endemic diseases to which the displaced population has no immunity.[12] Additionally, mass displacement makes populations vulnerable to environmental factors as well as reinforcing these.[12 21] Mass displacement can exacerbate insecurity and therefore reignite a vicious circle leading to further displacement and breakdown of healthcare, services and infrastructure.

Insecurity itself, whether exacerbated by mass displacement or not, is an important triggering mechanism for communicable disease risk factors in CHEs (as shown in figure 4). Insecurity, including political instability, armed conflict and social disruption, destroys services that previously prevented the spread of communicable diseases or disallows access to these services by making accessing them unsafe.[2 10 14 19 28 30 31 33 36 39 40] This is particularly important for healthcare services that in the last few years have increasingly become a target of armed conflict and attacks, decreasing the safety of both staff and patients.[41–43] Additionally, disease prevention programmes are likely to be disrupted and infrastructure to be destroyed.[15 17 20 36] With regard to humanitarian response, which can under certain circumstance step into the place of previously government-provided services, insecurity makes an adequate humanitarian response difficult.[10 34] Not only will access to affected populations be difficult, especially in situations when insecurity and active fighting lead to entrapment or even to siege situation, as recently seen in Syria and Iraq, but insecurity also poses risks to aid workers' security both for domestic/national and international/expatriate staff.[10 34] Aid organisations are—understandably—increasingly reluctant to accept very high risks to their personnel, leading to gaps in provision of services, which would otherwise have been filled by a humanitarian response. Insecurity also increases the risk of the loss of domestic experts in disease prevention due to injury, death and flight.[42]

These are only some aspects of two of the many mechanisms by which CHEs drive risks for communicable diseases. We identified further cascades triggered by economics and infrastructure and risk factor cluster interaction for WASH and health systems risk factors. However, the level of complexity in these types of emergencies makes it impossible to capture all levels of interaction adequately. It is not so much that complex emergencies create different risk factors than other humanitarian crises but that they exacerbate any individual risk factors and compound interaction effects. Levels of risk factors will invariably be higher in a complex emergency and the amount of interacting risk factors creates a 'perfect storm'[44] where a multifaceted, well-funded and logistically and politically highly integrated humanitarian response is not possible due to political, financial or security reasons. These conditions make the danger of one or more outbreaks of communicable diseases extremely high.

While complex humanitarian emergencies do not trigger risk factors that are unknown in other types of emergencies and disasters, they produce much higher levels of risk and often tend to trigger more of the known risk factors as well as risk factor cascades. Risk factors related to poor sanitation and hygiene,[45–52] nutrition,[46 53–55] mass population displacement and overcrowding[47 53 56–60] have been discussed extensively in the academic literature as being important in most types of emergencies, while risk factors resulting from an inadequate humanitarian response, armed conflict and a breakdown in government services are generally more associated with complex emergencies and other situations linked to failing statehood, such as civil war.

The question remains of how to make useful this information on risk factors and their interactions. While many of the risk factors and even starting points of risk factor cascades are addressable, the context of a complex emergency often prevents any such interventions. A key first step in any attempt to address these issues in a given complex emergency is a rapid but thorough initial needs assessment,[3 61–63] including an assessment of the most critical risk factors present in that specific complex emergency in order to develop an evidence-based intervention strategy. However, it is unclear how to best undertake such a needs assessment. Moreover, beyond the development of evidence-based risk assessment and management methods, there is a need for more rigorous research into the operational and structural barriers that make it difficult to address risk factors in CHEs.

Limitations

This systematic review included subjective interpretation as risk factors were rarely the main focus of the included articles. Authors do not always clearly describe the risk factors and their mechanisms. This introduced an interpretative and subjective element within the included articles, which became more subjective due to the level of interpretation required to complete the thematic synthesis. However, the authors maintained constant feedback to one another and discussed challenges, interpretations and limitations to ensure reliability and validity of the findings to the degree that a qualitative analysis allows. We are therefore confident that our interpretation properly reflects the data, although agreeing that other interpretations are possible and may be equally valid. This review was necessarily a qualitative synthesis as the evidence base (heterogeneous and qualitative in nature) did not support quantitative analysis.

CONCLUSION

CHEs pose a significant threat to public health. The described cascades, interactions and feedback loops are only some of the most striking examples. The increased exposure to very many interacting risk factors and the resulting risk factor cascades created by a complex emergency encourages a perfect storm of communicable diseases risk.

However, despite these extremely increased risks and the exceptional situation that CHEs pose, we did not find a correspondingly high level of academic engagement with the issue. Most of the included articles discussed situations of mass displacement into camps, which is arguably the best studied situation concerning complex emergencies. However, conflicts like Syria and Yemen demonstrate that this might not be the most important situation in the 21st century. Syria and Yemen feature high levels of entrapment,[64–67] as they are characterised by limited or no displacement due to a lack of safe humanitarian corridors. This situation coincides with a high level of most other risk factors, especially lack of access to healthcare, lack of humanitarian response, lack of WASH and other services, food insecurity and high levels of insecurity. We conclude that more rigorous research on the risk of communicable disease outbreaks in complex humanitarian emergencies could elucidate opportunities to either prevent or better manage such events. Such research should be undertaken in collaboration between practitioners and academics. More CHE research on entrapment situations is especially desirable, in response to the nature of recent conflicts.

Contributors All authors (CCH, JB, PRH) contributed to the conceptualisation of the research. Primary coding was done by CCH, except for one article in Spanish, which was primary coded by JB. JB and CCH confirmed the primary codes and added secondary codes for all articles. CCH wrote the draft manuscript and JB and PRH contributed feedback to and revisions of the manuscript. All authors revised and approved the final version of the manuscript.

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RESEARCH ARTICLES

Risk factors for communicable diseases in humanitarian emergencies and disasters: Results from a three-stage expert elicitation

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Abstract

Background: Humanitarian emergencies including disasters associated with natural hazards, conflict, complex emergencies and famines can pose significant risks to public health, especially when they lead to population displacement into inadequate conditions. To reduce the risk of communicable disease outbreaks in such situations it is necessary to know the key risk factors, their thresholds (quantitative risk factors only) and their relative importance in different types of emergencies.

Methods: We conducted a three-stage structured expert elicitation. Experts from the fields of health protection and humanitarian assistance were invited to complete three successive online questionnaires. Experts were asked to choose the 20 most critical risk factors and in subsequent rounds to determine thresholds for urgent (yellow threshold level) and critical action (red threshold level). Additionally, experts were asked to assign weights for the risk factors in different emergency types.

Results: We identified 20 key risk factors, which include factors related to water, sanitation and hygiene, access to health care, vaccination, nutrition, political will and others. Nine out of the 20 risk factors were quantifiable, for those risk factors yellow and red thresholds are given. 11 risk factors were qualitative. All risk factors scored highly when weighted in different emergency types and differences between risk factor weights in different types of emergencies were limited.

Conclusion: Communicable disease risks in humanitarian emergencies are a nexus of complex and often interrelated individual issues. Knowing key risk factors and their thresholds and weight in different types of emergencies can help guide emergency response and risk reduction efforts.

Keywords: communicable diseases, humanitarian emergencies, expert elicitation, risk factors, prioritisation

Introduction:

Communicable diseases are one of the primary concerns in humanitarian emergencies and disasters. (1-20). Humanitarian emergencies include disasters associated with natural hazards such as earthquakes, floods and tsunamis, as well as man-made disasters such as famine, conflict and complex emergencies. These emergencies usually require a large-scale international response and affect large proportions of a community, country or region. The importance and overall risk of communicable diseases and communicable disease outbreaks differs between different disaster types. It is particularly low in geo-disasters such as earthquakes or volcanic eruptions (21), higher for flooding (14-20), and much worse again in refugee crises (2, 4-8, 10-12, 22) or complex humanitarian emergencies (1, 23).

While the problem of a potentially increased risk of communicable diseases in humanitarian emergencies is well documented, information on specific risk factors and the levels at which these risk factors become critical is lacking. Yet, the identification of risk factors and their interaction is crucial for risk management. Knowing the overall risk profiles can help identify those sites where proactive interventions may reduce the impact of communicable diseases. Key risk factors for communicable diseases identified in the academic literature can be broadly grouped into categories such as Water, Sanitation and Hygiene (WASH), health and public health system, environment, humanitarian response, infrastructure, insecurity, living conditions, nutrition, mass population displacement and economy (23). Within those broader categories, individual risk factors are defined more specifically, although the categories themselves serve as general risk factors as well (1, 2, 23-33). While similar groups of risk factors have been identified as significant for all emergency types, their weights can differ depending on the individual setting, as does the overall risk of a communicable disease

outbreak. For example, as Floret et al. (21) noted, the risk of communicable disease outbreak is almost negligible in geo-disasters that do not trigger a secondary disaster such as a displacement crisis. For each site, it is also important to know which risk factors are of the most pressing concern to allocate resources correctly and prioritise interventions.

In this paper, we summarise the results from three stages of structured online expert consultations we performed to determine the 20 most critical risk factors (across all types of humanitarian emergencies), the thresholds for those factors that could be assessed by a quantitative indicator, and their weights in different types of emergencies. These data were later used in the development of a rapid risk assessment tool to be used by non-experts to assess needs and priorities in humanitarian emergencies. The factors selected to be the 20 most critical were included in the tool and the thresholds and weights for each factor were used as the basis for a risk score for each factor and a combined overall risk score. The risk factors identified, their weights and thresholds, and especially the rapid risk assessment tool do not substitute detailed needs assessment and are designed to rapidly assess communicable disease outbreak risk and, as such, are not a suitable basis for humanitarian programming.

Methods

We conducted a three-stage structured expert elicitation.

Recruitment and participants

Participants who self-identified as having experience in health protection and/or humanitarian assistance were invited to take part. Participants were recruited by email through dedicated listservs that cover areas such as health protection, public health intelligence, humanitarian assistance and disaster studies as well as through the personal and professional contacts of the research team. Participants were then guided to an online questionnaire.

Recruitment included personalised emails to 16 individuals we knew professionally and via dedicated relevant listservs. Recipients were encouraged to share with interested colleagues. Most of the targeted individual recipients had recent field experience supporting response to humanitarian disasters. Table 1 lists the affiliations of targeted individuals and the specific list serves; most affiliations were with public health agencies, charitable aid organisations and/or research institutions. Many targeted respondents had multiple relevant affiliations. To help assure confidentiality we did not ask during the survey for identifying information such as current employer, job title or years of experience. The specific Email listservs we used and characteristics of the individuals we personally asked to fill in the survey are listed in Table 1.

Questionnaires are included in the supplemental files. Participants could fill out one or more of the three stages of online questionnaires. Participation in a previous questionnaire was not required to take part in the second and/or third stages. The first questionnaire asked participants to identify the 20 most critical risk factors from a list compiled based on the wider literature and a recent literature review by the research team (23). The first questionnaire also asked participants to assign weights (on a scale from 0-5) to each risk factor to allow the calculation of a weighted average for each factor. The weighted average was calculated from the mean score of level of importance (on a scale from 0-5) times the number of participants selecting this weight for this factor. Weighted averages were calculated in case the initial mechanism for selection of the 20 most critical factors based on how many participants considered them to be in the top-20 proved to be inconclusive. In the second questionnaire, participants were invited to assign yellow (urgent, action required) and red (critical, action required immediately) thresholds for all quantifiable risk factors.

The third and final questionnaire sought to identify the respective weights (on a scale from 1-5) of the 20 most critical risk factors in nine different types of emergencies, as broadly described by Spens and Kovács (34). The types of crises were: famine (F), complex emergency (CHE), conflict (C), refugee and IDP camp (RC), flooding (FL), geo-disaster (GD), protracted crisis (PC), tropical storm (TC) and tsunami (T). Complex emergencies describe situations in which widespread internal or external conflict has led to a complete breakdown of authority and widespread damage to society. They are defined by requiring a multi-facetted, multi-agency international response (23, 35). Conflicts include inter- and intra-state warfare, civil war and insurgency. Geo-disasters include earthquake, landslides, volcanic eruptions and other disasters caused by geological hazards. Flooding refers to fresh water flooding. Tropic storms include Hurricanes, Typhoons, Cyclones and similar hydro-meteorological hazards. This list of types of emergencies was not meant to be complete or to comprise mutually exclusive types of crises. Displacement crises are usually an additional humanitarian emergency secondary to conflicts, complex emergencies, or disasters associated with a natural hazard. However, we believe the risks for communicable disease outbreaks differ significantly enough for these to form distinct categories.

Analysis

Answers were collected online and analysed in Microsoft Excel. Weighted averages, median and mean scores were calculated where appropriate. Additionally, correlations were done in SPSS version 23 using Pearson correlation.

Table 1. Email list servers (n=11), with affiliations and characteristics of targeted individuals (n=16)

Public Health Agencies:	
Philippine Ministry of Health, Public Health England, World Health Organisation, Unicef, UNESCO, UNRWA	
NGOs involved with Humanitarian response:	
Global Student Embassy, Médecins Sans Frontières, Mercy Corps Indonesia	
Universities or Research Institutions:	
Adnan Menderes Üniversitesi, Institute of Tropical Medicine in Antwerp, Northumbria University, Tufts University, University of East Anglia, Würzburg University	
Job titles of targeted individuals:	
Associate Professor, Consultant for WHO, Consultant in Global Disaster Risk Reduction, Director of Health programme, Director of Operations Research, Geostatistical Modeller, Operations Researcher, Professor, Research Fellow, Researcher, Senior Fellow, WASH cluster coordinator, Water Coordinator, Water Hygiene and Sanitation Officer	
Email List servers	
German Disaster Research Listserv	JISCMAIL Health Geography Listserv
Healthcare Information for All listserv	JISCMAIL Public Health Listserv
JISCMAIL Medical Sociology Listserv	JISCMAIL Disaster Research Listserv
JISCMAIL Disaster Research Listserv	JISCMAIL Global Health Listserv
JISCMAIL Public Health Listserv	Humanitarian Listserv
Society of Apothecaries	Healthcare Information for All listserv

Results

Responses

The first questionnaire was completed by 21 participants; the second questionnaire was completed by 24 and the last questionnaire by 25 persons. We only stored, recorded and analysed completed questionnaires and not those left half-completed in order to comply with the possibility for participants to withdraw consent to partake until the end of the survey. Given that the surveys were advertised widely, this represents a relatively small proportion of possible respondents. However, it is not possible to characterise the actual response rate.

Risk Factors

The first questionnaire sought to identify the 20 most critical risk factors, irrespective of the emergency type and their relative importance. The 20 risk factors chosen by the most respondents (see column 'Selected (n)' in Table 2) were input to the Stage 2 and 3 surveys. 19/20 of these also had the overall highest weighted average scores (see Table 3).

Thresholds

Table 4 shows the expert-identified yellow and red thresholds for the nine quantifiable risk factors. A yellow threshold indicated a situation of concern that should be addressed as soon as possible while a red threshold indicated a highly critical situation that needs to be a top priority. These thresholds are described individually below.

Access to clean water was measured in litre per person per day. The median red threshold was 2 (mean 5.25, SD 5.01) litres and the median yellow threshold 6.5 (mean 10.5, SD 8.92) litres.

The available number of hospital beds per 10,000 persons was used as a proxy indicator for the risk factor health care facilities. The median red threshold was 5 beds (mean 18.77, SD 27.28) per 10,000 persons and the median yellow threshold was 20 beds (mean 45, SD 54.70) per 10,000 persons.

The median red threshold for functioning toilets was 4 (mean 4.92, SD 4.95) toilets per 100 persons and the median yellow threshold was 9 (mean 10.86, SSD 11.74) toilets per 100 persons.

The number of health professionals per 10000 was measured in three categories. The median red threshold for doctors per 10000 persons was 1.5 (mean 19.21, SD 35.24) and the median yellow threshold was 5 (mean 27.31, SD 55.91) doctors per 10000 persons. The median red threshold for nurses was 6 (mean 96.79, SD 256.24) per 10000 persons and the median yellow threshold 10 (mean 63, SD 111.29) nurses per 10000 persons. The median red threshold for community health care workers was 8.5 (mean 15.86, SD 26.18) per 10000 persons and the median yellow threshold was 20 (mean 42.46, SD 55.51) community health care workers per 10000 persons.

Vaccination coverage was measured for the following four diseases: measles, meningococcal meningitis, polio and hepatitis B. The median red threshold for measles vaccination coverage was 75 % (mean 67.21, SD 23.46) and the median yellow threshold was 90 % (mean 81.92, SD 14.88). The median red threshold for meningococcal meningitis vaccination coverage was 72.5 % (mean 62.21, SD 23.92) with a median yellow threshold at 80 % (mean 73.08, SD 21.53). The median red threshold for polio vaccination coverage was 75 (mean 64.31, SD 25.89) percent with a median yellow threshold of 87.5 % (mean 83.33, SD 12.80). The median red threshold for Hepatitis B vaccination coverage was 50 % (mean 52.00, SD 23.90) with a median yellow threshold of 72.5 % (mean 70.83, SD 17.42).

Table 2: List of the selected 20 most critical risk factors irrespective of emergency type and setting. Participants (n=21) were asked to select 20 factors out of the given 59 options.

Risk factor	Selected, n (%)	Included in stage 2-3 surveys
No access to clean water	19 (90.48)	Yes
Lack of functioning toilets	19 (90.48)	Yes
Exposure to disease vectors	17 (80.95)	Yes
Lack of waste management	17 (80.95)	Yes
Lack of health facilities	16 (76.19)	Yes
Lack of health professionals (doctors, nurses, community health workers)	16 (76.19)	Yes
Insufficient vaccination coverage	15 (71.43)	Yes
Poor health status of the population	15 (71.43)	Yes
Extreme poverty	15(71.43)	Yes
Overcrowding	14 (66.67)	Yes
Lack of medicines	12 (57.14)	Yes
Insufficient nutrient intake	11 (52.38)	Yes
Lack of health education	11 (52.38)	Yes
Inadequate distance between housing etc. and human waste disposal	11 (52.38)	Yes
Ongoing conflict	11 (52.38)	Yes
Population displacement	11 (52.38)	Yes
Lack of organisational and political will to address public health problems	11 (52.38)	Yes
Flooding (waste water)	10 (47.62)	Yes
Breakdown of government services	10 (47.62)	Yes
Reluctance to follow recommended procedures to limit disease spread	10(47.62)	Yes
Lack of disease surveillance	9 (42.86)	No
Inadequate shelter	9 (42.86)	No
No soap	8 (38.10)	No
Local endemicity of key communicable diseases	8 (38.10)	No
Lack of trust in health care provided	7 (33.33)	No
Flooding (fresh water)	7 (33.33)	No
Environmental vulnerability	7 (33.33)	No
Local endemicity of disease vectors	7 (33.33)	No
Inequalities	7 (33.33)	No
Political instability	7 (33.33)	No
Lack of electricity	6 (28.57)	No
Illiteracy (among target recipients of aid)	6 (28.57)	No
Unsafe burial rites	5 (23.81)	No
Breakdown of authority	5 (23.81)	No
Displacement into camp(s)	5 (23.81)	No
Low levels of education (among target population)	5 (23.81)	No
Indoor fires/air pollution	4 (19.05)	No
Sexual and Gender-based Violence	4 (19.05)	No
Increased contact with domestic animals	3 (14.29)	No
Flooding (sea water)	3 (14.29)	No
Very high temperatures	3 (14.29)	No
Lack of belief in germ model – preference for other explanations of diseases	3 (14.29)	No
Ethnic rivalry	2 (9.52)	No
Seismic risk (dry mass displacement)	2 (9.52)	No
Landslide risk (wet mass displacement)	2 (9.52)	No
High precipitation	2 (9.52)	No
Very low temperatures	2 (9.52)	No
Violence	2 (9.52)	No
Increased contact with wildlife	1 (4.76)	No
Temporary housing (not tents)	1 (4.76)	No
Drought	1 (4.76)	No
Dust storms	1 (4.76)	No
De-forestation	1 (4.76)	No
Economic stagnation	1 (4.76)	No
Competition for resources	1 (4.76)	No
Arms proliferation	1 (4.76)	No
Lack of fuel for cooking or heating	1 (4.76)	No
Housing in tents	0 (0)	No
Volcanic risk	0 (0)	No

Poverty was measured in percentage of the population living below 1 $ US per person per day. The median red threshold was 20 % (mean 29.07, SD 25.70) and the median yellow threshold was also 20 % (mean 28.27, SD 22.88).

Overcrowding was measured in the number of persons living per 100 square metres (m2). The median red threshold was 10 (mean 20.58, SD 22.28) persons per 100 m2 and the median yellow threshold was 5 (mean 13.09, SD 14.53) persons per 100 m2.

Nutrition was measured in kcal per adult per day. The median red threshold was 1000 (mean 1009.30, SD 742.52) and the median yellow threshold was 1750 (mean 1716.67, SD 692.62) kcal per adult per day.

These figures – especially the seemingly 'high' figure for the yellow threshold must be understood in the context of the impact of mal- and undernutrition for the severity of communicable disease outbreaks through mechanisms such as increased susceptibility and greater shedding and transmission. Poor nutritional status is a common attribute of affected populations in many humanitarian emergencies and is known to exacerbate the size and severity of communicable disease outbreaks. (1, 24, 36-38).

The median red threshold for the distance between human waste disposal and housing was 20 metres (mean 71.00, SD 138.53) and the median yellow threshold was 50 metres (mean 79, SD 89.60).

Table 3. Weighted averages of the importance of the risk factors in humanitarian emergencies and disasters, irrespective of emergency type and setting. 0= Not selected/not important; 1= A little important; 2= Important; 3= Quite important; 4= Very important; 5= Extremely important. Green indicates those factors included in stages 2 and 3 while the factors marked in red were discarded after stage 1.

Risk factor	0	1	2	3	4	5	Weighted Average	Included
No access to clean water	2	0	0	0	3	15	4.35	Yes
Lack of functioning toilets	2	0	2	1	8	7	3.7	Yes
Lack of health facilities	5	0	1	0	7	7	3.25	Yes
Lack of health professionals (doctors, nurses, community health workers)	5	0	1	2	3	9	3.25	Yes
Extreme poverty	5	0	1	3	4	7	3.1	Yes
Insufficient vaccination coverage	6	0	1	3	3	7	2.9	Yes
Exposure to disease vectors	4	0	4	3	4	5	2.9	Yes
Lack of waste management	4	0	1	6	7	2	2.9	Yes
Poor health status of the populationo	6	0	0	4	8	2	2.7	Yes
Lack of medicines	9	0	0	2	4	5	2.35	Yes
Overcrowding	7	0	2	4	7	0	2.2	Yes
Ongoing conflict	10	0	0	3	3	4	2.05	Yes
Lack of organisational or political will to address public health problems	9	0	2	3	2	4	2.05	Yes
Insufficient nutrient intake	9	0	2	2	5	2	2	Yes
Inadequate distance between housing, etc. and human waste disposal	9	0	1	3	7	0	1.95	Yes
Flooding (waste-water)	11	0	0	1	5	3	1.9	Yes
Lack of health education	9	0	1	6	3	1	1.85	Yes
Population displacement	10	0	2	0	7	1	1.85	Yes
Breakdown of government services	10	1	2	2	2	3	1.7	Yes
Inadequate shelter	11	0	2	3	1	3	1.6	No
Inequalities	13	0	0	0	5	2	1.5	No
No soap	13	0	1	0	3	3	1.45	No
Lack of disease surveillance	12	0	1	3	3	1	1.4	No
Reluctance to follow recommended procedures to limit disease spread	11	0	2	4	3	0	1.4	Yes
Political instability	13	0	1	1	3	2	1.35	No
Local endemicity of key communicable diseases	13	0	1	2	3	1	1.25	No
Flooding (fresh water)	13	0	1	2	4	0	1.2	No
Local endemicity of disease vectors	14	0	1	1	1	3	1.2	No
Environmental vulnerability	13	0	2	2	2	1	1.15	No
Lack of electricity	14	0	1	2	2	1	1.05	No
Breakdown of authority	15	0	0	1	2	2	1.05	No
Lack of trust in health care provided	14	0	0	4	2	0	1	No
Illiteracy (among target recipients of aid)	14	0	1	3	1	1	1	No
Displacement into camp	5	0	1	1	2	1	0.9	No
Low levels of education (among target persons)	15	0	0	3	1	1	0.9	No
Sexual and Gender-based Violence	16	0	0	1	2	1	0.8	No
Indoor fires/indoor air pollution	16	0	0	2	1	1	0.75	No
Increased contact with domestic animals	17	0	0	1	2	0	0.55	No
Unsafe burial rites	16	0	2	1	1	0	0.55	No
Ethnic rivalry	18	0	0	0	1	1	0.45	No
Flooding (salt-water)	17	0	1	1	1	0	0.45	No
Very high temperatures	17	0	0	3	0	0	0.45	No
Lack of belief in germ model – preference for other explanations for disease causes	17	0	1	1	1	0	0.45	No
Violence	18	0	0	1	0	1	0.4	No
Seismic risk (dry mass displacement)	18	0	1	0	0	1	0.35	No
Very low temperatures	18	0	0	1	1	0	0.35	No
Increased contact with wildlife	19	0	0	0	0	1	0.25	No
Landslide risk (wet mass displacement)	18	0	1	1	0	0	0.25	No
High precipitation	18	0	1	1	0	0	0.25	No
Drought	19	0	0	0	0	1	0.25	No
Economic stagnation	19	0	0	0	0	1	0.25	No
Arms proliferation	19	0	0	0	0	1	0.25	No
Dust storms	19	0	0	0	1	0	0.2	No
De-forestation	19	0	0	0	1	0	0.2	No
Lack of fuel for cooking or heating	19	0	0	0	1	0	0.2	No
Temporary housing (not tents)	19	0	1	0	0	0	0.1	No
Competition for resources	19	0	1	0	0	0	0.1	No
Housing in tents	20	0	0	0	0	0	0	No
Volcanic risk	20	0	0	0	0	0	0	No

Weights in different emergency types

Weights for the different risk factors were similar for different types of emergencies, with only minor differences (see figure 1 and tables 5 and 6). On a scale from 1 (not important) to 5 (very important) all included risk factors score above 4 (both mean and median) when combining all emergencies. The only two risk factors with a median of 3 were 'insufficient nutrient intake' and 'lack of health education' in the context of a tropical storm. Mean values for all risk factors in all different emergency types (not combined) remained above 3.4, except for 'lack of health education' in the context of flooding (mean 3.29, SD 1.14, median 4) and 'lack of health education' in the context of a tropical storm (mean 3.22, SD 1.28, median 3). This suggests a reinforcement of the importance of these risk factors across different humanitarian emergency types.

There was considerable correlation between risk factors, demonstrating the highly interactive nature of risk and risk factors in humanitarian emergencies as well as the complexity of such situations (see table 7).

Table 4. Summary of yellow and red thresholds for 9 quantifiable risk factors.

Risk Factor	Threshold	Min	Max	Median	Mean	SD	n
Clean water in litre per person per day	Yellow Red	0.00 0.00	30.00 15.00	6.50 2.00	10.50 5.25	8.92 5.01	16 20
Hospital beds per 10 000 persons	Yellow Red	5.00 1.00	200.00 100.00	20.00 5.00	45.00 18.77	54.70 27.28	13 13
Functioning toilets per 100 persons	Yellow Red	1.00 1.00	50.00 20.00	9.00 4.00	10.86 4.92	11.74 4.95	14 13
Doctors per 10 000 persons	Yellow Red	1.00 0.00	200.00 100.00	5.00 1.50	27.31 19.21	55.97 35.24	13 14
Nurses per 10 000 persons	Yellow Red	1.00 0.00	400.00 1000.00	10.00 6.00	63.00 96.79	111.29 256.24	13 14
CHW per 10 000 persons	Yellow Red	1.00 0.00	200.00 100.00	20.00 8.50	42.46 15.86	55.51 26.18	13 14
Measles vaccination percentage	Yellow Red	40.00 1.00	95.00 90.00	90.00 75.00	81.92 67.21	14.88 23.46	13 14
Meningitis vaccination percentage	Yellow Red	10.00 1.00	90.00 85.00	80.00 72.50	73.08 62.21	21.53 23.92	13 14
Polio vaccination percentage	Yellow Red	45.00 1.00	95.00 90.00	87.50 75.00	83.33 64.31	12.80 25.89	12 13
Hepatitis B vaccination percentage	Yellow Red	20.00 1.00	90.00 90.00	72.50 50.00	70.83 52.00	17.42 23.90	12 13
Persons living under 1 $ US percentage	Yellow Red	1.00 1.00	60.00 80.00	20.00 20.00	28.27 29.07	22.88 25.70	11 14
Persons per 100 square meters	Yellow Red	1.00 1.00	50.00 75.00	5.00 10.00	13.09 20.58	14.53 22.28	11 12
Kcal per adult per day	Yellow Red	800.00 1.00	3500.00 2500.00	1750.00 1000.00	1716.67 1009.30	692.62 742.52	12 13
Distance housing and human waste disposal (meters)	Yellow Red	10.00 1.00	300.00 500.00	50.00 20.00	79.00 71.00	89.60 138.53	10 11

Table 5. Median values for the weights of the selected risk factors in different types of emergencies

Risk Factor	F	CHE	C	F	GD	PC	RC	TS	T
No access to clean water	5	5	5	5	5	5	5	5	5
Lack of functioning toilets	4	5	5	5	5	5	5	5	5
Exposure to disease vectors	4.5	5	4	5	5	5	5	5	5
Lack of waste management	4	4	4	4.5	4	5	5	4	4
Lack of health facilities	4.5	5	5	4.5	5	5	5	5	5
Lack of health workers	4	5	5	4	5	5	5	4	4
Insufficient vaccine coverage	4.5	4	4	4	4	4.5	5	4	4
Poor health status	5	5	4.5	4	4	5	4.5	4	4
Extreme poverty	4.5	4	4	4	4	5	4.5	4.5	4
Overcrowding	4	4	4	4	4	4	5	4	4
Lack of medicines	4	5	5	4	5	5	5	4	4
Insufficient nutrient intake	5	4	4	4	4	5	5	3	4
Lack of health education	4	4	4	4	4	4	4	3	4
Inadequate distance between housing and human waste disposal	4	4	4	4	4	5	5	4	4
Ongoing conflict	5	5	5	4	4	5	5	4	4
Population displacement	4.5	4	5	4.5	4	5	5	4.5	4
Lack of organisational and/or political will to address public health problems	5	5	5	5	4	5	5	4	5
Flooding (waste water)	4	4	4	5	4	4.5	4	5	5
Breakdown of government services	5	4	5	4.5	4	5	4.5	4	4
Reluctance to follow disease control procedures	4	4	4	4	4	4	4.5	4	4

Figure 1: Distribution of mean weights in different emergency types

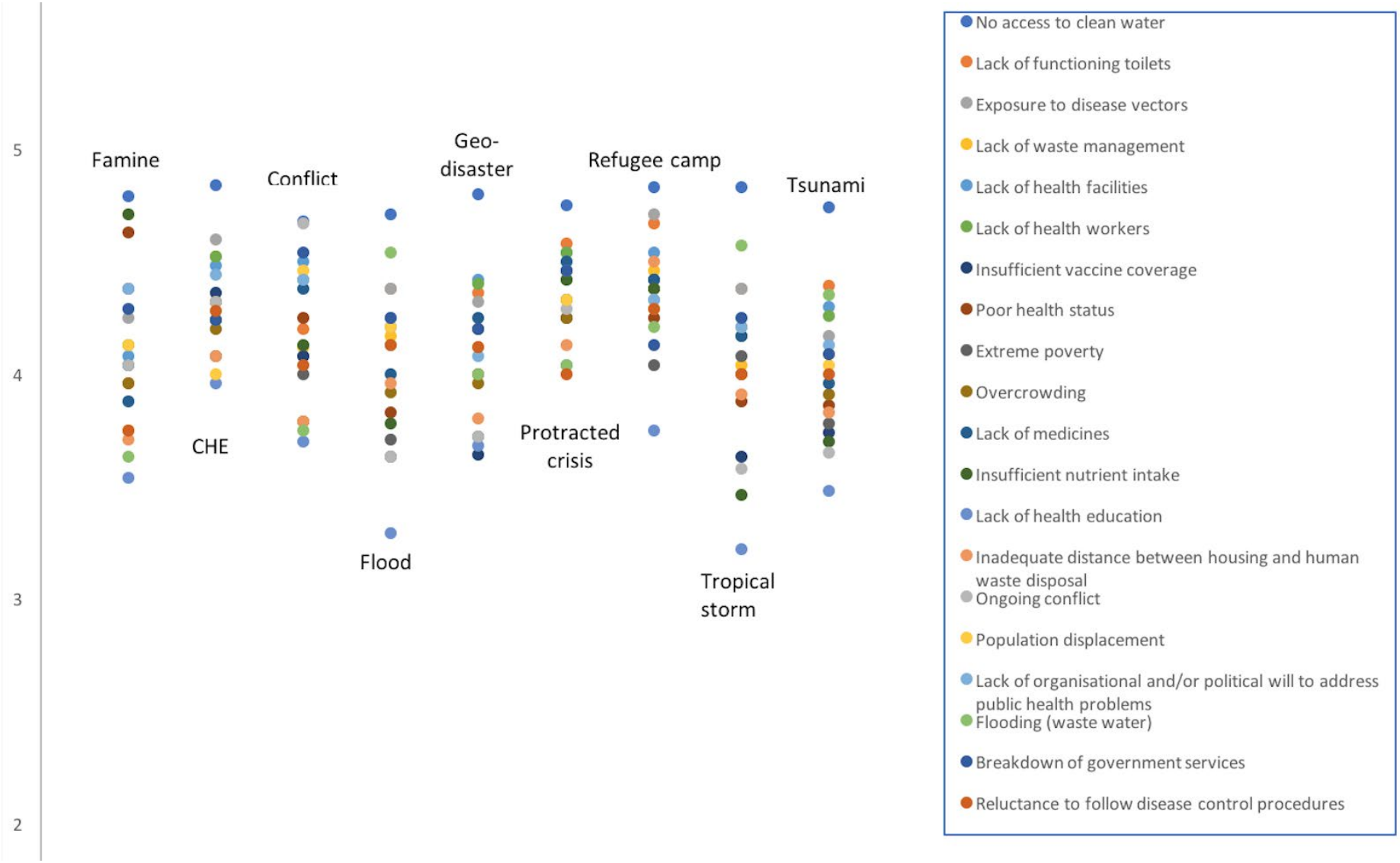

Table 6. Mean values for the weights for the risk factors in different emergency types (standard deviations in brackets).

	F	CHE	C	FL	GD	PC	RC	TS	T
No access to clean water	4.79 (0.41)	4.84 (0.46)	4.68 (0.55)	4.71 (0.54)	4.80 (0.40)	4.75 (0.43)	4.83 (0.47)	4.83 (0.37)	4.74 (0.44)
Lack of functioning toilets	3.96 (1.27)	4.52 (0.90)	4.20 (1.10)	4.38 (1.03)	4.36 (1.02)	4.58 (0.76)	4.67 (0.80)	4.38 (1.03)	4.39 (1.05)
Exposure to disease vectors	4.25 (0.83)	4.60 (0.57)	4.08 (0.89)	4.38 (0.90)	4.32 (0.84)	4.42 (0.76)	4.71 (0.54)	4.38 (1.07)	4.17 (1.20)
Lack of waste management	3.75 (1.33)	4.32 (0.79)	4.12 (1.07)	4.17 (1.07)	4.20 (0.80)	4.46 (0.82)	4.46 (0.87)	4.04 (1.10)	4.09 (0.93)
Lack of health facilities	4.08 (1.11)	4.48 (0.70)	4.50 (0.76)	4.21 (1.00)	4.42 (0.81)	4.54 (0.76)	4.54 (0.71)	4.21 (1.04)	4.30 (0.95)
Lack of health workers	4.13 (1.05)	4.52 (0.70)	4.42 (0.70)	4.13 (1.01)	4.40 (0.75)	4.54 (0.71)	4.38 (0.86)	4.17 (0.99)	4.26 (0.94)
Insufficient vaccine coverage	4.04 (1.24)	4.36 (0.69)	4.08 (0.95)	3.63 (1.15)	3.64 (1.05)	4.25 (0.92)	4.42 (0.86)	3.63 (1.18)	3.74 (1.03)
Poor health status	4.63 (0.56)	4.32 (0.93)	4.25 (0.88)	3.83 (1.25)	4.00 (0.98)	4.46 (0.76)	4.25 (0.92)	3.88 (1.05)	3.86 (1.22)
Extreme poverty	4.38 (0.70)	4.24 (0.81)	4.00 (1.04)	3.71 (1.21)	4.20 (0.89)	4.33 (0.90)	4.04 (1.21)	4.08 (1.15)	3.78 (1.21)
Overcrowding	3.96 (1.21)	4.20 (0.69)	3.79 (1.04)	3.92 (0.95)	3.96 (1.00)	4.25 (0.83)	4.38 (0.81)	4.00 (1.08)	3.91 (0.93)
Lack of medicines	3.88 (1.17)	4.24 (0.86)	4.38 (0.81)	4.00 (1.22)	4.25 (0.88)	4.50 (0.71)	4.42 (0.81)	4.17 (0.94)	3.96 (1.16)
Insufficient nutrient intake	4.71 (0.61)	4.08 (0.93)	4.13 (0.97)	3.78 (1.06)	3.72 (1.08)	4.42 (0.81)	4.38 (0.81)	3.46 (1.08)	3.70 (1.08)
Lack of health education	3.54 (1.22)	3.96 (0.82)	3.70 (1.20)	3.29 (1.14)	3.68 (1.05)	4.04 (0.84)	3.75 (1.09)	3.22 (1.28)	3.48 (1.02)
Inadequate distance between housing and human waste disposal	3.71 (1.24)	4.08 (0.93)	3.79 (1.26)	3.96 (1.14)	3.80 (0.94)	4.13 (1.09)	4.50 (0.87)	3.91 (1.10)	3.83 (1.01)
Ongoing conflict	4.04 (1.31)	4.32 (0.88)	4.67 (0.75)	3.63 (1.41)	3.72 (1.15)	4.29 (1.06)	4.33 (0.94)	3.58 (1.41)	3.65 (1.34)
Population displacement	4.13 (1.13)	4.00 (0.94)	4.46 (0.64)	4.21 (0.96)	4.12 (0.82)	4.33 (0.85)	4.29 (1.10)	4.21 (0.96)	4.04 (1.12)
Lack of organisational and/or political will to address public health problems	4.38 (0.99)	4.44 (0.70)	4.42 (0.76)	4.25 (1.01)	4.08 (0.84)	4.46 (0.71)	4.33 (0.99)	4.21 (0.91)	4.13 (1.15)
Flooding (waste water)	3.63 (1.41)	4.24 (0.76)	3.75 (1.20)	4.54 (0.82)	4.00 (1.06)	4.04 (1.10)	4.21 (0.91)	4.57 (0.71)	4.35 (0.91)
Breakdown of government services	4.29 (1.02)	4.24 (0.65)	4.54 (0.71)	4.25 (0.92)	4.20 (0.75)	4.46 (0.71)	4.13 (1.09)	4.25 (0.83)	4.09 (0.97)
Reluctance to follow disease control procedures	3.75 (1.23)	4.28 (0.78)	4.04 (0.93)	4.13 (0.93)	4.12 (0.86)	4.00 (1.04)	4.29 (0.84)	4.00 (1.04)	4.00 (0.98)

Table 7. Correlation between risk factors (all emergency types combined)

W = Water; T = Toilets; V = Vectors; WM = Waste Management; HF = Health Facilities; HC = Health Care Workers; VA = Vaccinations; HS = Health Status; P = Poverty; O = Overcrowding; M = Medicines; N = Nutrition; HE = Health Education; D = Distance between housing and human waste disposal; C = Conflict; DI = Displacement; W = Will to address problems; F = Flooding (waste water); B = Breakdown of government services; R = Reluctance to follow procedures

PC = Pearson Correlation

		W	T	V	WM	HF	HC	VA	HS	P	O	M	N	HE	D	C	DI	W	F	B	R
W	PC	1	.522**	.350**	.314**	.378**	.306**	.301**	.262**	.280**	.310**	.354**	.337**	.204*	.336**	.309**	.329**	.368**	.363**	.243**	.405**
T	PC	.522**	1	.463**	.692**	.486**	.361**	.357**	.297**	.293**	.554**	.482**	.297**	.388**	.586**	.400**	.406**	.427**	.622**	.367**	.519**
V	PC	.350**	.463**	1	.507**	.547**	.507**	.584**	.420**	.441**	.467**	.509**	.423**	.337**	.415**	.469**	.474**	.432**	.374**	.401**	.592**
WM	PC	.314**	.692**	.507**	1	.566**	.447**	.384**	.313**	.311**	.539**	.632**	.260**	.523**	.623**	.359**	.445**	.485**	.495**	.467**	.490**
HF	PC	.378**	.486**	.547**	.566**	1	.874**	.540**	.453**	.397**	.492**	.796**	.432**	.485**	.531**	.545**	.500**	.562**	.394**	.522**	.549**
HC	PC	.306**	.361**	.507**	.447**	.874**	1	.539**	.508**	.513**	.484**	.737**	.452**	.482**	.467**	.560**	.531**	.612**	.289**	.605**	.525**
VA	PC	.301**	.357**	.584**	.384**	.540**	.539**	1	.611**	.570**	.422**	.547**	.525**	.555**	.376**	.565**	.519**	.503**	.246**	.423**	.628**
HS	PC	.262**	.297**	.420**	.313**	.453**	.508**	.611**	1	.796**	.544**	.504**	.744**	.530**	.301**	.559**	.476**	.453**	.193**	.418**	.441**
P	PC	.280**	.293**	.441**	.311**	.397**	.513**	.570**	.796**	1	.644**	.449**	.633**	.479**	.312**	.593**	.592**	.539**	.244**	.553**	.478**
O	PC	.310**	.554**	.467**	.539**	.492**	.484**	.422**	.544**	.644**	1	.511**	.503**	.517**	.426**	.503**	.524**	.549**	.368**	.485**	.475**
M	PC	.354**	.482**	.509**	.632**	.796**	.737**	.547**	.504**	.449**	.511**	1	.485**	.619**	.584**	.551**	.542**	.642**	.450**	.583**	.589**
N	PC	.337**	.297**	.423**	.260**	.432**	.452**	.525**	.744**	.633**	.503**	.485**	1	.473**	.399**	.526**	.388**	.411**	.192*	.335**	.408**
HE	PC	.204*	.388**	.337**	.523**	.485**	.482**	.555**	.530**	.479**	.517**	.619**	.473**	1	.428**	.484**	.406**	.463**	.290**	.389**	.503**
D	PC	.336**	.586**	.415**	.623**	.531**	.467**	.376**	.301**	.312**	.426**	.584**	.399**	.428**	1	.438**	.352**	.370**	.629**	.365**	.620**
C	PC	.309**	.400**	.469**	.359**	.545**	.560**	.565**	.559**	.593**	.503**	.551**	.526**	.484**	.438**	1	.610**	.572**	.271**	.509**	.528**
DI	PC	.329**	.406**	.474**	.445**	.500**	.531**	.519**	.476**	.592**	.524**	.542**	.388**	.406**	.352**	.610**	1	.642**	.417**	.598**	.531**
W	PC	.368**	.427**	.432**	.485**	.562**	.612**	.503**	.453**	.539**	.549**	.642**	.411**	.463**	.370**	.572**	.642**	1	.368**	.828**	.558**
F	PC	.363**	.622**	.374**	.495**	.394**	.289**	.246**	.193**	.244**	.368**	.450**	.192*	.290**	.629**	.271**	.417**	.368**	1	.340**	.547**
B	PC	.243**	.367**	.401**	.467**	.522**	.605**	.423**	.418**	.553**	.485**	.583**	.335**	.389**	.365**	.509**	.598**	.828**	.340**	1	.464**
R	PC	.405**	.519**	.592**	.490**	.549**	.525**	.628**	.441**	.478**	.475**	.589**	.408**	.503**	.620**	.528**	.531**	.558**	.547**	.464**	1

*. Correlation is significant at the 0.01 level (2-tailed) **. Correlation is significant at the 0.001 level (2-tailed)

Discussion

The results from the first questionnaire, regarding the selection of risk factors, confirm that, as suggested in the wider literature, WASH (39-42), health care (36, 43), nutrition (1, 36, 37) and emergency specific risk factors such as poverty (44-46), displacement and overcrowding (1, 24, 28, 47), and (ongoing) armed conflict or war (48) are among the primary factors influencing communicable disease outbreaks in humanitarian emergencies and disasters. These results are further confirmed by the outcomes of the third questionnaire which indicates the high importance of the selected risk factors across all types of humanitarian emergencies. While some of the risk factors identified in this research were – deliberately – broad, additional discussion with humanitarian aid providers (which were not strictly speaking part of this research) revealed some of the most common interpretations of these risk factors and showed that, while encompassing a range of issues, they were interpreted similarly by all people we spoke to. For example, 'breakdown of government services' was generally interpreted as encompassing wider infrastructure issues such as transportation and roads, telecommunications, safety and security, and sometimes education. Many of these have complex interaction pathways (23).

For some of the risk factors, responses included seemingly extreme values. Due to this we suggest, for any use of the data, to rely on median values rather than means to make sure that extremes have little effect. However, we are not confident enough that they are simply mistakes to omit them from the analysis. Extremes of 1 or 0 could also mean that the responder didn't think this was a relevant factor. We cannot know why such a value was selected. If such values had been mentioned in interviews, it would have been highly interesting to know if this was a mistake or an intentional way to signify that a risk factor or threshold would – in the responder's opinion – not have a significant effect on communicable disease outbreak risk.

While we focused on the 20 most critical risk factors, this does not mean that other factors are not important when assessing the risk of communicable disease outbreaks in such situations. However, our aim was to establish which factors need to be priority concerns. We were interested in identifying quantitative thresholds for the risk factors that could support quick assessment using minimal resources and man-power by not requiring professional judgements. The argument could be raised that thresholds for many of these factors can be as easily obtained from the Sphere standards (49). However, the thresholds listed in the Sphere standards have important limitations if used for the purpose of assessing the risk of communicable disease outbreaks in humanitarian emergencies. The Sphere standards were developed to assess the adequacy of overall humanitarian response and provide general minimum standards. Thus, the Sphere standards are neither intended as risk assessment nor are they specific to communicable diseases. Secondly, the Sphere standards have a normative component, as they indicate standards that should be reach based on ethical considerations rather than those that empirically relate to changes in the level of risk experience. While this makes the Sphere standards an unsuitable comparison, it might be interesting to see how this difference in approach shapes the suggested thresholds. Sphere standards indicate a minimum of 15 litres of water per person per day. (49) Our survey found a yellow threshold for clean water availability at 6.5 litres per person per day. This difference is explained by the fact that the thresholds we sought to identify are only thresholds for increases in disease outbreak risk. A yellow threshold for clean water at 6.5 litres per person per day does not suggest that a person does not need more that 6.5 litres of water per day but rather that below that the risk for a communicable disease outbreak critically increases. Additionally, some of the risk factors and especially their measurements are simply proxies. This becomes clear when looking at vaccination coverage. The selected vaccines are not meant to be the main, the only, or even vaccination priorities at all in all emergencies but rather they are used as proxies to estimate the reach of vaccination programmes.

Keeping this in mind, the measures and risk factors identified are entirely unsuitable to base humanitarian programming upon. This should follow a suitable method for needs assessment – which obviously communicable disease outbreak risk assessment, which the factors suggested here are meant for, is not – and an estimation of minimum standards based on internationally accepted levels such as the Sphere standards.

In contrast, the thresholds identified by our surveys indicate precise and transferable tipping points for levels of risk. They are the first step towards developing a rapid risk assessment mechanism for communicable disease outbreaks in humanitarian emergencies that, rather than asking the person or persons completing it for qualitative and personal assessments of the severity without any indicators what this should be based on, uses pre-defined thresholds and risk levels against which a situation can be judged. Hence our thresholds are hopefully useful in real world risk assessment, because they identify specific risk thresholds using simple quantitative indicators.

Limitations

While we made every attempt to maximise participation, the main limitation of this work is the small number of respondents. However, it can be argued that the field of experts suitable for participation is not large. Our expert opinions are in line with assessments in scientific literature of the relative importance of different risk factors. Expert elicitations have their limits and are subject to biases (50, 51). Overconfidence in the results of expert

elicitations should be avoided (51). Hence, we do not recommend accepting the results without further inquiry, even if they are mostly in line with the literature.

Additionally, the above-mentioned lack of specification and possibly blurred and broad definitions of some of the risk factors is a potential limitation. That would certainly be the case if the results from this research would be used uncritically to make decisions in the field, even if they were used just for risk assessment without further additional investigation. However, considering that we do not recommend using these results beyond the realm of risk assessment and that for risk assessment we considered this research to be a first stage within a larger research project, the results form a good starting point to understand expert opinion on some of the most critical risk factors for communicable disease outbreaks in humanitarian emergencies.

Conclusion

Communicable disease outbreaks remain a significant concern in the aftermath of emergencies and disasters, especially in low- and middle-income countries. Broadly, expert consensus seems to be that WASH, access to healthcare, nutrition and wider societal and emergency specific factors are among the most important indicators and risk factors for communicable disease outbreaks in such situations. These factors remain important across different types of humanitarian emergencies. Beyond establishing current expert opinion, this research also serves as a starting point to assess and improve risk assessment tools, methods and protocols for communicable disease risks in humanitarian emergencies and disasters. Current risk assessment tools, such as the WHO tool used in the context of the EWARN system (52, 53), also use individual risk factors. However, there is a strong need to make risk assessments clearer and more explicit by using, where possible, previously determined risk factor thresholds that can be assessed without expert knowledge in each domain. Ideally, this risk summary would be based on an independent needs assessment and require minimal additional primary data collection in the field. The expert consultation described in this article, combined with a systematic review performed in parallel (23) and additional research by the research team, seeks to be the basis for such a pragmatic, easy-to-use and novel risk assessment tool. No system captures the complexity and diversity of humanitarian emergency settings perfectly and even accepted international standard such as Sphere are under constant revision and do not cover all aspects of humanitarian response. However, such a risk assessment tool can be seen as an attempt to capture some of the main risk factors for communicable disease outbreaks in such settings, especially as it does not assume considerable expert knowledge from the person or persons using it, like the WHO's risk assessment tool for communicable diseases in humanitarian emergencies does (52, 53).

Ethical approval

The research study has been approved under the regulations of the University of East Anglia's Faculty of Health and Medicine Ethics Committee.

Competing Interest statement

The authors declare no competing interests.

Author's contributions

All researchers helped design the study and provided input for the surveys. CH designed the tool with support from JB. Analysis was done by CH under supervision from PH and with input from JB. All authors approved the final analysis and manuscript.

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RESEARCH ARTICLES

Rapid risk assessment for communicable diseases in humanitarian emergencies: validation of a rapid risk assessment tool for communicable disease risk in humanitarian emergencies

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Abstract

Background: Communicable diseases pose a significant risk in humanitarian emergencies. This paper reports on the development and validation of a rapid risk assessment tool for communicable diseases in humanitarian emergencies.

Methods: We developed a tool assessing the 20 most critical risk factors for disease outbreaks in humanitarian emergencies. This paper reports on the development and validation of the tool consisting of face and content validation with key informant interviews (n=25) and a reliability validation (inter-rater reliability test) with groups of volunteer aid workers (n=4 groups).

Findings: Face and content validation confirmed the importance of rapid risk assessment methods and the suitability and usefulness of the developed tool. Participants without prior health protection experience were able fill in the tool with an accuracy of 81·25% (SD 4.08) across both scenarios (82·35% and 80·15% for scenarios 1 and 2 respectively). Errors primarily occurred when judging the severity of risk factors that could not be captured quantitatively. Revisions of the tool have been made based on the validation process.

Conclusion: The tool was successfully validated for the use in different humanitarian emergency settings and is suitable for users with and without experience in health protection.

Keywords: communicable diseases, disasters, epidemiology, health protection, humanitarian emergencies, risk assessment

Introduction

Humanitarian emergencies pose a significant risk to human health. Communicable diseases are one of the primary health concerns in humanitarian emergencies (1-18). The outbreaks of diphtheria and measles among the Rohingya refugees are striking examples of this (19-22).

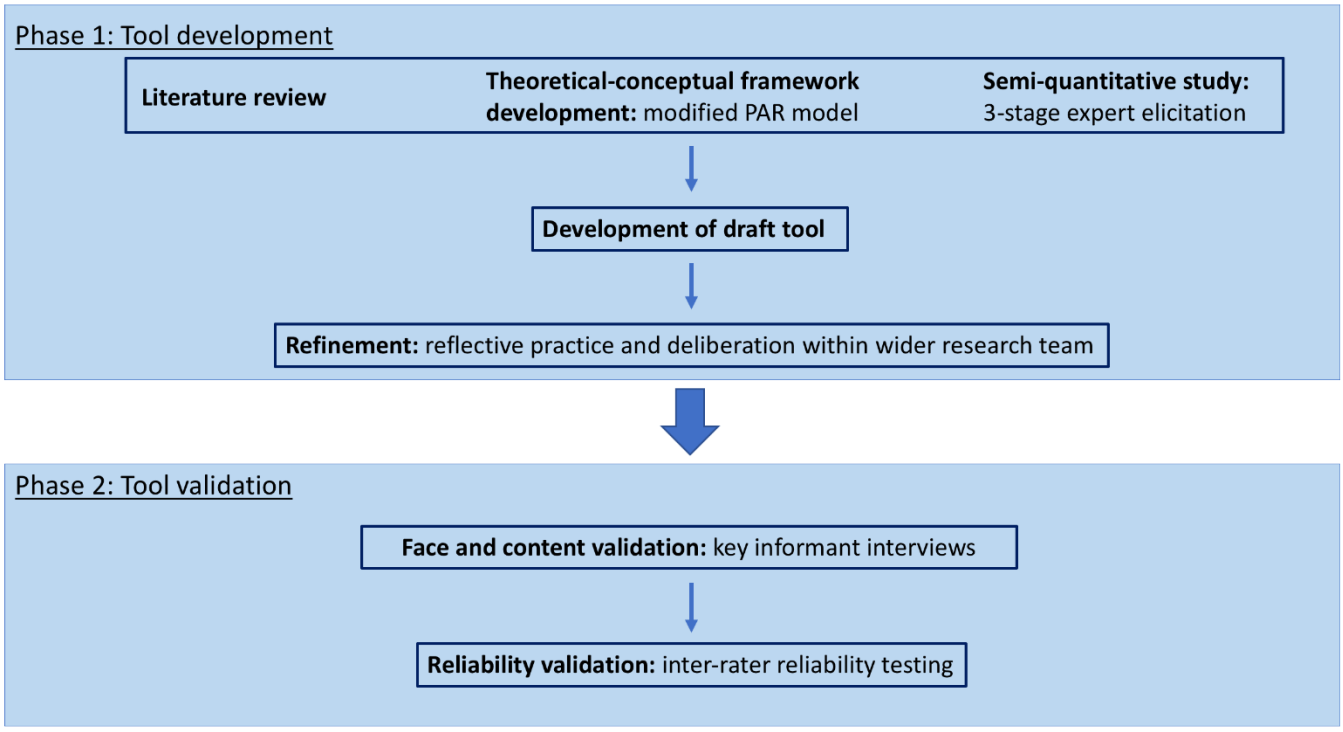
Early identification of at-risk populations is an important step towards not only a better response but also preparedness and prevention of outbreaks, or at least more serious outbreaks. Rapid risk assessment is therefore a priority research area. The aim of this study was to develop and validate an easy-to-use rapid risk assessment tool for communicable diseases in humanitarian emergencies. The tool was designed as part of a larger project to understand vulnerabilities towards communicable disease outbreaks in humanitarian emergencies other than a disease outbreak. The tool development draws on the existing literature on outbreaks in humanitarian crises, a systematic review of the literature on communicable disease risk factors in complex humanitarian emergencies (23), theoretical-conceptual framework development (24), expert elicitation (25) and the validation phase. The results were used to develop a rapid risk assessment tool for communicable diseases in humanitarian emergencies. An early draft was further refined after reflective practice and deliberations with the research team prior to the validation and testing process described in this paper (see Figure 1). The tool captures data on the 20 most critical risk factors that indicate a heightened risk for communicable disease outbreaks in humanitarian emergencies, which fall into three categories: water, sanitation and hygiene (WASH), health and socio-political. Table 1 gives an overview of the risk factors and their sub-factors. Table 2 gives definitions of the main elements of the tool. The tool is accompanied by a guide. The tool presents the results of the risk assessment both numerically – in the form of weighted risk scores – and visually – using a traffic light system. Ideally, the risk assessment should be completed immediately following the onset of an emergency or the set-up of a response operation, within the first 72

hours to 14 days. Subsequent iterations of the assessment should be repeated at regular intervals throughout the response and recovery phases.

The tool differs considerably from previous tools such as the risk assessment matrix described as part of the World Health Organization's (WHO) early warning system (EWARN) (26, 27). Our tool does not draw on a qualitative assessment of the riskiness of the individual factors with regard to outbreak risk nor does it provide an overall risk assessment of that, meaning that users are asked to answer questions such as, 'how many liters of clean water are available per person per day?' and the tool calculates what the answer means in terms of outbreak risk. Thus, this tool enables responders with little or no health protection experience to input secondary or primary data and obtain an evidence-based and objective assessment based on that data. Subjectivity is thereby eliminated from the risk assessment process and the only level of subjectivity remains in the data collection and evaluation thereof, not in the assessment of the consequences of the factors for outbreak risk. This should also reduce the cognitive bias often inherent in risk assessment processes. As such, this tool serves a different purpose than the WHO EWARN risk assessment matrix. For organisations not involved in health protection, the overall weighted risk score can be used to support their overall risk assessment. For organisations involved in health protection or coordination, the individual weighted risk scores can be used to prioritise response, as can the overall weighted risk score if the tool is done for multiple spatial units (e.g. sections of a refugee camp). Overall, the tool can be useful for smaller organisations that do not have extensive health protection portfolios, as well as as a companion for existing well-established mechanisms, such as WHO EWARN or similar mechanisms.

The aim of the research described in this paper – the validation phase – was to test the validity of the content of the tool and its reliability. This was done in a structured process with tiered changes to the tool based on the results of previous work.

Figure 1. Tool development process



Methods

The first part of this study was performed remotely with experts from the fields of humanitarian aid and health protection and the second part of the study was performed in the field with volunteer aid workers. The tool that was tested was in English. The aims of this research were to determine the validity of the content of the tool and its inter-rater reliability when used by aid workers with no or limited expertise in health protection. We used mixed methods to ensure robust testing and optimal fulfilment of the aims.

Study site, partners and participants

Validity testing was done with key-informant interviews. This was done remotely to include a wide variety of participants from different backgrounds and geographic locations, including persons currently deployed in the field. The reliability testing was done in August 2018 in Thessaloniki, Northern Greece. Thessaloniki remains a hotspot for the response efforts to the European migration crisis and hosts many of the smaller and volunteer-based organisations. We partnered with the InterEuropean

Human Aid Association (IHA). IHA started as an entirely volunteer-based organisation in 2015 and has since developed professional recognition. The organisation works with Greek and international partners and provides services to refugees in camps in Northern Greece. However, the reliability testing was not done specifically in the context of the migration crisis as the response effort in Greece is considerably different from other humanitarian emergencies. Rather, volunteers from IHA were involved to test whether the tool was reliable for volunteers with a background in humanitarian aid but not necessarily in medicine or health protection.

Table 1. Risk factors and sub-factors (items) in tool.

Category	Risk Factors	Sub-factor
WASH	Lack of clean water	Not applicable
WASH	Lack of toilets	Not applicable
WASH	Inadequate distance between housing and human waste disposal	Average distance between housing and human waste disposal
		Shortest distance between housing and human waste disposal
WASH	Flooding (waste water)	Not applicable
WASH	Lack of waste management	Not applicable
WASH	Exposure to disease vectors	Not applicable
Health	Lack of health facilities	Access to health facilities
		Availability of clinics and/or health posts (or other primary care facilities)
		Disease surveillance
		Hospital beds
Health	Lack of health workers	Doctors
		Nurses
		Community health care workers
Health	Insufficient vaccine coverage	Measles
		Meningococcal disease
		Polio
		Hepatitis B
Health	Poor health status of the population	Not applicable
Health	Lack of medicines	Not applicable
Health	Reluctance to follow disease prevention measures	Local health professionals
		General population
Health	Insufficient nutrient intake	Not applicable
Health	Lack of health and hygiene education	Not applicable
Socio-political	Extreme poverty and food insecurity	Not applicable
Socio-political	Overcrowding	Not applicable
Socio-political	Ongoing conflict	Not applicable
Socio-political	Population displacement	Not applicable
Socio-political	Lack of organisational and political will to address public health issues	(I)NGOs and donors
		Local and national government
Socio-political	Breakdown of government and infrastructure services	Transport
		Communications
		Education
		Electricity

Table 2. Main elements of the rapid risk assessment tool (for more detailed descriptions refer to the tool guide in the supplemental files).

Element	Description
Category	Category describes the sphere of the risk factor in question.
Risk Factor	The risk factor is the factor being measured; it can have multiple sub-factors.
Measure	The measure defines how this risk factor is measured. Measures can be quantitative or qualitative.
Answer	The answer is the observed situation, measured either quantitatively or via a selection of options for qualitative factors.
Score (0-2)	The score is the quantification and standardisation of the answer (with pre-defined categories for scores of 0; 1; and 2)
Weight in this type of emergency (0-4)	The weight is pre-determined by the selection of the emergency type.
Weighted Risk Score (0-8)	The weighted risk score is derived from the score reached and the weight of the risk factor in the emergency type (multiplicatory).
Overall weighted risk score (0-8)	The overall weighted risk score combines the weighted risk scores for all included risk factors. It works on the same scale as the weighted risk scores.

Study population

For the first part of the study, we invited participants with backgrounds in humanitarian medicine, health protection, disaster and humanitarian studies, and humanitarian aid. We interviewed 25 people. We did not determine the study size a priori as we agree with Sim et al. (28) that a priori determination of the sample size for qualitative key-informant interviews is wrought with problematic issues due to the underlying "questionable philosophical and/or methodological assumptions". We reached saturation after 20 interviews and conducted another five interviews to confirm. We interviewed 17 people with a health background, five academics and three humanitarian generalists (these represent the primary backgrounds of the participants, several participants fell into multiple groups). Specific practitioner backgrounds included expertise in water, sanitation and hygiene, epidemiology, microbiology, health protection, logistics, clinical medicine and nursing. Apart from academics from institutions in Europe and North America, we interviewed participants from Public Health England, the WHO, Doctors Without Borders, the UK Public Health Rapid Support Team, the United Nations Relief and Works Agency in Jordan and several other organisations. Participants were from Europe, Asia, Africa and North America.

For the reliability testing we invited volunteers from IHA and partner organisations to take part. We conducted adapted focus groups with four groups of two participants each. Participants were from various countries in Europe and all had a background in humanitarian aid, specifically in response in formal and informal refugee camps with varying experience. Participants had no prior training in health protection, epidemiology or risk assessment.

Validity testing

Validity testing covered both content validity testing, defined as the usefulness, appropriateness, relevance and suitability of the tool (29), as well as face validity, defined by the level to which the tool actually measures communicable disease risk and hence a measure of accuracy (30). Participants were given access to the tool. They were asked to comment on the design of the tool, specifically the layout and ease of use, the order and inclusion of risk factors, and the amount of information (i.e. the length of the tool). Additionally, risk factors and their measurements were discussed individually regarding their suitability. The interview concluded with a discussion of the colour-coding system and the interpretation of the results given by the tool. The interviews used a mix of open-ended introductory questions and more detailed further queries. If the participants desired, they were provided with details on the development of the tool and the data sources used. Interviews were performed using an open-ended interview guide and responses were recorded on standardised response sheets. Response sheets were reviewed after each interview and key themes and repeated suggestions for improvement were recorded on a running document.

Reliability testing

The tool was designed so that aid workers with little or no experience in health protection would be able to consistently fill in the tool with the right information. This was assessed by a reliability testing with two fictitious scenarios (31). Participants filled in the tool for both scenarios – one a displacement crisis set in a refugee camp and the other a response to an earthquake. They had access to the tool, the tool guide and a scenario description. The tool was completed in pairs and inter-rater reliability testing was done based on the filled-in tool documents provided by the participants. Scenarios were modelled after real emergencies (mainly by combining aspects of different past emergencies) and authentically reflected situations with incomplete information. Scenarios were provided in written form. There was no time limit for participants to complete the tool but times to completion were recorded for each group and scenario. Analysis was done against an answer sheet and agreement with the answer sheet was recorded for the overall weighted risk score as well as line-by-line

for each individual risk factor and sub-factor. Accuracy was determined as inter-rater reliability when tested against the answer sheet. Any answer that was not in line with the answer sheet was considered a mistake, even if it consisted of a blank. We recognise that there are some answers that could be contested, hence our aim was for 70% agreement with the answer sheet and not higher. Potentially contestable answers were those that required a qualitative judgement of the situation. After completion of the two scenarios, all groups came together as one focus group to discuss the ease of use of the tool. Results of this discussion were recorded in the form of field notes and considered in the final changes made to the tool.

Changes to the tool were made after each phase of the testing. After analysis of the reliability testing, the tool was finalised and is included as Supplementary Files 1 (digital) and 2 (print). The guide is available as Supplementary File 3. The two scenarios are available as Supplementary Files 4 and 5.

Results

Validity testing

Participants generally found the tool useful, comprehensible and accurate (24/25). Positive feedback was given for the inclusion of both a print and a digital version of the tool. Those who suggested the inclusion of other risk factors agreed that the 20 included were suitable after discussion of the data sources and evidence upon which the design of the tool was based. Suggestions for changes made by the participants included issues regarding the layout and design of the tool, the measurement of qualitative risk factors and the breakdown of risk factors into sub-factors. Changes were incorporated in subsequent iterations of the tool.

Specific changes were made based on the face and content validation. The risk factor 'health facilities', which initially only included hospital beds, was extended to include primary care facilities, access to health care and disease surveillance. For several risk factors, responses were broken down by groups. For example, 'lack of political and organisational will to address public health issues', was split into the groups 'local and national government' and 'non-governmental organisations and donors'. A risk factor concerning government services was clarified into government and infrastructure services and broken down into roads/transport, communications, electricity and education. Minor changes were made to the wording of some risk factors. Additionally, for the digital version, a tab with a mock filled-in version was added to give users a visual example and risk factors were sorted into clusters based on suggestions from participants. Participants also provided detailed input into issues to be included in the accompanying guide, including the use of a smaller spatial scale where possible and the need to re-do the assessment if significant changes to the situation have occurred.

Reliability testing

Inter-rater reliability testing was done based on the completed tools provided by all groups for both scenarios (n=8). The time that the participants needed to complete the tool decreased with the second scenario, with the average time for completion being 33 minutes and 1 second for scenario 1 and 13 minutes and 15 seconds for scenario 2 (see Table 3). This leads to the assumption that the tool is easier to use once participants have some experience with it. Discussions with the participants confirmed this assumption.

The aim of the analysis of the completed tools was to test whether participants with little or no experience with health protection could fill in the tool and reach accuracy levels of 70% or greater. Participants without prior health protection experience were able to fill in the tool with an accuracy of 81.25% (SD 4·08) across both scenarios (82.35% and 80.15% for scenarios 1 and 2 respectively). Answers that required a qualitative judgement of the situation were the most likely to be answered wrongly.

Table 3. Completion time for both scenarios.

Group	Scenario 1	Scenario 2
1	39 min 14 sec	14 min 48 sec
2	38 min 20 sec	12 min 51 sec
3	27 min 15 sec	12 min 30 sec
4	27 min 15 sec	15 min 11 sec
Average	33 min 01 sec	13 min 50 sec

Scenario 1 (see Table 4)

For 50% of the items, 100% of the groups gave the correct answers. For 11 items (out of 34 items in total) three groups gave the correct answer (75%). The final six items were correctly completed by less than three groups (50% or lower). Quantitative items were generally more likely to have been identified correctly (8 completely correct answers out of 14 quantitative items versus 11 completely correct answers out of 20 qualitative items).

Scenario 2 (see Table 5)

58.82% of items were correctly answered by 100% of participants. 17.65% were correctly answered by three groups. Half the groups or less answered the remaining 23.53% (eight items) correctly. As in scenario 1, quantitative items were more likely to be answered correctly (92.86% of quantitative items answered correctly by all groups versus 35% of qualitative items answered correctly by all groups).

Additional to the line-by-line and group-by-group analysis, the overall risk scores were compared with the overall risk score ascertained with the answer sheets (see Table 6).

Table 4. Item and group validation for scenario 1 (line-by-line and group-by-group comparison of the answers of all four groups for scenario one in comparison with the answer sheet); for each item a score of 0, 1 or 2 may be given, N/A refers to items with no score assigned (i.e. not answered) by the respective group.

Risk Factor	Type	Answer Sheet (score)	Group 1 (score)	Group 2 (score)	Group 3 (score)	Group 4 (score)	Number correct	% Correct
1	quant	0	0	0	0	0	4	100
2	quant	2	2	2	2	2	4	100
3a	quant	1	1	1	N/A	1	3	75
3b	quant	1	1	1	1	1	4	100
4	qual	0	0	0	0	0	4	100
5	qual	1	1	1	1	1	4	100
6	qual	1	2	1	1	1	3	75
7a	qual	0	2	1	1	0	1	25
7b	qual	0	2	0	1	0	2	50
7c	qual	N/A	N/A	N/A	1	1	2	50
7d	quant	1	1	1	1	2	3	75
8a	quant	0	0	0	0	1	3	75
8b	quant	0	0	0	0	2	3	75
8c	quant	1	1	1	1	2	3	75
9a	quant	0	0	0	0	0	4	100
9b	quant	N/A	N/A	N/A	N/A	N/A	4	100
9c	quant	N/A	N/A	N/A	N/A	N/A	4	100
9d	quant	N/A	N/A	N/A	N/A	N/A	4	100
10	qual	1	1	1	N/A	1	3	75
11	qual	1	1	1	1	1	4	100
12a	qual	N/A	N/A	N/A	N/A	N/A	4	100
12b	qual	N/A	N/A	N/A	N/A	N/A	4	100
13	qual	0	0	0	0	0	4	100
14	qual	0	2	N/A	1	1	0	0
15	quant	N/A	N/A	N/A	N/A	N/A	4	100
16	quant	0	0	1	0	0	3	75
17	qual	1	1	1	1	1	4	100
18	qual	2	2	N/A	N/A	2	2	50
19a	qual	1	1	0	1	1	3	75
19b	qual	1	1	0	0	0	3	75
20a	qual	0	0	0	0	0	4	100
20b	qual	1	1	1	2	1	3	75
20c	qual	N/A	N/A	N/A	N/A	N/A	4	100
20d	qual	1	1	1	1	1	4	100
Correct		34	29	29	26	28		
% Correct		100	85.29	85.29	76.47	82.35		82.35

Table 5. Item and group validation for scenario 2 (line-by-line and group-by-group comparison of the answers of all four groups for scenario two in comparison with the answer sheet); for each item a score of 0, 1 or 2 may be given, N/A refers to items with no score assigned (i.e. not answered) by the respective group.

Risk Factor	Type	Answer Sheet (score)	Group 1 (score)	Group 2 (score)	Group 3 (score)	Group 4 (score)	Number correct	% Correct
1	quant	1	1	1	1	1	4	100
2	quant	2	2	2	2	2	4	100
3a	quant	N/A	N/A	N/A	N/A	N/A	4	100
3b	quant	N/A	N/A	N/A	N/A	N/A	4	100
4	qual	N/A	N/A	N/A	N/A	N/A	4	100
5	qual	2	2	2	N/A	2	3	75
6	qual	N/A	N/A	N/A	N/A	N/A	4	100
7a	qual	2	2	1	2	1	2	50
7b	qual	N/A	N/A	2	2	1	1	25
7c	qual	2	2	N/A	2	2	3	75
7d	quant	2	2	2	2	2	4	100
8a	quant	2	2	2	2	2	4	100
8b	quant	2	2	2	2	2	4	100
8c	quant	N/A	N/A	N/A	N/A	N/A	4	100
9a	quant	0	0	0	0	0	4	100
9b	quant	N/A	N/A	N/A	N/A	N/A	4	100
9c	quant	0	0	0	0	0	4	100
9d	quant	N/A	N/A	N/A	N/A	N/A	4	100
10	qual	0	0	0	2	1	2	50
11	qual	N/A	N/A	2	2	1	1	25
12a	qual	N/A	N/A	N/A	N/A	N/A	4	100
12b	qual	N/A	N/A	N/A	N/A	N/A	4	100
13	qual	N/A	N/A	N/A	2	N/A	3	75
14	qual	2	N/A	0	2	N/A	1	25
15	quant	2	N/A	N/A	2	N/A	1	25
16	quant	N/A	N/A	N/A	N/A	N/A	4	100
17	qual	0	N/A	0	2	N/A	1	25
18	qual	N/A	N/A	N/A	N/A	2	3	75
19a	qual	N/A	N/A	N/A	N/A	N/A	4	100
19b	qual	N/A	N/A	N/A	N/A	N/A	4	100
20a	qual	2	2	2	2	2	4	100
20b	qual	2	2	N/A	2	2	3	75
20c	qual	0	0	2	0	N/A	2	50
20d	qual	2	2	N/A	2	2	3	75
Correct		34	31	25	28	25		
% Correct		100	91.18	73.53	82.35	73.53		80.15

Table 6. Overall weighted risk scores for all groups compared against answer sheet

Group	Scenario 1	Scenario 2
1	3.67	5.00
2	2.75	4.36
3	2.69	6.00
4	3.50	5.30
Mean	3.14	5.19
SD	0.44	0.59
Answer Sheet	2.89	4.73

Discussion

This study successfully validated a newly developed tool to rapidly assess communicable disease risks in humanitarian emergencies. The results of the validity and reliability testing suggest that the tool is useful and appropriate for aid workers with and without training in health protection to rapidly assess the risk that communicable diseases pose in the context of their field deployment. While reliability testing was done in Greece, no part of the study was specific to one singular context and the tool is suitable for all types of humanitarian emergencies that are not caused by the outbreak of a communicable disease. This tool can be used in the following settings: conflicts and war zones, floods, tropical storms and other hydro-metrological disasters, geo-disasters such as earthquakes, complex emergencies, famines, tsunamis, protracted crises and displacement crises with displacement into refugee and similar camps.

The participants' feedback on the tool was positive and reflected both face and content validity. They determined the tool easy to use and remarked that for those risk factors that are not quantitative, an element of subjectivity remains, but that this is limited with the detailed descriptions in the tool guide. Based on the feedback from the participants the tool was modified.

This tool can only be as reliable as the data that is used to fill it in. If data is missing the tool can be used with an incomplete data set; however, that can potentially lead to an inaccurate representation of the actual risk. Alternatively, additional data can be collected on the missing factors and sub-factors. While the tool is mainly designed to draw on already existing data, a suitable method for additional data collection would be cross-sectional surveys with random or cluster random sampling.

The results from the evaluation of the completed tools for the two scenarios show that aid workers with little or no experience in health protection, risk assessment or epidemiology can successfully and adequately use this tool to assess the risk of a communicable disease outbreak in different types of emergencies. We agreed prior to field validation that a reliability of 70% or greater was considered suitable for considering the tool reliable in the field, especially if the main source of error was to be qualitative assessments. We acknowledge that some of the qualitative items are open for debate and as such the answer sheet is not as directive for them as it is for the quantitative items. Hence, we consider these results to show the adequateness of the tool.

While the overall weighted risk scores that the participants calculated were higher than those from the answer sheet, they were close enough to consider the tool adequate. In relation to the overall weighted risk scores, we considered adequateness to be achieved if the overall weighted risk score of the answer sheet lay within one standard deviation of the mean overall weighted risk score achieved by the participants. This was the case for both scenarios (see Table 6). Additionally, the scores achieved by the participants were generally higher than the overall weighted risk score assumed based on the answer sheet and, as we consider erring on the side of caution to be advisable, any discrepancies between the answer sheet and the participants' answers are particularly unproblematic is in this context.

Based on the reduction in time for completion from scenario 1 to scenario 2, we assume that repeatedly working with the tool will increase the ease of use and the time needed to complete it. Familiarity with the tool does not seem to increase the accuracy. However, we assume that two scenarios are too few to make any substantial comments on the likelihood that repeated use of the tool makes an individual or group more accurate when using it.

Limitations

There are several limitations to this study, as well as to the tool itself. The tool is only suitable for certain emergency types. Due to the conceptual basis of the tool, it is not suitable for any emergency in which an outbreak of an infectious disease constitutes the humanitarian emergency, such as the 2014 West Africa Ebola outbreak. Additionally, the tool does not have a specific emergency type for entrapment crises or displacement crises where most of the displaced population(s) is displaced into urban and non-camp settings. Should such emergencies occur in a situation where one of the other emergency types – most likely conflict – also apply, this is the emergency type that is the most suitable, which will be the case for most if not all entrapment crises. However, should urban/non-camp displacement be too far removed from the original cause of the displacement, this tool is not suitable. The decision to not include such situations was made based on the comparably limited evidence base for such situations and the authors call for more primary research into health needs and communicable diseases in both entrapment crises and displacements into urban/non-camp settings.

As this tool focuses on the 20 most critical risk factors for communicable disease outbreaks in humanitarian emergencies, we expect that some users will feel that important issues are missing. Risk factors

were selected based solely on their ability to be a reliable indicator of risk and not on any other considerations. Issues like sexual and reproductive health, as well as the protection of vulnerable groups, are extremely important in humanitarian emergencies. They are not included in this tool because they are not among the best indicators of disease outbreak risk – not because they are not important.

The scores calculated by the tool will be less reliable in situations of considerable inequity. In such situations, smaller spatial units should be used. If measures are not distributed equitably, their reliability and the reliability of the overall score is questionable.

While the study included systematic validity and reliability testing, the results and hence the suitability and value-added of the tool will only be entirely clear after the tool has been used in the field for a longer time and in multiple occasions. Such a test was not within the scope of this study. We hope that over the next months and years, organisations and individuals involved in the response to humanitarian emergencies will make use of the tool either on its own or alongside other risk assessment procedures and we would welcome any feedback any organisations using the tool would be willing to provide. The small sample size of the inter-rater reliability test is another limitation. However, the consistency of the answers and especially of the qualitative data obtained suggests that despite the small sample size the results are reliable. Finally, the majority of our participants represent (international) response organisations rather than host countries and affected populations.

Conclusion

We attempted to develop a rapid risk assessment tool for communicable diseases in humanitarian emergencies that gave both quantitative and qualitative indications of risk level and could be used by aid workers with little or no training in health protection.

The tool works as an initial assessment tool and is applicable across a large range of different settings.

In some cases, specialised organisations might want to have a more focused risk assessment only looking at their own area. Thus, one hurdle is that the tool is interdisciplinary and it may be difficult to convince organisations that the tool is suitable and useful at first instance even if they have their own more detailed and subject-specific assessments. This applies particularly to highly specialised organisations. However, one of the main groups this tool is aimed at are smaller organisations that do not have extensive health protection portfolios. For those organisations, this tool can be empowering when used together with an initial needs assessment to understand priority areas for action both within and beyond their own scope.

In the context of larger – especially country-level – responses, we do not see this tool as a substitute or in competition with well-established mechanisms such as the WHO's EWARN (26, 27). Rather it is a companion that seeks to quantify outbreak risk (to a degree) and make rapid risk assessment for communicable diseases in humanitarian emergencies possible without the expert knowledge necessary to complete a qualitative risk assessment. Additionally, the results of the tool can shed light on how the wider humanitarian crisis is affecting health outcomes in the context it is completed in.

In addition to the digital and print versions of the tool, it is possible to develop the tool into an app for mobile devices such as tablets and smartphones. The tool can be used as a general rapid risk assessment tool that users can become highly familiar with across different deployments, as well as be adapted for specific circumstances and settings. The tool and the accompanying guide are available in the public domain and the authors are available for any questions regarding the use and adaptation of the tool. We would also welcome any feedback from organisations adopting the tool as part of their rapid risk assessment.

Ethical approval

The research study has been approved under the regulations of the University of East Anglia's Faculty of Health and Medicine Ethics Committee. All participants provided written informed consent prior to participating.

Competing interest statement

The authors declare no competing interests.

Author's contributions

All researchers helped design the study and provided input for the tool. CH designed the tool and programmed changes based on the testing. CH did the interviews, conducted the field investigation and wrote the draft manuscript. All authors approved the final analysis and manuscript.

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