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Estimating indicators of population health in acute and protracted humanitarian crises

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Abbreviations

3W	Who, What, Where (3W matrix maps Health Cluster partners in a humanitarian crisis)
ANC	Antenatal care
AJS	Acute jaundice syndrome
ALNAP	Active Learning Network for Accountability and Performance in Humanitarian Action
CAR	Central African Republic
CBS	Community-based surveillance
CFR	Case fatality rate
CI	Confidence interval
CMR	Crude mortality rate
CXB	Cox's Bazar, Bangladesh
DC	Detention centre
EBPH	Evidence-based public health
EBS	Event-based surveillance
ELRHA	Enhanced Learning And Research For Humanitarian Assistance (a global charity)
EPI	Expanded program on immunisation
ETU	Ebola treatment centre
EVD	Ebola virus diseases
EWAR	Early warning alert and response
GIS	Geographic information system
HAV	Hepatitis A virus
HBV	Hepatitis B virus
HCV	Hepatitis C virus
HEV	Hepatitis E virus
HIS	Health information system; same as health management information system (HMIS)
HIV	Human immunodeficiency virus
HMIS	Health management information system; same as health information system (HIS)
IBS	Indicator-based surveillance
ICCM	Integrated community case management
IOM	International Organisation for Migration
MDA	Mass Drug administration (of antimalarial drugs)
MHS	Maternal Health Services
MMR	Maternal mortality ratio

MoH	Ministry of Health
MSF	Médecins Sans Frontières
MUAC	Middle-upper arm circumference
OPD	Outpatient department
PHIS	Public health information services in activated Health Clusters and other humanitarian health coordination mechanisms
PNC	Postnatal care
TBA	Traditional birth attendant
SAR	Search and Rescue
SGBV	Sexual and gender-based violence
SMART	Standardized Monitoring and Assessment of Relief and Transition
SRH	Sexual and reproductive health
U5MR	Mortality rate in children less than five years
UN	United Nations
UNHCR	United Nations High Commissioner for Refugees
WHS	Water, hygiene and sanitation
WHO	World Health Organisation

1 Introduction

1.1 Evidence-based Public Health

Improving population health is the ultimate aim of all public health interventions. The translation of relevant research findings into evidence-based, context-appropriate and feasible strategies and concepts that improve health and reduce disparities is key to successful public health interventions.

Evidence is defined by the Oxford English Dictionary as "The available body of facts or information indicating whether a belief or proposition is true or valid" (1). In the field of public health, these facts or information can be based on various sources and methods including routine program monitoring and evaluation, surveillance data or research studies (2–4).

There is no universally agreed definition of evidence-based public health (EBPH). According to Jenicek (5), and similar to the definition of evidence-based medicine (6), EPBH could be defined as "… the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of communities and populations in the domain of health protection, disease prevention, health maintenance and improvement (health promotion)" ((5) p.190).

The concept of EBPH has been developed further by multiple researchers (7–12) and key steps include utilising available data and information systematically, evaluating the quality of available research and identifying the best available evidence (8,10). The quality of evidence depends heavily on, but is not solely determined by, the design of the study (3,13–15). Systematic reviews of randomised controlled trials (RCTs) are rated as the highest possible evidence (15). However, depending on the research question and feasibility, other studies and data sources, such as observational studies that are more common in public health, contribute to generating the much-needed evidence (3,4,10,14–16).

Evidence in public health can provide answers to different types of questions regarding 1.) who is affected by which health problem or threat, 2.) what could help to address the problem and 3.) how to best do this (10). The evidence that provides an answer to the first question usually describes the existence of a problem, the type of problem, the magnitude and severity of the problem or threat and the population at risk (3,7,10).

To provide evidence with regards to question 1.) of who is affected by what on which scale is crucial information required to initiate and adapt meaningful public health responses in case of humanitarian crises (17). Evidence is needed to ensure humanitarian relief reaches the groups most vulnerable and hardest affected by the crises and targets the biggest contributors to morbidity and mortality in order to yield maximum impact of humanitarian assistance (3,4). However, conducting research and providing a solid basis for evidence-based decisions regarding priority interventions to improve population health is particularly challenging in humanitarian crises (4) (see chapter 1.2.2).

1.2 Evidence for decision making in humanitarian crises

1.2.1 Acute and protracted humanitarian crises

Humanitarian crises are increasingly frequent and a growing number of people are in need of humanitarian assistance (18,19). There is no agreed definition of what constitutes a humanitarian crisis (4). It is commonly referred to as events such as natural disasters, epidemics, violence or conflicts that impact on health and safety of a significant proportion of the population and threaten their human rights; the arising humanitarian needs require multisectoral external assistance (19–23).

The European Council, Parliament and Commission define humanitarian crises in a joint statement (24) as follows:

> Humanitarian crises include both man-made and natural disasters. Their impact is increasingly severe, linked to a number of factors, such as the changing nature of conflict, climate change, increasing competition for access to energy and natural resources, extreme poverty, poor governance and situations of fragility. The main victims are civilians, often the poorest and most vulnerable among them, mainly living in developing countries. Humanitarian crises have led to large numbers of displaced people, both refugees and internally displaced persons. ((24), p.C25/1)

In addition to acute crises that are characterised by a duration of less than six months (19), protracted crises are becoming a more and more common phenomenon (18,25). Protracted crises continue for a longer duration and are characterised by the ongoing threat to health and wellbeing, the continuous risk of loss of livelihood and weak governance that provides little or no response to these threats (26). The World Health Organisation (WHO) defines a protracted emergency in the emergency response framework (19) as follows:

> An environment in which a significant proportion of the population is acutely vulnerable to death, disease and disruption of livelihoods over a prolonged period of time. Governance in these settings is often weak, with limited state capacity to respond to, and mitigate, the threats to the population, or provide adequate levels of protection. ((19), p.4)

Chad and the Central African Republic (CAR) are two examples of countries in protracted crises that had a humanitarian response plan in place for more than 15 years (18).

In addition to humanitarian crises bound to specific countries, on the Mediterranean Sea a crisis has evolved as migrants, refugees and asylum seekers aim to travel across the Mediterranean in small boats to reach Europe (27).

1.2.2 Conducting research and generating evidence in humanitarian crises

Research in humanitarian crises should follow the same ethical standards as research outside humanitarian crises and protocols should be reviewed by institutional review boards (28–30). In addition, research in crises requires a specific justification as to why the research is needed during a humanitarian crisis, because populations living through humanitarian crises are particularly vulnerable and at the same time, ethics oversight in many humanitarian crises is particularly weak (28–30). If it is possible to extrapolate evidence from non-crises settings to a crisis setting, the evidence should be generated in non-crises settings to minimize risks to participants (30–32).

The vulnerability of the population under study makes it a key requirement to utilise data that is already available whenever possible – instead of conducting new research that can cause potential harm (30–32). Additionally, primary data collection in humanitarian crises is challenged by insecurity, access problems, complicated logistics and by an extremely vulnerable population under research (31–33). A review of research methodologies in humanitarian crises commissioned by the organisation Enhancing Learning and Research for Humanitarian Assistance (ELRHA) (32) made the following recommendations for improving research in humanitarian settings: “greater focus on the adaptation of established methods, better knowledge transfer from “stable” settings, better routine data collection, and the improved analysis of existing data.” ((32), p.15)

Due to challenges in research implementation and the need to reduce risks to participants (and researchers) to a minimum, evidence in humanitarian settings is often flawed and incomplete (4). Evidence-based decisions often require dealing with imperfect evidence and making appropriate use of the best available evidence that is frequently based on rapid assessments, population-based surveys and surveillance data instead of RCTs (4).

1.2.3 Evidence-based public health action in humanitarian crises

Humanitarian response is aiming to reduce morbidity and mortality of populations affected by crises by addressing underlying factors such as provision of food, water and sanitation and shelter but as well by providing health care (23). With 274 million people in need of humanitarian assistance in 2021 and a forecasted global UN budget of 41 billion US Dollars to target the populations most in need (18), there is a tremendous importance to address the major contributors to morbidity and mortality in the most vulnerable populations based on the best available evidence (2,3). The Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP) summarises that "The failure to generate and use evidence in policy and response makes humanitarian action less effective, less ethical and less accountable" ((3), p.5).

For humanitarian crises, the evidence required to allow evidence-based decision making is outlined in the *Standards for Public Health Information Services (PHIS) in Activated Health Clusters and other Humanitarian Health Coordination Mechanisms* (17)[1]:

a) "Health Status and Threats for affected populations" ((17), p.8) such as estimates of mortality, major causes of morbidity and public health threats of epidemic-prone diseases,

b) "Health Resources and Services Availability" ((17), p.8) and

c) "Health System Performance" ((17), p.9) including coverage, utilisation and quality of care (17,23).

Indicators for these domains of population health are required during the initial assessment and analysis stage of the humanitarian response cycle but as well as baseline data to monitor changes in population health throughout the crisis (17,34,35). Often these indicators that describe the health situation of a population or sub-population are compared against "accepted crisis thresholds" ((3), p.12) to demonstrate that an emergency situation is met and an intervention is needed (3,17,36).

In order to translate the evidence regarding the domains of population health in humanitarian crises into action, the information needs to be communicated in an appropriate format to communities under research, donors and to the agencies and governing bodies that are in the position to apply the evidence to their operational decisions (2). According to ELRHA, successful research dissemination and uptake can be facilitated by better use of routine data, translating research into actionable recommendations, employing persons who can translate and communicate the research findings to their operational relevance, close partnerships between academia and humanitarian practitioners, research leadership from the Global South and leadership in evidence utilisation (2).

1.3 Population health indicators relevant in humanitarian crises

1.3.1 Health status and threats – Mortality, morbidity and public health threats

Evidence-based data about population mortality, population morbidity and the monitoring of health threats represent the vital metrics required to initiate, monitor and adapt adequate humanitarian response (17,23). To operationalise the domain of population mortality the following indicators are commonly utilised: crude- and cause-specific mortality rates (the number of deaths over a defined time in a defined population) and proportional mortality ratio (different causes of deaths expressed as percentages of the total number of deaths) (17,37,38).

[1] The Global Health Cluster is a coordination mechanism in humanitarian crises that is led by WHO and promotes and supports effective humanitarian response of the health sector during a humanitarian crisis (23)

Population mortality indicators

To operationalise the domain of population mortality the following indicators are commonly utilised: crude- and cause-specific mortality rates (number of deaths over a defined time period in a defined population) and proportional mortality ratio (different causes of deaths expressed as percentages of the total number of deaths) (17,37,38).

Population mortality is the gold standard indicator of population health in crisis (17,23,37,38). While humanitarian crises may impact in multiple ways directly and indirectly on physical and psychological well-being of the people affected, population mortality measures the final hard outcome of crises on health (23,37,38). However, population mortality provides information on the population's health status at a point where prevention is not possible anymore for those deaths already counted (38,39). Yet, mortality is the key metric to benchmark the magnitude of the crisis and the required scale of the response (23,38). In addition to using thresholds for benchmarking crises - relevant for advocacy and allocation of resources - mortality estimates can provide crucial information for fine-tuning interventions with regards to how many people are affected, since when, on what scale by which causes of deaths (37).

The key mortality indicators in humanitarian crises are the crude mortality rate (CMR) and the mortality rate in children under five years of age (U5MR) (37,38). The CMR describes deaths of all causes in a specific population during a defined time period; it is usually expressed during emergencies as the number of deaths per 10,000 population per day (37,38). The U5MR describes deaths of all causes among children less than 5 years old in a specific population aged less than 5 years old during a defined time period; it is usually expressed during emergencies as the number of deaths in children under five years of age per 10,000 population under five years of age per day (37,38).[2] The CMR and U5MR have steadily been declining over the past decades in all parts of the world (40). The least developed countries are thought to have a baseline CMR of ~0.2/10,000/day according to the World Bank (40). However, these mostly modelling-derived estimates are unlikely to reflect the true magnitude of baseline mortality in many crisis-affected and unstable settings as population movements, conflict-impacts and security constraints are often unpredictable (41). A doubling of the local baseline mortality or a CMR beyond 1 death/10,000 population/day is commonly considered the threshold to declare a humanitarian emergency (37,38). For the U5MR, a doubling of the local baseline mortality or a U5MR beyond 2 deaths/10,000 population/day is commonly considered the emergency threshold (37,38).

In addition to crude mortality rates, cause-specific mortality rates are often calculated in order to measure the direct impact of a specific disease (e.g., Ebola-related deaths) or crisis-specific events (e.g., violence-related deaths) on population mortality (37,38). The cause-specific mortality rates are expressed as deaths per 10,000 population per day (37,38).

Proportional mortality provides an additional measure of the contribution of different causes and diseases to population mortality, the indicator of proportional mortality can help to target the most common diseases and reduce mortality (37,38). Proportional mortality is usually expressed as a proportion or percentage and not a rate (e.g., most common causes of deaths: malaria 50%, respiratory diseases 15%, diarrhoeal diseases 14%, etc.) and is one of the core health indicators required in any humanitarian crisis (42).

As data about deaths from health facilities is usually only reflecting a biased fraction of the deaths happening in the population, mortality indicators are usually obtained on population level. Mortality at population level in crises is typically measured by population-based surveys (see chapter 1.4.3) or

[2] The U5MR as defined here should not be confused with the under-five mortality ratio that is defined as deaths in children under five years per 1,000 live-birth and is usually calculated over longer periods and less commonly used in emergencies (37)

community-based mortality surveillance; the latter can be very resource intensive as it requires staff to visit a defined population in a defined period (usually each week) to inquire about recent deaths, it also requires ongoing supervision, data collection and analysis (37,38).

Population morbidity indicators

To operationalise the domain of population morbidity the following indicators are commonly utilised: proportional morbidity ratio (different causes of disease expressed as percentages of the total number of diseases) and disease incidence rates (number of cases of a disease during a defined time period among a defined population) (17,23,43).

Population morbidity data provides a faster indicator of population health than mortality data as the health outcome (i.e., disease) appears earlier (38,39). Population morbidity in humanitarian crises is often operationalised as a simple calculation of proportional morbidity expressed in percentages derived from health facility-based data (42). The PHIS Toolkit of the Health Cluster (42) describes proportional morbidity as one of the key indicators for general population health in humanitarian crises (42). Proportional morbidity measured at health facility level provides an indicator of the most common diseases that require health care but might obscure the treatment needs of populations that cannot access health care or for diseases that cannot be treated in the current health system (42).

In addition to proportional morbidity, incidence rates for diseases of high concern (context-specific) are established from surveillance data if appropriate denominator data is available (42,43).

Routinely, further data for conditions and threats of specific concern during emergencies are also obtained, among them are typically measles vaccination status, nutritional status among children, mental health status and sexual and gender-based violence (SGBV) reports and further physical disease data (e.g., chronic conditions, reproductive health etc) (43).

Morbidity data can complement mortality data in that it provides information on diseases and conditions that might not have caused death (yet) but have the potential to do so and/or impact substantially on well-being.

Indicators of public health threats

Public health threats to populations during humanitarian crises can be posed by epidemic-prone diseases, population movements or health-service disruptions or other context-specific risks (17). These threats are typically monitored by surveillance systems on health facility level and/or community level that include an early-warning alert and response (EWAR) component (see chapter 1.4.2). There are no standard indicators of what constitutes a public health threat in humanitarian crises as the assessment of threats is context dependent; rather there are recommended processes that taken together create an EWAR system for detection, verification, risk assessment- and characterisation of and response to public health threats (17,43–45) (see chapter 1.4.2).

1.3.2 Health resources and services availability – Functionality of services

Documenting the availability and functionality of health services in the crisis area is a key step to establish the gaps and unmet needs in a humanitarian crisis (23). A list of partners and a systematic survey of who does what where (3W) are at the heart of the health service availability and functionality assessment (17). The partners list and 3W are complemented by a Health Services Availability Monitoring System (HeRAMS) that should repeatedly be undertaken to establish the exact services and staff available to which population during the crisis (17). The domain of the assessment of health resources is described in the PHIS standards (17) as "[…] information on preventive and curative health services, infrastructure, personnel and supplies provided by health authorities or other actors, as well as the degree of access that affected populations actually have to those services." ((17), p.8).

As the assessment of health resources is a standardized process requiring minimal epidemiological input, it does not form part of the work presented here.

1.3.3 Health system performance – Coverage, utilisation and quality of care

The monitoring of the performance of the health system provides information about the care actually delivered and used by the population affected by crisis (17). The performance assessment represents the next step following the assessment of availability and functionality (see chapter 1.3.2). While availability merely describes the existence of health services, the performance assessment aims to provide information about coverage and utilisation of the health service by the target group and the quality of care at the health services (17,23).

Indicators of health service coverage

The main indicator for health service coverage is defined as the overall proportion of the population that is reached in practice by the service (17).

> Health service coverage depends on the ability of a health service to interact with the people who should benefit from it (the target population), i.e., the ability to transform the intention to serve people into a successful intervention for their health. ((46), p.295)

Coverage estimates of specific health services (e.g., immunisation services or reproductive health services) are usually obtained in population-based surveys (see 1.4.3). Coverage can sometimes be inferred based on HMIS data about consultations for a specific service and population denominators. However, this method is often hampered by the lack of exact population denominators and particularly risks to miss coverage gaps among hard-to-reach and hidden groups (17). Population-based surveys allow to establish the proportion of the population (or subgroups thereof) that has access to the health service and uses it, and to identify barriers to the service utilisation (see 1.4.3).

Indicators of health service utilisation and health-seeking behaviour

The utilisation of health services is usually operationalised as the simple output of available health services based on the health management information system (HMIS; also referred to as health information system (HIS)) (17). The HMIS collects and analyses data from health facilities about the number and cause of consultations and the services provided per week (e.g., number of outpatient consultations, number of admissions to inpatient therapeutic feeding centres) (17).

Data on utilisation patterns beyond the HMIS are not routinely collected in humanitarian crises as part of the PHIS and no standard indicators are established for humanitarian crises to describe the knowledge, attitude and behaviour and practice of seeking health care nor to operationalise health-seeking behaviour (17).

Indicators of health service quality of care

Quality of care is defined as “The degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge” ((47), p.6). To achieve a good quality of care, humanitarian response aims to follow a standardized process to care delivery and the health care provided is compared to standards of care that are set by WHO and the health cluster (23,48). However, there are multiple challenges to achieving adequate quality of care such as the existence of fragmented and poorly resourced health systems, lack of trained staff and multiple actors following different protocols to care (23).

Quality of care can be assessed by facility audits, surveys among patients and lastly by analysing HMIS data from health facilities, as the case fatality rate of a specific disease can be a proxy for quality of care for some diseases (43). Quality of care is however not (yet) part of the standard public health information provided during emergencies and there are no standard indicators available (17).

1.4 Data sources and methodologies to estimate population health indicators in humanitarian crises

Establishing population health indicators in humanitarian crises to inform the need and scope of public health interventions is difficult and only partially standardized (4,43,49–51). In the following I will present data sources and methodologies for population health indicators regarding a) the health status and health threats as well as c) health system performance. As b) health service availability is established by a simple list of actors and their response capacity with minimal epidemiological input, the indicators for health service availability do not form part of this research:

a) Health status and health threats: **Mortality, morbidity and health threats**
b) Health service availability: will not be included
c) Health system performance: **coverage, utilisation and quality of care**

Following initial rapid assessments at the onset of the crisis, there are three main sources for evidence on health status and threats as well as health system performance: 1. health program data such as HMIS data, 2. data from surveillance systems and 3. population sample survey data (17,43,50) as illustrated in Table 1.

Table 1: Data sources and methods for obtaining indicators of population health in humanitarian crises (adapted from Checchi et al. 2018, page 2301 (43)*)*

Population health indicators		Data sources and methods available to generate evidence			
		HMIS data	Surveillance data	Population-based survey data	Other
Health status	Population mortality	NA*	Prospective death surveillance as part of community-based surveillance	Retrospective population-based mortality survey	Grave counts, media reports, modelling
	Population morbidity	Analysis of routine HMIS data to establish magnitude and severity of different conditions and diseases	Analysis of surveillance data for key diseases to establish incidence rates based on population size and composition**	Retrospective population-based survey to establish prevalence of diseases and conditions	Desk-based analysis of data from similar settings and pre-crisis morbidity data
	Health threats	Integration of HMIS data into the EWAR function of the surveillance system to identify potential threats early	EWAR component forms part of the surveillance system to identify potential threats early	NA	Desk-based analysis of epidemic profile of the crisis setting (endemic and epidemic diseases, other potential threats)
Health system performance	Coverage	Analysis of routine HMIS data (output) and comparison to expected utilisation based on population size and composition**	NA	Retrospective population-based survey to establish population coverage of specific services	NA
	Utilisation and health-seeking behaviour	Analysis of routine HMIS data (output) to quantify utilisation in absolute numbers	NA	Retrospective population-based survey to establish health service utilisation patterns, health-seeking behaviour and barriers to care	Qualitative methods to establish health service utilisation patterns, health-seeking behaviour and barriers to care
	Quality of care	Case fatality rates for specific diseases and services	NA	Retrospective population-based surveys to establish type and quality of care received	Facility audits, patient interviews, qualitative methods

Legend: EWAR = Early Warning Alert and Response HMIS = Health information system; NA = Not applicable.

* Health facility-based mortality is considered an indicator of the quality of care rather than providing information about mortality rates and causes at population-level

** requires availability of population denominator data including age-breakdown

1.4.1 HMIS data

Routine health program data such as HMIS data is the most readily available type of data in humanitarian crises, if any health care at all is in place (either newly established or dating from before the crises onset). Most healthcare providers have some HMIS in place to conduct at least basic monitoring of numbers, type and cause of patient consultations (17). At the same time, the quality of routine data collection and analysis is often poor and the wealth of information in the data is frequently not used to its full potential (2,32)

The PHIS standards (17) describe the HMIS as

> A Health Management Information System (HMIS) collects, analyses and reports data from health providers and facilities on causes of consultation and hospitalisation, services provided (e.g., number of antenatal consultations), and (at least in inpatient facilities) patient clinical outcomes. HMIS data, alone or in combination with catchment population figures, are used to construct a variety of indicators of proportional and absolute morbidity and mortality, service utilisation, and quality of care. These indicators inform planning, management, and decision-making both at the health facility level, and at aggregated levels, such as district-level planning by the Ministry of Health (MoH). ((17), p.17)

Some of the HMIS data routinely feeds into health facility-based surveillance systems for infectious diseases that are either operated at country-level or, if the national surveillance system is affected in its functioning and performance by the humanitarian crisis, an emergency-specific surveillance system is established within the Health Cluster coordinating body (17). HMIS data is often broader than surveillance data as it also includes information on non-communicable diseases and conditions as well as information about the types of services provided.

HMIS systems in emergencies range from sophisticated software solutions that can be tailored to context, bring large amounts of patient data together and provide automated analysis (like DHIS2 (52)) to systems based on simple tally sheets on paper. Even in its most basic form, HMIS data - if collected and analysed appropriately - usually allows to establish some evidence on total numbers of health care utilisation and proportional morbidities in the population.

In this research, HMIS data is used to establish proportional morbidities and main health concerns among migrants, refugees and asylum seekers in detention centres in Tripoli, Libya (53), and onboard a search and rescue vessel on the Mediterranean Sea (54).

1.4.2 Surveillance data

The WHO defines Public Health Surveillance in its technical guidelines for integrated disease surveillance and response (55) as follows

> Public Health Surveillance is the ongoing systematic identification, collection, collation, analysis and interpretation of disease occurrence and public health event data, for the purposes of taking timely and robust action, such as disseminating the resulting information to the relevant people, for effective and appropriate action. ((55), p.1)

While public health surveillance in general can provide valuable data on long-term trends for infectious and non-infectious diseases, for humanitarian emergencies the most important function is the early warning alert and response (EWAR) component to detect and react to public health threats rapidly (17,23,43,44,55). EWAR information can derive from reports from health facilities as well as from communities and other sources such as pharmacies or the media (44,56).

The EWAR system usually includes an event-based surveillance (EBS) component that relies on reports of potential public health events by the public, community volunteers, health care providers or others (e.g., health facilities reporting ad hoc clusters of patients with severe and similar symptoms of an

unknown disease). All EBS reports undergo a quick triage to ensure they could represent a potential public health threat, and in case of positive triage, an alert is issued (44).

The EWAR system additionally includes an indicator-based surveillance (IBS) component that relies on pre-identified reporting sites such as health facilities or community health workers reporting in a defined frequency cases with specific diseases or conditions. These reports are based on case definitions that describe the specific symptoms or syndromes that are notifiable. The frequency of reporting is usually set to daily or weekly and reports are then compared against an alert threshold to identify any unusual increase in a specific disease or condition. If a threshold is crossed and the report could be verified, an alert is issued (44).

Any alert that is detected by the EWAR system undergoes a risk assessment that includes a) assessment of the hazard that might be causing the threat, b) assessment of the context and c) assessment of the potential exposure and immunity of the population to the hazard (44,45). The decision if a specific pathogen represents a risk, therefore, requires a desk review of the context (e.g., camp vs no-camp setting, WHS conditions, food security) and the exposure and immunity; one case of measles might be considered sporadic and irrelevant in a rural setting with good vaccination coverage but it could represent a major threat in an overcrowded camp setting with low vaccination coverage and high rates of malnutrition (45,57). Thus, all alerts in the EWAR system from IBS or EBS alike undergo further risk assessment and investigation to check if they constitute a potential public health event that requires a response. Further investigations can include enhanced surveillance activities, patient follow-ups, and laboratory tests of samples from patients and/or the environment. In case of a positive risk assessment, the response can include but is not limited to case finding, health promotion activities, infection prevention control (IPC) measures, water, hygiene and sanitation (WASH) interventions, clinical case management and comprehensive outbreak response (e.g., in the case of a measles outbreak that would typically include mass vaccination campaigns, health promotion, provision of free health care) (44).

In this research, I present an outbreak investigation triggered by an alert of a potential public health threat to the EWAR system in Cox's Bazar, Bangladesh, among the Rohingya population in a camp setting (58).

1.4.3 Population-based surveys

Population-based surveys are the standard methodology to estimate mortality, nutrition status and vaccination coverage during humanitarian emergencies (23,59–61). Population-based surveys aim to collect information among the population on an individual level about the current health status or previous events (during a defined time frame) such as disease or death (23,59–61). In addition to mortality, nutrition status and vaccination coverage, surveys can also be used to establish morbidities in the past weeks, coverage and quality of health care services, health-seeking behaviour, and barriers to care (23,43,62).

Population-based surveys in humanitarian emergencies often use two-stage sampling, in the first stage, a village is selected with the chance of selection for the survey being proportional to the population size of the village. Within the selected village, in the second sampling stage, households are selected through a defined random sampling method (60,61,63). There is some controversy about the best random method to select the households: spinning a pen, GIS-supported selection or numbering all buildings are among the more commonly used approaches (63,64). Households are usually the final sampling units and within the households, all household members that fulfil eligibility criteria for the survey are asked to participate (60,61).

Surveys, if well conducted, can provide excellent indicators of the health status of a population (17,23,43). Their implementation entails a number of steps that may be challenging in humanitarian crises and may require context-specific adaptations and novel approaches (4,32,63). Standard procedures include but are not limited to the following steps (60,61,63–65):

- Survey design and planning: developing research protocols and seeking ethical review in the country of implementation, establishing population numbers by settlement in the survey area (for the allocation of clusters proportional to population size), the selection of villages proportional to population size and the approval of the administrative (or de-facto) authority in that village to conduct interviews, recruit and train surveyors;
- Survey implementation: transportation to selected villages, the selection of houses in selected villages with a suitable random method, asking households for consent followed by an interview in person by a trained surveyor, the collection of data in a standardized format and the transfer (digitally or physically) of that data to a common database respecting data protection requirements, debriefing with surveyors each evening, conducting data checks for consistency and data quality and if needed conduct additional on the job training;
- Survey analysis, interpretation and dissemination: statistical analysis and interpretation in context, preparation of appropriate dissemination formats for different stakeholders, engagement and discussion with decision makers to facilitate the use of evidence.

In this research, I present several survey methodologies to obtain indicators of population health in humanitarian crises: A population-based survey using an adaptation of the standard method in Ouaka prefecture, CAR, to establish mortality and health-seeking behaviour (66); a population-based survey in Monrovia, Liberia, using a novel phone-based method to establish mortality, morbidity and health-seeking behaviour during the Ebola outbreak in 2014 (67); a standard population-based survey in Sila region, Chad, to establish coverage, utilisation and quality of reproductive health care (68).

1.5 Research aim

1.5.1 Research objectives

The aim of this research synthesis is to demonstrate that context-appropriate research designs using available HMIS and surveillance data, as well as well-conducted standard approaches and adapted methods to population-based surveys, can overcome design and implementation challenges and allow to generate an evidence-base for decision-making in humanitarian settings.

For decades, decisions about aid distribution and health program designs in humanitarian crises used to be driven by experience and assumptions of aid workers and less so by evidence (2,3,35,69). However, the generation and use of evidence, i.e., information that is able to demonstrate if an assumption holds true (1), is required in humanitarian crises as much as in all other public health settings to ensure humanitarian aid is effective, ethical and accountable (3). While the required indicators and their data sources and the methods to obtain them are not rocket science, poor data quality and analysis have often hindered the use the HMIS and surveillance data to their full potential (2,32); and flaws in the design as well as challenges in the implementation of population-based surveys have limited their usefulness in the past (63,64,70,71).

The research methods presented here represent well-conducted standard approaches as well as novel methods to estimate a broad range of population health indicators. All of the presented studies are based on HMIS data, surveillance data or survey data collected during the humanitarian crises on behalf of Médecins Sans Frontières (MSF) and/or the Ministry of Health (MoH) of the respective country.

1.5.2 Research overview

The research includes two studies on mortality in humanitarian crises: two population-based surveys to estimate mortality in an acute humanitarian crisis in Liberia in 2015 (67) and a protracted crisis in CAR in 2020 (66). Additionally, the research includes three studies related to morbidity and disease threats in humanitarian crisis: two analyses of proportional morbidity patterns of migrants, refugees and asylum seekers detained during the protracted crisis in Libya, 2018-2019, (53) and onboard a search and rescue vessel on the Mediterranean Sea, 2016-2019 (54); and the description of disease trends and threats related to findings from an enhanced surveillance system for acute jaundice syndrome (AJS) during the acute humanitarian crisis in Bangladesh affecting the Rohingya population in the camps in Cox's Bazar in 2018 (58). And lastly, the research includes a study about health system performance in humanitarian crises: a survey that estimates maternal health service coverage, quality of care and health-seeking behaviour for women of reproductive age in a protracted crisis in Chad in 2019 (68).

The objectives of all the individual pieces of research presented here were to establish health indicators for populations affected by humanitarian crises in order to guide health service provision, broader relief efforts and advocacy strategies.

An overview of population health indicators, methods to estimate these indicators and the specific approaches described as part of this synthesis are illustrated in table 2.

Table 2: Data sources and methods for obtaining indicators of population health in humanitarian crises (adapted from Checchi et al. 2018 (43)*)*

Population health indicators		Data sources and methods available to generate evidence			
		HMIS data	Surveillance data	Population-based survey data	Other
Health status	Population mortality	NA*	Prospective death surveillance as part of community-based surveillance	Retrospective population-based mortality survey [1] [2]	Grave counts, media reports, modelling
	Population morbidity	Analysis of routine HMIS data to establish magnitude and severity of different conditions and diseases [3] [4]	Analysis of surveillance data for key diseases to establish incidence rates based on population size and composition** [5]	Retrospective population-based survey to establish prevalence of diseases and conditions [2]	Desk-based analysis of data from similar settings and pre-crisis morbidity data
	Health threats	Integration of HMIS data into the EWAR function of the surveillance system to identify potential threats early [5]	EWAR component forms part of the surveillance system to identify potential threats early [5]	NA	Desk-based analysis of epidemic profile of the crisis setting (endemic and epidemic diseases, other potential threats) [5]
Health system performance	Coverage	Analysis of routine HMIS data (output) and comparison to expected utilisation based on population size and composition**	NA	Retrospective population-based survey to establish population coverage of specific services [6]	NA
	Utilisation and health-seeking behaviour	Analysis of routine HMIS data (output) to quantify utilisation in absolute numbers [3] [4]	NA	Retrospective population-based survey to establish health service utilisation patterns, health-seeking behaviour and barriers to care [1] [2] [6]	Qualitative methods to establish health service utilisation patterns, health-seeking behaviour and barriers to care [1]
	Quality of care	Case fatality rates for specific diseases and services	NA	Retrospective population-based surveys to establish type and quality of care received [6]	Facility audits, patient interviews, qualitative methods [1]

Legend: EWAR = Early Warning Alert and Response HMIS = Health information system; NA = Not applicable. All fields shaded in yellow represent sources and methods applied in this research: [1] adaptation of this method utilised as part of the following original research - survey in CAR (66); [2] adaptation of this method utilised as part of the following original research - survey in Liberia (67); [3] method utilised as part of the following original research - HMIS data analysis in Libya (53); [4] method utilised as part of the following original research - HMIS data analysis at Mediterranean search and rescue intervention (54); [5] adaptation of this method utilised as part of the following original research - surveillance and HMIS data analysis for threat detection in Bangladesh (58); [6] this method utilised as part of the following original research - survey in Chad (68)

* Health facility-based mortality is considered an indicator of quality of care rather than providing information about mortality rates and causes at population-level

** requires availability of population denominator data including age-breakdown

2 Original articles

2.1 Mortality and health-seeking behaviour during the protracted humanitarian crisis in the Central African Republic, 2020

Robinson E, Lee L, Roberts LF, Poelhekke A, Charles X, Ouabo A, Vyncke J, Ariti C, Gbanzi MCA, Ouakouma MT, Gray N, Daly M, White K, Templeman S, Hejdenberg M, Hersevoort M, Pena SJ, **Kuehne A**. Mortality beyond emergency threshold in a silent crisis- results from a population-based mortality survey in Ouaka prefecture, Central African Republic, 2020. Confl Health. 2021 Jun 30;15(1):50. doi: 10.1186/s13031-021-00385-2. PMID: 34193238; PMCID: PMC8243074.

The Central African Republic (CAR) is one of the most fragile states in the world (72) and requires multisectoral international support since 19 years (18). The protracted crisis in CAR is characterised by cycles of violence and despite repeated peace deals, the population continues to be subject to human rights abuses (73,74). Ouaka prefecture is home to 7% of the country's population and is affected by a continuous conflict between armed groups (75). MSF supports some of the health infrastructure of Ouaka prefecture. MSF initiated the following population-based survey to establish the population age structure, the mortality rate and birth rate, causes of death and health-seeking behaviour (66).

We conducted an adapted population-based cluster survey (66). We utilised a two-stage cluster sampling and allocated clusters according to population size to the 16 communes of Ouaka prefecture (66). We selected cluster starting points from a list of buildings identified on satellite images (76): within each commune, we selected starting points for the clusters with systematic random sampling from a list of all buildings in the commune (66). The list was based on geographical building footprints that were derived from screening satellite images for buildings using artificial intelligence (76). We aimed for a sample size of 3,636 household members (66). The recall period started 26/05/2019 (Mother's Day) (66). The standard survey questionnaire was adapted to include an open question at the start of the interview ("What difficulties does your household and community face on a daily basis?") (66). We used a content analysis approach to identify common topics (77,78). Additionally, we adjoined a set of closed non-standard quantitative questions to elicit better information about newborn deaths and maternal mortality (66). All data were collected with a digital questionnaire using Kobo Toolbox (79) by surveyors who received four days of training on survey methodology, survey ethics, sampling and participant selection and the questionnaire (66).

We conducted the survey between 09/03/2020 and 09/04/2020 and included 591 households with 4,000 household members (66). The median age was 12 years and 23% (95% CI: 21.4-24.3%) of the population were less than five years old (66). The crude birth rate was estimated at 59.0 birth per 1,000 population per year (95% CI: 51.7-67.4). The maternal mortality rate (MMR) was estimated at 2,525 per 100,000 live births (95% CI: 825-5,794) (66). The CMR was estimated at 1.33 deaths per 10,000 population per day (95% CI: 1.09-1.61) and the U5MR at 1.87 per 10,000 population per day (95% CI 1.37-2.54) (66). The most common specified cause of deaths overall was malaria (66). Among participants ≥5 years of age violence was most often reported as the specific cause of death (66). Among those who died, 62% (95% CI: 53.2-70.0%) reported having sought care in the two weeks before their deaths (66). The challenges reported were related to access to health care, harsh living conditions and violence (66). The most common challenges reported were health problems and challenges in accessing appropriate health care because of distance to health care, money but also lack of medicine and lack of trained staff at health facilities (66).

The estimates for the crude, under five years and maternal mortality rates were higher than previously estimated (66,80–83). The CMR exceeded the emergency threshold for humanitarian crises (38,84). Similarly, high mortality rates were found in other prefectures in CAR in 2018 and 2019 (85,86). All these estimates speak to a very poor health status and indicate the severity of the crisis (66).

In addition to the high mortality, the young age of the population with 50% being 12 years old or younger was noteworthy and the proportion larger than modelled United Nations (UN) estimates (66,87). The accuracy of the high proportion of children under five years was corroborated by other surveys (85,86,88) and by our estimate of the birth rate which was also significantly higher than the UN births rate estimate (89). The proportional mortality confirmed the importance of malaria and other preventable infectious diseases such as diarrhoea and acute respiratory infections as the main reasons of death (66). Furthermore, it highlighted the excess mortality caused by violence (66). Violence was also reported as a major challenge by many households spontaneously (66).

Lastly, we found that 62% of the people who died did seek care but then still died (66). Problems to find adequate health care were additionally reported as challenges in response to the open questions (66). The reasons will need further research, possible explanations could include low-quality care, lack of diagnostic skills, lack of medicines or late presentation, or a combination of the above (66).

Our survey might have been affected by recall bias, reporting bias and survival bias (38,66). Moreover, the classification of cause of death was based on verbal reporting by household members and lacked clinical verification (66). In addition, we could not reach four of 16 communes in Ouaka because of security risks; this might have contributed to underestimation of the mortality as the places excluded were less accessible and more violent (66). We believe that our survey design also had specific strengths including a) the use of satellite imaging for sampling that allowed us to use a recent sampling frame and reduced sampling challenges typically associated with population-based cluster surveys (63), b) the omission of all other questions not directly related to mortality to avoid a focus on more pleasant or easier-to-measure content by surveyors, c) the opening question contributed to establishing rapport with the household and allowed us to elicit context information that helped to interpret our findings and d) the additional questions around birth and newborns enabled us to establish the birth rate and newborn deaths with more certainty than previous designs (66).

The survey was able to provide information for following evidence-based programming recommendations based on indicators of population health status and public health threats:

- Given the high proportion of children in the population and the high proportion of malaria and other preventable diseases as causes of deaths, we recommend to re-enforced MSF's focus on child health and malaria and a provision of services as close to the community as possible (66,90).
- The high maternal mortality rate was unexpected and concerning; maternal health was not a programmatic priority prior to the survey and we recommend to consider the re-prioritisation of maternal health services on community-level as well as follow-up operational research to confirm the MMR and to find out more about reasons for maternal deaths (66).
- The mortality estimates will be serving as a baseline for future program evaluation (66).

Recommendations based on indicators of health system performance:

- With regards to health-seeking behaviour, no lack of trust in formal health care nor lack of knowledge was identified, however, accessibility and the need for cost-free and close-to-home healthcare were repeatedly mentioned and re-affirms MSF's strategy of continuing and expanding integrated community care beyond children under five years of age (66,90).
- An additional focus for further research should be the quality of health care as lack of medication and staff were mentioned as challenges and the high proportion of persons who sought health care before death but then died warrants an investigation of quality of care (66).

Overall, our survey provided an account of concerning health indicators and reinforced communication and advocacy efforts to highlight the ongoing humanitarian crisis unfolding in CAR (91).

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Conflict and Health

RESEARCH Open Access

Mortality beyond emergency threshold in a silent crisis– results from a population-based mortality survey in Ouaka prefecture, Central African Republic, 2020

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Abstract

Background: The Central African Republic (CAR) suffers a protracted conflict and has the second lowest human development index in the world. Available mortality estimates vary and differ in methodology. We undertook a retrospective mortality study in the Ouaka prefecture to obtain reliable mortality data.

Methods: We conducted a population-based two-stage cluster survey from 9 March to 9 April, 2020 in Ouaka prefecture. We aimed to include 64 clusters of 12 households for a required sample size of 3636 persons. We assigned clusters to communes proportional to population size and then used systematic random sampling to identify cluster starting points from a dataset of buildings in each commune. In addition to the mortality survey questions, we included an open question on challenges faced by the household.

Results: We completed 50 clusters with 591 participating households including 4000 household members on the interview day. The median household size was 7 (interquartile range (IQR): 4—9). The median age was 12 (IQR: 5—27). The birth rate was 59.0/1000 population (95% confidence interval (95%-CI): 51.7—67.4).
The crude and under-five mortality rates (CMR & U5MR) were 1.33 (95%-CI: 1.09—1.61) and 1.87 (95%-CI: 1.37–2.54) deaths/10,000 persons/day, respectively. The most common specified causes of death were malaria/fever (16.0%; 95%-CI: 11.0–22.7), violence (13.2%; 95%-CI: 6.3–25.5), diarrhoea/vomiting (10.6%; 95%-CI: 6.2–17.5), and respiratory infections (8.4%; 95%-CI: 4.6–14.8). The maternal mortality ratio (MMR) was 2525/100,000 live births (95%-CI: 825—5794). Challenges reported by households included health problems and access to healthcare, high number of deaths, lack of potable water, insufficient means of subsistence, food insecurity and violence.

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Conclusions: The CMR, U5MR and MMR exceed previous estimates, and the CMR exceeds the humanitarian emergency threshold. Violence is a major threat to life, and to physical and mental wellbeing. Other causes of death speak to poor living conditions and poor access to healthcare and preventive measures, corroborated by the challenges reported by households. Many areas of CAR face similar challenges to Ouaka. If these results were generalisable across CAR, the country would suffer one of the highest mortality rates in the world, a reminder that the longstanding "silent crisis" continues.

Keywords: Central African Republic, Mortality survey, Quality of health care, Health services accessibility, Mortality, Maternal mortality, Child mortality, Humanitarian emergency, Violence, Armed conflicts

Background

"*One day, you will come back and you won't find anyone here because the problems will have killed us all,*" a mother of 11 children told Médecins Sans Frontières (MSF) staff in Ouaka prefecture in Central African Republic (CAR) in August 2018 [1].

CAR has suffered decades of political unrest and conflict, and the people of the Central African Republic are trapped in a cycle of indiscriminate violence [2, 3]. A coup d'état followed by a counterinsurgency in 2013 resulted in more than half a million displaced people and an unknown number of deaths [4]. Episodes of violent attacks subsequently continued across the country [5]. In February 2019, the Khartoum peace deal was signed between the government and 14 armed groups – the sixth peace agreement that has been negotiated since 2013 [6, 7]. However, armed actors continue to commit serious human rights abuses against civilians across the country and more than 70% of the country remains under the control of armed groups [5]. In 2018, CAR was ranked 188th out of 189 countries according to the human development index [8]. It is currently ranked as the 6th most fragile state in the world [9]. CAR has long been referred to as being in a state of "silent crisis", with many actors pressing that the country has not received the attention or support merited by the difficulties it faces [10, 11]. It is consistently one of the countries that comes furthest from reaching UN funding appeal targets [12].

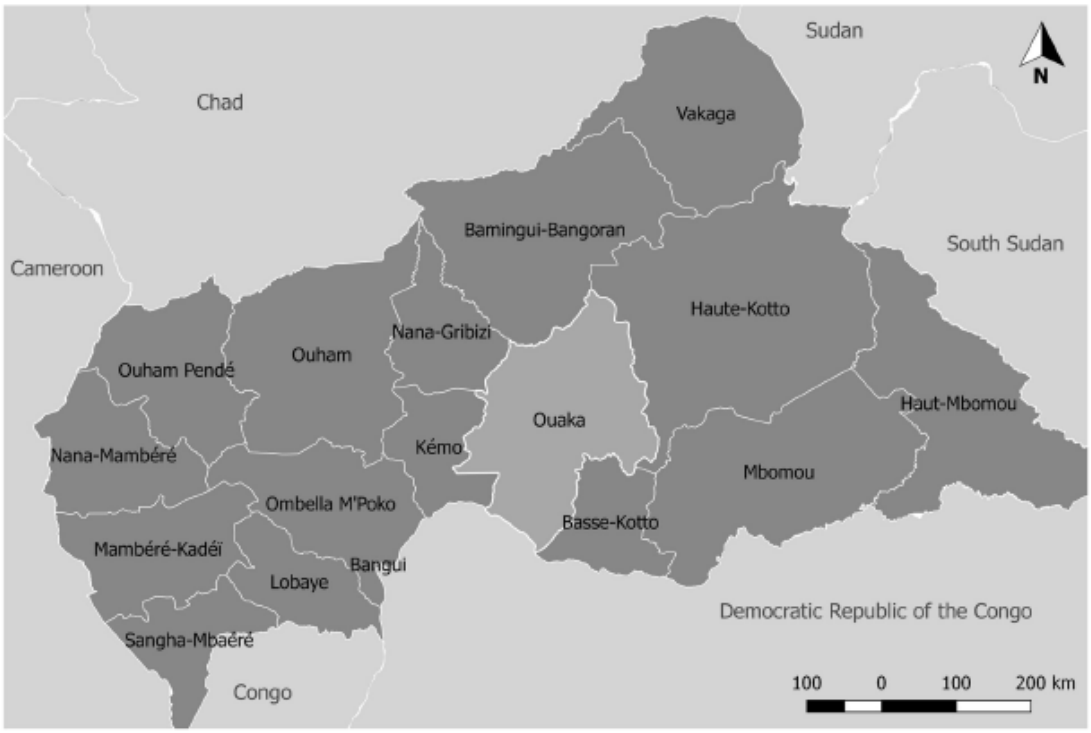
CAR is one of the lowest ranking countries in the world for a range of health indicators. The average life expectancy of 52.8 years in 2018 is one of the lowest in the world [13]. The median age of the population is estimated at 17.6 years, the second youngest population worldwide [14]. The estimated national maternal mortality ratio (MMR) is the 5th highest in the world at 829 deaths/100,000 live births in 2018 [15]. The estimated birth rate is 35.3 births per 1000 population per year [16], while the infant and neonatal mortality rates are 84 and 41 per 1000 live births respectively, all amongst the highest in the world [17].

The UN estimated a crude mortality rate (CMR) of 12.3/1000/year (equivalent to 0.34/10,000/day) for 2018 [18]. The 2019 and 2018 nationwide SMART surveys estimated higher mortality rates, with a national CMR estimate of 0.84 and 0.73/10,000/day respectively [19, 20]. The same SMART surveys estimated a national under 5 mortality rate (U5MR) of 1.12/10,000/day for 2019 and 0.76 for 2018. A number of regional mortality surveys in 2018 and 2019 estimated varying rates, with some being higher than those estimated by the national SMART surveys and the UN [21–24]. The discrepancy in mortality estimates, and the varying, and sometimes unclear methodologies of these surveys limit their reliability and prevent comparison between areas or over time.

Ouaka prefecture (Fig. 1) has an estimated population of 376,821, which represents 7.1% of CAR's population [25]. The number of internally displaced persons (IDP) in Ouaka decreased from nearly 80,000 in June 2019 to just over 45,000 in April 2020 [26, 27]. Ouaka's capital, Bambari, has gone through periods of armed conflict since 2014. Prior to a recent upsurge in conflict since mid-December 2020 [28], the last most significant clashes between armed groups took place in January 2019 and resulted in a strong response by the United Nations Multidimensional Integrated Stabilization Mission in the Central African Republic (MINUSCA) [29, 30]. Between then and the recent upsurge in December 2020, Ouaka prefecture had not experienced the same levels of violence as it had before. However, the sustained levels of criminality as well as conflicts between armed actors and attacks on civilians continued, mainly outside the city of Bambari [31].

The healthcare system in Ouaka prefecture includes 32 health posts, 31 health centres, 1 district hospital, 1 secondary hospital, and 1 regional hospital which are fully or partially functional [32]. MSF supports the regional hospital in Bambari, two health centres, one health post, seven points palu (providing care for simple malaria and diarrhoea) and community health promotion activities.

The recent SMART surveys estimated a slighyly lower CMR and U5MR for Ouaka than the national



This map is for information purposes only and has no political significance. This boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by MSF.

Fig. 1 Map of the Central African Republic and its prefectures

estimate – at 0.77/10,000/day (95% CI 0.47—1.26) and 0.90/10,000/day (0.41—1.96) respectively in 2019 [20], and 0.54/10,000/day (0.32—0.89) and 0.62/10,000/day (0.29—1.34) in 2018 [19].

We conducted a population-based mortality survey in Ouaka prefecture with the objective to estimate the CMR and U5MR, establish causes of death, and estimate the current birth rate and proportion of children < 5 years. Reliable mortality estimates will document the impact of the continued crisis on the health of the community. Knowledge of the most prominent causes of deaths and population structure will allow MSF to plan and prioritise programs accordingly.

Methods

We conducted a population-based two-stage cluster survey across Ouaka prefecture between 9 March and 9 April, 2020 in cooperation with the Ministry of Health and of the Population and the Central African Institute for Statistics and Economic and Social Studies (*Institut Centrafricaine des Statistique et des Etudes Economique et Sociales* (ICASEES)). The recall period commenced on the 26 May, 2019 (Mother's Day). We chose this date as it is a well-known celebration in CAR, it fit with our requirement that the recall period cover part of the rainy and the dry seasons, and it was close in time to the end of Ramadan in 2019 (4 June) and to the Catholic feast day of the Ascension (30 May), factors which might further aid recall amongst participants.

Using ENA software for SMART 2011 [33], we estimated a required sample size of 765 households and 3636 persons based on an estimated CMR of 0.72/10,000/day (double the UN estimate available at the time of protocol development [18]), precision of 0.25/10,000/day, design effect (DEFF) of 2, average household size of 5 [21], a non-response rate of 5%, and an average recall period of 265 days. We aimed to sample 64 clusters of 12 households each. The small cluster size was chosen to ensure it was feasible to complete clusters given the expected travel time to some areas, and to minimise time spent stationary in one location due to security risks.

We used two-stage cluster sampling. Cluster sampling is frequently used in settings such as CAR where limited resources, logistical challenges such as poor roads, and security concerns make simple or systematic random

sampling methods unfeasible [34–36]. First, we allocated clusters amongst the 16 communes of Ouaka proportional to population size according to population estimates for 2019 from ICASEES [25]. Secondly, we selected buildings as cluster starting points within each commune using systematic random sampling from a dataset of buildings. The sampling frame was created using a dataset of geographical building footprints (based on CAR Ecopia Building Footprint layer,©2019 Digital Globe, Inc) by commune [37, 38]. Buildings in settlements of less than ten buildings were excluded for feasibility reasons. From the cluster starting point, we selected subsequent households in a sequential manner by selecting the next closest building to the right until 12 households were included. We skipped buildings which were not households. In multi-household buildings, we selected one household randomly.

We defined a household as a group who slept under the same roof the previous night, or if a group was spread across several huts, who ate together the previous night. In eligible and consenting households, we included all persons who were members of the household during the recall period.

A priori, we did not exclude any area. We limited the number of clusters that could be replaced to 25%. If the locality of a starting point was deemed inaccessible in advance because of security concerns, we replaced it with another starting point in the same commune as per the stage two sampling previously described. If, on the day of the survey, we could not reach the starting point, or if there was no settlement at the starting point, we replaced the cluster with the next closest village on the return route. If after a second visit a household was still absent, we replaced it. If we did not achieve the target of 12 households after visiting all households in a settlement, we continued in the next closest settlement.

We undertook 4 days of training with the locally recruited survey team on the aim and objectives of the survey, methods, ethics, data protection and smartphone use. During the training, with the assistance of an interpreter, the correct and appropriate phrasing of the survey questions in Sango, the local language, were practiced. We conducted structured interviews (Additional file 1) with the head of household or a designate. The head of the household (or designate) could be any adult member of the household who could provide information on events in the household over the recall period. Households self-identified the head of the household. We started the survey with an open question about challenges the household faces ("What difficulties does your household and community face on a daily basis?") both to build rapport and to document general difficulties in the community. We noted the responses or a summary on paper. Then, using KoBoToolbox [39] on smartphones, we asked a series of questions on household composition during the recall period. For all identified members of the household during the recall period we asked demographic information, and noted arrivals or departures. For women aged 10–49 years we also asked about pregnancy during the recall period, and the outcome of the pregnancy. For deaths, the reported cause and place of death, and health seeking behaviour in the 2 weeks prior to the death was recorded. For the cause of death, the household was asked an open question and allowed to respond freely. If the response corresponded with one of the pre-defined categories listed in the questionnaire, (see Additional file 1) we marked this. If not, we noted as free text the reported cause of death or any additional information provided. The epidemiologist (ER who is a medical practitioner) reviewed these responses, and if sufficient information was available, categorised the cause of death.

The recall period ran from 26 May, 2019 to the interview date. For members who left/died or arrived/were born during the recall period, their person-time contribution was adjusted for the exact date of the event if known. Otherwise, the mid-month was used.

Using Poisson regression, we calculated the CMR and U5MR as deaths/10,000 population/day, the MMR as maternal deaths/100,000 live-births, and the neonatal mortality rate as deaths in the first 28 days of life/1000 live-births. We categorised the outcome of pregnancy as live-born, early pregnancy loss (< 3 months gestation or before a woman was visibly pregnant), late pregnancy loss (> 3 months or after a woman was visibly pregnant, including stillbirths). While we did not specifically ask if a pregnancy loss was a spontaneous or induced abortion, if the household mentioned it was an induced abortion this was noted.

We present descriptive analyses as proportions with 95% CIs for categorical variables and means and standard deviations (SD) or medians including interquartile ranges (IQR) for continuous variables. Where appropriate, we measured differences in proportions using Pearson $\chi 2$ test and present a p-value (p).

All analyses were conducted accounting for the survey sample weights and the effect of clustering induced by the two-stage sampling method. We undertook quantitative data analysis using Stata version 15.1 [40].

We digitalised the qualitative data collected in response to the introductory questions on difficulties faced. We coded it using a content analysis approach in order to identify themes and patterns from the data [41, 42]. We describe the identified themes and include a selection of illustrative quotations. Of note, during the first 2 days of interviews the responses of each individual household were not documented.

Of note, we planned to conduct six other surveys using the same methodology across CAR – four studies in the other prefectures where MSF is present (Ouham, Mambere-Kadei, Mbomou, and Haute Kotto); one in the capital region of Bangui; and one covering all other prefectures. We planned to merge and weight the results of each study to provide country-wide estimates. The studies were due to take place in a staggered fashion in the first half of 2020. Ouaka was the first prefecture to start and was almost complete when the first case of COVID-19/ Sars-CoV-2 was detected in CAR. Unfortunately, the other surveys, which had not yet started, could not proceed for a number of reasons including travel restrictions to and within CAR, redirection of resources towards the COVID-19 response, and uncertainty regarding the impact of COVID-19 on the security context in CAR.

Results

We completed 50 clusters across 12 communes (Fig. 2). Of the initial 64 clusters sampled, we discarded 21 due to insecurity and/or inaccessibility. A replacement cluster was accessible for seven of the discarded clusters. We did

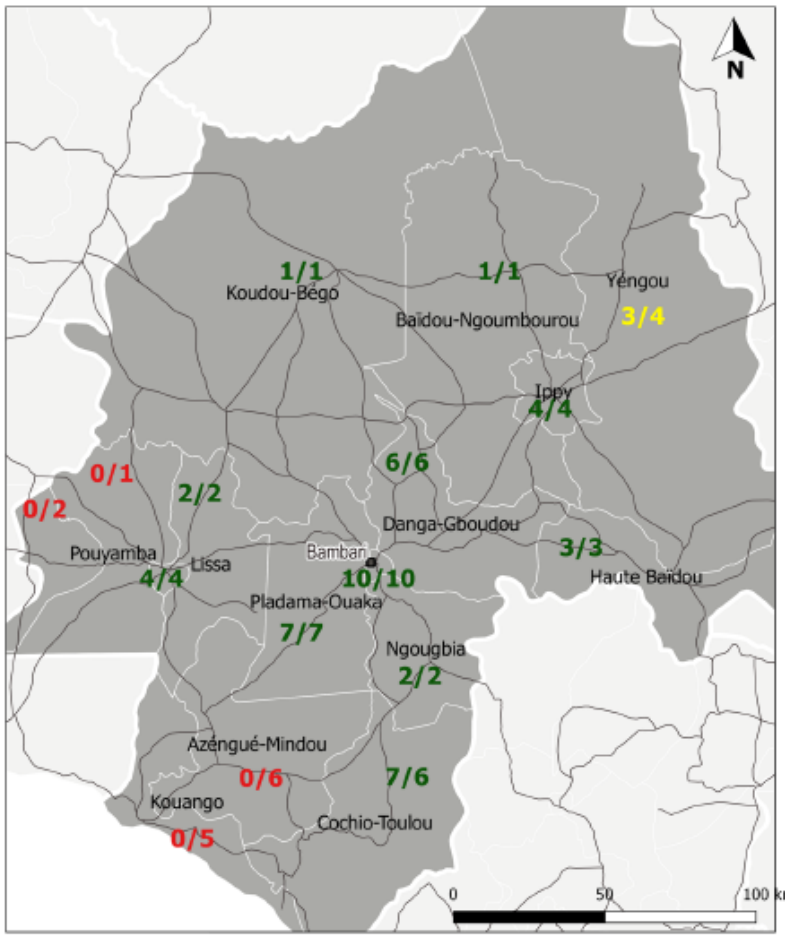


Fig. 2 Number of completed clusters for each commune of the prefecture of Ouaka, Retrospective mortality study, Ouaka, CAR, 2020

not complete any points in 4 of the 16 communes in the prefecture of Ouaka: Azengue-Mindou, Kouango, Pouyamba and Kobadja, due to insecurity in the commune or along the access route.

For 3 cluster starting points, no inhabited building could be found upon arrival at the point. We replaced these with the next nearest village passed.

We visited 693 households of which 93 were absent (13.4%) and 9 refused to participate (1.3%); of 600 households present, 591 (98.5%) participated. In the included households, there were 4272 household members during the recall period and 4000 household members on the interview day. There were 198 household members born and 14 who joined the household, while 160 died and 112 left the household during the recall period (Table 1). The median household size was 7 persons (IQR 4–9; mean 7.2 with 95% CI: 6.6–7.7).

Study population

The median age of the population was 12 years (IQR 5—27); 14 years (IQR 5—27) for females and 12 (IQR 5—28) years for males. The mean age was 18.1 years (95% CI: 17.6—18.7); same for males and females (18.1 years; 95% CI: 17.4—18.9 for both). Females contributed to 52.4% (2223/4272; 95% CI: 50.8—54.0%) of the population. Children under-five made up 22.8% (969/4270; 95% CI: 21.4—24.3%) of the population (Fig. 3 and Table 2). Persons aged 60 years or over made up 3.3% (144/4270; 95% CI: 2.7—4.0%) of the population.

Pregnancy and birth

Amongst the total population present on the day of the interview, 3.0% (120/4000; 95% CI: 2.5—3.5) were currently pregnant. The proportion of females aged 10 to 49 years who were pregnant during the recall period was 29.1% (346/1179; 95% CI: 26.4—31.9%). The median age of females who were pregnant at any stage during the recall was 23 years (IQR 19—29 years). Four females who were pregnant were under the age of 15, with the youngest being 12 years of age.

Of the 220 reported pregnancies which ended during the recall period, 87.1% (194/220; 95% CI: 80.2—91.9%) resulted in a live-birth (199 neonates due to five sets of twins); 5.8% (13/220; 95% CI: 3.1—10.7%) ended in early pregnancy losses and 5.3% (10/220; 95% CI: 2.7—10.1%) in late pregnancy losses and an additional four cases (1.8%, 4/220; 95% CI: 0.4—7.8%) were reported as induced abortions. We estimated the crude birth rate at 59.0 births per 1000 population per year (95% CI: 51.7—67.4).

Table 1 Arrivals and departures of included household members during the recall period, Retrospective mortality survey, Ouaka, CAR, 2020

Status during recall period	N	
Present at start		4060
Arrivals		212
Births	198	
Other arrival	14	
Departures		272
Deaths	160	
Other departure	112	
Present at end (during the interview)		4000

Mortality and causes of death

A total of 160 deaths were reported during the recall period. Of these, 29.4% (47/160; 95% CI: 22.4—37.4%) were in children under-five, and 59.2% (96/160; 95% CI: 49.3—68.3%) were in males.

The CMR was 1.33 deaths/10,000 persons/day (95% CI: 1.09—1.61), equivalent to 48.4 deaths/1000/year. The U5MR rate was 1.87 deaths/10,000 persons/day (95% CI: 1.37—2.54), and the neonatal mortality rate was 32.0/1000 births (95% CI: 14.6—70.1).

There was not a statistically significant difference in the CMR over different seasons of the recall period. From 26 May, 2019 (start of recall period) to 31 August, 2019, the CMR was 1.16 (95% CI: 0.84—1.61); from 1 September, 2019 to 31 December, 2019, the CMR was 1.11 (95% CI: 0.84—1.48); and from 1 January, 2020 to the end of the survey, the CMR was 1.46 (95% CI: 1.1—1.91).

Overall, the most frequently specified causes of death reported were fever/malaria (26/160; 16.0%; 95% CI: 11.0—22.7%), violence (22/160; 13.2%; 95% CI: 6.3—25.5%), and diarrhoea/vomiting (16/160; 10.6%; 95% CI: 6.2—17.5%) (Table 3). There was no evident seasonality of reported causes of death (data not shown).

Violence was the most common specified cause of death among participants ≥5 years, accounting for 16.7% (20/113; 95% CI: 7.7—32.5) of deaths. Males accounted for 20 of the 22 violent deaths. Violent deaths were reported by 16 households across 11 clusters and 7 communes: Bambari (n=10), Yengou (n=4), Cochio-Toulou (n=3), Danga-Gboudou (n=2), Lissa (n=1), Grimari (n=1), and Baidou- Ngouboudou (n=1). We did not ask specific questions relating to violent deaths, but when additional information was provided, the perpetrators were reported as armed groups (n = 13), bandits (n = 3), and a spouse (n = 1). The type of injuries inflicted were reported as gunshots (n = 5; specifically reported to have been caught in cross-fire in 4 cases), slashing of throat (n = 3), stabbing (n = 1), gunshot and slashing of throat (n = 1), and being pulled along the roadside by a vehicle (n = 1). For 11 cases it was reported that the victim was attacked or killed, but the exact method was not

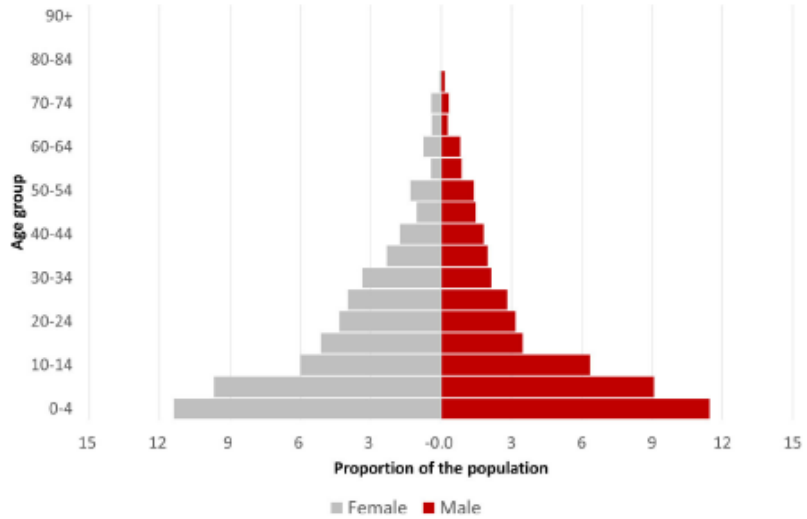


Fig. 3 Age distribution of population by five-year age groups and by gender; Retrospective mortality survey, Ouaka, CAR, 2020

reported. The violent deaths of two siblings occurred together and were related to a conflict in a neighbouring prefecture. The violent deaths of 4 members of the same household occurred together when they are reported to have been attacked by bandits as they travelled as part of the transhumance (the seasonal movement of pastoralists with their livestock). Otherwise, violent deaths were not clustered in time or related to known armed offensives.

For 48 deaths a specific cause was not identified. For 44 of these, the household could describe symptoms or the circumstances which preceded the death. However, these could not be reliably attributed to a specific cause (e.g. 'vomiting blood with cough'; 'swelling of legs, diarrhoea, weight-loss for several months') or the reported cause would not itself explain the death (e.g. sorcery). (See Additional file 2).

Five maternal deaths were identified – one following an early pregnancy loss and was preceded by abdominal pain and fever; one occurred intrapartum in hospital; one occurred postpartum following a procedure to clear the uterus; and two followed an abortion induced by taking medicines. Amongst women of reproductive age, 13.9% (5/34; 95% CI: 6.8—26.2) of deaths were maternal. The MMR was 2525/100,000 live-births (95% CI: 825—5794).

Healthcare seeking behaviour

Amongst those who died, 62.0% (99/160; 95% CI: 53.2—70.0%) reportedly sought care in a healthcare facility in the 2 weeks preceding death (Table 4). There was not a statistically significant difference in the proportion seeking care in a healthcare facility between males and females (61.9% vs 62.1%; $p = 1.0$) or between those < 5 years and ≥ 5 years (66.9% vs 60.0%; $p = 0.4$).

All cases of maternal deaths ($n = 5$) and malnutrition ($n = 2$) sought healthcare in the 2 weeks preceeding their deaths and more than two-thirds of cases who died of measles, malaria, respiratory infections and diarrhoea did so.

In all cases where healthcare was not reported to have been sought in a healthcare facility prior to the death (61/160; 38.0%; 95% CI: 30.0—46.8), the most common reasons for not seeking healthcare were immediate death or very short illness ($n = 30$), followed by a lack of money for consultations ($n = 15$), self-medication ($n = 8$), visiting a traditional healer ($n = 7$), security concerns ($n = 3$), and distance to a healthcare facility ($n = 3$).

Challenges reported by the households

Responses to the open question on challenges the household faced in the past year were documented for 520 of 591 participating households.

The most common theme was related to health and healthcare (378 households). The households described a high incidence of specific illnesses, in particular the burden of gastrointestinal illnesses: *"Diarrhoea, vomiting is widespread in this household"* [household 172, cluster 15, Danga-Gboudou commune]; malaria: *"The children have malaria constantly"* [household 231, cluster 21, Pladama-Ouaka commune]; and measles: *"We suffer a lot from measles"* [household 575, cluster 71, Ippy commune].

Table 2 Child and adult populations, by gender (number and weighted proportions; $n = 4272$); Retrospective mortality survey, Ouaka, CAR, 2020

Age	All participants		Females		Males		Female to male ratio
	n	%	N	%	n	%	
0—4 years	969	22.8	477	11.4	492	11.5	1.0
< 12 months	*215*	*5.1*	*105*	*2.5*	*110*	*2.6*	
0—2 months	*61*	*1.4*	*31*	*0.7*	*30*	*0.7*	
3—5 months	*62*	*1.5*	*35*	*0.8*	*27*	*0.7*	
6—8 months	*57*	*1.3*	*23*	*0.6*	*34*	*0.8*	
9—11 months	*35*	*0.9*	*16*	*0.4*	*19*	*0.5*	
12—23 months	*147*	*3.4*	*63*	*1.5*	*84*	*1.9*	
24—35 months	*201*	*4.8*	*104*	*2.5*	*97*	*2.3*	
36—47 months	*211*	*5.0*	*100*	*2.4*	*111*	*2.6*	
47—59 months	*195*	*4.6*	*105*	*2.6*	*90*	*2.1*	
5—9 years	803	18.8	415	9.7	388	9.1	1.1
10—14 years	527	12.4	255	6.0	272	6.4	0.9
14—19 years	371	8.6	217	5.1	154	3.5	1.5
20—24 years	324	7.5	183	4.3	141	3.2	1.4
25—29 years	288	6.8	166	4.0	122	2.8	1.4
30—34 years	232	5.5	140	3.4	92	2.1	1.6
35—39 years	186	4.4	100	2.3	86	2.0	1.2
40—44 years	149	3.6	72	1.8	77	1.8	1.0
45—49 years	108	2.5	46	1.1	62	1.5	0.7
50—54 years	112	2.7	54	1.3	58	1.4	0.9
55—59 years	57	1.3	20	0.4	37	0.9	0.5
60—64 years	66	1.6	33	0.8	33	0.8	0.9
65—69 years	29	0.7	17	0.4	12	0.3	1.4
70—74 years	34	0.7	20	0.4	14	0.3	1.3
75—89 years	11	0.3	4	0.1	7	0.2	0.4
80+ years	4	0.0	3	0.0	1	0.0	2.3
Unknown	2		1		1		
Total	4272		2223	52.4	2049	47.6	1.1

Difficulties in accessing healthcare due to either absence of healthcare facilities or distance were frequently cited (64 households): "*...it is necessary to go to Bambari for treatment*" [household 168, cluster 14, Pladama-Ouaka commune]; as were financial barriers to accessing care or medication (34 households): *"We have a health centre but that requires money, we don't have money"* [household 244, cluster 22, Pladama-Ouaka commune]. Lack of medicines and lack of (trained) staff in the healthcare facilities were described often (23 households): "*We have a health centre which doesn't have enough medicines*" [household 251, cluster 22, Pladama-Ouaka commune]; *"The centre does not have all the means to save lives here"* [household 553, cluster 70, Cochio Toulou commune].

Challenges related to reproductive health were mentioned by 14 households, including spontaneous and induced abortion, stillbirths, infertility, illness during pregnancy and access to maternal health care: "*The women have serious problems while they are pregnant*" [household 514, cluster 57, Cochio Toulou commune]; "*Care of pregnant women is not available at the centre which occasionally leads to the deaths of some pregnant women on the site*" [household 282, cluster 25, Pladama-Ouaka commune].

Challenge related to deaths and bereavement were not uncommon (67 households). Several households spoke generally about a high number of deaths in the family or the village: "*Too many deaths in our household given this crisis*" [household 108, cluster 9, Bambari commune]; while others spoke of the deaths family members, including outside the recall period. Households spoke of difficulties in looking after children after the death of a

Table 3 Causes of death by age group (number and weighted proportions), Retrospective mortality survey, Ouaka, CAR, 2020

Cause of death	Total		< 5 years		≥5 years	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Malaria/fever	26	16.0 (11.0—22.7)	15	30.5 (17.8—47.1)	11	9.9 (5.9—16.2)
Violence	22	13.2 (6.3—25.5)	2	4.8 (0.6—28.8)	20	16.7 (7.7—32.5)
Diarrhoea/vomiting	16	10.6 (6.2—17.5)	11	24.0 (11.9—42.7)	5	5.0 (1.9—12.2)
Respiratory infection	13	8.4 (4.6—14.8)	3	6.8 (2.1—20.1)	10	9.1 (4.6—17.1)
Neonatal	6	3.5 (1.6—7.5)	6	11.9 (5.3—24.7)		
Maternal	5	3.1 (1.4—6.8)			5	4.4 (2.0—9.4)
Measles[a]	4	2.6 (1.0—6.9)	3	6.6 (2.1—19.0)	1	0.9 (0.1—6.7)
Trauma/accident	3	2.3 (0.7—7.3)	1	2.3 (0.3—16.2)	2	2.3 (0.5—9.3)
Malnutrition	2	1.3 (0.3—4.9)	1	2.4 (0.3—16.5)	1	0.9 (0.1—6.0)
Other – specified[b]	15	9.3 (5.4—15.3)	0		15	13.1 (7.7—21.3)
Unknown	48	29.9 (21.7—39.6)	5	10.6 (4.2—24.3)	43	37.9 (26.6—50.6)
Total	160		47		113	

[a]One additional death in a child < 5 years was reported as having measles and malaria. The cause of death has been classified as malaria/fever for the analysis
[b]Includes: hernia ($n = 4$), 2 of which died post a surgical intervention; typhoid ($n = 4$); diabetes ($n = 2$); asthma ($n = 1$); snake-bite ($n = 1$); mumps ($n = 1$); meningitis ($n = 1$); and an abscess ($n = 1$))

parent: "*Lots of grandchildren to look after and I don't have the means to look after them properly. Their mother and father died 2 or 3 years ago*" [household 55, cluster 5, Bambari commune]; "*My brother died and his children are my responsibility*" [household 356, cluster 36, Ippy commune]. Several households were headed by widows, and other households spoke of the number of widows in the community: "*After the crisis there are a lot of widows*" [household 131, cluster 11, Danga-Gboudou commune].

Problems related to insecurity or conflict were common (130 households), mainly related to armed groups. Across nearly all interviews there were references to the conflict, referred to as "*the events*", "*the crisis*", and "*the conflict*". Many households spoke of deaths related to conflict including deaths outside of the recall period: "*I lost my wife and my 3 month old child due to crossfire*" [household 326, cluster 30, Ippy commune]. Households spoke of stress caused by conflict related deaths: "*Too many cases of death in our household given this crisis; too much stress given these cases of death*" [household 108, cluster 9, Bambari commune]. Households described the general menace to the civil population caused by the presence of armed groups and displacement due to security: "*We have to move every year*" [household 426, cluster 44, Lissa commune]. They also recounted how security issues limit their movements and the consequences of this: "*We can't go to the fields*" [household 187, cluster 16, Danga-Gboudou commune]; "*Roadblocks for the sick to go to the health centre which caused the death of my wife and children*" [household 201, cluster 17, Haute Baidou commune]. Some households reported taxes or fines imposed by armed groups on households and villages. Several households

Table 4 Reported health seeking behaviour amongst those that died ($N = 160$), Retrospective mortality survey, Ouaka, CAR, 2020

	Total		< 5		≥5	
	n[a]	% (95% CI)	n[a]	% (95% CI)	n[a]	% (95% CI)
Healthcare facility	99	62.0 (53.2—70.0)	32	66.9 (51.0—70.7)	67	60.0 (50.0—69.1)
Community health Facility	*41*	*27.1 (18.1—38.4))*	*19*	*42.5 (26.6—60.1)*	*22*	*20.7 (21.2—32.9))*
Health centre	*13*	*7.1 (3.3—14.5)*	*4*	*8.1 (2.3—25.3)*	*9*	*6.6 (3.2—13.2)*
Health post	*28*	*20.0 (12.4—30.9)*	*15*	*34.3 (21.2—50.3)*	*13*	*14.1 (7.1—25.9))*
Hospital	*59*	*35.3 (26.4—45.3)*	*13*	*24.5 (13.5—40.3))*	*46*	*39.8 (29.9—50.5)*
Self-medication	9	5.3 (2.9—9.7)	2	4.3 (1.1—15.2)	7	5.7 (2.8—11.5)
Traditional practitioner	7	4.7 (2.2—9.9)	1	3.0 (0.4—19.9)	6	5.4 (2.3—12.5)
No care sought	46	28.7 (20.3—38.8)	12	25.6 (15.0—40.5)	34	29.9 (20.1—42.0)
Total	160		47		113	

[a]more than one option could be noted

recounted specific incidents perpetrated on a household member by armed groups: "*She sells alcoholic drinks but when the armed groups arrive, they take it and don't pay*" [household 163, cluster 14, Danga-Gboudou commune]. Intra-familial conflict and missing household members related to the conflict were also mentioned. Problems related to theft and lootings, in particular armed thefts, were also mentioned. Several households reported having been plundered, and their houses being burnt down, in the past year: "*They burnt my house, I lost everything*" [household 579, cluster 72, Yengou commune].

Themes relating to poor living conditions were also common. A lack or absence of clean drinking water was frequently mentioned (198 households): "*To access water we must go 3km into the bush*" [household 541, cluster 66, Pladama-Ouaka commune]. Households spoke about the dirty water and linked the lack of clean water to the gastrointestinal illnesses they suffer: "*The lack of potable water means we drink backwater which results in stomach aches, intestinal worms*" [household 182, cluster 16, Danga-Gboudou commune]. Problems related to food insecurity (139 households): "*We live on only wild yams*" [household 131, cluster 11, Danga-Gboudou commune]; financial or other difficulties in means of subsistence (151 households): "*we have money difficulties*" [household 322, cluster 29, Ippy comune]; lack of non-food items including bednets (49 households): "*following the events we were looted*" [household 578, cluster 72, Yengou commune]; and lack of shelter were other common themes: (20 households): "*we don't have a tarpaulin for our roof*" [household 455, cluster 52, Koudou-Bego commune].

Discussion

Our survey showed a very young population with a high birth rate that is experiencing a high number of deaths affecting all members of society: adults, children and mothers. The median age was substantially younger than previous estimates at 12 years, while the mortality rates far exceeded previous estimates and the CMR crosses the threshold for an acute humanitarian emergency of 1 death/10,000 persons/day [18–20, 34, 43, 44].

Our estimate of the CMR in Ouaka for the period between May 2019 and April 2020 of 1.33 deaths/10,000 persons/day (95% CI: 1.09—1.61) is higher than other recent estimates for Ouaka, and approximately 4-times the UN national estimate of 0.34 deaths/10,000/day [18–20]. A possible reason could be that previous surveys included additional items such as malnutrition assessments and there is some evidence that mortality-only surveys, such as this one, might improve mortality estimates [45, 46]. In addition to the high CMR, deaths and their psychological and social impact was a strong theme emerging from the responses to the open question on challenges experienced by the household. Many households spoke of deaths which fell outside of the recall period, or the difficulties faced by being a widow or caring for orphans, suggesting a persistently high mortality rate.

We found violence to be the most common specified cause of deaths in those ≥5 years of age, responsible for 16.7% (20/113; 95% CI: 7.7—32.5) of deaths. An MSF survey in the neighbouring area of Alindao (Basse-Kotto prefecture) in 2019, found a similarly high proportion (15%) of violence-related deaths, albeit after an armed offensive in the area [21]. The large proportion of violence related deaths is particularly notable as there was not widespread or prolonged conflict across Ouaka during the recall period. Violence related deaths were reported in 7 out of 12 communes reachable for the survey, including Bambari town, an apparent "weapon free" zone with a strong presence of peace-keeping forces [47]. In addition, some areas, were not reached by the study due to localised security concerns. Therefore, violence related deaths may in fact be underestimated. It is also notable that most of the violence related deaths appeared to be single acts of violence rather than part of a particular offensive of armed groups. Correspondingly, in response to the open question, households across the prefecture spoke of the menace posed by armed groups, and how conflict, or the fear of violent attacks impacts on their daily lives. Incidents of non-fatal attacks were also reported.

The U5MR (1.87 deaths/10,000 persons/day (95% CI: 1.37—2.54)) rests just below the emergency threshold of 2 deaths/10,000 persons/day [34, 43, 44]. The upper confidence limit extends beyond the threshold, suggesting the U5MR may meet the emergency threshold. The U5MR is twice as high as that previously reported for Ouaka [19, 20]. Underreporting of child deaths, particularly neonatal deaths, during household surveys has been reported previously [45, 46, 48]. We started with an open question to build rapport with households, potentially making it easier for the household to discuss distressing or possibly stigmatising events such as the death of a child. In addition, our surveyors received specific training on the usual course of pregnancy and birth as well as asking sensitive questions about the outcome of birth. These features may have enabled us to capture more neonatal deaths than the previous SMART surveys and partially explain the difference in estimates. Another explanation may be because the SMART surveys in both years were conducted between September and October/December with a 90-day recall period and therefore may not have included the entire peak malaria season [19, 20].

Of deaths in children < 5 years, 64% were caused by three common and treatable illnesses: malaria, diarrhoea and respiratory infections. In addition, and unsurprisingly given a known measles outbreak in Ouaka during the recall period, measles was the 4th most common cause of death for children < 5. In response to the open question, households also spoke about a high incidence of these illnesses amongst children. The households additionally spoke of living conditions which would contribute to these illnesses such as lack of access to potable water and bednets Many households also spoke of barriers to accessing care including the absence of a healthcare facilities, distance, and cost.

CAR is estimated to have the 5th highest MMR in the world at 829 deaths/1000,000 live-births [15]. Our MMR estimate for Ouaka is considerably higher at 2525/100,000 live-births. While the lower confidence limit (825 deaths/100,000 live-birth) of our estimate is similar to the UN estimate, the upper confidence limit extends to 5794 deaths/100,000 live-birth, suggesting the true MMR in Ouaka could be up to seven times higher than the UN estimate for CAR [15]. Our MMR estimate indicates that Ouaka might be among the deadliest places for pregnant women globally. The estimated MMR needs to be interpreted with caution as the sample size was not powered to provide a precise estimate. However, we also found a high neonatal death rate and a high birth rate, both linked to maternal health and mortality. Poor health during pregnancy and difficulty in accessing care while pregnant was also reported by a several households in response to the opening question. Notably, two of the five maternal deaths were reported to have occurred following an induced abortion. Complications from unsafe abortions are responsible for 18% of maternal mortality in Africa [49]. While we did not delineate between safe and unsafe abortions, given the restrictive legal framework in CAR we can assume that the availability safe abortion care in this region is limited. Our findings indicate the need for improved access to sexual and reproductive health services, including safe abortion and post abortion care.

The mortality estimates of this study are considerably higher than recent UN estimates for CAR which raises questions about the reliability of the UN health statistics, and their underlying, sometimes outdated, data sources. Various UN mortality estimates for CAR cite sources for their modelled estimates including the 2003 census, the 2010 MICS and the 1995 DHS [15, 50–52] i.e. the latest source being more than a decade old and pre-dating the start of the conflict in 2013. The recent 2019 MICS estimated that 99 of 1000 children born die by their 5th birthday [53], which is in fact lower than the UN estimate for 2019 of 110. However, both estimates approximate to only a fraction of U5MR reported by this and other recent studies [19–21, 54]. Surveys with many components such as MICS, and surveys with long recalls can grossly underestimate mortality, especially in this region [45, 46, 55]. Estimates of mortality which are modelled from national data which is outdated, of low-quality, or not representative (due to the exclusion of inaccessible areas) may not reflect the true situation, particularly in unstable settings such as CAR, and therefore should be interpreted with caution. Well designed and implemented population-based mortality surveys can provide more reliable data in such settings [56].

Regarding the population structure, we found a younger median age and higher proportion of children < 5 years than estimated by the UN [14]. Two recent population-based surveys in other prefectures estimated a similarly high proportion of children < 5 years: 21.1% in in Alindao (Basse-Kotto) in 2019 [21], and 23.2% in Ouham Pendé in 2018 [57]. The 2019 MICS survey, estimated 20.2% of the population was < 5 years old [53]. Similarly, the birth rate we estimated is higher than the UN estimate [16]. There are no reliable civil registration data available to monitor birth or death rates in CAR. A population-based surveillance system implemented by MSF in Lobaye prefecture found a similar birth rate of 61.8/1000 person-years (95% CI: 54.7—6 9.9) in 2010 [58]. This potential underestimation of the birth rate may indicate an underestimation of population growth, which in turn may underestimate child and maternal care needs, vaccination coverage denominators and other crucial indicators for population health.

The reasons why many who sought healthcare still died was not explored. While a desirability bias may have caused over-reporting of healthcare seeking, other possibilities include: delays in seeking care; barriers to adhering to treatment; or because the care available was inadequate or of poor quality. Notably, very few households mentioned seeking care at a traditional practitioner and many reported seeking care at a health facility, which might also indicate some desirability bias. In response to the open question, some households questioned the quality of care available, speaking of a lack of medicines, healthcare workers or other means in healthcare facilities. It is increasingly recognised that increasing access to care and utilisation of services is not sufficient to improve child mortality if the care available is of poor quality [59].

The responses to the open question provided an insight into the challenges faced by the community and their impact on health. While health problems and access to healthcare was the predominant theme to emerge, other challenges were evident. Many of these have a clear direct impact on health such as food

insecurity and access to potable water, as manifested by the leading contribution of diarrhoeal disease to death in children While the high proportion of deaths related to violence detected in the mortality questionnaire does demonstrate the direct impact of conflict on health, it misses the long lasting psychological and social impacts which are evident from the responses to the open question. Other challenges reported, such as lack of shelter, non-food items and means of subsistence, are major contributors to the wider determinants of health. It is a reminder that improving health requires actions far wider than the provision of healthcare.

In response to these results, the MSF project in Ouaka will continue to focus on child health programmes, in particular the prevention and management of the main preventable and easily treatable illnesses. One method of doing this is the expansion of the coverage of integrated community case management (iCCM) to improve basic but quality healthcare for malaria, diarrhoea and respiratory infections in hard-to-reach areas. Furthermore, MSF will increase easily accessible basic pregnancy care and explore the magnitude and causes of maternal deaths further.

In addition to supporting operational decisions, this study aimed to document the impact of the continued crisis on the health of the community and to advocate for more comprehensive support for the country. Decades of political instability, limited development of structures, and cyclical conflict problems are inextricably and symbiotically linked, ultimately resulting in highly vulnerable communities [60]. Despite the hope arising from the 2019 peace agreement, the security and humanitarian situation across CAR had deteriorated in 2020 [61, 62]. A recent upsurge in violence across CAR has led to an even further deterioration, with over 276, 000 people displaced since mid-December 2020, widespread disruption of supply chains into and around CAR, and violations of basic international humanitarian law principles, including an armed offensives in Ouaka which damaged an MSF supported health centre [28, 63–65]. Between mid-December 2020 and early March 2021, 111 war-wounded patients were treated by MSF in Bambari [63]. Decreased patient consultations at MSF supported healthcare facilities have been noted, and access to certain areas of the prefecture by MSF teams has been blocked (personal communication MSF project Ouaka). Mortality might be even higher now than it was at the time of this survey.

Even prior to the current upsurge in conflict in late 2020, it was predicted that, 2.8 million people across CAR, more than half of the population, would require humanitarian assistance in 2021 [28]. Meeting the needs arising from CAR's protracted crisis requires considerable, sustained, and effective humanitarian and development support across all domains. However, since 2011, only between 38 and 70% or UN funding targets were met by donors [12].

Ouaka is not unique in the challenges it faces [61], making it a reasonable assumption that the results of this survey might be generalisable to other regions of CAR. We have shared the results with governmental and non-governmental agencies working in Ouaka and across CAR for programming and advocacy. We will use these results of this study to advocate for the people of Ouaka and CAR, both within CAR and globally.

Limitations

We cannot rule out underestimation of the true mortality as we were unable to include 4 communes due to insecurity in the area. It is possible that we have missed areas with worse living conditions and increased deaths due to violence and limited access to healthcare. The study is subject to limitations commonly associated with this study type including recall bias, reporting bias, and survival bias [34]. We relied on verbal reporting by the household head and causes of death were not verified through other sources. Non-specific symptoms such as fever and diarrhoea can have a wide differential diagnosis, particular in young children. Therefore, the reported causes of death may not reflect the exact contributors to mortality. The verbal reporting also resulted in a high proportion of unknown causes of death, many of which could be due to common morbidities as identified in the global burden of disease study [66] such as tuberculosis (TB) and HIV/AIDS with can have insidious clinical presentations. The global burden of disease data estimates TB, diarrheal diseases, lower respiratory tract infections, HIV/AIDS, neonatal disorders and malaria to be the most prominent causes of death [66].

Of note, the qualitative data arises from a single introductory question which asked what difficulties the household faces. While it has provided valuable data, a more comprehensive qualitative approach is required for a deeper understanding of challenges faced by the community. In addition, the responses to the open question were not recorded verbatim or audio recorded, which may have introduced a bias based on the surveyor's interpretation of the household's response or inter-surveyor variability in how responses were recorded. Translation from Sango to French by the surveyors may have introduced inaccuracies.

Lastly, we excluded buildings in settlements with less than 10 buildings from the sampling frame for feasibility reasons. Such settlements may be in rural remote areas, with less access to healthcare and therefore have a worse health status. By excluding them we may have underestimated the CMR.

Need for further research

To get a better understanding of the national health situation, the planned country-wide survey will be undertaken as soon as feasible. Given the lack of other reliable data, security permitting, we will aim to conduct mortality surveys every 5–10 years thereafter for as long as our program run. In addition, complementary studies should be carried out to get more precise estimates of maternal mortality and its causes. Further research is needed to understand barriers to available care, health seeking behaviour and health literacy.

Conclusion

While the region was not considered an acute humanitarian emergency at the time of the survey, we found high mortality estimates in excess of previous estimates, including a CMR which exceeds the emergency threshold [18–20, 34, 43, 44]. The reasons of death speak to poor living conditions, persistent violence and lack of access to healthcare and preventive measures.

The U5MR is also higher than previously estimated and nearing the emergency threshold but might still underestimate the true extent of deaths in children < 5 years. Violence continues to be a threat to life and to the physical, mental and social wellbeing of the civilian population despite the presence of MINUSCA forces and a reduction in fighting in the years prior to the study. The preventable and/or easily treatable illnesses of fever/malaria, diarrhoea, respiratory infections and measles are also leading causes of mortality, particularly amongst children < 5 years. Furthermore, the study showed that there are barriers to accessing healthcare, in particular distance to care and financial barriers. The fact that the majority of those that died reportedly sought care, might represent a troubling indicator for the quality of care available. The findings reinforce the need to increase access to free, proximate and good quality primary and secondary healthcare. The high MMR and neonatal mortality rate, the contribution of complications of induced abortions to maternal mortality, the high birth rate and the large proportion of pregnant women among women of reproductive age call for accessible reproductive healthcare including safe deliveries, contraception and safe abortion care.

The answer to our opening question provided a terrifying glimpse on challenges Central Africans face as part of their daily lives - even before the conflict intensified again in December 2020 - and are a reminder that improving health requires actions far wider than the provision of healthcare.

It appears that the challenges have changed little since 2018 when the mother of 11 from Ouaka foreboded that 1 day the "*…problems will have killed us all*". While this study is only of one prefecture, many areas of CAR face similar challenges to Ouaka. If the results found in this study were generalisable across CAR, it would suffer one of the highest mortality rates in the world. An upsurge in violence across CAR, including in Ouaka, since December 2020, has likely further worsened the humanitarian situation. Each year, CAR is far from meeting its UN appeal for funding targets, allowing a silent crisis to continue. To reduce mortality in CAR, a comprehensive approach aiming to improve in basic living conditions and assure access to quality healthcare and preventive measures, underpinned by the achievement of peace, is urgently needed.

Abbreviations

CAR: Central African Republic; CMR: Crude mortality rate; 95% CI: 95% confidence interval; DEFF: Design effect; HIV: Human immunodeficiency virus; ICASEES: Institut Centrafricaine des Statistique et des Etudes Economique et Sociales (*Central African Institute for Statistics and Economic and Social Studies*); IDP: Internally displaced person; IQR: Interquartile range; MINUSCA: Mission multidimensionnelle intégrée des Nations Unies pour la stabilisation en République centrafricaine (*United Nations Multidimensional Integrated Stabilization Mission in the Central African Republic*); MMR: Maternal mortality ratio; MSF: Médecins sans Frontières; TB: Tuberculosis; U5MR: Under-five mortality rate (mortality rate in children under 5 years of age); UN: United Nations

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13031-021-00385-2.

Additional file 1 Survey questionnaire in XML format, Retrospective mortality survey, Ouaka, CAR, 2020.

Additional file 2 Symptoms reported for deaths where the cause was not known ($N = 48$), Retrospective mortality survey, Ouaka, CAR, 2020.

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Authors' contributions

ER, AP and AK drafted the manuscript. ER, LL, LR, AO, JV, MCAG, MTO, SJP and AK developed the study protocol. AK was the principal investigator. ER, LL, XC, AO, MHer, MHej and AK implemented the study. CA supported the quantitative analysis and NG supported the qualitative analysis and interpretation. MD, KW and ST supported the interpretation of the results. All Authors reviewed the manuscript.

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Availability of data and materials

MSF has a managed access system for data sharing that respects MSF's legal and ethical obligations to its patients to collect, manage and protect their data responsibility. Ethical risks include, but are not limited to, the nature of MSF operations and target populations being such that data collected are often highly sensitive. Data are available on request in accordance with MSF's data sharing policy (available at: http://fieldresearch.msf.org/msf/handle/10144/306501). Requests for access to data should be made to data.sharing@msf.org.

Declarations

Ethics approval and consent to participate

We received ethical approval from the MSF Ethics Review Board (ERB) (ID 1987) and the national ERB of CAR (Comité Scientifique charge de la validation des protocoles d'étude et des résultats, Université de Bangui, Faculté de Science de la Sante) (No 2/UB/FACSS/CES/20). The Ministry of Health assented to the undertaking of the study.
On the day of the survey, we visited the village chief or a designate to inform them of the purpose of the study and seek their approval before proceeding. In the selected household, we provided the household head with oral and written information about the study and obtained oral consent.

Consent for publication

Not applicable.

Competing interests

None declared.

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Publisher's Note

2.2 Mortality, morbidity and health-seeking behaviour during the acute humanitarian crisis in Liberia, 2015

Kuehne A, Lynch E, Marshall E, Tiffany A, Alley I, Bawo L, Massaquoi M, Lodesani C, Le Vaillant P, Porten K, Gignoux E. Mortality, Morbidity and Health-Seeking Behaviour during the Ebola Epidemic 2014-2015 in Monrovia Results from a Mobile Phone Survey. PLoS Negl Trop Dis. 2016 Aug 23;10(8):e0004899. doi: 10.1371/journal.pntd.0004899. PMID: 27551750; PMCID: PMC4994996.

In 2014/2015 Liberia was affected by one of the biggest Ebola virus disease (EVD) outbreaks in history (92). From March 2014 to the end of the outbreak in Liberia in September 2015 10,666 cases of EVD including 4,806 deaths were notified in Liberia (92). The total number of cases and deaths reported is thought to represent the 'peak of the iceberg' only as an unknown figure of cases never accessed health care services and went unreported (93). In the presented study, MSF together with the MoH of Liberia set out to describe health-seeking-behaviour and to assess the crude and EVD-specific mortality in order to inform and potentially redirect their health programmes in Monrovia (67).

Population-based surveys conducting face-to-face interviews with households are considered to be the gold standard method for mortality surveys (17,38). However, the restrictions in movement and social distancing rules in Liberia during the Ebola epidemic rendered the implementation of a survey following standard methodology impossible. Instead, we conducted a mobile-phone-based survey using a simple random sample of mobile-phone owners who were logged into the network in Monrovia in the past 30 days (67). A text message was sent to all sampled phone numbers informing them that they have been selected for a survey by MSF and that they will receive 1 US Dollar phone credit if they agreed to participate (67). We aimed to include 8,660 household members in the survey and expected a non-response of 50% based on the network provider's experience with previous surveys (67). The survey covered a recall period from the 14th May 2014 (National Unification Day in Liberia) to the day of the survey (67).

However, we were faced with a response rate of only 13% and had to resample based on the same sampling frame to reach the required sample size (67). After two rounds of sampling (between 12/2014-03/2015), we were able to include 905 respondents, reporting health and mortality for 6,813 household members (overall response rate 9%) (67). Respondents came from all neighbourhoods in Monrovia but inclusion ratios varied from 31 participants/10,000 population to 111 participants/10,000 population (67).

We estimated a crude mortality rate (CMR) of 0.33/10,000/day (95% Confidence Interval (CI): 0.25-0.43) including an EVD-specific mortality rate of 0.06/10,000/day (95% CI: 0.03-0.11) (67). Additionally, we identified a total of 17 cases (including 10 cases that died) meeting the EVD case definition during the recall period of which 76% (13/17) were reported to have been hospitalised in an Ebola Treatment Unit (ETU) (67). In the 30 days prior to the survey, 4% (277/2,813) of household members reported to have been sick; 54% (150/277) were reportedly sick with malaria, followed by acute respiratory infections (10%; 28/277) (67). Among the household members sick with diseases other than EVD, 43% (121/276) did not seek care at a healthcare facility (67).

The non-EVD mortality seemed to be in keeping with previous estimates for Monrovia (94). Our study indicates that the overall mortality did not increase as much as feared by humanitarian actors; the emergency threshold for the CMR was probably not crossed (doubling of previous estimates or 1/10,000 population per day) (38,67). A similarly small effect on overall mortality was found in a survey in neighbouring Sierra Leone during the EVD epidemic (95). However, EVD did cause excess mortality (67). In addition, the health-seeking behaviour indicated that only about 3/4 of EVD cases were treated and isolated

in ETUs and overall close to half of all sicknesses were treated outside health facilities (67), as described previously in similar settings (95,96).

The study has some substantial limitations, among them are the following: the representativity of the sample is unclear as our sample included only persons who owned a phone and were literate (67). The response rate turned out to be as low as in high-income countries (97). Withstanding these limitations, our sample included household members from all neighbourhoods of Monrovia and had a similar age and household size as previous surveys and our estimates are in keeping with previous data (94,98), suggesting acceptable representativeness (67). Additional limitations are recall bias and social desirability biases, maybe more so as the participants might have been in a public space while participating in the interview as they were called on a mobile phone in an unknown location (67). The study was conducted later than initially planned and because of decreasing Ebola incidence at the time and recall bias, the number of deaths and the number of Ebola cases, might have been underestimated (67). Moreover, we have no baseline mortality data specifically for Monrovia and the mortality estimates available for Liberia might not have accurately reflected the baseline mortality in the capital city, thus making it possible that our estimate of non-EVD-related deaths of 0.27/10,000 (95%-CI: 0.20–0.36) persons per day does indeed present an increase from a previously lower (but unpublished) mortality rate in Monrovia (67).

To our knowledge, this was the first time a mobile-phone survey was conducted among the population in the middle of a humanitarian response. Our survey is affected by more uncertainties and potential biases than conventional population-based surveys. There is some indication that areas with better socioeconomic status were better represented than more deprived ones (e. g. varying participation ratio per neighbourhood, use of private clinics and low proportional malaria mortality). Given the movement restrictions on the ground, conducting a standard survey for method comparison was not possible. Of note, despite mortality surveys being the standard method to establish crude and excess mortality in humanitarian crises, only one other mortality survey conducted during the entire Ebola epidemic in West Africa (82) is to be found in the peer-reviewed literature, indicating the complications in implementing such surveys and need for alternative approaches to population-based survey methods for crises with access or security constraints. A mobile-phone survey would not be the first choice when access to the population is feasible but provides an option when field studies are impossible and mobile-phone coverage is good, such as in many urban crisis settings. Despite the limitations, the survey was able to provide information for evidence-based programming recommendations in humanitarian aid in Monrovia in 2015.

Recommendations based on indicators of population health status and public health threats:

- The estimated overall mortality did not increase to the extent predicted by many actors in Liberia. This might suggest that the direct and indirect impact of the EVD pandemic was potentially not as detrimental as feared. The absence of a large indirect effect on mortality suggests focusing additional activities on EVD care and interventions in health promotion rather than health care provision (67).
- EVD caused (unsurprisingly) substantial additional mortality and improvements in identifying and isolating EVD cases early are still required (67).
- The proportional morbidity analysis suggested that 54% of all morbidities reported for the past 30 days might have been malaria, which aligns with available estimates for the country (99) and re-affirms the need to strengthen health promotion of prevention measures for malaria (67).

Recommendations based on indicators of health system performance:

- The reported health-seeking behaviour indicated that a large proportion of the population sought care outside the healthcare system. Further community engagement is needed to identify reasons for not seeking care and to find ways of increasing utilisation, in order to improve health as well as to ensure suspect EVD cases can be identified early in health care services (67).

PLOS | NEGLECTED TROPICAL DISEASES

RESEARCH ARTICLE

Mortality, Morbidity and Health-Seeking Behaviour during the Ebola Epidemic 2014–2015 in Monrovia Results from a Mobile Phone Survey

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Data Availability Statement: The minimal data set underlying the findings of this study are available on request, in accordance with the legal framework set forth by Médecins Sans Frontières (MSF) data sharing policy (Karunakara U, PLoS Med 2013). MSF is committed to share and disseminate health data from its programs and research in an open, timely, and transparent manner in order to promote health benefits for populations while respecting ethical and legal obligations towards patients, research participants, and their communities. The MSF data sharing policy ensures that data will be available upon request to

Abstract

Between March 2014 and July 2015 at least 10,500 Ebola cases including more than 4,800 deaths occurred in Liberia, the majority in Monrovia. However, official numbers may have underestimated the size of the outbreak. Closure of health facilities and mistrust in existing structures may have additionally impacted on all-cause morbidity and mortality. To quantify mortality and morbidity and describe health-seeking behaviour in Monrovia, Médecins sans Frontières (MSF) conducted a mobile phone survey from December 2014 to March 2015. We drew a random sample of households in Monrovia and conducted structured mobile phone interviews, covering morbidity, mortality and health-seeking behaviour from 14 May 2014 until the day of the survey. We defined an Ebola-related death as any death meeting the Liberian Ebola case definition. We calculated all-cause and Ebola-specific mortality rates. The sample consisted of 6,813 household members in 905 households. We estimated a crude mortality rate (CMR) of 0.33/10,000 persons/day (95%CI:0.25–0.43) and an Ebola-specific mortality rate of 0.06/10,000 persons/day (95%-CI:0.03–0.11). During the recall period, 17 Ebola cases were reported including those who died. In the 30 days prior to the survey 277 household members were reported sick; malaria accounted for 54% (150/277). Of the sick household members, 43% (122/276) did not visit any health care facility. The mobile phone-based survey was found to be a feasible and acceptable alternative method when data collection in the community is impossible. CMR was estimated well below the emergency threshold of 1/10,000 persons/day. Non-Ebola-related mortality in Monrovia was not higher than previous national estimates of mortality for Liberia. However, excess mortality directly resulting from Ebola did occur in the population. Importantly, the small proportion of sick household members presenting to official health facilities when sick might pose a challenge for future outbreak detection and mitigation. Substantial reported

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interested researchers while addressing all security, legal, and ethical concerns. All readers may contact the generic address data.sharing@msf.org or Ms. Aminata Ndiaye (aminata.ndiaye@epicentre.msf.org) to request the data.

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health-seeking behaviour outside of health facilities may also suggest the need for adapted health messaging and improved access to health care.

Author Summary

During the Ebola outbreak in 2014/2015 more than 4,800 people died of Ebola in Liberia. Health care providers in the field have assumed that closure of health facilities and mistrust in existing structures resulted not only substantial additional deaths from Ebola but also impacted on death rate of other diseases and on the way people tried to seek health care. We conducted a mobile phone survey in Monrovia to identify deaths and diseases a household had faced since the beginning of the Ebola outbreak and the kind of health care they sought. We estimated that the non-Ebola-related death rate in Monrovia was not higher than previous national estimates for Liberia. However, additional deaths occurred in the population of Monrovia directly resulting from Ebola. Of the household members that were sick of any disease during the survey period, 43% did not visit any health care facility. The high proportion among the sick household members that sought health care in pharmacies or drug stores or by health care workers among their peers but outside health facilities emphasizes the importance of ensuring access to non-Ebola-related health care as outbreak control is challenged by sick community members staying undiagnosed and untreated.

Introduction

Between March 2014 and July 2015, more than 10,500 Ebola virus disease (EVD) cases, including over 4,800 deaths, occurred in Liberia; the majority of these cases was identified in Montserrado County, where the capital city of Liberia, Monrovia, is located [1].

However, official reported numbers of EVD cases might underestimate the size of the outbreak for several reasons: i) during the intense phase of the outbreak in August 2014, Ebola treatment units (ETUs) were overwhelmed with patients, some of whom were turned away uncounted [2]; ii) the continued identification of cases that had not been registered as contacts of known EVD cases beforehand indicates that contact tracing remained incomplete throughout the outbreak and cases are likely to have been missed [3] and iii) communities hesitated to send sick members to ETUs [2,4]. A capture-recapture study conducted in August 2014 suggested that actual case numbers could be three times higher than the number of notified EVD cases [5].

Health care providers in the field have assumed that closure of health facilities and mistrust in existing structures resulted not only in EVD-related excess morbidity and mortality but also had an impact on non-EVD morbidity and mortality: In Monrovia—similar to what has been described in other affected countries and cities [6]–the capacity of health care facilities was greatly reduced in August 2014 as compared to prior to the epidemic [7–10]. Even in health facilities that continued to provide health care in Monrovia, the number of consultations was reduced by at least 40% compared to previous years [7]. In addition, the health care system in Liberia lost at least 178 health care workers to EVD from the beginning of the outbreak until the end of 2014 [11]. Fear of EVD and mistrust in existing health care structures led to underutilization of services [7,8,12].

In 2013, crude mortality rates (CMR) in Liberia were reported between 0.22/10,000 persons/day [13], 0.25/10,000 persons/day [14] and 0.27/10,000 persons/day [15].

To quantify mortality and morbidity and to describe health-seeking behaviour in Monrovia during the EVD outbreak, Médecins Sans Frontières (MSF) conducted a mobile phone survey in Monrovia. The specific objectives were to a) retrospectively estimate the all-cause-mortality rate (non-EVD and EVD) during the recall period, b) retrospectively estimate disease-specific attack rates for non-EVD and EVD during the 30 days preceding the survey, c) retrospectively estimate the EVD attack rate during the recall period and d) describe health-seeking behaviour.

Methods

Study design, setting and period

The study was conducted in Monrovia, Liberia, from December 2014 to March 2015. Classical survey designs, such as household visits with face-to-face interviews, were determined unfeasible due to the risk of EVD transmission given the contact and movement requirements to implement a community household survey. To minimize these risks we chose instead to conduct a mobile phone based survey.

The survey covered a recall period from the 14th May 2014 (National Unification Day in Liberia) to the day of the survey. The study population included the whole population of greater Monrovia. Greater Monrovia is located at the northern portion of the Liberian coast at the mouth of the Mesurado River and extends across a series peninsulas and wetlands. Greater Monrovia consists of a population of about 1 million inhabitants (MSF operational data) and is the most urbanized area in Liberia, its capital and main port. Telecommunication using landlines is almost absent in most parts of Monrovia. The sampling frame therefore included households where at least one person in the household owned a Subscriber Identity Module (SIM) card from a selected large mobile phone network provider in Monrovia and had been connected to the network in Monrovia at some point in the 30 days prior to the date of the survey. The selected network provider had, according to the company, coverage of more than half of the population of Monrovia with customers in all age-groups that represented diverse socio-demographic strata.

Sample size

The calculation of the sample size is based on the crude mortality rate and the expected EVD attack rate. For an expected crude mortality rate of 0.5/10,000/day based on doubling of the national baseline mortality [13–15], a precision of 0.15 and a recall period of 255 days (from 15 May 2014 to mid-survey date, 24 January 2015), a total of 5,986 individuals in 1,197 households were needed in the sample, assuming an average household size of five household members. Assuming that real case numbers were threefold higher than those notified [5], and thus an expected attack rate of 0.51% for EVD during the whole study period (based on notified cases in the Liberian EVD patient database up to 9 November 2014 according to WHO data packages) and a precision of 0.15%, 8,660 individuals in 1,732 household were needed. Non-response was estimated at 50% as suggested by the telephone network provider, based on their usual response rates in previous telephone surveys. Therefore, 3,500 households were included in the sample.

Sampling procedures

The network provider drew a simple random sample of telephone numbers. The network provider sent a text message to the selected customers informing them that they had been randomly selected to participate in an MSF survey. Participants sent a text message if they agreed to have their phone number forwarded to MSF and received one US Dollar of free airtime after providing this consent (regardless of whether they eventually completed the survey when contacted by the surveyors). Trained MSF surveyors made a maximum of three attempts to contact

each telephone number. Respondents were only included in the survey if they were over 18 years of age, lived in greater Monrovia and consented to participation.

Definitions

Any sickness or death was counted as EVD-related if it fulfilled the Ebola case definition of the Liberian Ministry of Health (MOH) for suspect, probable or confirmed cases [16]. A household was defined as a group of people living under the same roof and sharing the same meal at least 3 times a week regardless of family ties.

Data collection

We trained 15 surveyors for three days to collect data using standardized questionnaires on tablets. Surveyors entered data directly into an Open Data Kit (ODK) form on the tablet during the telephone interview. At the end of each day the lead epidemiologist reviewed any recorded deaths and EVD cases together with the surveyors to ensure data quality.

Each respondent was asked to answer the questions on behalf of the entire household. For each household, the number of members of the household was recorded. Respondents were asked about any sick person in the household within the past 30 days. For each EVD case according to the case definition, information about symptoms, history of contact, isolation of the cases and burial circumstances (where applicable) was obtained. We also inquired about non-EVD deaths among household members during the recall period, along with cause of death according to the respondent and the circumstances of burial.

Data analysis

Reported EVD cases were compared to the case definition of the Liberian Ministry of Health.

We calculated disease specific attack rates in the past 30 days–and for EVD for the whole recall period–using the sampled population at the beginning of the recall period as the denominator.

Crude mortality rate (CMR) and EVD-related-mortality-rate per 10,000 population per day were calculated using the recall period as the denominator. Household members who left, arrived or were born during the recall period were considered as having lived in the household half of the recall period. For deceased members the exact time under observation (14 May 2014 to date of death) was used as a denominator. Statistical analysis was conducted in STATA version 13 (Stata corporation, Texas, USA).

Ethical considerations

The procedures conducted were in accordance with the ethical standards of the Helsinki Declaration. Additionally, the National Research Ethics Board of the Ministry of Health of Liberia granted ethical approval and authorization to conduct this survey.

An information sheet was read and explained to each respondent at the beginning of the interview. Participation was voluntary. For each respondent, oral informed consent was requested and this response was documented. No personal identifiable information was collected. Telephone numbers were kept confidential and stored securely.

Results

Response and household size

768 (22%) persons of 3,500 that were contacted by the network provider from 19 December to 2 January 2015 responded to the text message and agreed to be contacted for the survey, 446

Table 1. Response in two rounds of sampling; mortality, morbidity and health-seeking behaviour survey during the Ebola epidemic in Monrovia, Liberia, May 2014-March 2015.

Response		Round 1		Round 2		Total	
		19Dec14-02Jan15		29Jan15-07Mar15		19Dec14-07Mar15	
		N = 3,500		N = 7,000		N = 10,500	
		n	%	n	%	n	%
Customers responding to text message		768	22%	781	11%	1549	15%
Customers reached in three tries by cell phone		630	18%	684	9.8%	1314	13%
	Respondent did not consent	49	1,4%	38	0,5%	87	0,8%
	Respondents under 18 years	41	1,2%	45	0,6%	86	0,8%
	Respondent did not live in greater Monrovia	94	2,7%	142	2,0%	236	2,2%
Customers included into the survey		446	13%	459	6.6%	905	8.6%

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were reached by the surveyors and fulfilled the required eligibility criteria (overall response rate 13%; 446/3,500) (Table 1). They provided information for 3,363 household members, indicating an average household size of 7.5 persons per household.

As a result of the response outcome through early January 2015, the sample size was recalculated, adjusting the household size estimate (5 → 7.5) and the expected non-response rate (50% → 90%). A second round of sampling was launched in order to reach the required numbers of respondents, with an additional 7,000 phone numbers contacted by text (total contacted, 10,500).

Of the 7,000 texts messages sent to a new random sample of mobile phone owners between 29 January and 7 March 2015, 781 customers replied with agreement to participate (11%; 781/7,000) (Table 1). 459 households were eligible for inclusion (Table 1); they represented 3,450 household members (average household size 7.5).

After both rounds of sampling, the survey included a total of 905 households. The total number of days in the recall period ranged from 215 days (first interview) to 293 days (last interview).

Sample characteristics

At the beginning of the survey period, 6,813 household members were included in the sample (Table 2). The crude birth rate was 29.1 births per 1,000 persons per year.

The median age of the 905 respondents was 29 years (interquartile range: 23–36). Respondents came from all parts of Monrovia; between 31 and 146 persons/10,000 population per neighbourhood participated in the survey (Table 3). The proportion of households included was lower for precarious neighbourhoods and higher in more affluent neighbourhoods.

Table 2. Changes in household composition among respondents; mortality, morbidity and health-seeking behaviour survey during the Ebola epidemic in Monrovia, Liberia, May 2014-March 2015.

Household members	Frequency	Percent
Household members on 14 May 2014	6813	100%
Household members that left during the recall period	481	7.1%
Household members that arrived during the recall period	291	4.3%
Births during the recall period	133	2.0%
Non-Ebola deaths during the recall period	45	0.7%
Ebola deaths during the recall period	10	0.1%
Household members at the day of the survey	6701	98.4%

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Table 3. Number of households And household members included in the survey by neighbourhood of residence; mortality, morbidity and health-seeking behaviour survey during the Ebola epidemic in Monrovia, Liberia, May 2014-March 2015.

neighbourhood in Monrovia	population size (MSF operational data)	Households in the sample	Household members in the sample	Median household size	Persons included per 10,000 population
Barnesville	36,014	64	462	7.2	128
Caldwell	27,754	48	405	8.4	146
Central Monrovia	85,819	63	421	6.7	49
Clara Town	56,446	27	193	7.1	34
Congo Town	n.a.	42	273	6.5	n.a.*
Gardnersville	81,590	73	558	7.6	68
Lapkazee	40,753	16	127	7.9	31
Logan Town	56,350	36	337	9.4	60
New Georgia	58,958	40	259	6.5	44
New Kru Town	75,191	34	357	10.5	47
Old Road	49,012	43	282	6.6	58
Paynesville	330,066	344	2,569	7.5	78
Sinkor	42,041	65	465	7.2	111
Westpoint	30,830	10	105	10.5	34
Total	939,994	905	6813	7.5	72

n.a. = not available

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Mortality rates for all causes of death (non-EVD and EVD) during the recall period

Overall 55 deaths occurred during the recall period, indicating a crude mortality rate of 0.33/10,000 (95%-CI: 0.25–0.43) persons per day. Fifty-five deaths occurred in 47 households, indicating that over the entire recall period, 5.2% of households experienced at least one death. Six (0.7%) households experienced more than one death.

Forty-five (82%) of 55 deaths did not meet the EVD case definition, indicating a non-EVD mortality rate of 0.27/10,000 (95%-CI: 0.20–0.36) persons per day.

Deaths due to a cause other than EVD were chronic diseases (n = 20), injuries (n = 6), birth- or pregnancy-associated deaths (n = 3), "African sign" (n = 3), ulcers (n = 2), "old age" (n = 1), stomach pain (n = 1), food poisoning (n = 1), "no good care" (n = 1) and jaundice (n = 1). For six deaths the reason was unknown.

EVD attributable deaths were 10 of 55 (18%; 95%-CI: 9–31%), indicating an EVD specific mortality rate of 0.06/10,000 (95%-CI:0.03–0.11) persons per day. Individuals that died of EVD had a lower median age than those dying of non-EVD causes (median age 32 and 36 years, respectively; interquartile range 25–33 and 21–56, respectively) and were more frequently reported to have died in an ETU (Table 4).

Six (11%) of 55 deaths were of children under 5 years of age; their causes were reported as EVD (n = 1), asphyxia at birth (n = 1), "African sign" (n = 1), "no good care" (n = 1) and ulcers (n = 2).

Morbidity—Disease specific attack rates for non-EVD and EVD during the 30 days preceding the survey

277 (4%) of 6,813 household members were reported to have been sick in the 30 days prior to the survey. 19 of those sick reported suffering from more than one disease, resulting in 277 sick persons with 295 disease episodes. The most frequently reported diseases were malaria (2.2% of all household members), acute respiratory infections (ARI) (0.4%) and chronic diseases (0.3%) (Table 5). One EVD case was reported during the 30 days preceding the survey.

Table 4. Characteristics of deceased cases (n = 55); mortality, morbidity and health-seeking behaviour survey during the Ebola epidemic in Monrovia, Liberia, May 2014-March 2015.

	EVD* related death (N = 10)		Death from other causes (N = 45)	
	n	%	n	%
Sex male	4	40%	23	51%
Places of death				
Public or private Health facility	2	20%	15	33%
Ebola treatment units	6	60%	5	11%
Home	2	20%	23	51%
Another location	-	-	2	4%
Body disposal by specialized burial team	9	90%	5	11%

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Table 5. Respondent-reported morbidity; mortality, morbidity and health-seeking behaviour survey during the Ebola epidemic in Monrovia, Liberia, May 2014-March 2015.

Self-diagnosis	Frequency of disease within the past 30 days	Attack rate among household members (N = 6813)	Percentage of sick people (N = 277)
Malaria	150	2,2%	54,2%
Acute respiratory infection	28	0,4%	10,1%
Chronic diseases	21	0,3%	7,6%
Headache	15	0,2%	5,4%
Typhoid	11	0,2%	4,0%
Trauma	11	0,2%	4,0%
Diarrhoea	6	0,1%	2,2%
Stomach pain	4	0,1%	1,4%
Constipation	4	0,1%	1,4%
Arthritis	4	0,1%	1,4%
Worms	2	0,0%	0,7%
Fever	2	0,0%	0,7%
Pregnancy-related illness	2	0,0%	0,7%
Tooth decay	2	0,0%	0,7%
Ebola	1	0,0%	0,4%
Allergy	1	0,0%	0,4%
Back pain	1	0,0%	0,4%
Body pain	1	0,0%	0,4%
Skin rash	1	0,0%	0,4%
Fatigue	1	0,0%	0,4%
Food poison	1	0,0%	0,4%
Hernia	1	0,0%	0,4%
Throat pain	1	0,0%	0,4%
Swollen lower extremity	1	0,0%	0,4%
Urinary tract infection	1	0,0%	0,4%
Jaundice	1	0,0%	0,4%
Unknown	22	0,3%	7,9%
Total	295	4,3%	106,5%

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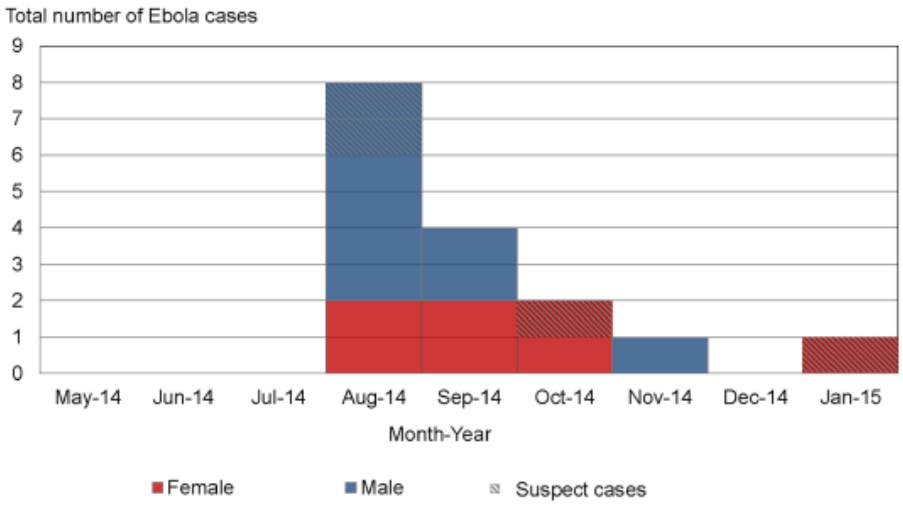

Fig 1. Number of Ebola cases by month of disease onset (n = 16); mortality, morbidity and health-seeking behaviour survey during the Ebola epidemic in Monrovia, Liberia, May 2014-March 2015.

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10 (4%) of the 277 household members that had been sick in the 30 days prior to the survey were children under five years of age, 70% (7/10) of these children were reported to have had experienced an episode of malaria.

Morbidity—Attack rate of EVD during the recall period

19 EVD cases were reported to have occurred between 14 May 2014 and the date of interview. However, three of the reported EVD cases did not meet case definition. Of the remaining 16 cases, four met the case definition for a suspect case, one for a probable case and eleven for a confirmed case. One additional death reported as a non-EVD death met the case definition for a suspect case. The overall attack rate of reported cases meeting the EVD case definition (n = 17) among all household members was 0.25% (95%-CI: 0.15–0.40). Of 17 EVD cases, 10 were reported to have died (case fatality rate: 59%).

Median age of the reported EVD cases was 29 years, 53% of cases were male. 76% were reported to have been hospitalised in ETUs. Date of symptom onset was available for 16 cases, eight of which had symptom onset in August, after which the number of cases declined (Fig 1).

Health-seeking behaviour

Nine (3%) of the 276 individuals, who had been sick during the 30 days prior to the survey with non-EVD diseases, did not seek any health care. Forty-three (16%) of the 276 sick people accessed health care in a government-run health facility. 112 (41%) accessed health care in private health facilities. 54 (20%) found treatment either in pharmacies or drug stores and 50 (18%) asked a health care worker (HCW) to take care of them at home, 6 (2%) visited a traditional healer, one sought healthcare at the church and one elsewhere.

Of the 150 reported cases of malaria, 35% (52/150) did not seek care at neither a public nor a private health facility; an additional 16% (24/150) were reported to have been treated at home by a health care worker.

Discussion

The estimated CMR and its confidence intervals were considerably below the emergency threshold of 1/10,000 persons per day [17]. The non-EVD-related mortality was similar to national estimates of the mortality rate prior to the outbreak for Liberia [13–15], suggesting that there was no increase of non-EVD-related mortality during the EVD outbreak to the extent initially expected by actors in the field. A similar observation was made in a mortality survey conducted in Sierra Leone's capital Freetown that indicated no increase in non-EVD mortality during the EVD outbreak [18]. In fact the strict hygiene measure implemented to prevent Ebola transmission, such as limited movements, no touch policy and rigorous hand-washing might have positively impacted on non-EVD-related mortality and morbidity.

However, it is possible that the mortality rate in Monrovia prior to the Ebola epidemic was lower than the countrywide estimates, as access to health care was better in Monrovia compared with other parts of the country [10,19]. Furthermore our mortality estimate might be underestimated; mortality among children under five years of age accounted for only 11% of reported deaths and seems to be insufficiently represented as mortality amongst children under five is usually higher than amongst adults [4,17]. Additionally, no deaths due to fever or malaria were reported, suggesting further underestimation in the sample. As respondents from more affluent neighbourhoods were overrepresented in the sample, malaria episodes might have been more often treated and resolved, resulting in lower than average numbers of malaria-related deaths.

On the other hand, malaria mortality might have in fact been low in Monrovia during part of the recall period due to a mass drug administration (MDA) of malaria chemoprevention carried out in October to December 2014 by MSF in the West part of Monrovia with a population of approximately 550,000 [23].

EVD contributed 0.06 deaths per 10,000 persons per day and was the cause of death for at least 18% of all-cause-mortality observed in the survey. In the sample an additional two deaths were reported to have happened in an ETU, but as no information on symptoms or laboratory tests was available, they were not counted as EVD deaths. Our estimates suggest that in Monrovia during the recall period, the CMR increased by 22% due to deaths directly associated with EVD. Extrapolating the EVD mortality rate observed in the study to the population of Monrovia (1,144,806 individuals [20]) indicates an estimate between 1,254 and 4,596 EVD deaths in one year in Monrovia, which is in keeping with the 2,300 EVD deaths notified to MOHSW in Monrovia up to March 2015 [21]. Thus, underestimation of EVD case notification data in Monrovia does not seem to be as high as previously estimated [5].

More than half of the reported morbidity was due to malaria, the disease reported to be one of the main reasons for outpatient consultations in Liberia [22]. The estimated attack rate for malaria was in accordance with those found in other surveys at the end of 2014 in Monrovia [23]. EVD accounted for 0.4% of morbidity within the month prior to the survey. However, EVD case numbers were sharply decreasing after August 2014—in the sample and in national notification data–thus EVD probably accounted for a larger proportion of morbidity earlier in 2014.

76% of EVD cases were reported to have been isolated in an ETU, indicating some functionality and trust in EVD-related treatment facilities. On the other hand, respondents might have been reluctant to report if they were in fact not admitted.

Of the household members experiencing any illness, 43% did not seek care at a health facility, a proportion consistent with that of previous studies [24]. Low utilisation of public health facilities for illnesses other than EVD may have resulted in under-diagnosis and no treatment of diseases. However, EVD-hygiene-measures, the MDA and alternative care seeking behaviour, such

as home treatment and the use of local pharmacies, may have contributed to little or no observed increase in mortality. Given the low proportion of health facility utilisation, more comprehensive and timely implementation of EVD triage training (combined with functioning and trusted telephone help lines) provided to local drug store keepers and any health care worker–even unemployed–might have been key to prevent EVD spread by home treatment.

The proportion of health care seeking at private health facilities might have been lower in less affluent parts of Monrovia that are underrepresented in this sample and might add to the underestimation of mortality.

Feasibility of the mobile phone survey and its limitations

We have shown that a mobile phone survey can be implemented in a context where access to the population is limited–be it due to the risk of infection by Ebola, as in this case or, potentially to other contexts such as insecure conflict environments, difficulties in transportation during rainy season or after natural disasters, or difficult access caused by the risk of kidnapping.

There are several limitations introduced by using the mobile telephone methodology:

First, the dependence on a network provider for random sampling created some delay and contributed to a lack of full transparency in the process.

Second, data on population coverage of the network provider in Monrovia was unknown as were the socio-demographic characteristics of customers, leading to uncertainties regarding the representativeness of the sample for Monrovia's whole population. Low rates of inclusion of households in precarious neighbourhoods of Monrovia suggest that the sample frame might not have been as representative of the population of greater Monrovia as implied by the provider. Thus, poverty associated diseases and deaths, including EVD, may be underestimated in this survey. Despite these limitations, mean age of the respondents and household size was similar to previously published estimates for Monrovia [23] and estimates for birth and death rates [15], morbidity [22,23] and health seeking behaviour [24] were in accordance with previous research indicating acceptable representation of Monrovia's population. In future mobile phone surveys underrepresentation could possibly be mitigated with an adapted quota sampling strategy, if sociodemographic and -economic characteristics of the customers of the partnering company are available.

Third, the respondents' environment can have an influence on the quality of data gathered from mobile phone surveys. Mobile phone respondents can be in situations where survey participation is not feasible or the connection not adequate. Despite these potential limitations, studies have shown that the interview mode does not influence significantly the quality of data measurement [25].

Fourth, the initial response was much lower than expected by the provider but in keeping with response in telephone surveys performed in industrialized countries [26]. The low response necessitated a new round of sampling and extended the recall period. Our experience suggests that for future mobile phone based surveys, the sample size calculations should account for a proportion of non-response as high as in industrialized countries.

As with all retrospective mortality studies, there is the potential for recall and survivor bias that may have affected the results. Additionally, stigma, fear, an environment of mistrust and the trauma of the experience may have led to under-reporting of EVD; the format of the survey–dependent on the reporting of sensitive health information to an unknown surveyor on the phone–may have exacerbated this effect.

For operational reasons–given the context and the "no-touch-policy"–we could not compare the telephone survey method with a gold standard community based survey to evaluate the specificity and sensitivity.

Conclusion

The mobile phone based survey was found to be a feasible and acceptable alternative method when data collection in the community is impossible.

CMR was estimated below the emergency threshold of 1/10,000 persons per day. Our results suggest excess mortality in the population directly resulting from Ebola. However, non-EVD mortality did not increase to the extent originally expected.

Importantly, the small proportion of sick household members presenting to official health facilities when sick might pose a challenge for future outbreak detection and mitigation. Substantial reported health-seeking behaviour outside of health facilities may also suggest the need for adapted health messaging and improved access to health care.

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Author Contributions

Conceived and designed the experiments: AK AT LB MM KP EG.

Performed the experiments: AK EL EM AT IA CL KP EG.

Analyzed the data: AK EG.

Contributed reagents/materials/analysis tools: EG CL.

Wrote the paper: AK EL EM AT IA LB MM CL PLV KP EG.

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2.3 Morbidity among migrants, refugees and asylum seekers in detention during the protracted humanitarian crisis in Libya, 2018-2019

Kuehne A, van Boetzelaer E, Alfani P, Fotso A, Elhammali H, Khamala T, Thorson T, Angelova I, Benvenuti B, Pop-Stefanija B, Verdecchia M, Kremer R. Health of migrants, refugees and asylum seekers in detention in Tripoli, Libya, 2018-2019: Retrospective analysis of routine medical programme data. PLoS One. 2021 Jun 4;16(6):e0252460. doi: 10.1371/journal.pone.0252460. PMID: 34086778; PMCID: PMC8177456.

Since Colonel Muammar Gaddafi was overthrown in 2011, Libya has experienced violent clashes between different armed groups and large-scale a breakdown of state functions with severe economic and social consequences for the population (100). Since 2015 Libya is subject to intersectoral humanitarian response and has since become a protracted crisis in a failed state (18).

Despite the conflict, Libya remains a major destination and transit country for migrants, refugees and asylum seekers (101). Many of them are held in detention centres throughout the country (102). In order to document living conditions, health status and utilisation of care of migrants, refugees and asylum seekers in detention centres (DCs) in Libya, MSF analysed data from the HMIS and water, hygiene and sanitation (WHS) documentation system from eight detention centres in Tripoli from July 2018 to December 2019 in which MSF provided health care and WHS support (53). Additionally, malnutrition screening data from one DC was analysed to ascertain with a linear regression model whether there was an association between reported length of stay in detention and malnutrition (53).

In these eight DCs, MSF had partial or full access and was able to collect data in 65% of the month that MSF tried to access a DC (53). The median space per person was below the standard of 3.4m^2 (51) in six out of seven cells for male detainees and in three out of seven cells for female detainees (53). The minimum size of the cell opening for ventilation was below the standard of 10% of the total floor space (51) in all cells (53).

Overall, there were 27,307 outpatient department (OPD) consultations conducted, an additional 953 consultations for sexual and reproductive health and an additional 55 consultations for sexual violence; 1,235 patients required referral to clinics outside the DC (53). In several months the number of consultations outnumbered the number of detainees (53). Among the OPD consultations, 25,135 consultations were new consultations among patients who were five years or older; acute respiratory tract infections were the most common reason for consultation with 27% (6,775/25,135), followed by 24% musculoskeletal diseases (6,058/25,135), 14% skin diseases (3,538/25,135) and 10% heartburn and reflux (2,502/25,135) (53). Of note, 190 consultations were conducted for violence-related injuries and 70 for fuel-burn injuries sustained at attempted crossings of the Mediterranean with small boats (53). Additionally, 170 people were treated for severe dehydration (53). 190 cases of confirmed tuberculosis were detected (53). Of the female population, 4.9% (144/2,944) had a first antenatal care (ANC) visit and 32.4% (953/2,942) of the female population consulted for a sexual and reproductive health (SRH) problem or pregnancy care.

Furthermore, during a malnutrition screening of all detainees in one DC in January 2019 it was shown that with each month that detainees reported to have spent in DC, the mean middle upper arm circumference (MUAC) decreased by 2.5mm (95% CI: 1.3-3.7, p<0.001) and the BMI decreased by 0.16 kg/m2 (95% CI 0.15-0.29, p=0.028) (53).

Health system performance in this setting was severely hampered by reliable access of MSF to detainees; in the eight DCs that are part of this study, access was not granted in about 1/3 of the months of reporting

(53). The consultations outnumber the counted numbers of detainees in several months, potentially indicating an unusually large need for health care even for crisis settings (53).

The reasons for OPD consultations were to a large extent diseases that may be associated with overcrowding, water availability, poor ventilation and nutriment (103,104) such as respiratory diseases including tuberculosis, skin diseases such as scabies, musculoskeletal diseases and digestive diseases (53). Moreover, consultations for conditions sustained by violence and boat crossing (53). In addition, we identified several cases of primary adult malnutrition (i.e., caused by a deficit in nutrients and not by another disease such as tuberculosis) (105) and found an association of malnutrition with the reported length of stay in detention (53). The association does not prove causation but is concerning as it indicates that detainees are more likely to be malnourished the longer they stay in detention (53).

The study is affected by several limitations. The data was not collected for research purposes and the quality might be additionally affected by lack of privacy and time pressure during consultations (53). Moreover, health facility data mostly reflects the conditions for which treatment can be provided and often fails to identify health problems that are complicated to treat in the setting; in our case, this might have led to an underestimation of mental health problems for example (53). Furthermore, it is unknown whether the detention centres visited are representative of all detention centres in Tripoli or Libya; the included DCs might in fact provide better living conditions and hold healthier detainees as MSF is supporting WHS activities and provides health care (53).

The results of the study confirmed qualitative evidence (106,107) and anecdotal observations by the project team that they are to a large extent witnessing diseases among migrants, refugees and detainees that are potentially associated with living conditions (53). It also substantiated how rarely the living conditions of migrants, refugees and asylum seekers in DCs met the standards that MSF is aiming to achieve (53). Overall, the analysis reinforced the programmatic priorities that were already part of the MSF medical strategy such as negotiating access to DCs, improvements in the WHS conditions and advocacy to reduce overcrowding and human rights abuse in DCs and ultimately to end arbitrary detention in Libya (53).

The study was able to provide information for the following evidence-based programming recommendations based on indicators of population health status and public health threats:

- Based on this analysis of proportional morbidities including injuries and the WHS situation, as well as previous reports, we reached the conclusion that a large proportion of these conditions might be associated with living conditions and health threats in detention itself. The data substantiates MSF's work to advocate for the end of detention in its current form (53).
- The data indicates that at least 5% of the female population in detention centres was pregnant and 1/3 needed a sexual and reproductive health consultation. It should be considered to reinforce SRH care as one pillar of medical care in detention (53).
- The systematically poor ventilation and the high number of tuberculosis cases were concerning and advocate for possible expansions of MSF's tuberculosis program for detainees in Libya (53).

Recommendations based on indicators of health system performance:

- Access to detainees was variable and healthcare utilisation depended on MSF's possibilities to receive permission (or not) to access a DC (53). MSF will need to consider if partial access to detainees still allows MSF to sufficiently achieve its mission of alleviate suffering and bear witness.
- Health service utilisation indicated in many months more consultations than detainees and provided one more piece of evidence of the large health care needs in DCs (53); indicating a substantial need for health care and will require a careful weighing of access and security concerns against medical needs.

PLOS ONE

RESEARCH ARTICLE

Health of migrants, refugees and asylum seekers in detention in Tripoli, Libya, 2018-2019: Retrospective analysis of routine medical programme data

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Data Availability Statement: MSF has a managed access system for data sharing that respects MSF's legal and ethical obligations to its patients to collect, manage and protect their data responsibility. Ethical risks include, but are not limited to, the nature of MSF operations and target populations being such that data collected are often highly sensitive. Data are available on request in accordance with MSF's data sharing policy (available at: http://fieldresearch.msf.org/msf/

Abstract

Libya is a major transit and destination country for international migration. UN agencies estimates 571,464 migrants, refugees and asylum seekers in Libya in 2021; among these, 3,934 people are held in detention. We aimed to describe morbidities and water, hygiene, and sanitation (WHS) conditions in detention in Tripoli, Libya. We conducted a retrospective analysis of data collected between July 2018 and December 2019, as part of routine monitoring within an Médecins Sans Frontières (MSF) project providing healthcare and WHS support for migrants, refugees and asylum seekers in some of the official detention centres (DC) in Tripoli. MSF had access to 1,630 detainees in eight different DCs on average per month. Only one DC was accessible to MSF every single month. The size of wall openings permitting cell ventilation failed to meet minimum standards in all DCs. Minimum standards for floor space, availability of water, toilets and showers were frequently not met. The most frequent diseases were acute respiratory tract infections (26.9%; 6,775/25,135), musculoskeletal diseases (24.1%; 6,058/25,135), skin diseases (14.1%; 3,538/25,135) and heartburn and reflux (10.0%; 2,502/25,135). Additionally, MSF recorded 190 cases of violence-induced wounds and 55 cases of sexual and gender-based violence. During an exhaustive nutrition screening in one DC, linear regression showed a reduction in mid-upper arm circumference (MUAC) of 2.5mm per month in detention (95%-CI 1.3–3.7, p<0.001). Detention of men, women and children continues to take place in Tripoli. Living conditions failed to meet minimum requirements. Health problems diagnosed at MSF consultations reflect the living conditions and consist largely of diseases related to overcrowding, lack of water and ventilation, and poor diet. Furthermore, every month that people stay in detention increases their risk of malnutrition. The documented living conditions and health problems call for an end of detention and better protection of migrants, refugees and asylum seekers in Libya.

handle/10144/306501). Requests for access to data should be made to data.sharing@msf.org.

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Abbreviations: ANC, antenatal care; BMI, body mass index; DC, detention centres; IPD, Inpatient department; MSF, Médecins Sans Frontières; MUAC, Mid-upper arm circumference; NGO, Non-governmental organisations; OPD, Outpatient department; PNC, Postnatal care; SGBV, Sexual and gender-based violence; SRH, Sexual and reproductive health; TB, tuberculosis; WHS, water, hygiene, and sanitation.

Introduction

"I was working a day to day job for one month until one day I was taken by some police officer 'cause I was illegal in the country. I stayed in detention for one month, January 2019. The detention called [name of a detention centre in Tripoli]. The situation was really bad. The guards use to beat us every day for no reason, just out of boredom. There is no dignity. . .." Account told by a 16-year-old Sudanese boy to Médecins Sans Frontières (MSF) staff, after being rescued on the Mediterranean Sea in August 2019.

Libya is geographically the fourth largest country in Africa, with a population of 6.7 million [1]. Since 2011, and the ousting of Colonel Muammar Gaddafi, successive Libyan governments have struggled to assert control amid the proliferation of rival political groups competing for power [2]. This has resulted in wide-scale conflict and system collapse with dire security, social, and economic consequences. The conflict is indiscriminate in nature and attacks on civilians and infrastructure are frequent; the conflict has resulted in substantial internal population displacement [2]. Violent clashes between armed groups escalated again in April 2019 and occurred throughout the year in Tripoli [2]. According to the Human Development Index, Libya has fallen from a ranking of 67 to 110, and the economic crisis is affecting all parts of society [2, 3], with migrants and refugees considered some of the most vulnerable groups in the country [2].

Libya is a major transit and destination country for international migration [4]. While the majority of migrants in Libya report that they originally intended to stay and work in Libya, the country has become an important departure point for migrants to Europe [4, 5]. As of February 2021, there were 571,464 migrants, refugees and asylum seekers in Libya [6]. In response to pressure from European countries, Libya implemented restrictive policies to stem the transit of people on the move [7, 8]. The European Union (EU), on its side, set the aim to rapidly stem the flow of irregular arrivals in Europe and prevent departures from Libya as one of the pillars of its migration policy for the Central Mediterranean [9, 10]. Since 2017, the EU has funded a project of the Italian government to support migration management in Libya [11]. Capacitating the Libyan Coast Guards to assume the responsibility in an expanded search and rescue region has been one of the central components of the project [11–13]. Improving the human rights situation for migrants has been a cross-cutting objective [12, 13]. However, despite the publicly available evidence of continued abuses against migrants and refugees in Libya [7, 14–18], neither the European Commission nor the Italian government have to date disclosed information on human rights performance monitoring.

Since 2017, more than 50,000 people have been returned to Libya by the Libyan Coast Guards [19–23]. This has been accepted as the new normal and, as departures from Libya and arrivals in Europe have decreased, the EU has publicly praised the efforts of the Libyan Coast Guards [24]. Across Libya, there are numerous detention centres (DCs) run by authorities or a variety of militia or traffickers [7, 8, 25]. Migrants, refugees and asylum seekers are frequently intercepted on the Mediterranean Sea, or are arrested in neighbourhood raids, and are subsequently held in DCs. The United Nations High Commissioner for Refugees estimates that 3,934 migrants, refugees and asylum seekers are still held in official DCs in Libya, as of February 2021 [26]. An unidentified number of people are additionally held in unofficial places of captivity. DCs are officially managed by the Libyan Directorate Combatting Illegal Migration (DCIM), which is also one of the target beneficiaries of EU funding [12, 25, 27]. The true number of detention centres and detainees in Libya is unknown.

DCs are consisting of hangars, regularly near or within the vicinity of military or armed group facilities. Conditions in official DCs are often reported to be grossly inadequate, featuring chronic overcrowding, poor sanitation, insufficient access to healthcare, and inadequate

quantity and quality of food [7, 17]. Cells are usually large and overcrowded, often with tiny windows, only one door and metal roofs that contribute to substantial heat in summer months and cold in winter. Individuals in detention in Libya have reported forced labour, violence, rape, abuse and torture in DCs [7, 17]. Several organisations have documented that detention centres are often run by, or heavily influenced by militias controlling the surrounding territory, often seeking to gain financially from their activities [7, 8, 17]. Migrants, refugees and asylum seekers typically have no access to judicial processes and effective monitoring systems do not exist, thus there is no oversight of guards or protection against violations and abuse [7, 17, 25].

MSF is present in Libya and the Central Mediterranean to respond to loss of life and the abuse and neglect suffered by migrants, refugees and asylum seekers, through the provision of lifesaving interventions, medical care, protection measures and advocating for changes to harmful migration deterrence policies and practices [28–30]. MSF has advocated for the end of arbitrary detention in Libya for several years and provided medical care within several of Tripoli's DC's since June 2016. MSF typically aims to visit the population of each DC at least once each week to provide general medical, obstetrical and gynaecological consultations, including antenatal and postnatal care (ANC and PNC), and mental health consultations. Patients that require further health care, such as surgical or inpatient care, are referred to clinics outside DCs. Furthermore, MSF's water, hygiene and sanitation (WHS) team provides and treats water in some DCs, improving the existing latrines and showers and implementing vector control activities for communicable diseases such as scabies. Additionally, MSF distributes cleaning material and other non-food items (underwear, hygiene articles etc.) to detainees.

To date, no epidemiological information on health of migrants, refugees and asylum seekers in detention in Tripoli is available. We aimed to contribute to the systematic epidemiological description of health conditions among detained migrants, refugees and asylum seekers in Libya. Our analysis used a retrospective analysis of routine medical and WHS data, in order to contribute to documentation of living conditions and health in Libya's DCs.

Methods

We conducted a retrospective analysis of data collected between July 2018 and December 2019 as part of the routine monitoring of an MSF project that provides health care and WHS services for migrants, refugees and asylum seekers in detention in Tripoli, Libya.

Study population

The study population within our analysis consisted of all migrants, refugees and asylum seekers to which MSF had access during visits to DCs in Tripoli, Libya from July 2018 to December 2019.

Data sources and data collection

Routine programme data covered the total number of detainees seen during every mobile clinic visit by the medical team; this was recorded in a database every month for the last visit of the month, in all DCs to which MSF had access.

Routine environmental data was routinely collected once per month by the MSF WHS specialist in each DC, documenting WHS conditions, with comparisons made against standards for prisons [31] and humanitarian programmes [32]. These standards include those for floor space (m^2/person), ventilation (size of wall opening allowing ventilation/cell) and water, shower and toilet availability (persons/tap or shower or toilet).

For routine medical data, data collection took place as a routine medical activity. The datasets used in our analysis contained data from all detainees presenting at MSF outpatient consultations with a medical complaint or that were referred to a medical facility, in all DCs to which MSF had access. Data collection within outpatient clinics includes the number of new and follow-up outpatient department (OPD) consultations, the number of sexual and reproductive health consultations, the number of sexual and gender-based violence consultations, the number of tuberculosis (TB) patients and the number of referrals for TB and other conditions that could not be treated in DCs. For OPD consultations, the presenting main medical condition is documented on first visit. Suspect TB patients that were identified during OPD consultations based on clinical symptoms were referred for diagnostic procedures to an outside private clinic. If TB was confirmed, patients were treated and followed-up by MSF. There was no TB screening in place.

For nutrition screening data, these outcomes pertain to an exhaustive nutrition screening project that was conducted in one DC in January 2019 by MSF following reports of lack of food and cases of severe malnutrition. The assessment carried out by MSF staff included all detainees within that DC at the time, recording age, sex, self-reported duration of stay in the DC, middle upper arm circumference (MUAC) and body mass index (BMI) in kg/(height in m)^2.

Definitions

We defined MSF OPD consultations as all MSF OPD consultations in a given time, including consultations for children aged under five years, and any individuals aged five years and over, with both new and follow-up consultations included, unless specified otherwise.

For malnutrition, primary adult malnutrition as detected in OPD consultations was defined as a MUAC<160mm. Adult malnutrition as detected during nutrition screening in one DC was defined based on BMI cut-offs: <16, severe; 16-<17, moderate; 17-<18.5, mild; and ≥18.5 normal [33].

We defined "access to DCs" as meaning that consultations could be conducted as originally intended. "Partial access to DCs" was defined as access being denied, either to certain detainees or at specific dates where visits were intended.

Data analysis

Following data cleaning and transfer to STATA version 15 (Stata Corporation, Texas, USA), we conducted descriptive analysis of the available programme, medical, and environmental data.

For the analysis of malnutrition data, we excluded cases with incomplete or inconclusive data on length of stay and malnutrition, and cases that were aged under 18 years.

Indicators were either calculated as proportions (e.g. morbidities, malnutrition) or medians with their range (e.g. age, lengths of stay, living space in m^2 per person). We conducted linear regression to analyse the impact of length of stay on malnutrition and plotted residual to check for patterns. All results are presented in text, tables or graphs as appropriate.

Ethical considerations

This was a retrospective analysis of routinely collected data; therefore, it was exempted from full ethical review by the MSF research committee. The data in the utilized datasets did not contain individual identifiers; it was password protected and only accessible by the principal investigator.

Results

Access to migrants, refugees and asylum seekers in detention

Over the course of 18 months, MSF had access to 29,346 detainees according to monthly counts, including 2,942 women (10.0%; 2,944/29,346) and 1,324 minors (4.5%; 1,324/29,346).

From July 2018 to December 2019, MSF had access to eight different DCs in Tripoli. MSF provided patient care and WHS support in seven DCs. In one DC, MSF provided WHS support only and no medical care. Access was negotiated week by week and only one DC could be visited every month during the time period covered by our analysis (Fig 1).

Living conditions for migrants, refugees and asylum seekers in detention

The median number of persons per drinking water tap did not meet minimum standards [31, 32] for male detainees' cells in four of seven DCs with documented WHS conditions (Table 1).

The median space (in m^2) required per person met the minimum standards [31, 32] in only one DC for male cells, and in four DCs for cells intended for female detainees. The median ventilation (measured as the cell opening as a percentage of the floor area) failed to meet minimum standards in all DCs [31, 32].

Health and healthcare in detention

Between July 2018 and December 2019, MSF conducted 27,307 OPD consultation in total; among these, 1,979 were follow-up consultations (7.2%, 1,979/27,307) for a fluctuating population of approximately 29,346 detainees (Table 2).

MSF performed 144 first ANC consultations (4.9% (144/2,944) of the female population had a first ANC visit) and conducted 953 sexual and reproductive health (SRH) consultations overall (Table 2). Of the female DC population, 32.4% was seen for a SRH problem, including pregnancy care (953/2,942). Additionally, 55 cases of sexual violence reported as occurring within the DC, or outside, were documented (Table 2). MSF identified 190 cases of TB—among them two cases of multi-drug resistant TB—and followed up 13 to 92 cases of TB in any given month (Table 2). MSF organised 1,235 medical referrals to non-MSF clinics outside of the DCs (4.2% of the DC population; 1,235/29,346) (Table 2). Of the referred patients, 59.7% (737/1,235) were referred for inpatient treatment to the hospital. There is no complete list of diagnosis at referral; examples of common reasons for referrals were physical trauma–both, violence-related such as gunshots, stab wounds and beatings, as well as incidental trauma caused by falling, crushes sustained on overcrowded boats or chemical burns derived from fuel. Other common reasons for referral were pregnancy check-ups and pregnancy complications or labour, TB manifestations referred for diagnostics, psychiatric illnesses including post traumatic distress and untreated chronic non-communicable diseases such as diabetes.

Among children aged under five years, MSF conducted 193 consultations for new diseases, 10 follow-up consultations and 42 dressings or injections. Consultations among children aged under five accounted for 0.78% (213/27,307) of all consultations. Among all new consultations, 44.6% (86/193) were related to respiratory tract infections, and 25.4% (49/193) were skin diseases, including scabies (30.6% of all skin diseases; 15/49) (Table 3).

Among children aged 5 years and older and adults, MSF conducted 25,135 consultations for new diseases, 1,969 follow-up consultations and 939 dressings or injections (Table 4).

The number of monthly OPD consultations for new diseases varied from 4,096 in July 2018 to 148 in December 2019 (Table 4). Consultations approximately halved between August July and October 2018 due to ongoing conflict in Tripoli, and halved again between March and April 2019, due to intensified fighting in Tripoli.

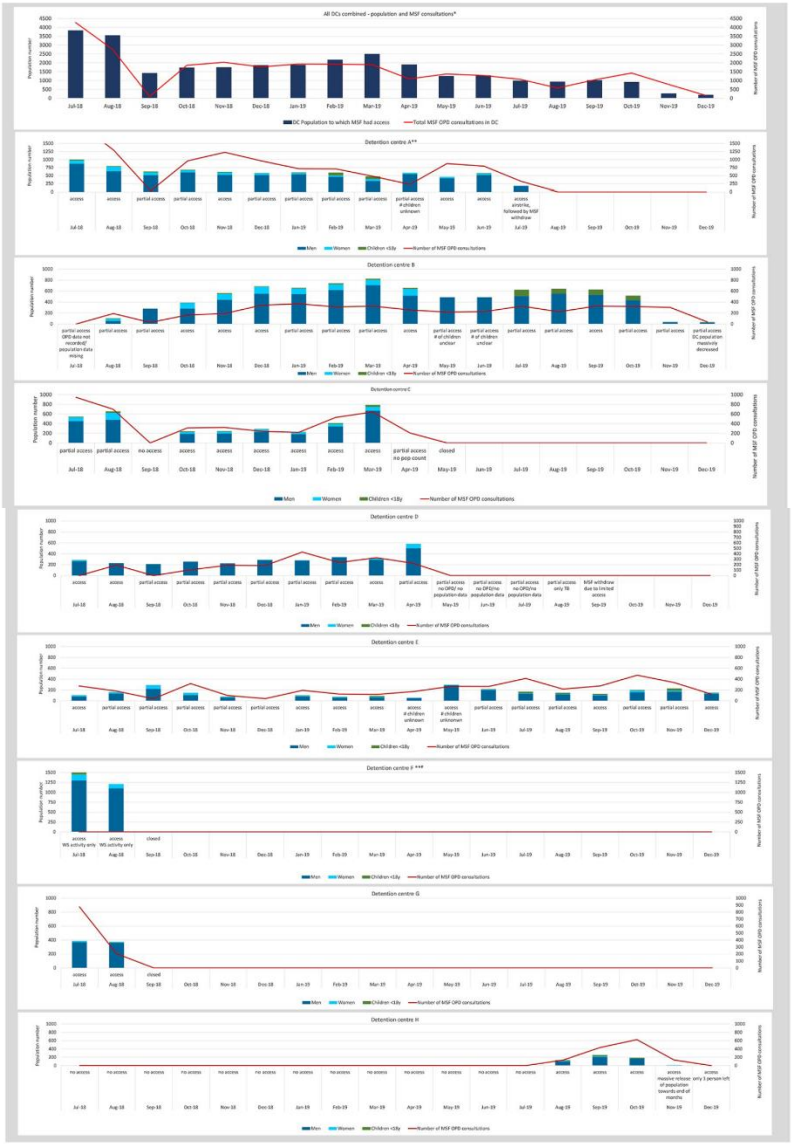

Fig 1. Health of migrants, refugees and asylum seekers in detention in Tripoli, Libya 2018–2019: Number of population and MSF outpatient consultations in 8 detention centres by month. DC: Detention centre; OPD: outpatient department. * Scale different to other graphs; for this graph the maximum is 4,500 population and MSF consultations. ** Scale different to other graphs; for this graph the maximum is 1,500 population and MSF consultations. # MSF Water, hygiene and sanitation activities only.

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Table 1. Health of migrants, refugees and asylum seekers in detention in Tripoli, Libya 2018–2019: Median water, hygiene and sanitation indicators for access to water, toilets and showers and space and ventilation available in 8 detention centres.

	DC A			DC B			DC C			DC D			DC E			DC F			DC G			DC H		
Water, hygiene, sanitation (WHS) activities																								
# months with MSF activities	13			18			9			14			18			2			2			5		
# months with WHS activities	13			16			8			12			14			2			2			5		
# months with data collection	10			13			8			9			6			2			2			0		
	median	min	max	median	min	max	median	min	max	median	min	max	median	min	max	median	min	max	median	min	max	median	min	max
Drinking water–standard*: max 50 people per tap																								
Male/tap	29	18	30	100	50	147	27	10	37	69	0	95	27	12	50	200	183	217	182.5	180	185			
Female/tap	14	12	23				9	9	44	26	26	26	12	6	24	39	28	50						
Washing water–standard*: max 50 people per tap																								
Male/tap	29	25	41	100	50	110	10.5	10	27	76	55	95	15	8	28	120	110	130	33.5	33	34			
Female/tap	14	14	27	25	21	25	9	8	44	26	26	26	6.5	3	12	22.5	16	29	5.5	5	6			
Hygiene and sanitation–standard*: max 50 people per toilet and shower																								
Male/toilet	39	38	73	71	37	110	9.5	6	32	35	22	133	56	31	111	150.5	138	163	73	72	74			
Female/toilet	30	28	41	33.5	25	50	20.5	13	88	1	1	28	8	6	24	39	28	50	4.5	4	5			
Male/shower	39	38	73	71	37	176	18.5	7	32	22	22	133	56	31	111	150.5	138	163	73	72	74			
Female/shower	24	21	41	50	42	50	21	13	88	14.5	1	28	8	6	24	39	28	50	16	14	18			
Space–standard*: 3.4 m^2 floor area per person absolute minimum in dormitories																								
Male—m2/person	3.3	2	3.4	1.25	0.1	3.8	9.4	3.8	9.7	3	0.8	3.3	1.5	0.7	2	1.5	1.4	1.6	2.25	2.2	2.3			
Female—m2/person	4.2	2.4	4.8	6.7	6.7	7.9	4.3	0.9	4.4	6.7	5	240	1.2	0.7	2.2	2.2	1.6	2.8	3.05	2.7	3.4			
Ventilation of cells–standard*: minimum size of the cell opening ≥ 10% total floor space																								
Male cell opening in % of the floor area	1.4	1	1.4	4	4	5	0.7	0.7	0.7	2	1.3	2	2.5	2.5	2.5	3	3	3	2	2	2			
Female cell opening in % of the floor area	2.8	2.8	3	4	4	4	2.7	2.6	2.7	3	3	3	4	4	4	8	8	8	2.1	1.2	3			

DC: detention centre; WHS: Water Hygiene Sanitation.

*Minimum standards as defined by SPHERE and the International Committee of the Red Cross [31, 32]

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Table 2. Health of migrants, refugees and asylum seekers in detention in Tripoli, Libya 2018–2019: MSF consultations and referrals in 7 detention centres by month.

	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Total
DC population estimate	3826	3537	1415	1721	1736	1854	1875	2166	2497	1891	1250	1285	986	926	1014	911	268	188	*
Outpatient department (OPD)																			
MSF OPD consultations new	4127	2627	95	1829	1945	1646	1783	1736	1702	993	1220	1137	944	512	941	1234	709	148	25328
MSF OPD consultations follow-up	143	135	0	36	86	119	146	182	196	99	142	150	120	63	96	184	69	13	1979
MSF OPD consultations total	4270	2762	95	1865	2031	1765	1929	1918	1898	1092	1362	1287	1064	575	1037	1418	778	161	27307
Sexual and reproductive health (SRH) and sexual and gender-based violence (SGBV)																			
MSF SRH consultations total	119	105	0	157	104	69	100	76	82	56	27	30	1	5	3	6	12	1	953
MSF 1st ANC visits	19	28	0	14	13	15	6	9	9	9	9	4	0	4	1	3	1	0	144
MSF ANC follow-up visits	55	61	0	86	50	21	41	32	51	29	17	22	0	0	2	0	10	1	478
MSF PNC visits	41	10	0	55	41	31	52	32	21	18	1	0	1	0	0	1	1	0	305
MSF other obstetric and gynecological visits	4	6	0	2	0	2	1	3	1	0	0	4	0	1	0	2	0	0	26
MSF deliveries after referral	4	4	1	3	5	1	2	0	4	0	0	1	0	0	0	1	2	0	28
MSF SGBV consultations	4	6	4	7	7	3	1	4	4	1	6	4	1	2	1	0	0	0	55
Tuberculosis (TB)																			
MSF newly confirmed TB cases	17	13	3	24	22	8	11	14	12	13	18	7	11	8	8	-	1	0	190
MSF total TB cases in cohort	79	90	69	75	91	92	91	80	84	54	55	53	48	47	43	-	13	13	*
Referrals to clinics outside of DC																			
MSF referrals to IPD	131	63	32	78	41	30	33	42	49	46	35	43	35	20	21	28	9	1	737
MSF referrals to OPD	18	28	18	36	42	21	27	30	46	35	31	30	38	19	27	27	23	2	498
Total MSF referrals	149	91	50	114	83	51	60	72	95	81	66	73	73	39	48	55	32	3	1235

DC: Detention centre; OPD: outpatient department; SRH: Sexual and reproductive health; SGBV: Sexual and gender-based violence; ANC: Antenatal care; PNC: Postnatal care; TB: Tuberculosis; IPD: inpatient department.

*Individuals may have been double counted in successive months, it is therefore it is not possible to calculate a total

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The most frequently diagnosed new conditions were acute respiratory tract infections (27%; 6,775/25,135), musculoskeletal diseases (24.1%; 6,058/25,135), skin diseases (14.1%; 3,538/25,135) and heartburn and reflux (10.0%; 2,502/25,135) (Table 4). Among the diagnosis of skin diseases, 41.9% were scabies (1,483/3,538).

Malnutrition in detention

Over the 18-month period, MSF detected 34 cases of primary adult malnutrition in DCs during OPD consultations, defined as a MUAC<160mm. MSF conducted extensive nutrition screening in DC "D" in January 2019, including assessments done amongst all 302 detainees at the time. All detainees were male, and the mean age of detainees was 23 years (median 22,

Table 3. Health of migrants, refugees and asylum seekers in detention in Tripoli, Libya 2018–2019: MSF outpatient department consultations among children < 5 years in 7 detention centres by month.

Diagnosis in outpatient department (OPD) in children < 5 years of age																			
	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Total
Acute upper respiratory tract infection	10	11	0	6	8	7	9	1	5	9	2	5	1	0	0	3	0	0	77
Acute lower respiratory tract infection	0	1	0	0	2	2	2	0	0	1	1	0	0	0	0	0	0	0	9
Skin disease	2	9	0	9	1	2	1	2	6	4	0	5	7	0	1	0	0	0	49
Acute watery diarrhoea	2	1	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	7
Fever of unknown origin	3	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	5
Dental problem	1	1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	5
Non-violence related injury	0	0	0	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	4
Heartburn/ reflux	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4
Eye infection	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Confirmed malaria	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Dehydration	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Urinary tract infection	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Chronic diseases	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Fuel burn	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Severe acute malnutrition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	3	0	0	0	0	0	0	2	0	1	17	0	0	0	0	0	0	0	23
Total	31	25	0	19	11	14	14	6	15	15	20	11	8	0	1	3	0	0	193

OPD: Outpatient department

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range 10–46); average self-reported duration of stay in the DC at the point of screening was 4.8 months (median 6, range 1–12). Mean MUAC among detainees ≥ 18 years (n = 233) was 264.5mm (median 262, range 208–364). Mean BMI among detainees ≥ 18 years was 21.1 kg/m^2 (median 20.7, range 16.1–37.7). Among all detainees aged above 18 years, we found 3.9% (9/233) with moderate malnutrition and 12.0% (28/233) with mild malnutrition.

Using linear regression analysis, we assessed the association between self-reported duration of stay and detainees' MUAC measurement. We estimated a reduction in mean MUAC of 2.5mm per month of length of stay (95% CI 1.3–3.7, p<0.001), after adjusting for detainees' age.

Additionally, we assessed the association between self-reported duration of stay and detainees' BMI. We estimated a reduction in mean BMI of 0.16 kg/m^2 per month of length of stay (95% CI: 0.15–0.29, p = 0.028) after adjusting for detainees' age.

Discussion

At any given time between July 2018 and December 2019 there were between 188 and 3,826 migrants, refugees and asylum seekers in eight DCs in Tripoli to which MSF had access. Even

Table 4. Health of migrants, refugees and asylum seekers in detention in Tripoli, Libya 2018–2019: MSF outpatient department consultations among patients ≥ 5 years and adults in 7 detention centres by month.

Diagnosis in outpatient department (OPD) in patients ≥ 5 years of age																				
	Jul-18		Aug-18		Sep-18		Oct-18		Nov-18		Dec-18		Jan-19		Feb-19		Mar-19		Apr-19	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Headache/ musculoskeletal pain	1035	25.3%	643	24.7%	21	22.1%	412	22.8%	462	23.9%	399	24.4%	392	22.2%	392	22.7%	370	21.9%	219	22.4%
Acute upper respiratory tract infection	817	19.9%	482	18.5%	11	11.6%	354	19.6%	415	21.5%	313	19.2%	339	19.2%	342	19.8%	287	17.0%	172	17.6%
Acute lower respiratory tract infection	376	9.2%	241	9.3%	9	9.5%	216	11.9%	186	9.6%	121	7.4%	228	12.9%	204	11.8%	192	11.4%	90	9.2%
Skin disease	581	14.2%	353	13.6%	15	15.8%	240	13.3%	254	13.1%	200	12.3%	208	11.8%	270	15.6%	283	16.8%	156	16.0%
Heartburn/ reflux	476	11.6%	332	12.8%	9	9.5%	186	10.3%	213	11.0%	196	12.0%	172	9.7%	125	7.2%	141	8.4%	84	8.6%
Constipation	23	0.6%	9	0.3%	0	0.0%	16	0.9%	39	2.0%	48	2.9%	38	2.1%	35	2.0%	24	1.4%	16	1.6%
Acute watery diarrhoea	92	2.2%	134	5.1%	3	3.2%	38	2.1%	42	2.2%	40	2.5%	25	1.4%	42	2.4%	13	0.8%	16	1.6%
Acute bloody diarrhoea	7	0.2%	0	0.0%	1	1.1%	1	0.1%	2	0.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Dental problem	175	4.3%	94	3.6%	3	3.2%	107	5.9%	87	4.5%	70	4.3%	67	3.8%	57	3.3%	48	2.8%	53	5.4%
Chronic diseases	24	0.6%	20	0.8%	0	0.0%	11	0.6%	11	0.6%	32	2.0%	56	3.2%	71	4.1%	74	4.4%	25	2.6%
Urinary tract infection	71	1.7%	43	1.7%	4	4.2%	60	3.3%	46	2.4%	42	2.6%	48	2.7%	23	1.3%	25	1.5%	21	2.1%
Eye infection	56	1.4%	56	2.2%	2	2.1%	32	1.8%	41	2.1%	35	2.1%	44	2.5%	35	2.0%	26	1.5%	18	1.8%
Dehydration	91	2.2%	55	2.1%	1	1.1%	2	0.1%	0	0.0%	9	0.6%	10	0.6%	10	0.6%	13	0.8%	3	0.3%
Anaemia	37	0.9%	39	1.5%	3	3.2%	38	2.1%	19	1.0%	19	1.2%	4	0.2%	15	0.9%	7	0.4%	13	1.3%
Gynaecological	37	0.9%	24	0.9%	11	11.6%	26	1.4%	25	1.3%	14	0.9%	13	0.7%	7	0.4%	24	1.4%	2	0.2%
Violence-related trauma, wound, burn	21	0.5%	10	0.4%	0	0.0%	7	0.4%	9	0.5%	10	0.6%	7	0.4%	10	0.6%	5	0.3%	5	0.5%
Non-violence related injury	32	0.8%	11	0.4%	0	0.0%	4	0.2%	12	0.6%	11	0.7%	5	0.3%	6	0.3%	10	0.6%	9	0.9%
Tuberculosis (suspected)	9	0.2%	2	0.1%	0	0.0%	7	0.4%	5	0.3%	7	0.4%	20	1.1%	1	0.1%	0	0.0%	3	0.3%
Fever of unknown origin	19	0.5%	10	0.4%	0	0.0%	4	0.2%	10	0.5%	6	0.4%	5	0.3%	6	0.3%	6	0.4%	7	0.7%
Fuel burn	29	0.7%	0	0.0%	0	0.0%	0	0.0%	1	0.1%	0	0.0%	1	0.1%	0	0.0%	15	0.9%	0	0.0%
Severe acute malnutrition	2	0.0%	1	0.0%	2	2.1%	1	0.1%	10	0.5%	2	0.1%	2	0.1%	1	0.1%	4	0.2%	4	0.4%
Pregnancy related consultation	0	0.0%	6	0.2%	0	0.0%	4	0.2%	0	0.0%	0	0.0%	6	0.3%	1	0.1%	0	0.0%	1	0.1%
Sexually transmitted infection—male	0	0.0%	1	0.0%	0	0.0%	3	0.2%	2	0.1%	2	0.1%	1	0.1%	0	0.0%	0	0.0%	1	0.1%
Sexually transmitted infection—female	0	0.0%	0	0.0%	0	0.0%	2	0.1%	1	0.1%	0	0.0%	1	0.1%	0	0.0%	0	0.0%	2	0.2%
Common Psychiatric Disorders	1	0.0%	0	0.0%	0	0.0%	1	0.1%	0	0.0%	0	0.0%	4	0.2%	2	0.1%	1	0.1%	1	0.1%

(*Continued*)

Table 4. (Continued)

Severe Psychiatric Disorders	0	0.0%	1	0.0%	0	0.0%	0	0.0%	0	0.0%	2	0.1%	0	0.0%	0	0.0%	1	0.1%	0	0.0%
Confirmed malaria	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	0.1%	0	0.0%	0	0.0%
Other	85	2.1%	35	1.3%	0	0.0%	38	2.1%	42	2.2%	54	3.3%	73	4.1%	73	4.2%	118	7.0%	57	5.8%
Total	**4096**		**2602**		**95**		**1810**		**1934**		**1632**		**1769**		**1730**		**1687**		**978**	
Follow-up consultations	143		135		0		31		86		119		146		177		196		99	
Dressing/ injection room	152		100		0		77		98		82		47		39		76		16	
Diagnosis in outpatient department (OPD) in patients ≥ 5 years of age																				
	May-19		Jun-19		Jul-19		Aug-19		Sep-19		Oct-19		Nov-19		Dec-19		Total			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%		
Headache/ musculoskeletal pain	294	24.5%	282	25.0%	248	26.5%	157	30.7%	250	26.6%	273	22.2%	175	24.7%	34	23.0%	6058	24.1%		
Acute upper respiratory tract infection	157	13.1%	196	17.4%	137	14.6%	79	15.4%	105	11.2%	147	11.9%	112	15.8%	29	19.6%	4494	17.9%		
Acute lower respiratory tract infection	82	6.8%	46	4.1%	53	5.7%	33	6.4%	30	3.2%	115	9.3%	46	6.5%	13	8.8%	2281	9.1%		
Skin disease	219	18.3%	136	12.1%	107	11.4%	70	13.7%	127	13.5%	161	13.1%	140	19.7%	18	12.2%	3538	14.1%		
Heartburn/ reflux	132	11.0%	114	10.1%	88	9.4%	26	5.1%	63	6.7%	96	7.8%	36	5.1%	13	8.8%	2502	10.0%		
Constipation	26	2.2%	31	2.8%	27	2.9%	15	2.9%	37	3.9%	58	4.7%	52	7.3%	7	4.7%	501	2.0%		
Acute watery diarrhoea	28	2.3%	10	0.9%	17	1.8%	2	0.4%	6	0.6%	18	1.5%	4	0.6%	6	4.1%	536	2.1%		
Acute bloody diarrhoea	0	0.0%	0	0.0%	1	0.1%	0	0.0%	0	0.0%	2	0.2%	0	0.0%	0	0.0%	14	0.1%		
Dental problem	42	3.5%	36	3.2%	35	3.7%	24	4.7%	67	7.1%	68	5.5%	34	4.8%	9	6.1%	1076	4.3%		
Chronic diseases	47	3.9%	50	4.4%	47	5.0%	20	3.9%	35	3.7%	65	5.3%	20	2.8%	3	2.0%	611	2.4%		
Urinary tract infection	23	1.9%	49	4.4%	36	3.8%	15	2.9%	43	4.6%	26	2.1%	12	1.7%	5	3.4%	592	2.4%		
Eye infection	26	2.2%	26	2.3%	22	2.4%	8	1.6%	23	2.4%	21	1.7%	4	0.6%	1	0.7%	476	1.9%		
Dehydration	1	0.1%	14	1.2%	17	1.8%	8	1.6%	16	1.7%	20	1.6%	4	0.6%	0	0.0%	274	1.1%		
Anaemia	7	0.6%	6	0.5%	4	0.4%	2	0.4%	3	0.3%	4	0.3%	3	0.4%	0	0.0%	223	0.9%		
Gynaecological	6	0.5%	5	0.4%	3	0.3%	2	0.4%	9	1.0%	13	1.1%	0	0.0%	2	1.4%	223	0.9%		
Violence-related trauma, wound, burn	20	1.7%	31	2.8%	7	0.7%	3	0.6%	15	1.6%	22	1.8%	7	1.0%	1	0.7%	190	0.8%		
Non-violence related injury	6	0.5%	7	0.6%	10	1.1%	6	1.2%	4	0.4%	4	0.3%	5	0.7%	0	0.0%	142	0.6%		
Tuberculosis (suspected)	1	0.1%	0	0.0%	11	1.2%	7	1.4%	11	1.2%	10	0.8%	8	1.1%	0	0.0%	102	0.4%		
Fever of unknown origin	5	0.4%	1	0.1%	1	0.1%	3	0.6%	2	0.2%	0	0.0%	0	0.0%	0	0.0%	85	0.3%		
Fuel burn	2	0.2%	18	1.6%	0	0.0%	1	0.2%	2	0.2%	1	0.1%	0	0.0%	0	0.0%	70	0.3%		
Severe acute malnutrition	3	0.3%	0	0.0%	1	0.1%	0	0.0%	1	0.1%	0	0.0%	0	0.0%	0	0.0%	34	0.1%		
Pregnancy related consultation	0	0.0%	0	0.0%	0	0.0%	0	0.0%	5	0.5%	1	0.1%	0	0.0%	0	0.0%	24	0.1%		

(*Continued*)

Table 4. (Continued)

Sexually transmitted infection—male	0	0.0%	0	0.0%	0	0.0%	1	0.2%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	11	0.0%		
Sexually transmitted infection—female	0	0.0%	2	0.2%	0	0.0%	0	0.0%	1	0.1%	4	0.3%	0	0.0%	0	0.0%	13	0.1%		
Common Psychiatric Disorders	1	0.1%	0	0.0%	0	0.0%	1	0.2%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	12	0.0%		
Severe Psychiatric Disorders	1	0.1%	0	0.0%	0	0.0%	1	0.2%	0	0.0%	1	0.1%	0	0.0%	0	0.0%	7	0.0%		
Confirmed malaria	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	0.0%		
Other	71	5.9%	66	5.9%	64	6.8%	28	5.5%	85	9.0%	96	7.8%	47	6.6%	7	4.7%	1039	4.1%		
Total	**1200**		**1126**		**936**		**512**		**940**		**1231**		**709**		**148**		**25135**	**100%**		
Follow-up consultations	142		150		120		63		96		184		69		13		**1969**			
Dressing/ injection room	37		67		43		16		41		39		6		3		**939**			

OPD: Outpatient department

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after the beginning of the conflict in Tripoli in April 2019 between the Libyan Government of National Accord and the Libyan National Army, more than 1,800 migrants, refugees and asylum seekers, including women and children, remained in DCs near conflict-affected areas. The number of migrants, refugees and asylum seekers decreased to fewer than 900 detainees for the first time in November 2019. On 2 July 2019, one of the DCs within which MSF was providing healthcare was hit by an airstrike, killing an estimated 64 detainees and injuring 70 others. In late 2019, MSF witnessed a decrease in access to DC's, as well as a decrease in the number of operational DC's, as the conflict in Tripoli escalated.

MSF's access to DCs is negotiated on a weekly basis, is unpredictable and does not always include direct access to all cells and detainees. Access has only been partially granted in 65% of the months that MSF has attempted access DCs. The number of detainees in our dataset represents a snapshot of those detainees to which MSF had access to on the last visit of the recording month; there is a high level of fluctuation from month to month. This fluctuation may relate to many factors, including detainees being transferred between different DCs, as well as migrants, refugees and asylum seekers being intercepted at sea and brought to DCs; additionally migrants, refugees and asylum seekers are often arrested during neighbourhood raids and then put under detention, and finally detainees may be evacuated, released or sold or are returned to their home countries [7, 8, 16, 17, 34]. This level of transfer makes monitoring and follow-up of patients extremely difficult. From one day to the next, people can be transferred between different DCs or moved to undisclosed locations. Some patients disappear without a trace.

The minimum standards for WSH in prisons as outlined by the International Committee of the Red Cross [31] and for humanitarian setting as outlined by SPHERE [32] were rarely met and "minimum conditions of human dignity" [35] are far from being reached. MSF documented severe overcrowding, especially for male detainees, in six out of eight DCs to which MSF had access. The minimum standard for living space of $3.5m^2$ per person, with adequate

room for sleeping and daily activities and privacy [31, 32], was met at no time throughout the 18 months of observation, for five DCs for male detainees, and for three DCs for females detainees. Such overcrowding is known to increase the risk of person-to-person transmitted diseases [7, 17]. All DCs consistently provided insufficient ventilation, in relation to accepted minimum standards, which may increase risks for airborne infections such as TB and other respiratory infections. These WHS conditions in detention are corroborated by several agencies [7, 17, 25] and testimonies of individuals that were rescued by MSF on the Mediterranean Sea reporting living on minimal space, sometimes remaining in standing position for days or being detained in underground cells with no ventilation and minimal food and water in DCs in Tripoli. In our study, access to water and sanitation did not meet minimum standards [31, 32] in several DCs, despite MSF providing support to attempt reaching those standards. Even where minimum standards for availability of water for washing, toilets and showers were met, access to these facilities was sometimes restricted to certain hours of the day. Overnight access to water and toilets was not always possible for detainees. Lack of space, poorly planned facilities and access restrictions limited opportunities to improving water and sanitation, and facilitated the spread of water-washed (e.g. skin and eye infections) and water-borne diseases (e.g. faecal-orally transmitted diseases), and confirming information previously reported by the United Nations and non-governmental organisations [7, 17].

MSF conducted 25,328 OPD consultations in 12 months, for which 92.8% were for conditions presented for the first time. In several DCs, MSF carried out as many or more consultations for newly diagnosed diseases as there were detainees within the DC–potentially indicating an unusually high need for medical care among detainees. MSF conducted 953 SRH consultations among 2,942 women and first time ANC consultations among 4.9% of all women detainees—indicating that at least 4.9% of all women in detention were pregnant. MSF was consulted for 55 cases of sexual and gender-based violence, which probably represents a lower bound to the estimated number of incidents that may have taken place. Women ex-detainees repeatedly reported sexual abuse, and occasional sexual abuse of men was also reported in testimonies to MSF by ex-detainees rescued by MSF on the Mediterranean Sea. Additionally, MSF identified 190 newly diagnosed cases of TB among detainees. While it is not possible to calculate TB incidence rates, because of the lack of robust denominator data, with overall population numbers changing by an unknown extent each month, the numbers seen point to a likely incidence similar to those seen in high-burden TB countries [36]. TB in detention is likely under-detected due to lack of systematic screening, limited diagnostic tools and lack of access by medical staff. At the same time transmission risks are high, driven by poor living conditions and overcrowding in large communal cells with little daylight and poor ventilation.

We know of no comparable data pertaining to the health of detainees in Libya, and no other comparable settings to the one studied here, where migrants, refugees and asylum seekers from multiple countries of origins and migration routes are placed arbitrarily, and detained in overcrowded cells with little light and ventilation and often lack of water for an undetermined time period. The diseases that detainees presented with at OPD consultations speak to the living conditions and show hardly any seasonal variation, as would be typically expected for many diseases. Our findings are corroborated by results from studies about the health of migrants, refugees and asylum seekers arriving in Europe by boat–studies from Greece and Italy described journey- and living- condition-related illnesses such as respiratory tract infections and skin diseases such as scabies as the most common presentations [37–39]. Musculoskeletal diseases account for nearly one quarter of all diseases, year-round, conceivably linked with the lack of space in the cells and limited opportunities to leave cells, resulting in few or no possibilities to stretch and exercise, sometimes for several months. Acute upper and lower respiratory

tract infections account for an additional quarter of all diseases, showing little typical seasonal variation and accounting for 14% of all diseases even in the month with the lowest proportion of respiratory tract infections (September 2019). Substandard ventilation and overcrowding may conceivably contribute to the spread of airborne diseases, driving conditions that result in continuous transmission of infections. Diseases potentially related to overcrowding, such as musculoskeletal conditions and respiratory tract infections, are followed in frequency by water-washed diseases. Water-washed diseases, that occur more frequently in settings with lack of water for personal hygiene—e.g. scabies, other skin diseases and eye infections—account for one sixth of all diseases and were also reported as very frequent diseases among migrants, refugees and asylum seekers in reception centres in Greece and Italy [37–39]. Diet-related diseases, e. g. heartburn, reflux and constipation, account for nearly one in eight diseases diagnosed; and corroborate observations from the MSF project team and other non-governmental organisations (NGOs) reporting a monotonous diet, provided at irregular intervals and in low quantities [7, 17]. We have additionally observed 274 cases of severe dehydration in DCs, which might be partially due to restricted access to drinking water and poor water quality, which was reported as salty by several ex-detainees in testimonies to MSF. 190 detainees were diagnosed with wounds and burns, linked with violence. In testimonies, ex-detainees reported physical abuse in DCs in Libya, often including beatings and electric shocks, however we did not have the means to verify the reports and the form of captivity. More than one sixth of all adults screened as part of the nutrition screening programme in one DC met criteria for malnutrition, based on BMI measurements. We have no direct robust data but do have access to anecdotal reports of lack of food and malnutrition in the DC's [7, 17, 34]. We were able to show an association between lower MUAC and BMI measurements and increasing length of stay.

Less than one percent of consultations were among children aged under five years. With 45% of consultations among children less than five years for respiratory tract infections and 23% for skin infections, the adverse health effect of overcrowding seems to be even more pronounced in young children.

Overall, the poor living conditions and type and quantity of health problems our teams have documented, speak to unbearable conditions and as MSF we are faced with numerous ethical dilemmas [28]. MSF aims to put the interest of vulnerable groups at the centre of its decisions: we continue to provide health care and WHS support, while advocating for changes to migration deterrence practices [28–30], providing relevant data that substantiates our statements with numbers, and being transparent about the compromises we have to make.

Limitations

All data presented was collected as routine MSF programme data and was not collected specifically for research purposes. Thus, some of the data, e.g. population numbers and WHS data is incomplete or inconclusive and could only partly be utilised in this analysis. While all procedures and case definitions stayed the same throughout the observation period, we cannot exclude that staff turnover and limitation in access may have led to variations in documentation and measurements. Furthermore, population numbers provide a point estimate for the population count on the last visit of the month, and cannot serve as a denominator for estimating incidence, as fluctuation in the population is not captured.

It is unclear whether the population observed is representative of the overall population of migrants, refugees and asylum seekers in detention in Tripoli. There is a possibility that the health of the overall population in detention is poorer than the health status of the cohort studied here, because detainees included in our analysis had access to MSF healthcare, which is not the case for all migrants, refugees and asylum seekers in detention in Tripoli and Libya.

MSF attempts to ensure maximum privacy during patient consultations. However, MSF is often required to carry out consultations with limited privacy and sometimes in the presence of guards. It is therefore likely that detainees with sensitive complaints might not access care or might not feel able to explicitly describe their problems. We therefore believe that problems linked with mental health concerns, or with exposure to physical or sexual and gender-based violence, are likely underreported in MSF consultation data [7, 17]. The fact that individuals who experienced detention in Libya and were subsequently interviewed on board of the MSF rescue ship on the Mediterranean Sea, reporting physical and sexual abuse in DCs, speaks to the incompleteness of our data in relation to these concerns.

Additionally, we did not conduct systematic screening for TB, hence our data may underestimate the true numbers of TB cases.

Furthermore, the linear regression model carried out using the nutrition screening data did only include age and self-reported duration of stay and no additional data on potential confounders and thus might under- or overestimate the effect of length of stay on MUAC and BMI. In addition, age and length of stay was self-reported and could not be verified. As we do not know how BMI and MUAC evolved over time among detainees, we cannot prove causality of length of stay and malnutrition but merely show a correlation that indicates that people who report longer length of stay display lower MUAC and BMI. Lastly, we do not know if the findings from the nutrition screening in one DC can be extrapolated to all DCs in Tripoli.

Conclusion

Detention of men, women, children continues to take place in Tripoli. Our data come from a context within which it is not possible to guarantee access to healthcare, with MSFs' access to DCs being renegotiated on a weekly basis. We describe a situation in which living conditions for detainees often fail to meet minimum requirements for water, sanitation and hygiene provision, as well as for living space and ventilation. Health problems that are diagnosed within MSF's consultations reflect the conditions within which migrants, refugees and asylum seekers are held, and include diseases linked with overcrowding, lack of water and ventilation and poor diet. Every month that individuals remain in detention was found to be linked with an increased risk of malnutrition. Additionally, detainees presented to MSF with violence-induced wounds and reports of sexual and physical abuse.

The documented living conditions and health problems call for an end of detention and better protection of migrants, refugees and asylum seekers in Libya. This can only be achieved if pressure to enforce human rights of migrants, refugees and asylum seekers in Libya is increased, if Europe ends its support to the system of forced returns and subsequent detention of migrants, refugees and asylum seekers to Libya, and if safe and legal pathways out of Libya become available to those migrants, refugees and asylum seekers trying to flee the country and reach safety and a dignified existence.

Since late 2020, DCs in Tripoli are increasingly reopening as the wider conflict decreases and migrants continue to be forcibly returned back to Libya when intercepted by the Libyan Coast Guard at the Mediterranean Sea. However, detention of migrants, refugees and asylum seekers in Libya does not meet minimum conditions of human dignity and negatively impacts on detainees' health.

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2.4 Morbidity among migrants, refugees and asylum seekers on board of search & rescue vessel during the protracted humanitarian crisis on the Mediterranean Sea, 2016-2019

van Boetzelaer E, Fotso A, Angelova I, Huisman G, Thorson T, Hadj-Sahraoui H, Kremer R, **Kuehne A**. Health conditions of migrants, refugees and asylum seekers on search and rescue vessels on the central Mediterranean Sea, 2016-2019: a retrospective analysis. BMJ Open. 2022 Jan 11;12(1):e053661. doi: 10.1136/bmjopen-2021-053661. PMID: 35017249; PMCID: PMC8753406.

Every year 10,000s of migrants, refugees and asylum seekers arrive to Europe crossing the Mediterranean Sea in small boats (110). Between 2013 and 2021 UNHCR reported more than 25,000 persons dead or missing at sea while attempting to reach Europe (111). On the Mediterranean Sea, a humanitarian crisis is evolving that leads to substantial loss of life year after year (27,111).

MSF operates search and rescue (SAR) vessels on the Mediterranean Sea since 2015 (54). After the rescue, migrants, refugees and asylum seekers can access OPD care, SRH care and consultations for SGBV. Patients with medical conditions that cannot be treated on board are referred for further treatment with a medical evacuation or treated upon arrival at a port of safety (54). We conducted a retrospective data analysis of HMIS data routinely collected on board the MSF SAR ship in order to systematically describe the utilisation of health care and morbidities among migrants, refugees and asylum seekers during the crossing (54).

Between November 2016 and December 2019, 22,966 migrants, refugees and asylum seekers were rescued, among them 3,420 women (15%) (54). Of the rescued women, 346 were pregnant (10%) (54). MSF conducted 12,438 medical consultations of which 9,811 were first-time consultations (54). An additional 143 ANC consultations were performed and 287 consultations for SGBV (54). There were 1,575 medical referrals conducted; 23 of them for immediately life-threatening conditions (54). Five deaths occurred on board including hypothermia as well as asphyxia due to human crushes and stampedes as probable causes of deaths (54). In addition, an unknown number of dead bodies of people who died before the rescue were onboarded from the small vessels (54).

The most common diagnosed morbidities were skin conditions (31%), motion sickness (28%), headache (15%) and acute injuries (6%) (54). Among the 1,017 acute injuries, 297 were burns caused by fuel and 257 were violence related (in addition to the 287 cases of SGBV documented separately) (54). We additionally documented 541 cases of severe dehydration and 177 cases of hypothermia (54).

Among all persons rescued, 43% required OPD consultations (54). Of the female population, 25% required a SRH consultation and 10% was pregnant (54). The proportion of pregnant women was found to be higher than in other emergencies, where usually <3.5% of the total population (depending on the birth rate) is pregnant (112). The morbidities presented in OPD were most non-severe and typically related to a lack of washing and drinking water (54,104). However, more than 10 % of the consultations were for injuries, violence-related health problems or other potentially life-threatening conditions related to extended exposure to the elements and fuel leaks into the boat while at sea (hypothermia, dehydration, chemical fuel burns) (54). An additional 23 people required immediate medical evacuation for life-threatening diseases with fast boats or helicopters (54).

This study has severe limitations caused by the quality of data collected on paper, in a rescue vessel, in an emergency situation, with people in distress on board, and by a rotating team of medical professionals (54). It was collected for basic routine documentation and not for research purposes (54).

Despite the gaps in completeness and the varying documentation procedures, it provided evidence that was used for recommendations for medical programming and advocacy.

Recommendations based on indicators of population health status and public health threats:

- Proportional morbidities documented were mostly mild. Of concern were the high proportion of injuries, the level of reported SGBV and health conditions related to the exposure to cold and lack of water during the journey. The findings confirmed observations by the medical team that the population is comparatively healthy but suffers journey-related illnesses that require appropriate staff and resources on board. In addition, the study can substantiate MSF's advocacy efforts to develop safer possibilities to access Europe for migrants, refugees and asylum seekers (54).
- The unexpectedly high proportion of pregnant women requires resources for reliable provision of ANC on board (54).

Recommendations based on indicators of health system performance:

- All offered health services were also used; nearly half of all migrants, refugees and asylum presented with at least one acute health condition, indicating a large need for acute health care at SAR vessels. For planning health services, it needs to be considered that conditions for which no treatment could be offered on board are underreported in this analysis but not necessarily non-existent, e.g., chronic conditions. Upon arrival at a port of safety migrants, refugees and asylum seekers should be given the opportunity to access services beyond outpatient treatment for acute conditions to detect and treat chronic health problems (54).
- Given the level and type of injuries seen and the testimonies given by migrants, refugees and asylum seekers on board, the number of SGBV consultations likely represents the 'tip of the iceberg' and more systematic offers of SGBV consultations at the SAR vessel should be considered (54).

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Health conditions of migrants, refugees and asylum seekers on search and rescue vessels on the central Mediterranean Sea, 2016–2019: a retrospective analysis

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ABSTRACT

Objectives This study will contribute to the systematic epidemiological description of morbidities among migrants, refugees and asylum seekers when crossing the Mediterranean Sea.

Setting Since 2015, Médecins sans Frontières (MSF) has conducted search and rescue activities on the Mediterranean Sea to save lives, provide medical services, to witness and to speak out.

Participants Between November 2016 and December 2019, MSF rescued 22 966 migrants, refugees and asylum seekers.

Primary and secondary outcome measures We conducted retrospective data analysis of data collected between January 2016 and December 2019 as part of routine monitoring of the MSF's healthcare services for migrants, refugees and asylum seekers on two search and rescue vessels.

Results MSF conducted 12 438 outpatient consultations and 853 sexual and reproductive health consultations (24.9% of female population, 853/3420) and documented 287 consultations for sexual and gender-based violence (SGBV). The most frequently diagnosed health conditions among children aged 5 years or older and adults were skin conditions (30.6%, 5475/17 869), motion sickness (28.6%, 5116/17 869), headache (15.4%, 2 748/17 869) and acute injuries (5.7%, 1013/17 869). Of acute injuries, 44.7% were non-violence-related injuries (453/1013), 30.1% were fuel burns (297/1013) and 25.4% were violence-related injuries (257/1013).

Conclusion The limited testing and diagnostics capacity of the outpatient department, space limitations, stigma and the generally short length of stay of migrants, refugees and asylum seekers on the ships have likely led to an underestimation of morbidities, including mental health conditions and SGBV. The main diagnoses on board were directly related to journey on land and sea and stay in Libya. We conclude that this population may be relatively young and healthy but displays significant journey-related illnesses and includes migrants, refugees and asylum seekers who have suffered significant violence during their transit and need urgent access to essential services and protection in a place of safety on land.

Strengths and limitations of this study

- We will present data from onboard outpatient consultations (n=12 438) that were systematically offered to all rescued people on one of the largest and longest running rescue vessels on the Mediterranean Sea.
- This study will contribute to the systematic epidemiological description of morbidities among migrants, refugees and asylum seekers when crossing the Mediterranean Sea.
- Due to the limited testing and diagnoses capacity of the outpatient department, space limitations and the generally short length of stay of migrants, refugees and asylum seekers on the ship, it was not feasible to provide in-depth medical and psychological treatment and support, which has likely led to an underestimation of actual morbidities, including mental health conditions and sexual and gender-based violence.
- All data presented were collected as routine Médecins sans Frontières programme data, which needed to be recorded quickly so as not to create further delays for migrants awaiting medical care; therefore, some of the data were incomplete and could only be partly used for this analysis.

BACKGROUND

Since 2014, a large number of migrants, refugees and asylum have attempted to cross the Mediterranean Sea to reach Europe. Between 2014 and 2019, 1 995 651 migrants, refugees and asylum seekers arrived in Italy, Spain, Malta, Greece and Cyprus by boat.[1] The total number of deaths and missing people on the central Mediterranean Sea route is unknown. The United Nations High Commissioner for Refugees (UNHCR) has reported 15 946 deaths and missing people between 2014 and 2020, which is likely an underestimation.[2] The underestimation is due to the occurrence of

invisible migrant shipwrecks that remain unreported and the number of victims unknown.[3] The most frequently recorded countries of origin varied over time as well as by destination,[4–6] and include Eritrea, Ethiopia, Guinea, Chad, Gambia, Ivory Coast, Libya, Mali, Nigeria, Senegal, Sudan and South Sudan.[6]

Many migrants, refugees and asylum seekers are fleeing protracted humanitarian emergencies in their countries of origin, embarking on long inter-regional travel prior to arriving in North Africa.[5] Some migrants, refugees and asylum seekers set out to reach Europe, while others initially plan to find employment and a place to live in Libya and later might decide to travel onwards to Europe. The central Mediterranean Sea route, often via Libya to Italy, has been consistently used.[1] In addition to Libya's strategic location, conflicts and instability in the country have hindered border control and created an environment where smuggling networks can flourish.[5] Prior to attempting the crossing of the central Mediterranean Sea, migrants, refugees and asylum seekers often spend long periods in unofficial and official places of captivity in Libya.[5] Several reports have documented unhygienic and extremely unhealthy conditions in these detention centres, characterised by overcrowding, lack of ventilation, insufficient quantities and quality of food and lacking water and sanitation facilities.[7 8] Recently, MSF published data on health conditions of migrants, refugees and asylum seekers detained in eight official detention centres where MSF has provided medical services. This report documented the dire living circumstances and adverse health effects of arbitrary detention on migrants, refugees and asylum seekers at official detention centres in Libya.[9] Even prior to arriving in Libya, many migrants, refugees and asylum seekers have experienced violence including extortion, ill-treatment, trafficking, forced labour and sexual exploitation in their country of origin or along the way.[5]

Since 2015, Médecins sans Frontières (MSF) has conducted search and rescue activities on the central Mediterranean Sea to save lives, to provide medical services, to witness and to speak out. Between 2015 and 2018, MSF has operated the ship 'Aquarius' in partnership with non-governmental organisation SOS Mediterranee. Between December 2018 and July 2019, MSF had to halt their search and rescue activities on the ship 'Aquarius'. In July 2019, search and rescue operations were resumed with SOS Mediterranee on the ship 'Ocean Viking'.[10]

On these vessels, MSF has been providing outpatient medical consultations, screening and triage, referrals, sexual and reproductive health services, including support for survivors of sexual and gender-based violence. MSF does not provide systematic mental health screening for migrants, refugees and asylum seekers, but psychological first aid. Treatment and diagnoses were performed by physicians and nurses based on clinical assessment and routine tests (body temperature, blood pressure, pulse oximetric, haemoglobin test, blood sugar, urine dipstick, malaria rapid test, pregnancy test). Treatment options were limited to basic wound care, oxygen and a limited number of pharmaceuticals. Any patient requiring more complex treatment needed medical evacuation. As on other search and rescue vessels, the MSF medical teams are working under constant pressure of the urgent assessment and treatment and support of hundreds of rescued persons in distress when a rescue is completed, complex logistical arrangements and depending on the season, harsh meteorological circumstances.[11–13]

There have been publications on the health conditions of migrants, refugees and asylum seekers in migrant reception centres in Italy, Spain and Greece.[14–17] These studies show that the majority of the diagnoses at migration reception centres were dermatological, such as scabies, skins infections and dermatitis of various origins. Respiratory infections and varicella were the most frequent infectious diseases, commonly related to the conditions experienced during the journey.

Limited quantitative data are available on the health of migrants, refugees and asylum seekers while they are on search and rescue vessels.[11 13] Unlike previous studies, we will present data from onboard consultations that were systematically offered to all rescued people on one of the largest and longest running rescue vessels on the Mediterranean Sea. This study will contribute to the systematic epidemiological description of morbidities among migrants, refugees and asylum seekers when crossing the Mediterranean Sea.

METHODS

We conducted retrospective data analysis of data collected between January 2016 and December 2019 as part of the routine monitoring of the MSF's outpatient healthcare services for migrants, refugees and asylum seekers on two search and rescue vessels on the central Mediterranean Sea. We analysed data that were collected on the vessel 'Aquarius' between January 2016 and December 2018 and on the vessel 'Ocean Viking' between January and December 2019.

Study population

The study population consists of all migrants, refugees and asylum seekers who were rescued by MSF search and rescue vessels ('Aquarius' and 'Ocean Viking') on the central Mediterranean Sea between January 2016 and December 2019.

Data sources and data collection

Routine programme data

The total number of migrants, refugees and asylum seekers are established and recorded by the medical team at the start of each rescue in a register. Some basic demographic information is also captured, including sex, numbers of children under 5 years old, unaccompanied minors and pregnant women and the country of origin of the migrants, refugees and asylum seekers.

Routine medical data

Clinical data collection took place as a routine medical activity. The data sets contain data from all migrants, refugees and asylum seekers who presented at the MSF outpatient department (OPD) on the search and rescue vessels with a medical complaint. The medical data collection includes the number of new and follow-up OPD consultations and sexual and reproductive health consultations, including consultations for sexual and gender-based violence (SGBV). Medical evacuation and ambulatory referrals on disembarkation were made based on case severity as assessed by the medical team and were captured in the routine medical data. The medical databases also contain data on the diagnoses of patients seen at the OPD, aggregated per week.

Data analysis

Following data cleaning and transfer to STATA V.16 (Stata Corporation), we conducted descriptive analysis of the available programme and medical data. Indicators were calculated as proportions (eg, morbidities).

Patient and public involvement

For this study, we retrospectively analysed aggregated routine data from the OPD on two search and rescue vessels. Patients were not involved in the study design or implementation. Due to the short length of stay of patients on the search and rescue vessels, we are unable to disseminate the study findings to the patients.

RESULTS

Demographic characteristics

Over the course of 3 years (November 2016–December 2019), 22 966 migrants, refugees and asylum seekers were rescued by MSF's search and rescue vessels on the central Mediterranean Sea. UNHCR reported that during this same period, 176 278 crossed the central Mediterranean Sea to Italy.[18] Among rescued migrants, refugees and asylum seekers were 3420 women (14.9%, 3420/22 966). A total of 12 438 medical consultations were conducted between January 2016 and December 2019. Due to the number of rescued people and the characteristics of the intervention, the number of outpatient consultations fluctuated per month (figure 1).

Between November 2017 and December 2019, 4261 unaccompanied minors were rescued (18.6%, 4261/22 966). Of the total number of rescued people, 328 were children under 5 (1.4%, 328/22 966). Of the female population, 2205 women were travelling alone (59.2%, 2205/3 420) and 346 of the rescued women were pregnant (10.1%, 346/3420). The countries of origin of migrants, refugees and asylum seekers were Nigeria (18.0%, 4140/22 966), followed by Eritrea (10.4%, 2395/22 966), Guinea Conakry (8.3%, 1916/22 966), Ivory Coast (7.2%, 1656/22 966) and Bangladesh (6.2%, 1432/22 966) (table 1).

Health conditions

Between January 2016 and December 2019, MSF conducted 12 438 outpatient consultations, of which 9811 were new consultations (78.9%, 9811/12 438). Additionally, MSF performed 143 antenatal care consultations (41.3% of self-reported female pregnant population, 143/346) and conducted 853 sexual and reproductive health consultations (24.9% of female population, 853/3420).

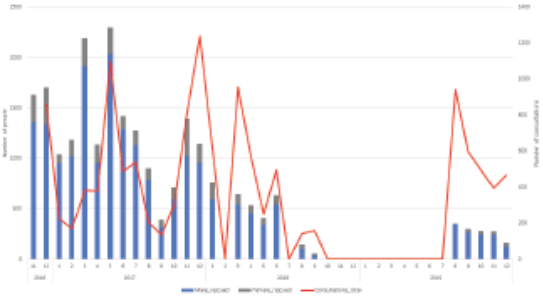

Figure 1 Number of migrants, refugees and asylum seekers rescued by MSF's search and rescue vessels on the Mediterranean Sea and number of consultations at MSF's Outpatient Department by month. No rescues took place in February and July 2018 and between October 2019 and July 2019. Data on number of outpatient department consultations missing for June, 2017. Blue: number of rescued males. Grey: number of rescued females. Red: number of outpatient department consultations. MSF, Médecins sans Frontières.

In addition, MSF documented 287 consultations for SGBV, of which the vast majority (99.7%, 286/287) took place 72 hours or more after the incident occurred. Five women were recorded who were pregnant after a rape. There were eight women recorded who requested termination of pregnancy, of which six were referred on disembarkation in Europe.

MSF organised 23 urgent medical referrals, which required immediate transport to referral health facilities by fast boat or by helicopter. An additional 1552 non-urgent medical referrals were organised who were referred to non-MSF clinics on arrival on the mainland (table 2).

Among all diagnoses for children under 5, 46.8% (51/109) were related to skin conditions. The most frequently diagnosed health conditions among children aged 5 years or older and adults were skin conditions (30.6%, 5475/17 869), motion sickness (28.6%, 5116/17 869), headache (15.4%, 2748/17 869) and acute injuries (5.7%, 1013/17 869). Of acute injuries, 44.7% were non-violence-related injuries (ie, injuries that were not caused by violence) (453/1013), 30.1% were fuel burns (297/1013) and 25.4% were violence-related injuries (257/1013) (table 3).

Sexual and gender-based violence

MSF documented a total of 482 consultations for SGBV, of which 30 were for male and 452 were for female survivors (table 3). Of the 482 consultations for SGBV, 95 were first consultations for rape specifically in 2018 (78) and 2019.[17] Of these first consultations, 99% (94/95) took

Table 1 Demographic characteristics and country of origin of migrants, refugees and asylum seekers rescue by MSF's search and rescue vessels on the Mediterranean Sea, November 2016–December 2019

	n	%*
Number of rescued people	22966	
Male	19546	85.1
Female	3420	14.9
Women travelling alone	2025	59.2†
Pregnant women	346	10.1†
Unaccompanied minors	4261	18.6
Children<5 years	328	1.4
Country of origin		
Sub-Saharan Africa		
Nigeria	4140	18.0
Eritrea	2395	10.4
Guinea Conakry	1916	8.3
Ivory Coast	1656	7.2
Sudan	1195	5.2
Senegal	1166	5.1
Gambia	1128	4.9
Ghana	857	3.7
Cameroon	593	2.6
Somalia	436	1.9
Sierra Leone	351	1.5
Ethiopia	167	0.7
Guinea Bissau	155	0.7
Mali	129	0.6
Burkina Faso	118	0.5
Togo	102	0.4
Niger	99	0.4
South Sudan	59	0.3
Chad	49	0.2
Benin	31	0.1
Democratic Republic of Congo	9	0.0
Uganda	9	0.0
Central African Republic	4	0.0
Liberia	2	0.0
Asia		
Bangladesh	1432	6.2
Syria	334	1.5
Pakistan	273	1.2
Palestina	41	0.2
Yemen	22	0.1
Iraq	5	0.0
Afghanistan	3	0.0
North Africa		
Egypt	199	0.9
Algeria	126	0.5
Tunesia	57	0.2
Morocco	21	0.1
Libya	18	0.1
Other/unknown		
Other	96	0.4
Unknown	3573	15.6

*Pertentage of total number of rescued people.
†Percentage of total number of rescued women.
MSF, Médecins sans Frontières.

place more than 72 hours after the incident. The majority of survivors were female (91.6%, 87/95) and 15 years or older (99%, 94/95). Most survivors of rape came from Nigeria (36.8%, 35/95), followed by Cameroon (21.1%, 20/95) and Ivory Coast (19%, 18/95) (table 4).

Mortality on board

Between January 2016 and December 2019, five deaths occurred on MSF's search and rescue vessels. Probable causes of death included compressive asphyxiation due to human crushes and stampedes on the wooden boats or dinghies or while getting on the boat, and severe hypothermia. In addition to these five deaths, the search and rescue vessels frequently onboarded people who had already died on their journey prior to reaching the MSF vessels.

DISCUSSION

We were able to present data from onboard consultations that were systematically offered to all 22 966 rescued people on one of the largest and longest running rescue vessels on the Mediterranean Sea over the course of 3 years (November 2016—December 2019).

The number of rescues varied per month due to the constantly changing 'search and rescue landscape', including restrictions on search and rescue activities of Non-Governmental Organizations (NGOs) and the increased involvement of the Libyan Coast Guard in rescues, returning large numbers of migrants, refugees and asylum seekers to Libya.[19 20] Additionally, the number of migrants, refugees and asylum seekers attempting to make the crossing also fluctuated per month depending on weather conditions.[20]

Between January 2016 and December 2019, MSF conducted 12 438 outpatient consultations. MSF situational reports showed that the length of stay of migrants, refugees and asylum seekers on the search and rescue vessels varied, with increasingly long standoffs on sea in 2019. At times, the ship needed to stay off-coast for weeks with rescued people onboard while waiting to be assigned

Table 2 MSF consultations and referrals of migrants, refugees and asylum seekers on MSF's search and rescue vessels on the Mediterranean Sea, 2016–2019

	N	%
All consultations	12 438	
Number of new consultations	9811	78.88
Other follow-up	211	1.70
Number of dressings new	772	6.21
Number of dressings follow-up	334	2.69
Number of injections	1310	10.53
SRH consultations*	853	6.86
ANC consultations†	143	25.04
SGBV consultations*	287	2.31
SGBV consultations<72 hours‡	1	0.35
SGBV consultations>72 hours‡	286	99.65
Pregnant due to rape§	5	6.58
TOP requests†	8	1.40
TOP referrals†	6	1.05
Referrals	1575	12.66
Urgent—Medevac (fast boat/ helicopter)	23	1.46
Not urgent (on arrival)	1552	98.54

*Number of SRH and SGBV consultations recorded between May 2016 and December 2019. Percentages calculated over the total number of consultations in the same period.
†Number of ANC consultations, TOP requests and TOP referrals recorded between September 2017 and December 2019. Percentage calculated over the total number of SRH consultations in the same period.
‡Number of SGBV consultations that took place within and after 72 hours recorded between December 2016 and December 2019. Percentages calculated over the total number of SGBV consultations in the same period.
§Number of women pregnant due to rape recorded between January 2018 and December 2019. Percentage calculated over total number of pregnant women during the same period.
ANC, ante-natal care; MSF, Médecins sans Frontières; SGBV, sexual and gender-based violence; SRH, sexual and reproductive health; TOP, termination of pregnancy.

a place of safety for disembarkation. This had a direct impact on the volume of OPD consultations and medical and psychological complaints, as crowded living conditions and confined spaces onboard were causing discomfort and rescued people needed multiple consultations while awaiting non-urgent referrals.

Women represented 14.9% of the rescued migrants, refugees and asylum seekers. While this percentage is lower than the percentage of women seeking asylum in the European Union, the demographic breakdown was similar on other search and rescue vessels on the central Mediterranean route.[13 21] The percentage of children under 5 and unaccompanied minors was also lower than expected compared with the percentages seeking asylum in the European Union. The central Mediterranean route is considered relatively difficult and might be less often attempted by women and children. Moreover, in critical rescues, which occur frequently on this part of the sea, there is oftentimes much loss of life, which impacts women and children disproportionately.[2]

The high proportional morbidity of skin conditions has been noted on other search and rescue vessels as well, frequently with superinfection.[13 14] Scabies is typically associated with long permanence in conditions of poor hygiene, crowd, poverty and detentions.[22–24] Therefore, the high burden of skin conditions among migrants, refugees and asylum seekers included in this study, like scabies, could be linked to the living conditions on the migrants' journey and while they are in Libya.[9]

Almost 6% of the diagnoses on board (n=1017) were fuel burn wounds, violent and non-violent trauma. Similar chemical burns due to benzene were found on other search and rescue vessels, due to the mixture of saltwater with fuel that is often spilled inside the boats and stays attached to the clothing and body, causing deep burns due to prolonged skin contact.[13 25] Women appear to be disproportionately affected by fuel burn wounds. An explanation could be that women often sit in the middle of the boat to be protected from the waves as they often cannot swim. If there is any fuel leakage, this often accumulates in the middle of the boat where the women sit. Some non-violent injuries may have been sustained on the dinghies or during the rescue operations. The long journey to Libya and often prolonged stay in Libya, during which people are on the move and often face exploitation, contributed to the violence-related injuries that were diagnosed.

Non-communicable diseases (NCD) only made up for 0.4% of all diagnoses. Similarly, complications from NCDs were identified in 0.7% of migrants, refugees and asylum seekers on the search and rescue vessel of NGO Open Arms on the Mediterranean Sea (n=4516).[13] The lack of testing equipment, the short length of stay and the prioritisation of urgent medical care on the rescue vessels could lead to an underestimation of NCDs in rescued people. The young age and initially relatively good health of migrants that take the central Mediterranean route could also play a role.

Time and space constraints on board make it not feasible or desirable to conduct systematic mental health screening on board. Only self-reported mental health reports were recorded at the outpatient clinic. Migrant reception centres and health facilities in Europe that are implementing mental health services have found a high burden of mental health conditions.[15 26 27] Similar mental health conditions following trauma have been seen along other migratory routes, such as the western Balkan corridor to Northern Europe. A study showed that nearly one-in-three migrants seen at MSF mental health clinics experienced physical or psychological trauma along their journey, many of which reporting anxiety and mental trauma.[28] Considering the treacherous journey that the migrants, refugees and asylum seekers will have

Table 3 Health conditions of migrants, refugees and asylum seekers on MSF's search and rescue vessels on the Mediterranean Sea, 2016–2019: MSF outpatient department consultations

	<5 years		≥5 years			
Diagnosis	Male	Female	Male	Female	Total	Proportional morbidity (%)
Acute injuries	4	0	834	179	1017	5.66
Fuel burn	0	0	212	85	297	1.65
Non-violence related injury	3	0	399	54	456	2.54
Resuscitation	1	0	3	3	7	0.04
Violence-related injury	0	0	220	37	257	1.43
Chronic diseases	0	0	58	13	71	0.39
Dehydration	2	1	503	35	541	3.01
Hypothermia	0	2	153	22	177	0.98
Infectious diseases	8	8	740	101	857	4.77
Acute bloody diarrhoea	0	0	30	6	36	0.20
Acute flaccid paralysis	0	0	0	0	0	0.00
Acute lower respiratory tract infection	1	1	58	10	70	0.39
Acute upper respiratory tract infection	6	6	373	41	426	2.37
Acute watery diarrhoea	1	1	194	26	222	1.23
Malaria (confirmed)	0	0	2	1	3	0.02
Measles (suspected)	0	0	0	0	0	0.00
Meningitis (suspected)	0	0	0	0	0	0.00
Sexually transmitted infection	0	0	51	13	64	0.36
Tuberculosis (suspected)	0	0	32	4	36	0.20
Typhoid fever	0	0	0	0	0	0.00
Gynaecological conditions	0	0	0	575	575	3.20
Gynaecological disease	0	0	0	93	93	0.52
Pregnancy related	0	0	0	482	482	2.68
Skin conditions	24	27	4839	636	5526	30.74
Scabies	7	9	1401	210	1627	9.05
Skin disease	14	18	3259	421	3712	20.65
Skin infection	3	0	179	5	187	1.04
Mental health	0	0	14	12	26	0.14
Common psychiatric disorders	0	0	9	11	20	0.11
Severe psychiatric disorders	0	0	5	1	6	0.03
Motion sickness	2	3	4344	772	5121	28.48
Other conditions	15	13	2987	561	3576	19.89
Anaemia	0	0	8	3	11	0.06
Fever without identified cause	4	3	80	19	106	0.59
Headache	0	0	2363	385	2748	15.29
Urinary tract infection	0	0	28	21	49	0.27
Eye infection	1	1	73	15	90	0.50
Other	10	9	435	118	572	3.18
Severe acute malnutrition	0	0	7	2	9	0.05
Sexual violence	0	0	30	452	482	2.68
Total	55	54	14509	3360	17978	100

*Number of times disease or condition was diagnosed at the outpatient department between January 2016 and December 2019. The total number of diagnoses exceeds the total number of consultations due to staff turnover that lead to variation in procedures, documentation and measurements. For example, for some months, the deck management of motion sickness, headache and deck inspection of scabies were included in the OPD consultations, while other months they were excluded from the total OPD consultation counts.
MSF, Médecins sans Frontières; OPD, outpatient department.

Table 4 Consultations for rape of migrants, refugees and asylum seekers on MSF's search and rescue vessels on the Mediterranean Sea, 2018–2019

	2018		2019		Total	
	N	%	n	%	n	%
Number of first consultations for rape	78		17		95	
Time since incident						
<72 hours	1	1.28	0	0	1	1.05
>72 hours	77	98.72	17	1.00	94	98.95
Age						
<5 years	0	0	0	0	0	0
5–14 years	1	1.28	0	0	1	1.05
≥15	77	98.72	17	1.00	94	98.95
Gender						
Female	71	91.03	16	0.94	87	91.58
Male	7	8.97	1	0.06	8	8.42
Country of origin						
Cameroon	15	19.23	5	29.41	20	21.05
Eritrea	2	2.56	0	0	2	2.11
Ghana	1	1.28	0	0	1	1.05
Guinea Conakry	1	1.28	0	0	1	1.05
Ivory Coast	13	16.67	5	29.41	18	18.95
Liberia	1	1.28	0	0	1	1.05
Mali	1	1.28	0	0	1	1.05
Morocco	3	3.85	0	0	3	3.16
Nigeria	31	39.74	4	23.53	35	36.84
Senegal	1	1.28	0	0	1	1.05
Sierra Leone	5	6.41	1	5.88	6	6.32
Somalia	3	3.85	2	11.76	5	5.26
Sudan	1	1.28	0	0	1	1.05

MSF, Médecins sans Frontières.

had to endure, including the attempt to cross on often-times overcrowded dinghies or wooden boats with lacking hygiene conditions and food and water availability, and in combination with underlying trauma, the psychological first aid offered by MSF is essential. Especially with the increasingly longer stand offs on sea, keeping migrants, refugees and asylum seekers on board of the search and rescue vessels for weeks. However, the limitations of space, capacity and lack of interpreters, as also noted on search and rescue vessels in Greece, will continue hinder the medical team's ability to provide more in-depth mental health support on the ships.[25 29]

Out of the 482 SGBV consultations, there were 95 first consultations specifically for rape. The MSF medical team attempted to have systematic consultations with all rescued women and carefully ask about SGBV and any support they may need. However, this was difficult to implement due to space and time constraints and the hesitance of SGBV survivors to speak out due to fear of stigmatisation. Only 30 consultations were conducted for male survivors of SGBV in general, of which seven consultations were conducted for male survivors of rape specifically, which is a likely underestimation of the true number of male survivors. Additional male survivors of SGBV have been identified by non-medical staff on board and is confirmed by testimonies given by rescued people, but they refused medical consultation and were, therefore, not included in the analysis.

LIMITATIONS

The need for services was high and onboard staff were often overwhelmed with sudden influxes of rescued people. This impacted the ability of the medical team to collect accurate data and properly document diagnoses and demographic characteristics. Therefore, we do not have reliable population counts, which could be used as denominators for the calculation of disease incidence or assess whether the length of stay had an effect on the number of OPD consultations or diagnosed morbidities.

Due to the limited testing and diagnoses capacity of the OPD, space limitations and the generally short length of stay of migrants, refugees and asylum seekers on the ship, it was not feasible to provide in-depth medical and psychological treatment and support, which has likely led to an underestimation of actual morbidities including mental health conditions and SGBV.

All data presented were collected as routine MSF programme data, that needed to be recorded quickly so as not to create further delays for migrants awaiting medical care. Therefore, some of the data were incomplete and could only be partly used for this analysis. While case definitions stayed the same throughout the observation period, staff turnover lead to variation in procedures, documentation and measurements. For example, for some months, the deck management of motion sickness, headache and deck inspection of scabies were included in the OPD consultations, while other months they were excluded from the total OPD consultation counts. The recording of skin diseases, skin infections and scabies also varied over time, which resulted in three diagnosis categories that are difficult to disentangle retrospectively.

CONCLUSION

MSF's access to the rescue areas in the central Mediterranean Sea has varied over the past 3 years and has been unpredictable. In line with findings from other studies of morbidities on search and rescue vessels, the main diagnoses on board where MSF teams have operated were non-severe and directly related to the migration journey on the boat and previously on the way to and in Libya such as overcrowding, lack of drinking and washing water, extreme sun exposure, heat or cold. Approximately, one-third of total diagnosis were scabies, one-third motion sickness and one-sixth headache. However, of the diseases on board, we also identified potentially severe conditions related to the journey in about 10% of the population, namely, dehydration, hypothermia and acute injuries. Additionally, we identified survivors of sexual and gender-based violence and violence-related injuries, which most likely are only the top of the iceberg. The number of diagnoses of infectious diseases was very low compared with other diagnoses.[18–15] We conclude that this population may be relatively young and healthy but displays significant journey-related illnesses and includes migrants, refugees and asylum seekers who have suffered significant violence during their transit and need urgent and direct access to essential services and protection in a place of safety on land.

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Patient consent for publication Not applicable.

Ethics approval This study involves human participants; but this research fulfilled the exemption criteria set by the Médecins Sans Frontières Ethics Review Board for a posteriori analyses of routinely collected clinical data and thus did not require MSF ERB review. It was conducted with permission from Melissa McRae, Medical Director, Operational Centre Amsterdam, Médecins Sans Frontières. This is a retrospective analysis of routinely collected data. Therefore, it has been exempted from full ethical review by MSF Holland's research committee. The data in the used datasets did not contain individual identifiers. The data sets were password protected and only accessible by the first and last author.

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2.5 Public health threat detection with an EWAR system among Rohingya refugees during the acute humanitarian crisis in Cox's Bazar, Bangladesh, 2018

Mazhar MKA, Finger F, Evers ES, **Kuehne A**, Ivey M, Yesurajan F, Shirin T, Ajim N, Kabir A, Musto J, White K, Baidjoe A, le Polain de Waroux O. An outbreak of acute jaundice syndrome (AJS) among the Rohingya refugees in Cox's Bazar, Bangladesh: Findings from enhanced epidemiological surveillance. PLoS One. 2021 Apr 29;16(4):e0250505. doi: 10.1371/journal.pone.0250505. PMID: 33914782; PMCID: PMC8084213.

In Cox's Bazar (CXB) District, Bangladesh, unfolded an acute humanitarian crisis commencing August 2017 with the arrival of more than 700,000 newly arriving refugees (113). Within weeks in mid-2017, the camp in CXB grew to a population of over 900,00 Rohingyas who fled violence in Myanmar (113). Horrendous overcrowding and poor sanitation left the camp population vulnerable to outbreaks (114) In order to detect health threats early an early warning alert and response (EWAR) system was implemented by the MoH and WHO (115). A desk review suggested that Hepatitis A and E could spread particularly well in the camp setting and low immunity within the population for hepatitis E (HEV) was deemed likely (58). In January 2018 the EWAR system triggered an alert that indicated a rapidly increasing number of consultations for acute jaundice syndrome (AJS) in the camp (58)

The alert was considered to potentially indicate an outbreak of HEV that could represent a deadly public health threat to the population in the camp (58). The EWAR system was consecutively amended to allow daily reporting of all AJS cases using a uniform line list that contained information on sociodemographic and clinical characteristics, risk factors and laboratory tests (58). The case definition used for AJS cases was a person with acute onset of jaundice in the absence of other known causes, with or without fever (58). Because laboratory testing for pathogens potentially causing AJS was not routinely performed in CXB, an enhanced laboratory surveillance system was implemented to complement the syndromic surveillance conducted by the EWAR system (58). The laboratory surveillance was conducted on a subset of AJS cases that were reported between week 8 and week 12 of 2018 in 18 health facilities that reported AJS cases in the previous weeks and had sufficient capacities to collect, store and transport AJS blood samples (58).

During the time period of the enhanced surveillance, 575 cases of AJS were reported in CXB (58). 275 presented to one of the eight participating health facilities and had their blood sample taken and processed (58). Of the 275 cases, 57% were male and 45% were less than 10 years old (58). The weekly mean attack rate was 0.6 per 10,000 population (95% CI: 0.28-0.92) and was highest among children less than 5 years old and in inhabitants of camp no. 9 (58). The most common symptoms recorded were fever (67%), nausea (56%), abdominal pain (41%) and vomiting (25%) (58). Two-thirds of the samples were positive for hepatitis A (HAV) (67%), 13% for hepatitis B (HBV) and 9% for hepatitis C (HCV), 5% for leptospirosis and 0.4% for hepatitis E (HEV); 25% of the samples were negative for all pathogens; 9% tested positive for more than one pathogen (58).

The presented study exemplifies the key function of an EWAR system in a humanitarian crisis. The EWAR system allowed the timely detection of the increase in AJS cases and provided for the rapid implementation of a line list and daily reporting (58). The public health threat detection led to an outbreak investigation including enhanced laboratory surveillance that allowed to rule out an HEV outbreak (58). HEV outbreaks in refugee camps had in the past shown case fatality rates (CFR) among pregnant women of 10% (116)and an HEV outbreak under the WHS conditions in CXB camp was expected to cause high attack rates and high CFR (58). Instead, a less dangerous HAV outbreak was

confirmed (58). However, in addition to the acute outbreak of HAV, a big proportion of chronic viral hepatitis (HBV 13% and HCV 9%) were detected (58). In 2019, a study by the National Liver Foundation of Bangladesh confirmed unusually high levels of HBV and HCV prevalence among Rohingya refugees in CXB (117).

The presented study suffers from several limitations regarding data quality and selection bias: line lists were not filled correctly nor completely and only a fraction of health facilities was able to collect laboratory samples (58). It fulfilled however its purpose of identifying the cause of the outbreak. The study was able to provide the following recommendations based on the obtained evidence.

Recommendations based on indicators of population health status and public health threats:

- Following the detection through the EWAR system, an outbreak of HAV was identified which highlights the need to improve WHS conditions in the camp to prevent HAV to spread and other outbreaks of waterborne diseases from occurring (58).
- A high proportion of HBV and HCV was detected indicating a need to scale up immunisation (HBV only) as well as detection and treatment capacities for HBV and HCV in the camp in CXB (58).

PLOS ONE

RESEARCH ARTICLE

An outbreak of acute jaundice syndrome (AJS) among the Rohingya refugees in Cox's Bazar, Bangladesh: Findings from enhanced epidemiological surveillance

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Abstract

In the summer of 2017, an estimated 745,000 Rohingya fled to Bangladesh in what has been described as one of the largest and fastest growing refugee crises in the world. Among numerous health concerns, an outbreak of acute jaundice syndrome (AJS) was detected by the disease surveillance system in early 2018 among the refugee population. This paper describes the investigation into the increase in AJS cases, the process and results of the investigation, which were strongly suggestive of a large outbreak due to hepatitis A virus (HAV). An enhanced serological investigation was conducted between 28 February to 26 March 2018 to determine the etiologies and risk factors associated with the outbreak. A total of 275 samples were collected from 18 health facilities reporting AJS cases. Blood samples were collected from all patients fulfilling the study specific case definition and inclusion criteria, and tested for antibody responses using enzyme-linked immunosorbent assay (ELISA). Out of the 275 samples, 206 were positive for one of the agents tested. The laboratory results confirmed multiple etiologies including 154 (56%) samples tested positive for hepatitis A, 1 (0.4%) positive for hepatitis E, 36 (13%) positive for hepatitis B, 25 (9%) positive for hepatitis C, and 14 (5%) positive for leptospirosis. Among all specimens tested 24 (9%) showed evidence of co-infections with multiple etiologies. Hepatitis A and E are commonly found in refugee camps and have similar clinical presentations. In the absence of robust testing capacity when the epidemic was identified through syndromic reporting, a particular concern was that of a hepatitis E outbreak, for which immunity tends to be limited, and which may be particularly severe among pregnant women. This report highlights the challenges of identifying causative agents in such settings and the resources required to do so. Results

written approval was obtained from the MoHFW to use this anonymised data set only for the purpose of sharing the results of this outbreak investigation and in the context of this manuscript. Any further request to access the data has to be approved by the MoHFW responsible for overseeing the Rohingya refugee response. The contact details are given below: - Civil Surgeon Office, Ministry of Health & Family Welfare, - Kolatoli Road, Cox's Bazar, Bangladesh - Email: coxsbazar@cs.dghs.gov.bd.

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from the month-long enhanced investigation did not point out widespread hepatitis E virus (HEV) transmission, but instead strongly suggested a large-scale hepatitis A outbreak of milder consequences, and highlighted a number of other concomitant causes of AJS (acute hepatitis B, hepatitis C, Leptospirosis), albeit most likely at sporadic level. Results strengthen the need for further water and sanitation interventions and are a stark reminder of the risk of other epidemics transmitted through similar routes in such settings, particularly dysentery and cholera. It also highlights the need to ensure clinical management capacity for potentially chronic conditions in this vulnerable population.

Introduction

Since August 2017, an estimated 745,000 Rohingya—including more than 400,000 children below 18 years—have fled to Cox's Bazar district, Bangladesh from Rakhine state in Myanmar [1]. Pre-existing settlements, from earlier influxes rapidly expanded into large and dense mega-settlements. Today, an estimated total of 860,000 [2] stateless refugees live in 34 densely populated camps in Cox's Bazar district, in what has been described as one of the largest and fastest growing refugee crises in the world [3]. The rapid settlement of this vulnerable population into overcrowded camps, with inadequate provision of water, sanitation, or general hygiene standards, combined with the high population density are some of the factors that led to an increased risk of infectious disease outbreaks, compounded by vulnerability factors such as nutritional deficiencies and low pre-existing routine vaccination coverage [4].

An Early Warning, Alert and Response (EWAR) system was put in place by the World Health Organization (WHO) and the Bangladesh Ministry of Health and Family Welfare (MoHFW) in collaboration with multiple partners across the camps to help monitor and rapidly detect potential infectious diseases threats [5,6]. This allowed health facilities to report weekly case counts of different conditions/syndromes for which set thresholds were established which, when triggered, required investigation within 48 hours. In addition, EWAR health facilities immediately report unusual events of potential severity or any potential case or cluster requiring immediate investigation after initial verification of the event.

Acute Jaundice Syndrome (AJS) is not uncommon in refugee settings and can be caused by various infectious etiologies, such as acute viral hepatitis E, A, B, C, or more rarely leptospirosis, as well as non-infectious liver disease. The main differential diagnoses for these diseases and their transmission routes are summarised in S1 Appendix. Given the high population density and poor sanitation conditions usually found in such settings, hepatitis A and E can easily spread within a susceptible population. Of particular concern is Hepatitis E which can cause severe outcomes in pregnant women, with case fatality ratios (CFR) up to 10% reported in recent outbreaks [7–9] and which has been the leading cause of acute hepatitis in pregnancy in Myanmar [10]. In addition, Hepatitis E is less endemic, meaning that a lower proportion of adults tend to be immune, compared to hepatitis A, which classically affects mostly younger age groups in highly-endemic settings [7–9].

The prevalence of chronic hepatitis (B and C), vary among refugee populations [11]. The country of origin of patients has shown to be an important factor and Myanmar has a high reported incidence of acute and chronic liver disease, mostly caused by Hepatitis B virus (HBV) and Hepatitis C virus (HCV) [10,12]. The incidence of leptospirosis is not well documented in Bangladesh due to lack of diagnostic tests, though it has been reported in the region and the environmental factors are present to spread the infection [13]. Similarly, the incidence of leptospirosis in Myanmar has not been studied to date.

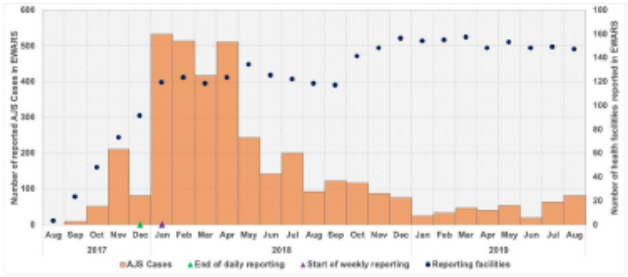

Fig 1. Epidemiology curve of reported AJS cases against number of facilities reporting (monthly average) in EWAR system; and timing of changes to the surveillance system from daily to weekly.

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In January 2018, alerts for Acute Jaundice Syndrome (AJS) were triggered by the surveillance system due to a rapid increase in the reported weekly incidence (initially defined as twice the average of the last three weeks reported number of cases, from each facility). Between January and April 2018, a total of 1976 cases were reported through the system, with a weekly number of 77–147 cases (average 116 per week). The number of reporting health facilities remained stable (between 110–120 per week) throughout that period, and increased to 140 by the end of the year after reported case counts tailed off (Fig 1).

Following the alerts triggered by the surveillance system, and with over 1300 reported cases and 6 deaths since late 2017, a rapid field investigation was undertaken between 5-8th February 2018. Findings from these suggested multiple etiologies with initial laboratory results from 27 patient samples collected showing 37% (10/27) positive for HAV IgM, 7% (2/27) positive for HCV, 4% (1/27) positive for HEV, and the remaining 52% (14/27) negative for all Hepatitis markers and Leptospirosis IgM. The presence of multiple etiologies found in this initial investigation, especially HAV and HEV, prompted the simultaneous establishment of an enhanced surveillance strategy to ensure detailed information about each case could be gathered and analysed, combined with and exhaustive laboratory outbreak investigation to better understand the etiologies. Here, we describe the process and findings from this enhanced surveillance and outbreak investigation.

Methods

Establishment of enhanced surveillance

An enhanced surveillance for AJS including daily reporting of cases was implemented since the beginning of 2018 in Cox's Bazar, with the objective to identify more detailed epidemiological characteristics of reported cases. A digital case report form was developed and available on the EWAR system [6]. The form included information on detailed demographic characteristics, geographical origin of patients, clinical presentation, exposure factors (water and sanitation exposure, household environment) and laboratory results for any samples that were taken (S2 Appendix).

Exhaustive laboratory outbreak investigation

A serological investigation was conducted for approximately one month between 28 February and 26 March 2018 based on exhaustive testing of all patients presenting at a subset of 18 healthcare facilities in the camps. The main purpose of testing was to better document the etiologies at play, assuming likely co-circulation of HAV and HEV as the main causative agents,

and other acute (or flare ups of chronic) HBV and HCV, potential cases of leptospirosis as well as acute hepatitis from non-infectious causes. The duration (four weeks) of the enhanced laboratory investigation was based on an opportunistic sampling exercise which was required to provide enough understanding of the key drivers of infection, based on a distribution of etiologies in an initial sample of 27 patients (collected between 5-8th February 2018), as well as pragmatic considerations of stock availability, transport, storage and sample collection and testing capacity.

Participating health facilities were proposed as those who reported >10 cases of AJS between January and February 2018 (week 1–8) in EWAR, and who self-identified as having the capacity to collect and transport samples.

Any person with acute onset of jaundice- with or without fever and absence of any known precipitating factors (EWARS Bangladesh Case Definition for Acute Jaundice Syndrome, see S3 Appendix) fulfilling the below criteria was invited to provide a blood sample:

1. presenting at one of the 18 participating facilities (Fig 2).

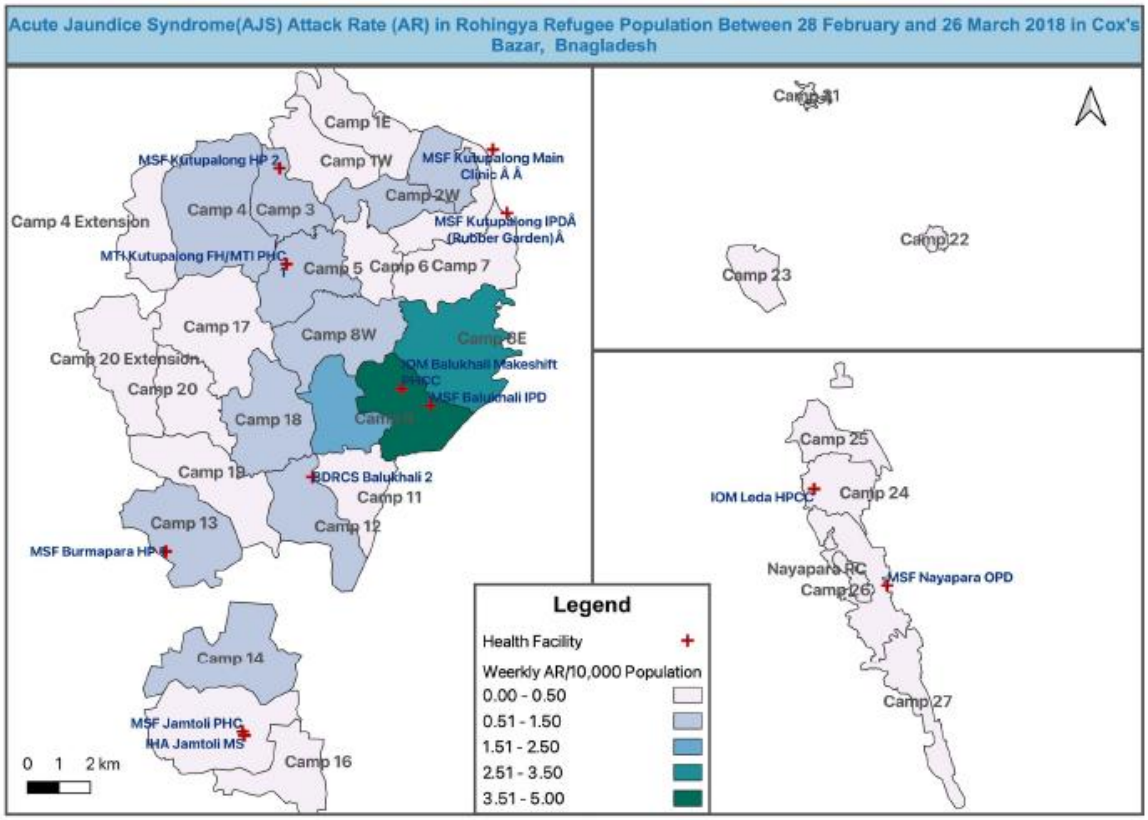

Fig 2. Map of AJS attack rate (per 10,000 population) reported through enhanced epidemiological surveillance strategy between 28 February and 26 March 2018 in the Rohingya refugee camps and locations of reporting health facilities in Cox's Bazar, Bangladesh

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2. with a completed Case Report Form (CRF), including demographic details, clinical details, family history, patient outcome
3. Having provided consent to having a sample taken and other information collected.

Participants were provided with information about the reason for the blood tests, and how their information would be handled and stored. Verbal consent was obtained by the medical team in charge at each of the 18 participating facilities. Participants who refused to provide consent, were excluded from sample collection.

Laboratory procedures

Samples (venous blood) were collected in a pro-coagulation (red-top) tube and stored vertically maintaining a cold chain at 2–8˚C (for coagulation) before serum separation. Samples were labeled with unique IDs and transferred to a central facility (Médecins sans Frontières Kutupalong Clinic) for serum separation. Samples were later transported to the laboratory at the Institute of Epidemiology Disease Control and Research (IEDCR) in Dhaka for etiological analyses.

All samples were tested for HAV, HBV, HCV, HEV and leptospirosis using the diagnostic tests indicated in Table 1. Hepatitis testing was done using ELISA and Leptospira-IgM was tested using rapid immunochromatographic test (ICT).

Statistical analyses

Descriptive analyses were conducted for all reported AJS cases followed by a post-hoc nested case control (case-case) analysis within the cohort of patients tested during the enhanced surveillance phase, to identify specific factors associated with hepatitis A, which was identified as the main cause for the AJS epidemic. In the analysis "Case" was classified as having Positive Hep A IgM result (HAV +ve cases) and "Control" was classified as having Negative Hep A IgM result (HAV -ve cases). Controls are not from the general population but from same cohort who presented with AJS symptoms and tested negative for Hepatitis A marker, irrespective of test results for other etiologies (Hepatitis B, C, E and Leptospirosis). Analysis was conducted to determine risk factors associated with predicted outcome (disease development) and effects of other independent variables (gender, age, age-groups, reported household transmission etc.) by measuring odds ratio with 95% confidence interval. All analysis was conducted using Stata 16.

Environmental investigation

No specific investigation was undertaken during the enhanced surveillance phase for AJS, however findings from a large water quality surveillance exercise conducted shortly before the increased incidence of AJS alerts (18 September-14 November 2017) identified significant

Table 1. Testing algorithm.

No	Disease/Pathogen	Diagnostic test to be performed
1	Hepatitis A Virus	HAV ELISA for IgM
2	Hepatitis B Virus	Hepatitis B surface antigen
3	Hepatitis C Virus	Anti-HCV antibodies
4	Hepatitis E Virus	Anti-HEV ELISA for IgM
5	Leptospirosis	Leptospira lateral flow for IgM

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contamination at water sources and household levels, underlining the presence of conditions for spread of water-borne disease (S4 Appendix).

Ethical consideration

The data reported were collected as part of routine public health outbreak response activities. For this publication, no additional primary data collection took place other than the data required for outbreak response and surveillance. Therefore, no additional ethical approval was sought at the time of data collection. The formulation of this work was presented and discussed with the Civil Surgeon Cox's Bazar from the Ministry of Health & Family Welfare (MoHFW) responsible for overseeing the Rohingya refugee crisis. All individual case data was anonymized.

Results

A total of 575 AJS cases were reported through weekly reporting with a weekly average of 115 cases ranging from 88 to 158 cases from 28 February to 26 March 2018 between week 8 to week 12 in 2018. Of these reported cases, 275 were reported in the enhanced surveillance system from whom blood samples were collected. Of these, 57% (156) were male and 68% (186) were children (below <18 years) (Table 2).

Camp-wise weekly attack rate (AR) per 10,000 population was calculated for the reported 275 AJS cases detected by the enhanced epidemiological surveillance strategy between 28 February and 26 March 2018. The weekly mean attack rate over the enhanced surveillance period (28 February to 26 March 2018) was 0.60 (95% CI: 0.28 to 0.92) per 10,000 population, across all the camps for the reported AJS cases. However, the AR varies among age-groups and was higher in younger age-groups (see Table 3). AR (per 10,000 population) for different age-groups is graphically presented in S5 Appendix.

All AJS cases presented with jaundice, as per reporting definition, combined with other symptoms. In total 67% (183/275) presented with fever, 56% (155/275) with nausea, 41% (113/275) with abdominal pain, 25% (70/275) with vomiting, 21% (57/275) with fatigue, 14% (38/275) with itching, 13% (37/275) with joint pain, 9% (27/275) with loss of appetite, 9% (26/275) with dark urine, 3% (7/275) with bleeding and 2% (6/275) with convulsion (Fig 3).

Out of the 275 samples, 206 were positive for at least one of the agents tested. The laboratory results confirmed multiple etiologies including 154 (56%) samples tested positive for Hepatitis A, 1 (0.4%) positive for Hepatitis E, 36 (13%) positive for Hepatitis B, 25 (9%) positive for Hepatitis C, and 14 (5%) positive for Leptospirosis.

Among all specimens tested 24 (9%) showed evidence of co-infections with multiple etiologies. Of these, 4% (11/275) had HAV-HBV co-infection, 0.7% (2/275) had HAV-HCV co-infection, 0.4% (1/275) had HAV-HEV co-infection, 0.4% (1/275) had HAV-LEPT co-infection; 0.7% (2/275) had HBV-HCV co-infection, 0.4% (1/275) had HBV-LEPT co-infection and 0.4% (1/275) had HCV-LEPT co-infection. The remaining 69 (25%) samples tested negative for all tests.

Table 2. Gender and age-group distribution of reported AJS cases.

Age Group of Reported Cases	Male	Female	Total
0 to 4 years	45 (16%)	22 (8%)	67 (24%)
5 to 9 Years	34 (12%)	25 (9%)	59 (21%)
10 to 17 Years	34 (12.3%)	26 (9.4%)	60 (21.7%)
18 years or more	43 (15.6%)	46 (16.7%)	89 (32.3%)
Total	**156 (56.7%)**	**119 (43.3%)**	**275 (100%)**

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Table 3. Attack rate of reported AJS cases by age-group* and gender among all 34 camps between 28 February and 26 March 2018 in Cox's Bazar, Bangladesh.

	Weekly AR/10,000 population (95% CI)
Overall	0.60 (0.28 to 0.92)
By age-group	
0–4 years	0.80 (0.34 to 1.26)
5–11 years	0.73 (0.36 to 1.10)
12–17 years	0.71 (0.31 to 1.11)
18+ years	0.43 (0.15 to 0.92)
By gender	
Female	0.49 (0.21 to 0.77)
Male	0.71 (0.33 to 1.09)

* Population data from UNHCR Bangladesh Operational Update, 1–15 August 2018, was used to calculate the AJS attack rate [14].

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Descriptive age-group analysis showed that among all Hepatitis A positives cases (154), 38% (58/154) were aged 0–4 years, 34% (3252/154) were aged 5–9 years, 21% (32/154) were aged 10–17 years and the remaining 8% (12/154) were adults (18 years or above). The only case found to be positive for Hepatitis E was aged 5–9 years. Half (18/36) of the Hepatitis B positives case were reported among younger age-groups (<18 years), whereas for HCV only 8% (2/25) were reported in younger age-groups (<18 years). Among all (14) leptospirosis cases there were male predominance (64%) and all cases were in older children (29% in 10 to 17 years) and in adult (71% in 18 years or above) age groups (Fig 4).

Among all AJS cases, 8% (23/ 275) reported household exposure, of which 13 (56%) were female and 10 (44%) were male which represents 11% (13/113) of all reported female and 6.4% (10/156) all reported male AJS cases. Of these 23 cases reported with household exposure, only 11 females and 5 males tested positive for Hepatitis A.

Additional analyses were performed to examine the association between hepatitis A sero-positivity with age, gender and other risk factors. Univariate regression analysis showed that the odds of developing hepatitis A was lower in older age groups (10–17 and 18+ years) compared to younger age-group (0–4 years) with a p-value of <0.001. (Table 4). Univariate

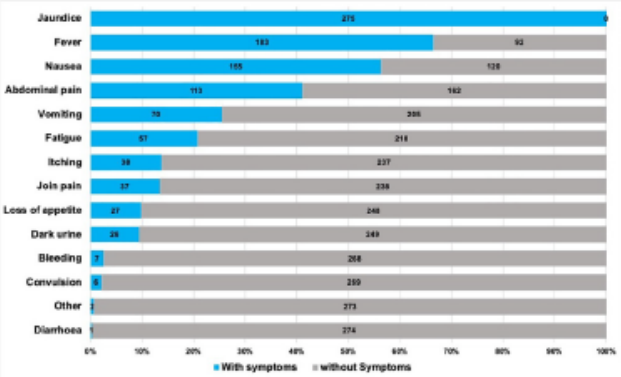

Fig 3. Presenting symptoms of reported AJS cases.

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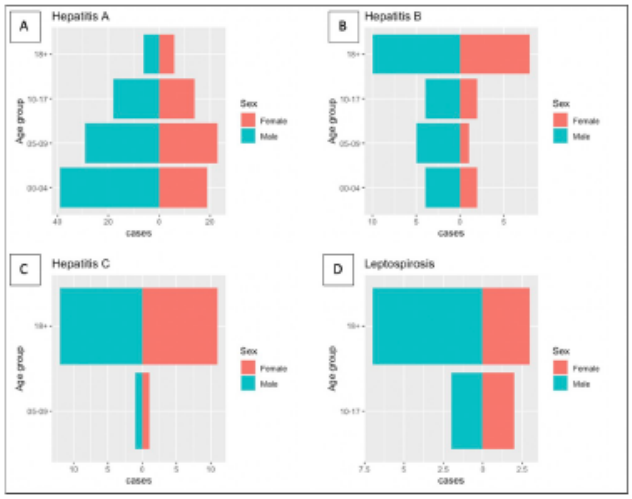

Fig 4. Age and sex distribution of AJS cases with their seropositivity collected during exhaustive sampling, 28 February– 26 March 2018, Cox's Bazar, Bangladesh. (A) Hepatitis A seropositivity. (B) Hepatitis B seropositivity. (C) Hepatitis C seropositivity. (D) Leptospirosis seropositivity.

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analysis also showed no association between hepatitis A seropositivity and gender (p-value 0.256) (Table 4).

We explored whether presenting symptoms among AJS cases were associated with hepatitis A seropositivity. Univariate analysis showed that HAV was positively associated with fever (OR 2.25; 95% CI: 1.35 to 3.76); dark urine (OR 3.63; 95% CI: 1.32 to 9.94); loss of appetite (OR 3.83; 95% CI: 1.40 to 10.45) and vomiting (OR 1.85; 95% CI: 1.05 to 3.27), and negatively associated with joint pain (OR 0.42; 95% CI 0.21–0.86) (Table 4). Etiological risk factor data collected from the cases indicate different sources were used for drinking water including tube wells, communal tap, water supply trucks. However, univariate regression analysis showed no association between reported drinking water source type and hepatitis A seropositivity (Table 4 and Fig 5).

Additional nested case control (case-case study) analyses showed no association between hepatitis A seropositivity and a reported case of AJS in the household (p-value 1.77). However, sub-group analysis showed that female HAV cases were more likely to have reported household transmission (for definition see S6 Appendix) than males, with a OR of 5.93 (95% CI:1.25 to 28.1; p-value: 0.025). The univariate regression analysis among age-groups showed that, compared to younger age groups (0–4 years; 5–9 years and 10–17 years), adult HAV cases (18 years or above) were more likely to have reported household transmission with an OR of 18.75 (95% CI: 2.96 to 118.92; p-value: 0.002) (see Table 5).

Discussion

The investigation into an outbreak of acute jaundice syndrome in the Rohingya refugee camps revealed a hepatitis A epidemic and multiple other infectious etiologies contributing to AJS (acute HBV, HCV, leptospirosis). Data from enhanced epidemiological surveillance suggests that at least 154 were infected (56% of the reported AJS cases) with HAV between February and March 2018 which was the most common underlying cause of AJS among the tested cases,

Table 4. Association of hepatitis A seropositivity with age-group, gender, presenting symptoms and drinking water sources.

	OR (95% CI)	P-value
Age-group		
0–4 years (n = 67)	1.0*	-
5–9 years (n = 59)	1.15 (0.40 to 3.13)	0.79
10–17 years (n = 60)	0.18 (0.07 to 0.42)	< 0.001
18+ years (n = 89)	0.02 (0.01 to 0.06)	< 0.001
Gender		
Female (n = 119)	1.0*	-
Male (n = 156)	1.32 (0.82 to 2.14)	0.256
Presenting symptoms#		
Fever (n = 183)	2.25 (1.35 to 3.76)	0.002
Nausea (n = 155)	1.19 (0.76 to 1.93)	0.479
Abdominal pain (n = 113)	0.81 (0.50 to 1.31)	0.385
Vomiting (n = 70)	1.85 (1.05 to 3.27)	0.034
Fatigue (n = 57)	0.83 (0.46 to 1.50)	0.542
Itching (n = 38)	1.23 (0.61 to 2.47)	0.563
Joint pain (n = 37)	0.42 (0.21 to 0.86)	0.018
Loss of Appetite (n = 27)	3.83 (1.40 to 10.45)	0.009
Dark Urine (n = 26)	3.63 (1.32 to 9.94)	0.012
Bleeding (n = 7)	1.04 (0.23 to 4.74)	0.960
Convulsion (n = 6)	0.38 (0.07 to 2.12)	0.271
Drinking water sources^		
Tube-well (n = 170)	1.27 (0.78 to 2.06)	0.342
Tap water (n = 45)	1.22 (0.63 to 2.33)	0.555
Unknown sources (n = 58)	0.56 (0.32 to 1.01)	0.055

*Baseline category

#Diarrhoea (n = 1) and other (n = 2) symptoms were omitted from the summary table

^ water truck (n = 2) was omitted from the summary table.

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and driving the epidemic dynamics, followed by Hepatitis B and hepatitis C which likely contributed to background levels of AJS in the camps Hepatitis E was observed in only one of the 275 samples.

The results highlight the importance of early warning, alert and response (EWAR) system in humanitarian contexts, as well as the need for such surveillance processes to be versatile and easily adaptable to respond to new outbreaks as they arise. Here, following the identification of an AJS outbreak through EWAR, a short-term enhanced surveillance system was put in place to investigate the potential causative agents and related risk factors linked to them, in order to guide outbreak response.

Since sampling was conducted at selected sites and during a short period of time, results are likely to have been exposed to selection bias. The results nevertheless provided a good overview of the causative etiologies of AJS in the camps.

Sub-standard water and sanitation conditions and lack of hygiene practices in the camps were observed at the time of data collection as indicated by the findings from the water quality surveillance (S Appendix), coupled with crowded living conditions are fertile grounds for enteric and waterborne pathogens, including hepatitis A. Hepatitis A and E are most commonly transmitted via the fecal-oral route [15], and Consumption of contaminated food and

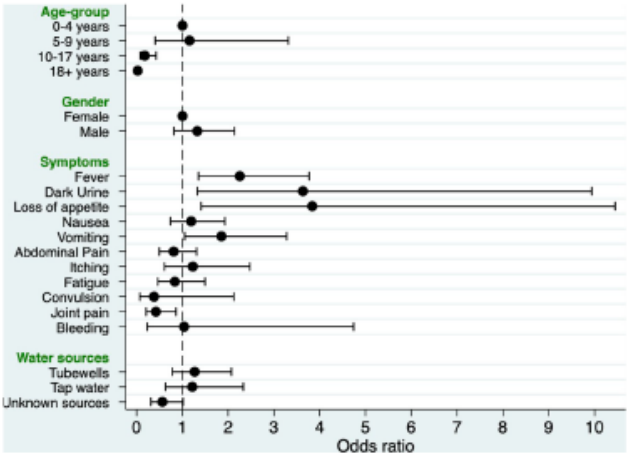

Fig 5. Odds ratio for the association of hepatitis A seropositivity with age-group, gender, presenting symptoms and drinking water sources.

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water is the leading cause of HAV and HEV outbreaks in refugee camp settings [7]. In high incidence settings, hepatitis A infection tend to mostly affect children, due to existing immunity in older age groups, as corroborated by our results. One of the concerns at the start of the epidemic was a Hepatitis E outbreak, which may cause fetal loss and high maternal mortality, and which has often been associated with large water borne outbreaks [16]. HEV is also one of the most common causes of acute viral hepatitis in this region and is common in rural areas in

Table 5. Odds ratio for the association between household transmission and hepatitis A seropositivity by gender.

AJS case in the household**		OR (95% CI)	P-value
Overall	Hepatitis A negative (n = 121)	1.0*	-
	Hepatitis A positive (n = 154)	1.88 (0.75 to 4.75)	0.177
By Gender			
Female	Hepatitis A negative (n = 57)	1.0*	-
	Hepatitis A positive (n = 62)	5.93 (1.25 to 28.06)	0.025
Male	Hepatitis A negative (n = 64)	1.0*	-
	Hepatitis A positive (n = 92)	0.68 (0.19 to 2.45)	0.553
By age-groups			
0–4 years	Hepatitis A negative (n = 9)	1.0*	-
	Hepatitis A positive (n = 58)	0.15 (0.03 to 0.83)	0.029
5–9 years	Hepatitis A negative (n = 7)	1.0*	-
	Hepatitis A positive (n = 52)	1.0 (omitted)	-
10–17 years	Hepatitis A negative (n = 28)	1.0*	-
	Hepatitis A positive (n = 32)	0.87 (0.11 to 6.59)	0.890
18+ years	Hepatitis A negative (n = 77)	1.0*	-
	Hepatitis A positive (n = 12)	18.75 (2.96 to 118.92)	0.002

*Baseline category

** In the 8 weeks preceding symptom onset.

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Bangladesh [17,18]. While the investigation did not point towards extensive HEV circulation, presence of the virus and the similarity of transmission routes with Hepatitis A called for particular attention to be given to pregnant women, who are at high risk of complications if affected by HEV within the third trimester, and continued vigilance of any flare up of AJS in the camps in the future.

Our investigation showed that, among adults, the risk of HAV positivity was higher for individuals who reported previous AJS cases in their household, within 8 weeks, and females in particular had a higher risk. This may reflect differential risks of infection within the household setting, potentially linked to care giving roles.

While Hepatitis B and C were not drivers of the AJS epidemic, the detection of significant number of infections requires attention and likely reflects high prevalence of chronic infections. l. One small study has shown significant prevalence of HBV and HCV among the Rohingya population in Bangladesh [15] and warrants further serological investigation in particular given limited capacity for clinical management within the district. Hepatitis B vaccination is part of the routine EPI programmes in the camps, and our results highlight the need to ensure adequate coverage, as well as a zero dose to new-borns to protect from spread of the infection, with close monitoring of identified cases. There is also need to maintain routine immunization programmes, to improve vaccine coverage of Hepatitis B among women of reproductive age (WRA) and under-five children both in the camps and the surrounding host community [4]. This might, in turn, reduce the perinatal transmission of hepatitis viruses [19].

Presence of leptospirosis has been a surprising but not unexpected finding. Laboratory testing for leptospirosis is not commonly practiced in Cox's Bazar. The camps have associated environmental factors like a temperate climate and floods due to heavy rainfalls and recreational activities including swimming are common, so these may spread the infection [20]. Environmental exposures are likely higher in male and also in older age groups and might contribute to developing the disease.

For conducting this rapid investigation in the Rohingya camps, one of the biggest challenges was to ensure a minimum standard for sample collection. At the time of the investigation, very few facilities were using rapid tests to confirm clinical diagnosis for Hepatitis A and Hepatitis E. To improve the diagnostic capacities and appropriate clinical management rapid diagnostic tests should be available and tests should be done routinely. Sample collection for blood and stool have since been incorporated into the Minimum Service Package required for health facilities in the camps.

AJS has been shown to be a regular public health problem in refugee settings, and in the Rohingya population in Cox's Bazar district in particular. The characterization of the causative etiology is important to tailor appropriate preventive and responsive measures. Our results highlight the need to continue efforts to improve the long-term quality of water and sanitation in the camps, as well as for an improved detection and clinical management of Hepatitis B and C.

Supporting information

S1 Appendix. Etiologies of acute jaundice syndrome.
(PDF)

S2 Appendix. Acute jaundice syndrome case report form.
(PDF)

S3 Appendix. Acute jaundice syndrome—case definition.
(PDF)

S4 Appendix. Water quality testing results in refugee settlements from 18 September to 14 November 2017, Cox's Bazar, Bangladesh [21].
(PDF)

S5 Appendix. Map of AJS attack rate (per 10,000 population) by age-groups reported during enhanced epidemiological surveillance strategy (between 28 February and 26 March 2018) in the Rohingya refugee camps in Cox's Bazar, Bangladesh © 2021 by Md Khadimul Anam Mazhar is licensed under CC BY 4.0.
(TIF)

S6 Appendix. Reported AJS household transmission–definition.
(PDF)

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2.6 Health service coverage and health-seeking behaviour among women of reproductive age during the protracted humanitarian crisis in Chad, 2019

Marquis A, O'Keeffe J, Jafari Y, Mulanda W, Carrion Martin AI, Daly M, van der Kam S, Ariti C, Bow Gamaou A, Baharadine C, Pena SJ, Ringtho L, Kuehne A. Use of and barriers to maternal health services in southeast Chad: results of a population-based survey 2019. BMJ Open. 2022 Mar 7;12(3):e048829. doi: 10.1136/bmjopen-2021-048829. PMID: 35256438; PMCID: PMC8905870.

In Chad, 5.5 million people, that is about one-third of the entire population is in need of humanitarian aid in 2022 as a result of conflict, migration, public health emergencies, food insecurity and climate change (18). The protracted humanitarian crisis continues since more than 15 years and leaves women and girls in Chad particularly vulnerable as they are already affected by limited access to health care, education, income and protection (18). The maternal mortality ratio in Chad is estimated to be the second highest in the world (118) and the gender inequality index is the third lowest in the world (119).

Sila region in the east of Chad is a rural area with approximately half a million inhabitants (120). Sila region is characterised by seasonal food insecurity, instability and violence (121). An initial rapid assessment of the most pressing health needs in Sila region conducted by MSF in 2018 indicated that patriarchal customs limited women's autonomy and together with limited health infrastructure and a lack of humanitarian actors created a setting that might require a humanitarian intervention targeting women and children (122). In 2019, MSF conducted a population-based survey among girls and women of reproductive age to assess health system performance in terms of coverage of antenatal care (ANC), delivery care in a health facility, postnatal care (PNC) and contraceptive methods (CM); health seeking behaviour and barriers to health care; and quality of care for maternal health services (MHS). The aim of the survey was to prioritise humanitarian health programming in the region based on MHS performance (68).

We conducted a population-based survey using a two-stage cluster survey design (68). Clusters were allocated according to population size; households were identified using a random walk procedure (68). Girls and women were included if they had given birth in the 2 years prior to the survey (68). The questionnaire consisted of questions regarding demographic information, utilisation of MHS, health-seeking behaviour, perceived barriers to care and quality of care (68). The analysis accounted for the effect of clustering and household selection (68).

We included 624 women, of which 95% were illiterate (68). ANC use was reported by 57.6% (350/624; 95% CI: 49.3% to 65.5%), and delivery care in a health facility was reported by 22.5% (134/624; 95% CI: 15.7% to 31.1%) and PNC was reported by 32.9% (95% CI: 25.8% to 40.9%) (68). Of all women, only 15% (93/622) reported four or more ANC visits; of those who did report ANC visits, only 47% (159/624) reported a complete ANC visit including at least one assessment of blood pressure, reception of malaria prophylaxis and tetanus vaccination (68). Noteworthy that 36.2% (34/93) of women reporting at least four ANC visits still did not receive complete ANC care (68). Having used ANC care increased the odds of delivering in a health care facility by 4.3 (95% CI 1.5-12.2; p=0.006) (68). Overall, the majority of women reported having delivered outside a health facility with a traditional birth attendant (TBA) (59.7%; 374/624) (68). More than 2/3 of the women paid for support during delivery, both inside and outside the hospital (68). The use of PNC was positively associated with having used ANC previously (OR=6.4; 94% CI: 3.7-11.1; p<0.001) and having delivered in a health facility (OR 3.4; 95% CI 1.7-7.0; p<0.001) (68). All MHS were utilised significantly more frequently by women living in urban areas compared to women living in rural areas (68). Of all women, 36.8% (228/624) reported that they had heard about CM, and 26 women (4%) reported having ever used any method of contraception

(68). Cultural and transport barriers were most often reported as reasons for not seeking care: the most often reported reason was too far or inaccessible due to security issues followed by the perception of not being sick enough and not being the custom to access care (68).

The coverage of MHS services was far from reaching WHO standards for maternal health care (123). ANC was used more frequently than other services and to offer high-quality ANC care could provide access to communities as it seems to be the most accepted service, and using ANC increased the likelihood of using other services in the reproductive health continuum such as health facility-based delivery and PNC (68). Delivery typically happened outside health facilities and without formally trained health professionals, most often assisted by TBAs (68). Less than one-third of women received any kind of postnatal care (68). Most methods for family planning were unheard of (68). Interestingly, the barriers were only partially due to infrastructure and costs; and in fact, delivery care required payment both inside and outside the health facility (68). A large proportion of women reported they could not see any need for care or it is not their custom (68). These findings indicate that any MHS programming will need to go beyond simply offering free care - assuming women will start utilising MHS as soon as it is available (68). Regarding the quality of care, available ANC care seems to be of low quality and support to improve the care that is already in place could improve health outcomes for a large proportion of women already accessing ANC (68).

Our study might have been affected by recall bias and social desirability bias (68). Additionally, we have no record of the refusal rate but an estimate by surveyors that only about a dozen women refused to participate throughout the survey (68).

The results of the survey provided the basis for the following recommendations, directly relevant to MSF's intervention planning:

Recommendations based on indicators of health system performance:

- The coverage of MHS was below 60% for all services. These findings and the findings regarding the health-seeking behaviour support the opening of a health program aiming to provide care as close as possible to the community to avoid transportation barriers and tailored to community needs and beliefs (68).
- The coverage of ANC was highest among all MHS. Additionally, having attended ANC increased the odds of using delivery care in a health facility and PNC. As ANC is the most frequently used MHS, it might be a good starting point for engaging with women as it seems most accepted and increases attendance of other MHS along the continuum of care (68).
- With regards to utilisation and health-seeking behaviour, women reported transportation and the belief that MHS were not needed as the most frequent reasons for not attending care. *Not feeling sick enough* and *Seeking care not being the custom* were the most common explanations. Before starting a new project, community consultations and engagement is required to build trust and learn about local customs and beliefs and acceptable ways of offering care (68).
- ANC was incomplete among 47% of women who attended ANC indicating room for improvement regarding the quality of available care. In order to maximize impact, a close collaboration with formal (health professionals) and informal (TBAs) MHS providers would be beneficial as many women already seek (incomplete) care inside and even more outside the formal health care system. The data indicate that collaboration with and training of these providers could potentially improve the quality of available care (68).

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Use of and barriers to maternal health services in southeast Chad: results of a population-based survey 2019

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ABSTRACT

Objectives Chad reports the second highest maternal mortality worldwide. We conducted a survey in Sila region in southeast Chad to estimate the use of maternal health services (MHS) and to identify barriers to access MHS.

Design Retrospective cross-sectional, population-based survey using two-stage cluster sampling methodology. The survey consisted of two strata, Koukou Angarana and Goz Beida district in Sila region. We conducted systematic random sampling proportional to population size to select settlements in each strata in the first sampling stage; and in the second stage we selected households in the settlements using random walk procedure. We calculated survey-design-weighted proportions with 95% CIs. We performed univariate analysis and multivariable logistic regression to identify impact factors associated with the use of MHS.

Setting We interviewed women in selected households in Sila region in 2019.

Participants Women at reproductive age, who have given birth in the previous 2 years and are living in Koukou Angarana and Goz Beida district.

Primary outcomes Use of and access barriers to MHS including antenatal care (ANC), delivery care in a health facility (DC), postnatal care (PNC) and contraceptive methods.

Results In total, 624 women participated. Median age was 28 years, 95.4% were illiterate and 95.7% married. Use of ANC, DC and PNC was reported by 57.6% (95% CI: 49.3% to 65.5%), 22.5% (95% CI: 15.7% to 31.1%) and 32.9% (95% CI: 25.8% to 40.9%), respectively. Use of MHS was lower in rural compared with urban settings. Having attended ANC increased the odds of using DC by 4.3 (1.5–12.2) and using PNC by 6.4 (3.7–11.1). Factors related to transport and to culture and belief were the most frequently stated access barriers to MHS.

Conclusion In Sila region, use of MHS is low and does not meet WHO-defined standards regarding maternal health. Among all services, use of ANC was better than for other MHS. ANC usage is positively associated with the use of further life-saving MHS including DC and could be used as an entry point to the community. To increase use of MHS, interventions should include infrastructural improvements as well as community-based approaches to overcome access barriers related to culture and belief.

Strengths and limitations of this study

- We conducted a representative population-based survey regarding use of maternal health services and access barriers to healthcare in southeast of Chad, a hard-to-reach region with scarce information on maternal health.
- Conducting a household survey instead of a health facility-based survey enabled the inclusion of women that are currently not reached by available services.
- Using a structured questionnaire, we were able to identify the perception of not being sick enough as a main barrier to access care and the use of antenatal care as impacting on the uptake of further services in the maternal health continuum, both findings having direct implications for future locally adapted service provision.
- Retrospective data collection on the use of maternal health services among women may have led to recall and desirability bias.
- Data collection on access barriers was limited to participants not using health services and did not include information about barriers encountered by those already using maternal healthcare service, thus foregoing insight on strategies to overcome existing barriers.

INTRODUCTION

In 2017, nearly 300 000 mostly preventable maternal deaths were reported worldwide.[1 2] Despite important progress made regarding maternal health, with a reduction in global maternal mortality by 38% in the period from 2000 to 2017, it remains a critical health issue.[1–3] According to the World Health Organisation (WHO) the main barriers to access maternal healthcare and contributing factors of maternal mortality are poverty, physical distance to healthcare service, lack of information on service availability and health risks, inadequate services and cultural beliefs and practice.[3] Addressing these

barriers to decrease global maternal mortality was part of the Millennium Development Goals signed in 2000 and of the Sustainable Development Goals adopted by WHO in 2015.[4 5] Several evidence-based WHO-guidelines for pregnancy, childbirth and the postnatal period have been developed to set standards of care for improving maternal health worldwide.[6–8] According to these guidelines eight antenatal visits are recommended and should include nutritional interventions, maternal and fetal assessments and context-specific preventive measures. For childbirth, essential and emergency intrapartum care by qualified healthcare workers is key to reduce maternal mortality. Regarding the postnatal period, a first medical check-up is recommended within 24 hours after birth and should be followed by three postnatal visits within 6 weeks after birth.[7]

Not all countries profited from the global reduction of maternal mortality; currently, 94% of all maternal deaths occur in low and lower middle-income countries.[2] Chad has the second highest maternal mortality ratio worldwide.[9] In 2018 WHO estimated the maternal mortality ratio to be 856 deaths per 100 000 live births for Chad.[3 10] The most recently published estimates regarding maternal health in Chad were collected in 2014–2015 as part of the last national survey on demographics and health (DHS14/15). According to those estimates, maternal deaths account for 45% of all deaths among women of reproductive age (15–49 years).[11] In Chad, coverage of maternal health service (MHS) at national level is low, with 64% of women reporting use of antenatal care (ANC), 24% reporting use of delivery care in a healthcare facility (DC) and only 22% reporting use of postnatal care (PNC) in 2014–2015.[1 11] In addition to coverage of MHS, gender-related inequalities are associated with maternal mortality.[12] Chad ranks 187 out of 189 countries regarding the Human Development Index and ranks 160 out of 162 countries in terms of gender inequalities.[10] Results of the DHS14/15 confirm gender-related inequalities[11]: The level of literacy is much lower among women (22%) compared with men (54%) and only 14% of women receive a secondary-level education compared with 33% of men.[11] Use of MHS differs according to level of education and region.[11]

Sila region is located in southeast Chad and had an estimated population of 526 290 inhabitants in 2018. More than 90% of the population lives in rural settings.[13] The population's main sources of livelihoods are agriculture and livestock.[14] Heavy seasonal rainfalls adversely impact on livelihoods and is resulting in seasonal food insecurity and malnutrition.[14 15] In 2019 the Chadian government imposed a state of emergency on the region due to increasing instability and violence mainly caused by intercommunal clashes between farmers and pastoralists.[15] Seasonal conditions and the current security situation adversely impact on access to healthcare in the region. Furthermore, health service provision in the region is limited in quantity and quality.[16 17] According to the latest national evaluation on obstetrical and neonatal care there are nine health facilities for maternal healthcare in Sila region, one provincial hospital, two district hospitals and six health centres.[17] Among those only one facility meets the conditions of comprehensive emergency obstetrical and newborn care, needed for severe, potentially life-threatening conditions during pregnancy, birth and the neonatal period.[17] Five of the nine facilities are located in urban settings.[17]

Since 2003, Médecins Sans Frontières (MSF) has been present in various districts in Chad implementing health projects for primary and secondary healthcare, malnutrition, malaria and emergency response.

Despite the need for action regarding improvement of maternal health in Chad, information about utilisation of MHS and barriers to access service is limited.

Therefore, MSF conducted a population-based survey in Sila region, to estimate the use of MHS and to identify barriers to access MHS in early 2019. The survey aimed to provide a detailed description of maternal health in the region in order to prioritise activities.

METHODS

In early 2019 (21 January 2019 to 07 February 2019) MSF in collaboration with the Chadian Ministry of Health performed a cross-sectional, retrospective, population-based survey using two-stage cluster sampling methodology in Koukou Angarana and Goz Beida district, located in the Chadian Sila region. The objectives of the survey were to estimate the use of MHS and to identify barriers to access MHS.

Research question and primary outcomes

The study's two main research questions were:

- What is the current utilisation rate for ANC, DC, PNC and contraceptive methods (CM) among women in reproductive age in Goz Beida and Koukou Angarana district?
- What are the main experienced or perceived barriers to access MHS among women in reproductive age in Goz Beida and Koukou Angarana district?

We defined following primary outcomes to answer the research questions:

- Reported proportion of utilisation of ANC, DC, PNC, and CM within the last 2 years among women in reproductive age living in Goz Beida or Koukou Angarana district.
- Reported proportion of experienced or perceived barriers to access ANC, DC, PNC and CM within the last 2 years among women in reproductive age living in Goz Beida or Koukou Angarana district.

Study population and area

Koukou Angarana and Goz Beida are two districts in Sila region. In an exploratory field visit by MSF to Sila region in late 2018, the two districts were identified as the areas in Sila region with the biggest need for intervention and therefore chosen as the study area. According

to population data from the district Ministry of Public Health in 2018, more than 80% of the population in Sila region lives in Koukou Angarana and Goz Beida district.

The study population consisted of women at reproductive age, living in Koukou Angarana and Goz Beida district and who have given birth in the last 2 years. According to the 2017 Chadian national census projections, which are based on the Chadian general population census conducted in 2009, the proportion of women at reproductive age was estimated to be 21.8% of the population in Sila Region.[18] Population figures for the settlement-level were obtained from the estimates produced by the district Ministry of Public Health (MPH) representative. These figures were derived from estimates produced during a bed net distribution and seasonal malaria prophylaxis campaign which took place in 2017.

Sampling and sample size

For the first stage of sampling, we selected settlements using probability proportional-to-size (PPS) sampling. For the PPS, a list of settlements with population figures at settlement-level was obtained from estimates produced by the district MPH representative. According to the provided estimates there were 330 settlements in Koukou Angarana district and 620 in Goz Beida district. In the second stage of sampling, we selected households in the settlements using random walk procedure as an adaptation of the WHO guidelines for cluster vaccination coverage surveys.[19]

We based the sample size calculation on the estimated prevalence of utilisation of ANC of 58.5% in Sila region[9] aiming for a precision of 7.5%, assuming a design effect of 1.5 and non-response of 10%. For calculation of the sample size we used ENA software for SMART.[20] According to this calculation a total of 315 women in each district (Goz Beida and Koukou Angarana) needed to be included in the sample. We selected 45 clusters in Goz Beida district and 45 clusters in Koukou Angarana district consisting of seven households each. We included one woman per household. Women were eligible for inclusion if they satisfied all of the following criteria: member of the selected households, being at least 15 years old, had given birth (live or stillbirth), living in Goz Beida or Koukou Angarana district in the previous 2 years and provided informed consent for herself and by the head of the household. If multiple women were eligible for inclusion in one household, we selected one woman per household at random.

Questionnaire, variables and definitions

The survey questionnaire on maternal health consisted of 69 closed questions including demographic data and data regarding ANC, DC, PNC and CM as primary outcomes. The questionnaire was based on the main indicators identified as relevant and actionable by MSF. Additionally, within the questionnaire we used same questions as the latest national survey on demographics and health (DHS14/15) and as comparable studies within the region.[16 21 22] The questionnaires were translated from French to Chadian Arabic and back translated to French to ensure consistency.

Demographic data were collected on age, marital status, level of literacy, pregnancy status and live and stillbirths in the past 2 years and nutrition status of women being pregnant or lactating at time of the study. For each type of service used (ANC, DC, PNC), we collected data on type of attendant (skilled or traditional) and payment of services.

Additionally, service-specific data were collected. For ANC, we collected the number of ANC visits per pregnancy and if ANC visits included blood pressure measure, tetanus and malaria prophylaxis. For DC, we collected additional data about mode of transport and time to a health facility.

Regarding CM, we collected data on knowledge about CM, use of CM and preferred method among those who had never used any CM.

For any service not used, we asked about barriers to access care. For barriers to access DC, multiple answers were possible.

We used the following definitions: *Women of reproductive age:* Women aged 15–49 years were defined as women of reproductive age. *Literacy:* Being able to read a phrase written on a piece of paper. *Nutrition status in pregnant and lactating women:* Severe acute malnutrition: mid-upper arm circumference (MUAC) of <185 mm; moderate acute malnutrition: MUAC 185–<230 mm. *MHS:* Includes ANC, DC and PNC. *Use of ANC:* At least one ANC visit during pregnancy. *Complete ANC:* At least one blood pressure check, receipt of malaria prophylaxis and tetanus vaccination during pregnancy. *Use of DC:* Assistance during birth by a skilled birth attendant in a health facility. *Use of PNC:* At least one visit within 42 days of birth.

Urban and rural: Categorisation into urban or rural setting was based on administrative delineations.

We defined and categorised reported barriers to access care retrospectively. We categorising access barriers into five groups according to previously used groups in low-income countries[23] : (i) barriers related to transport, including distance to healthcare facility and security issues; (ii) barriers related to culture, and belief, including belief of not being sick enough to use service, not being the custom to use service, using medications from the market, preference for traditional practitioner, preference of birth at home, lack of trust in the services and not aware of the potential benefit of seeking care; (iii) barriers related to economic factors, including not having money for trip or service fee; (iv) barriers related to family support, including having no time or not time yet, no child care, no one to accompany or no permission; and (v) barriers related to quality of care including no staff at healthcare facility. Answers of not knowing a reason for not using MHS or not understanding the question were categorised as 'others'. The categorisation is available in the online supplemental table 1 .

Training and data collection

We conducted a 3-day training on ethics, survey techniques, sampling method, questionnaires, data collection followed by a 1-day pilot for surveyors including debriefing session afterwards. According to results of debriefing minor changes to the questionnaire were made: changes to answer options, correction of translation errors and improvement of skip patterns of the digital questionnaire.

Data collection took place within the households by interviewing eligible and consenting women.

Surveyors worked in teams of two and collected the data for the study with KoboCollect electronic survey software on tablets. We did not collect personal identifiable data. All data were stored password-protected by MSF Holland. All data will be archived at the MSF Headquarters in Amsterdam for a duration of 5 years after the survey.

Data analysis

Primary outcomes of the study were use of and access barriers to ANC, DC, PNC and CM. In order to calculate correct population level summary statistics, we weighted all analysis for the population of Goz Beida and Koukou Angarana districts and additionally for the number of women in the household. Furthermore, all analyses were conducted accounting for the effect of clustering induced by the two-stage sampling design.[24] Most of the variables were categorical variables grouped according to the answer possibilities given in the questionnaire. Continuous variables were age, number of live and stillbirths within the last 2 years and number of ANC visits. Those were grouped in the following way: age (<29 years; ≥29 years), number of ANC visits (<4 visits; ≥4 ANC visits), number of live births within last 2 years (no live birth within the past 2 years; 1 live birth within the past 2 years, >1 live births within the past 2 years), stillbirths within the last 2 years (no stillbirth within the past 2 years; >1 stillbirth within the past 2 years). All categorical variables were reported as proportions with 95% CIs. For continuous variables, such as age, we determined the mean, median, range and IQR. As part of the descriptive analysis we compared urban versus rural settings. For comparing categorical variables in the two groups we used χ^2 tests with the Rao-Scott adjustment for the complex survey design.[24] Results are presented as proportions, 95% CIs and p values.

We conducted three multivariable analyses using logistic regression to understand factors associated with use of (1) ANC, (2) DC and (3) PNC. For all models we included as independent variables potential influencing factors such as maternal age (<29 years vs ≥29 years; age group split at median age), level of literacy (illiterate vs literate), setting of living (rural vs urban) and history of live births (0, 1, >1 live birth in the past 2 years) and stillbirths (no stillbirths, >1 stillbirth within the past 2 years). For the model regarding DC in a health facility we additionally included 'having ever used ANC' and for the model regarding PNC we additionally included 'having ever used ANC' and 'DC in a health facility'. Results are presented as adjusted ORs, 95% CIs and p values.

All statistical analyses were performed using the complex survey design commands (svy) in the Stata V.15 statistical package.[25]

Consent

Study consent was collected at different levels. The surveyors informed all village heads about the study in Chadian Arabic and asked for written consent before they proceeded to speak to households in the village. Within selected households, the surveyors informed the women about the study objectives and asked for written consent. If the head of the household was different from the woman, his or her written consent was also requested.

Patient and public involvement

No patient involved.

RESULTS

Study population

In total 624 women from the districts of Goz Beida and Koukou Angarana participated in the survey. Of the participating women, 67.7% (451/624) lived in rural settings, while 32.3% (172/624) lived in urban settings (table 1). Among the participating women the mean age was 27.7 years (median 28, IQR 22–32; range 15–45), 95.4% (595/624) were illiterate and 95.7% (595/624) were married. At the time of the survey, 18.0% (124/624) of women were pregnant and 4.2% (28/624) reported a stillbirth in the past 2 years (table 1). Severe acute malnutrition affected 0.7% (1/124) of pregnant women, 0.8% (2/416) of lactating women and no non-pregnant/non-lactating women (table 1).

Moderate acute malnutrition affected 5.3% (7/124) of pregnant women, 3.0% (14/416) of lactating women and no non-pregnant/non-lactating women (table 1).

Overall, use of ANC, DC and PNC was reported by 57.6% (95% CI: 49.3% to 65.5%), 22.5% (95% CI: 15.7% to 31.1%) and 32.9% (95% CI: 25.8% to 40.9%) of women, respectively (table 2).

ANC

Among all respondents, 57.6% (350/624) reported at least one ANC visit, with significantly higher use in urban settings (86.7%; 147/173) compared with rural settings (43.7%; 203/624) (p<0.001, table 2). Only one woman reported having eight visits as recommended by WHO; 15.6% (93/622) of women reported ≥4 visits. In urban settings the percentage of women with ≥4 ANC visits was 32.8% (53/171.), while among women living in rural settings 7.5% (40/451) reported ≥4 ANC visits (p<0.001). Of all respondents who attended ANC, 47.4% (159/350) received complete ANC (table 2). The number of ANC visits was associated with completeness of ANC. The odds of having complete ANC increased by 1.64 (1.30–2.06) with each additional ANC visit. However, 36.2% (34/93)

Table 1 Characteristics of the study population (N=624). Results of a population-based survey 2019 on use of and barriers to maternal health services in the southeast of Chad.

Characteristic		n	%	95% CI
Marital status	Never married	0	–	–
	Married	596	95.7	(93.7 to 97.1)
	Divorced	14	2.1	(1.2 to 3.6)
	Widowed	10	1.7	(0.8 to 3.6)
	Separated	4	0.5	(0.2 to 1.4)
Current status of pregnancy	Not pregnant	500	82.0	(78.8 to 84.9)
	Pregnant	124	18.0	(15.1 to 21.2)
Number of live births in past 2 years	0	10	1.4	(0.8 to 2.6)
	1	487	77.1	(71.8 to 81.6)
	2	119	20.6	(16.2 to 25.9)
	3	6	0.9	(0.4 to 2.0)
Number of stillbirths in past 2 years	0	596	95.9	(93.2 to 97.5)
	1	27	4.0	(2.4 to 6.5)
	2	1	0.2	(0.0 to 1.4)
District	Goz Beida	319	37.7	(35.9 to 39.5)
	Koukou Angarana	305	62.3	(60.5 to 64.1)
Setting	Rural	451	67.7	(56.5 to 77.1)
	Urban	172	32.3	(22.9 to 43.5)
Literacy level	Illiterate	595	95.4	(92.4 to 97.3)
	Literate	29	4.6	(2.7 to 7.6)
Moderate acute malnutrition	Pregnant women	7/124	5.3	(2.5 to 11.0)
	Lactating women	14/416	3.0	(1.6 to 5.4)
	Non-pregnant women	0/84	–	–
Severe acute malnutrition	Pregnant women	1/124	0.7	(0.1 to 7.3)
	Lactating women	2/416	0.8	(0.2 to 3.5)
	Non-pregnant women	0/84	–	

of women reporting ≥4 ANC visits still received incomplete ANC care. There was no difference with regards to completeness of ANC between rural and urban settings (table 2). Most women reported consulting a midwife (43.9%; 163/350) for ANC (table 3).

In multivariable logistic regression model the adjusted odds of having an ANC visit during pregnancy was 8.6 times (95% CI: 3.5 to 21.1) higher among those women living in urban settings compared with those living in rural settings. Other factors included in the model had no statistically significant impact on the odds of having ANC (table 4).

DC

Overall, 22.5% (134/624) of women reported using DC (table 2). This proportion was significantly higher in urban settings (57.5%; 103/173) compared with rural settings (5.8%; 31/451) (p<0.001; table 2). In adjusted analysis, the odds of using DC was 15.8 (6.9–36.1) times higher for women living in urban settings compared with those in rural settings and 4.3 (1.5–12.2) times higher for women having used ANC during pregnancy. The odds were 0.5 (0.25–0.93) times lower for women ≥29 years old compared with those <29 years old (table 4). Most women reported support during delivery by an untrained traditional birth attendant (TBA) outside a health facility (59.7%; 374/624) while only 18.2% (108/624) reported assistance by a midwife, nurse or doctor (table 3). The proportion of women reporting support by a TBA was significantly higher in rural settings (78.5; 352/451) than in urban settings (32.0; 51/173) (p<0.001). In contrast a significantly higher proportion of women in urban settings reported of support by a skilled attendant (57.9%; 104/173) than in rural settings (7.0; 38/451) (p<0.001). Payment for DC within a health facility was reported by 68.3% (90/134) of women. Payment for support during delivery outside a health facility was reported by 78.0% (373/490) of women. The proportion of women reporting payment for service during delivery did not statistically differ between formal and non-formal healthcare setting (p=0.154) and also did not differ between urban and rural settings (p=0.275).

Table 2 Use of maternal health services in Sila Region as reported by participating women (N=624). Results of a population-based survey 2019 on use of and barriers to maternal health services in the southeast of Chad.

Maternal healthcare service	Rural			Urban			Total			P value*
	n	%	95% CI	n	%	95% CI	N	%	95% CI	
Use of antenatal care (N=624)										
No antenatal care visit	248	56.3	47.9 to 64.4	26	13.3	6.4 to 25.8	274	42.4	35.4 to 50.7	<0.001
Any antenatal care visit	203	43.7	35.6 to 52.1	147	86.7	74.2 to 93.6	350	57.6	49.3 to 65.5	
***Complete antenatal care* (including blood pressure, malaria prophylaxis, tetanus vaccination) (N=350)**										
Incomplete	110	53.1	44.2 to 61.9	81	52.1	38.7 to 65.1	191	52.6	44.6 to 60.5	0.896
Complete	93	46.9	38.1 to 55.8	66	47.9	34.9 to 61.3	159	47.4	39.5 to 55.4	
***Number of antenatal care visits* (N=622)†**										
<4 antenatal care	411	92.5	88.8 to 95.1	118	67.2	58.1 to 75.1	529	84.4	79.3 to 88.4	<0.001
≥4 antenatal care	40	7.5	4.9 to 11.2	53	32.8	24.9 to 41.9	93	15.6	11.6 to 20.7	
Use of delivery care in a health facility (N=624)										
No delivery care	420	94.2	91.2 to 96.3	70	42.5	27.3 to 59.3	490	77.5	68.9 to 84.3	<0.001
Delivery care	31	5.8	3.7 to 8.8	103	57.5	40.7 to 72.7	134	22.5	15.7 to 31.1	
Use of postnatal care within 42 days after birth (N=624)										
No postnatal care visit	358	81.2	73.3 to 87.0	67	37.6	27.3 to 49.1	425	67.1	59.1 to 74.2	<0.001
Any postnatal care visit	92	18.8	13.0 to 26.3	106	62.4	50.9 to 72.7	198	32.9	25.8 to 40.9	

*Comparing proportions of reported barriers between rural and urban setting using χ^2 test adjusted for the complex survey design (Rao-Scott method (24)).
†2/624 women provided no answer on number of ANC visits during pregnancy.

Overall, the main reported mode of transport to reach a facility was walking, reported by 53.4% (73/133) women. Taking a moto was reported by 25.8% (34/133), transport by donkey or horse by 12.1% (15/133), taking a vehicle by 7.9% (10/133) and being carried by 0.8% (1/133) of women. The mode of transport to facility did not significantly differ between women living in rural settings compared with urban settings (p=0.088). Regarding the time of transport, 81.0% (95/118) of women reported to have reached a facility in less than an hour, 10.2% (12/118) in 2 hours, 5.8% (7/118) in 3 hours, 1.5% (2/118) in half a day and 1.5% (2/118) in more than 1 day. A lower proportion of women living in rural settings reported transport times of less than an hour (73.5%; 21/29) compared with women in urban settings (82.7%; 74/89) (p=0.055).

PNC

Among all women, 32.9% (198/624) reported a PNC visit within 42 days after birth (table 2). The proportion of women without PNC visit was significantly higher (p<0.001) in rural (81.2%; 358/450) than in urban settings (37.6%; 67/173) (table 2). Most often a midwife was consulted for PNC (46.6%; 93/198) (table 3). In multivariable analysis, the adjusted odds of having PNC visit was 22.4 (1.3–4.5) times higher among those living in urban settings compared with those living in rural settings. Furthermore, adjusted odds for having PNC was 6.4 (3.7–11.1) times higher for women having used ANC compared with those not having used ANC and 3.4 (1.7–7.0) times higher for women reporting DC in a healthcare facility compared with those without DC (table 4). All other potential influence factors included in the model did not show statistical association.

Barriers to care

Regarding barriers of access to care the three most commonly reported types of access barrier to any type of MHS were related to transport, factors related to culture and belief and economic factors (table 5 and online supplemental table 1).

For ANC, transport issues, factors related to culture and belief and economic factors were reported by 44.1% (118/274), 35.4% (93/274) and 14.4% (42/274) of women, respectively (table 5). With regards to DC, 33.3% (218/653) of women reported transport issues as

Table 3 Type of professional consulted for maternal health service in Sila region as reported by participating women (N=624). Results of a population-based survey 2019 on use of and barriers to maternal health services in the southeast of Chad.

	N	%	95% CI
Type of professional consulted for antenatal care for those reporting use of antenatal care visit (N=350 women*)			
Midwife	163	43.9	33.0 to 55.4
Nurse	153	38.6	29.7 to 48.3
TBA—inside health facility	68	16.9	11.3 to 24.5
TBA—outside health facility	2	0.5	0.1 to 1.9
Doctor	1	0.2	0.0 to 1.3
Type of assistance consulted for birth (N=624 women*)			
TBA—outside health facility, untrained	374	59.7	51.7 to 67.2
Midwife	78	13.4	8.1 to 21.3
Relative/friend	69	11.7	8.2 to 16.3
TBA—inside health facility	34	5.3	2.6 to 10.4
TBA—outside health facility, trained	29	3.8	2.3 to 6.1
Nurse	25	4.0	2.1 to 7.5
Doctor	5	0.8	0.3 to 2.0
No one	10	1.4	0.5 to 3.5
Type of professional consulted for postnatal care for those reporting use of postnatal care (N=198 women*)			
Midwife	93	46.6	33.4 to 60.4
Nurse	83	36.3	26.0 to 48.1
TBA—inside health facility	36	16.4	10.0 to 25.9
Doctor	1	0.3	0.0 to 2.3
Do not know	1	0.3	0.0 to 2.3

*Multiple answers possible, i.e. more than one professional could have been present for any given service

TBA, traditional birth assistant.;

main access barriers to care followed by factors related to culture and belief (32.4%; 213/653) and economic factors (27.9% 179/653) (table 5). For the use of PNC, the most commonly reported access barriers to care were factors related to culture and belief (47.2%, 197/425) and transport (33.3%, 145/425). Economic factors as access barrier to PNC were reported by 14.1% (60/425) of women (table 5).

For access barriers to care related to culture and belief, 'not being sick enough' and 'seeking care not being customary' were the most often reported reasons (online supplemental table 1). 'Not being sick enough' was reported by 19.9% (55/274), 20.5% (139/653) and 35.3% (151/425) of women for not accessing ANC, DC or PNC, respectively. 'Not being custom' to use service was reported by 10.9% (24/274), 9.4% (55/653) and 7.4% (24/425) in regards to ANC, DC and PNC, respectively. Seeking care at a traditional practitioner was reported by less than 1% of women for ANC, DC and PNC.

For ANC and PNC proportions of reported barriers to care differed significantly between urban and rural settings (table 5). For ANC, the most common reported barrier in urban settings was related to culture and belief while transport issues were only reported in rural settings (p=0.005; table 5). For PNC factors related to culture and belief were reported as main access barrier in both settings, whereby the proportion was significantly higher in urban settings (65.2%; 41/67) compared with rural settings (43.2; 156/358) (p=0.007; table 5).

Age, number of live births, history of stillbirth and level of literacy had no impact on the type of reported access barriers regarding use of ANC, DC or PNC.

CM

Only 36.8% (228/624) of women reported having heard about CM. There were significantly more women in urban settings (65%; 110/173) who reported having heard about CM compared with rural settings (24%; 118/451) (p<0.001). Among those who reported to have heard about CM, the most often named known method were injectables (52.6%; 194/228) and pills (34.5%; 124/228), without any significant differences between women from urban and rural settings (online supplemental table 2).

Among those who reported to have heard about CM, only 10.8% (26/228) women reported to have ever used any method, and the proportion between urban and rural settings did not differ. Among those who have used CM, use of injectables was most often reported (68.5%; 19/26). There was no difference on type of CM used between women from urban and rural settings.

Among those who reported to have heard about CM but have not used CM, 26.3% (54/202) reported being interested in using CM; using injectable was most frequently named as preferred method (69.1%; 37/54). Among those women who had not used CM but had heard about CM and were interested to use a CM, the most commonly reported reasons for not using CM were lack of knowledge about CM (23.4%; 11/51) and where to find CM (23.4%; 11/51) followed by disagreement by husband (12.4%; 5/51) and too long distance to a health facility (7.6%; 4/51). There was no difference in the proportion of reported reasons for not using CM between rural and urban settings (p=0.651).

Among those who have heard about CM without using CM in the past 2 years and no interest in using CM the main reasons for not being interested in using CM were desire for pregnancy (48.6%; 75/148), use of natural method instead (16.8%; 22/148) and opposition from husband (10.3%; 14/148). The proportion of reported reasons for no demand for CM did not differ between rural and urban settings (p=0.815).

Table 4 Impact of several influence factors on use of antenatal care, delivery care in a health facility and postnatal care in Sila region (N=624) — multivariable logistic regression. Results of a population-based survey 2019 on use of and barriers to maternal health services in the southeast of Chad.

	Use of antenatal care			*Use of delivery care in a health facility*			*Use of postnatal care*		
Influence factor	aOR	95% CI	P value	aOR	95% CI	P value	aOR	95% CI	P value
Setting of living									
Rural setting	ref			ref			ref		
Urban setting	8.61	3.52 to 21.07	<0.001*	15.8	6.9 to 36.1	<0.001*	2.4	1.3 to 4.5	0.007*
Maternal age									
>29 years	ref			ref			ref		
≥29 years	0.69	0.46 to 1.05	0.082	0.5	0.2 to 0.9	0.031*	0.84	0.55 to 1.29	0.428
Live births in the last 2 years									
No birth in last 2 years	ref			ref			ref		
1 birth in last 2 years	1.56	0.33 to 7.31	0.567	0.2	0.0 to 2.4	0.209	1.3	0.3 to 6.6	0.737
2–3 births in last 2 years	2.61	0.52 to 13.17	0.243	0.3	0.0 to 4.0	0.360	1.7	0.3 to 9.3	0.549
Stillbirths in the last 2 years									
No stillbirth in last 2 years	ref			ref			ref		
Having a stillbirth in last 2 years	0.64	0.15 to 2.70	0.536	0.9	0.3 to 3.0	0.909	0.69	0.17 to 2.7	0.590
Maternal literacy									
Illiterate	ref			ref			ref		
Literate	2.42	0.75 to 7.85	0.139	3.1	1.0 to 9.9	0.060	2.2	0.7 to 6.9	0.175
Use of antenatal care									
No	n.a.			ref			ref		
Yes	n.a.			4.3	1.5 to 12.2	0.006*	6.4	3.7 to 11.1	<0.001*
Delivery care in a healthcare facility									
No	n.a.			n.a.			ref		
Yes	n.a.			n.a.			3.4	1.7 to 7.0	0.001*

*Statistical significance at p<0.05.
aOR, adjusted odds ratio; n.a., not applicable; ref, reference group.

DISCUSSION

Use of MHS services in Sila region remains far below standard

This survey's results highlight that WHO-recommended standards regarding maternal health[6–8] are still far from being achieved and interventions to improve maternal health are needed in Sila region. This survey provides insight into use of and access barriers to MHS in Sila region and therefore adds valuable information to the scarce knowledge available on the topic for this region. The knowledge gained will be beneficial in guiding the decision-making process regarding region-specific strategies for improving maternal health.

When comparing our results with the findings for Sila region from the last DHS14/15, the use of ANC, which was reported by 57.6% women in our survey did not improve since the DHS14/15 when 58.5% of women in Sila region had used ANC by a healthcare professional.[11] Regarding use of DC our result indicate improvement with an increase from 11.4% in Sila region identified in the last DHS in 2014/15 to 22.5% in 2019.[11] Similarly,

Table 5 Access barriers to maternal health service in Sila region as reported by participating women that did not use the services. Results of a population-based survey 2019 on use of and barriers to maternal health services in the southeast of Chad.

Barriers	Barriers to antenatal care (N=274) n; % (95% CI)			Barriers to delivery care in a health facility (N=490)† n; % (95% CI)			Barriers to postnatal care (N=425) n; % (95% CI)		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Transport	118; 49.0 (38.3 to 59.9)	0	118; 44.1 (33.7 to 55.0)	198; 35.7 (29.7 to 42.1)	20; 21.2 (14.5 to 29.9)	218; 33.3 (28.0 to 39.1)	137; 38.2 (29.1 to 48.2)	8; 11.0 (5.0 to 22.6)	145; 33.3 (25.4 to 54.8)
Cultural, and belief factors	75; 31.2 (22.0 to 42.1)	18; 72.5 (57.2 to 83.9)	93; 35.4 (26.2 to 45.7)	183; 31.7 (25.0 to 39.4)	30; 35.6 (20.9 to 53.6)	213; 32.4 (26.1 to 39.3)	156; 43.2 (33.8 to 53.2)	41; 55.2 (48.2 to 79.0)	197; 47.2 (38.2 to 56.1)
Economic factors	37; 14.2 (8.5 to 22.8)	5; 16.3 (7.7 to 31.1)	42; 14.4 (9.1 to 22.1)	156; 27.9 (21.0 to 36.1)	23; 27.7 (11.7 to 52.6)	179; 27.9 (21.3 to 35.6)	49; 13.9 (9.1 to 20.7)	11; 15.0 (7.9 to 26.5)	60; 14.1 (9.8 to 19.9)
Family support	8; 2.5 (1.0 to 6.0)	0	8; 2.2 (0.9 to 5.4)	25; 4.0 (2.4 to 6.4)	13; 15.5 (6.8 to 31.7)	38; 5.9(3.8 to 9.0)	10; 2.9 (1.0 to 7.8)	4; 4.9 (1.7 to 12.9)	14; 3.3 (1.5 to 7.0)
Quality of care	2; 0.8 (0.2 to 3.2)	0	2; 0.7 (0.2 to 2.9)	Not asked for			Not asked for		
Others	8; 2.3 (1.1 to 4.9)	3; 11.2 (3.3 to 31.9)	11; 3.2 (1.6 to 6.2)	5; 0.7 (0.3 to 2.1)	0	5; 0.6 (0.2 to 1.7)	6; 1.8 (0.7 to 4.6)	3; 4.0 (1.4 to 10.8)	9; 2.2 (1.0 to 4.5)
P value*	0.005			0.071			0.007		

*Comparing proportions of reported barriers between rural and urban setting using χ^2 test adjusted for the complex survey design (Rao-Scott method (2-4)).
†Multiple answers possible.

our results indicate an increase for uptake of PNC from 10.8% in 2014/15 to 32.9% for Sila region.[11] However, despite some progress in the uptake of DC and PNC, the use of MHS in Sila region is still low and recommended WHO-standards are not met.[9 17] Additionally, our survey identified a very low level of knowledge and use of CM. Compared with the findings of the DHS14/15, which found for Sila region a proportion of 56.2% of women who have ever heard about CM, the proportion of women in our survey who have heard about CM was even lower with 36.8%.[11] The proportion of women in Sila region who have ever used any CM slightly increased since the DHS14/15, which found a proportion of 2.4% women who have ever used CM, to 10.2% in our survey but remains on a very low level.[11] Those findings emphasise that future MHS programmes should include family planning as more than 25% of women reported demand for CM.

Infrastructure, previous contact to MHS and literacy influence the use of maternal health services

Our survey confirms significant differences in use of any MHS between urban and rural settings in Sila region.

There is much lower use of services in rural settings compared with urban settings, a fact which has previously been identified at national level.[11] Research had shown that rural populations have lower maternal healthcare coverage.[16 26] This is especially important as 80% of the Chadian population currently lives in a rural setting and it is expected that this proportion will continue to grow based on projection up to 2050.[27 28] Therefore, the focus for future programmes targeting to improve maternal health outcomes should be on rural settings.

We were able to show that previous contact with MHS did improve the future use of MHS; women who attended ANC were more likely to use DC and PNC. Hence, ANC could be a starting point for future interventions as an effective form of health promotion and community engagement aiming to increase use of MHS. The positive impact of ANC on use of DC and PNC was previously shown in a study from Ethiopia, where those who have attended ANC were more likely to use further MHS in the course of pregnancy and motherhood.[29] Despite higher level of use for ANC compared with other MHS, level of completeness of ANC even among those with ≥4 ANC visits was low in Sila region. Therefore, interventions should aim to strengthen ANC in terms of availability and quality to improve use of MHS and consequently reduce maternal mortality.

Future intervention in the field of maternal health needs to account for the high level of illiteracy in Sila region (95%), which is higher than the national estimates (89%).[11] According to previous studies from Chad and Nigeria, educated women were more likely to use MHS.[1 26] Furthermore, according to results of the DHS14/15, 47.3% of women without formal education had no ANC visit compared with 1.2% of women with the highest level of education.[11]

According to our results, there was some, although non-significant, negative impact of literacy on the use of MHS.

Transportation, culture and belief and economic factors were main barriers to care

Regarding access barriers to MHS, this survey identified transport, economic factors and culture and belief as the strongest access barriers.

The importance of access barriers related to transport issues might be explainable by the low number of available health facilities in Sila region overall.[17] This is especially relevant for use of DC given the low number of facilities that are sufficiently equipped for obstetrical and neonatal care in Sila region.[17] According to the latest assessment of emergency obstetrical and neonatal care only 3.9% of all births received care in health facilities and 0.3% in a health facility providing emergency obstetrical and neonatal care in Sila region.[17] Furthermore in rural settings the number of available health facilities is even lower than in urban settings.[17] This might explain that transport as access barrier is especially of importance in rural settings.[18] Therefore, infrastructural improvements regarding number of and accessibility to health facilities, especially in rural areas are needed.

Access barriers related to culture and belief were the second most often reported access barriers to use of ANC and DC and the most often reported access barrier to PNC. For any of the three services the most often given answers, why women have not used particular service, were 'being not sick enough' and 'using the service is not their custom'. Other reasons such as consulting traditional practitioners, no trust in services or not knowing where to go were reported by less than 2% of women for any MHS. These findings indicate that preference for traditional services or mistrust of formal services might be less important in the context of barriers to accessing care than the perceived need for care. For use of ANC and PNC the proportion of women reporting access barriers related to culture and belief were significantly higher in urban than in rural settings. For use of DC the proportion of women reporting culture and belief factors as access barrier did not differ between urban and rural settings. To address access barriers related to culture and belief, community outreach programmes are needed, aiming to promote dialogue with the communities to understand setting-specific reasons to avoid or delay care and ways to overcome these barriers. Economic factors including no money for fee and transport were also reported as important access barriers to care and did not differ between urban and rural settings. However, informal care also involved payment of fees but was not perceived as access barrier in this context.

In order to address all categories of identified access barriers to use of MHS multilevel, setting-specific approaches are needed, as shown in previous findings for other countries in the region.[26 30] We therefore recommend, combining healthcare provision with community engagement to understand access barriers and locally acceptable ways to address these.

Limitations

Our survey has some limitations. Koukou Angarana and Goz Beida district are only representing about 80% of the population of Sila region and are the areas with the biggest need, thus our results are potentially not representative for the whole Sila region. For the cluster allocation sampling frame, we used population estimates derived from a national census conducted in 2009 and, for the village level we used estimates from a bed-net distribution campaign in 2017. Despite the fact that both estimates were adjusted considering growth rates, inaccuracies cannot be excluded, which might result in some bias in the sampling.

As an additional limitation, we have no written record of the refusal rate. Due to the security situation and the resulting time pressure while data were collected, the exact number of women refusing to participate are not available. Therefore, selection bias cannot be excluded. Verbal feedback from interviewers indicated that less than a dozen women refused participation throughout the entire survey.

Furthermore, there is a possibility of recall bias. Although events such as pregnancy and childbirth are perceived to be memorable in general, recall bias cannot be ruled out and needs to be accounted for in the interpretation of the results. There is also a possibility for social desirability bias, where the interviewees might have been more likely to respond in a way that they thought would be viewed more favourably by the study team. In order to reduce this bias, surveyors explained that data collection and analysis was conducted anonymously, responses would be kept confidential and that no individual incentives would be provided for participation in the study.

One additional identified limitation was that only women who have not used MHS were asked about barriers to access care. For an even more complete insight into existing barriers to access care it could be useful in future studies to ask also women who used MHS about their motivation for using MHS and any barriers they encountered and their strategies to overcome those.

CONCLUSIONS AND POLICY IMPLICATIONS

In southeast Chad current use of any MHS is low, especially in rural settings, and does not meet WHO-defined standards regarding maternal health. Among all services, use of ANC was better than for other MHS. ANC could be used as an entry point to communities as we were able to show that use of ANC positively impacts on the use of further services in the maternal health continuum of care. However, despite the higher use of ANC, the quality of available ANC was low. Improving ANC and reducing access barriers to ANC may serve as entryway for DC and consequently reduce maternal mortality. Additionally, improved access to and availability of CM is needed to account for the existing interest in use of CM.

The main access barriers to any service were related to transport issues indicating gaps in the available health infrastructure in the region and to factors related to culture and belief. Programmes tackling changes at different levels are needed to overcome reported access barriers. There is an urgent need for accessible and free services combined with community-based dialogue to overcome cultural access barriers. Furthermore, future programmes need to be specific to setting (rural or urban), as the type of setting was the most influential factor regarding the use of MHS and access barriers to care.

As most of the population of Chad lives in rural settings, maternal health programmes should prioritise adequate models of care for rural communities. These models should be built on community consultations to understand concerns about use and need for care, and should include community-based health promotion and strategies adapted to the level of literacy.

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3 Discussion

3.1 Estimating indicators of population health status in humanitarian crises

Basic population health indicators to allocate resources and target those most in need are required throughout all stages of planning humanitarian response (17,69). All the presented pieces of research yielded evidence-based context-specific recommendations for medical programming based on solid population health indicators. In the following, I will present common challenges in measuring the required indicators and the ways in which the presented research overcame some of these challenges.

3.1.1 Measuring mortality in humanitarian crises

In humanitarian emergencies, population-based surveys are the established standard to collect mortality estimates of populations in crises (38,42). Yet, a review of mortality surveys in humanitarian crises conducted between 1993 and 2004 indicated that only 3% of the 158 mortality surveys conducted were judged to be of good quality regarding survey design, implementation and reporting (124). Since then, several methodological guidances were produced aiming to improve survey quality and standardisation; today, the most widely used guidelines for mortality surveys in humanitarian emergencies are the "EPI method" (61), originally developed for vaccination coverage surveys, and the "SMART methodology" (60), developed for nutrition surveys that may have a mortality component. Still, the quality of mortality surveys varies and the best way to design, implement and report them has been of substantial debate over decades (39,63,64,70,124–126). Common challenges remain the random selection of households at the second stage of cluster surveys in humanitarian crises (63,64,125,127), the lack of standardisation and validation of mortality survey questionnaires (37,39,43,70) and the underreporting of neonatal deaths (37,128). Additionally, the reporting of mortality surveys is often incomplete, lacking clear descriptions of sampling, data collection methods, analysis, context, ethical considerations, limitations and specific recommendations (64,70) Generic recommendations with no operational relevance were also identified as a barrier to research update (2,3,69). In addition to these technical challenges, the context posed by humanitarian crises - insecurity, conflict, limited logistic capacity, lack of trained staff, remoteness, and break-up of community cohesion – complicates implementation (3,4,37).

And ALNAP concisely described the problem as follows: "Unfortunately, the circumstances that make information collection so important are precisely those that make it extremely difficult to do. Many humanitarian responses occur in situations where physical access is severely restricted, limiting possibilities for data collection." ((3), p.19)

Some researchers have argued that radically new methods are needed to establish the scale of mortality in crises (129). A recent systematic review, however, indicated that standard mortality surveys are the most frequent and useful ways to measure mortality in humanitarian crises and call instead to adapt existing standard methodologies to context and document the successes and failures of such adaptations better (32,130). The surveys in CAR and Liberia provide just this, standard survey methodology adapted to context and research question (66,67) in order to adjust to the crisis context and to render a solid evidence base for decision making.

The survey conducted in CAR followed the SMART methodology (60) in many aspects but was adapted in three small but crucial ways regarding sampling and questionnaire (66): a) For the sampling procedure, the cluster starting point was selected using a novel approach for second stage cluster selection: we conducted a simple random selection from a building footprint (76), i.e., a list of buildings generated by an artificial intelligence identifying buildings on recent satellite images. This allowed us to overcome common challenges of standard practices (60,61,127) for random selection of houses at

the second stage of sampling: it did not oversample houses closer to the centre of the village as the spin-the-pen-methods does and at the same time saved us the time that the grid or housing enumeration methods need on the ground (60,61,63,66,127). Using the building footprint proved to be a feasible and fast method on the ground as the starting point is easy to find for surveyors – and time spent in one location is limited in insecure settings like CAR to ensure the safety of surveyors (66). In a next step, it is planned to directly compare this sampling method to the standard methods in several locations. Another adaptation from the standard approach was that b) the standard questionnaire was complemented by questions to ask specifically for each woman (dead or alive) if she was pregnant during the recall period (66). The question about pregnancies and their outcomes allowed us to I) get a better estimate of the birth rate and II) obtain a better estimate for neonatal and maternal deaths as deaths of newborns that lived only hours or days are often underestimated in surveys (66,128). Training surveyors to systematically ask for the outcome of each pregnancy during the recall period ensured the outcome of mother and child was documented (66,128). The third divergence from the standard methodology was that c) the survey was started with an open question regarding challenges that households faced and the richness of information from this one qualitative question contributed tremendously to our ability to interpret the data and it also allowed the surveyors to build rapport with the families at the start of the interview (66). Following standard guidelines but adapting to context and the research question (and documenting these changes) made the survey a powerful tool to measure mortality and provide a foundation for evidence-based decision-making.

In Monrovia, Liberia, a standard survey could not be implemented due to movement restrictions and the risk of amplifying the outbreak by physically visiting one household after another at home (67). We thus tried a household survey method by mobile phone (67). While the sampling naturally differed from standard mortality surveys conducted in humanitarian crises, the questionnaire remained a largely standardised instrument as typically used for MSF surveys on mortality and morbidity (67). Applying a novel sampling methodology was a requirement in the context, not a choice (67). We would have liked to compare this methodology against the gold standard of house-to-house surveys, but for the reasons mentioned above, were unable to do so (67). What we did do was to follow standard methodology for all survey design, implementation and analysis parts, apart from the sampling procedure (67). To accommodate for this change we described our sampling methodology and process in great detail to inform future researchers facing similar challenges as recommended by most recent reviews on research methodologies in humanitarian settings (32). In fact, another mobile-phone mortality survey was recently implemented in Malawi to measure mortality in the entire country - drawing on our experiences for implementation - and finding the survey method to be a useful and feasible tool to measure population mortality (131). The adaptation of the sampling increased the bias of the research method but it allowed conducting a survey at all (67)– to our knowledge, this is the only estimate available of crude and Ebola-specific mortality during the Ebola epidemic in Liberia.

3.1.2 Measuring morbidity in humanitarian crises

Proportional morbidity is among the standard indicators in humanitarian crises (42). Morbidity indicators during emergencies often derive from HMIS and surveillance data (43). A recent review of research methodologies in humanitarian crises found that while HMIS and surveillance are implemented in nearly every emergency, the data quality was frequently inadequate and the analysis of the existing data was often not conducted; thus, the data was not used to its full potential (32).

In addition to poor quality data, HMIS and surveillance data might miss diseases and health conditions that are not presented to health facilities such as those that the patients feel uncomfortable to disclose (e.g., mental health conditions or stigmatised diseases such as HIV) or for which no treatment is

(assumed to be) available in the setting (e.g., chronic diseases such as hypertension or chronic viral hepatitis). In addition to diseases missed entirely, reported diseases may be underascertained (i.e., cases with the disease not attending health care) and underreported (i.e., cases reaching healthcare but not documented and/or notified correctly) to varying degrees (132).

Despite the limitations, Brownson et al. describe public health surveillance data as a ”critical tool for those using EBPH” ((10), p.183). Some scholars have argued that there is an urgent need to improve the routine data collection and use of standard HMIS data and standardised survey methodology – much more than there is a need for more and innovative research methods in the humanitarian field (2,32,130). The research presented in this overview illustrates how minimal morbidity data collected in a DC in Tripoli, Libya, and a SAR vessel on the Mediterranean Sea – some of the most unfavourable settings for good data – still contributed to the generation of evidence regarding the most prominent causes of ill-health and reasons for seeking care (53,54). We tried to mitigate poor data quality by meticulously crosschecking contradicting data and solid analysis allowed us to utilise the available evidence to its maximum as recommended in a recent systematic review of research methods in humanitarian crises by ELRHA, “The utilisation of existing data is a matter of both ethical importance and operational effectiveness.” ((32), p.34). For the interpretation, we took into account what the data might not show or underreport (such as mental health problems or SGBV) (53,54). These analyses, while simple, represent to date the biggest epidemiological description of health conditions in detention in Libya and on-board SAR vessels (53,54) and provided much-needed evidence for medical programming and advocacy.

3.1.3 Measuring public health threats in humanitarian crises

There are no indicators per se for public health threats (17). What constitutes a public health threat is highly context-specific (45). To decide if an alert of a public health threat represents a potential risk to the health of the population, risk assessments of the hazard, the context and the exposure are conducted (45). The challenge of all EWAR systems that are set up in emergencies to identify threats, inevitably will also detect false alerts and distinguishing real threats from background noise (i.e., information submitted to the EWAR system that does not represent potential threat) requires expertise and an adequate system to tell true threats apart from false alerts (44,56).

The description of the outbreak investigation of an alert detected by the EWAR system in the camp for Rohingya refugees in CXB provides one example of an indicator of a potential threat and the following risk assessment (58):

- Hazard: Cluster of AJS cases, pathogen not yet known,
- Context: Camp setting, poor WHS conditions, massive overcrowding. HEV outbreaks in refugee camp settings were previously described with CFR among pregnant women of up to 10%. HAV outbreaks are more common and known to produce milder disease and limited mortality,
- Exposure/Immunity: Cases were detected across the camp and overcrowding and poor water quality make large-scale exposure likely. Immunity is expected for HEV to be low across all age groups and for HAV to be high for older children and adults (58).

Based on the risk assessment by desk review, the alert of an AJS cluster was considered a potential public health threat due to the possibility of HEV aetiology and poor WHS conditions (58). Enhanced epidemiological and laboratory surveillance were able to rule out an HEV outbreak which was feared, but confirmed a less dangerous HAV outbreak and a high HBV and HCV prevalence (58). Based on these findings, improvements in WHS conditions and access to testing and treatment for HBV and HCV were therefore recommended (58).

3.2 Estimating indicators of health system performance in humanitarian crises

3.2.1 Measuring health service coverage

Health service coverage is described as the proportion of the target population successfully using the service (46). Health service coverage estimates during crises often include vaccination coverage (aiming to prevent outbreaks during crises) and less commonly include coverage of other health services (23).

However, coverage of ANC and PNC as well as the proportion of assisted deliveries form part of monitoring and evaluation indicators for the comprehensive package of maternal and newborn health services that should be implemented in protracted humanitarian crises (62). It is recommended to conduct population-based surveys to obtain these indicators (62), however, access challenges, insecurity and logistics can complicate survey implementation (see chapters 1.4.3 and 3.1.1).

The survey in Sila region, Chad, was complicated by long distances, risk of abduction of the surveying team, violent clashes of different groups in the survey area and limited freedom of women to express themselves, more so on a delicate topic such as reproductive health (68,122). However, good training, detailed planning for survey logistics and mitigation plans to reduce the security risks for the interviewing team and the participants as well as collaboration with local researchers and extensive communication with local authorities about the purpose of the survey made implementation possible (68). The survey exemplifies how well-planned standard coverage surveys can be implemented in volatile contexts in order to provide population health indicators for sexual and reproductive health needs of women in the area including MHS coverage and quality of care and health-seeking behaviour (68).

3.2.2 Measuring health service utilisation and health-seeking behaviour

Indicators of health service utilisation are typically derived from HMIS data (17,23). These data provide information about the output of consultations and services but hide population health needs for which no service is provided and thus no HMIS data collected. The HMIS data stemming from detention in Libya (53) and from the SAR vessel at the Mediterranean Sea (54) provide two examples of HMIS data analysed to provide information on utilisation and morbidities. While the data is collected in non-ideal circumstances and suffers from gaps and inconsistencies, it still provides evidence for the extensive use of health services; often every person on board or detained uses outpatient care and is diagnosed with a disease (53,54)

Beyond the numbers of health care utilisation based on HMIS data, limited data is usually collected in humanitarian crises and no standard indicators exist to describe health-seeking behaviour (23). In the presented research, representative population-based surveys were utilised to obtain additional information about health-seeking behaviour in order to adapt health services and approaches to health care based on the evidence provided by the studies (66–68): In CAR the open question at the start of the interview for the mortality survey indicated that seeking care was challenged by distance to health facilities, transportation, security concerns and lack of staff and medicines at the health facility, but none of the households mentioned distrust or fear of health care providers (66). The survey provided relevant evidence that resulted in the decision to provide more comprehensive care in more locations to move health care closer to the community in order to address concerns of transportation, costs and security constraints in accessing care (66,133).

In Monrovia, Liberia, a limited number of standard health survey questions provided some insight into health-seeking behaviour with 24% of household members sick with Ebola did not seek treatment at an ETU, as mandated during the Ebola outbreak (67). And 43% of household members sick with non-

Ebola-related diseases did not seek health care at a health facility (67). While limited in depth, the survey provided evidence that further community engagement is needed to understand and address reasons for not seeking care (67).

In Sila region, Chad, the population-based survey produced interesting results regarding health-seeking behaviour: the reasons most often given for not looking for care were transportation and distance to care but as well that it was not the custom to seek care for reproductive health matters (68). The latter piece of evidence impacted on the way the MHS project was planned as it became clear that simply opening MHS in the region will not lower maternal mortality as women and households were not seeing a need to attend MHS in addition to transportation challenges (68). For the first time in MSF history, MSF co-designed a humanitarian aid project with the community: the project in Sila as it was finally implemented, started with a community consultation process and continues to develop the services in a collaborative approach (133,134).

3.2.3 Measuring health service quality of care

Information about quality of care is not (yet) part of the PHIS in humanitarian crises and there are no standard indicators available (17,23). A small body of literature reporting quality of care and its measurement in humanitarian settings grew over the past five years and indicates that measuring quality of care in humanitarian crises is possible and needed, albeit challenging (135–138). Two of the research pieces presented, provide a snapshot of quality of care in two protracted crises (66,68):

In Ouaka prefecture, CAR, during the mortality survey, quality of care was not the focus of the study; nevertheless the open qualitative question about challenges the household had faced that was asked at the start of each interview provided insight into problems including absent health care staff and lack of medicines at health posts and was corroborated by the fact that for more than half of the people who died during the recall period, it was reported that they did seek health care but still died – reasons for this can be plentiful such as advanced diseases or non-adherence, but they might as well be quality-of-care-related (66). As the reports of poor quality of care by households during the study substantiated unconfirmed observation of medical staff on the ground, the MSF project in CAR is focussing its mission on improving the quality of available healthcare since 2021 (66).

In Sila region, Chad, as part of the survey on MHS coverage, it was found that only about half of the women who did attend ANC care received the full recommended package of care during their ANC visits (68) – a finding that contributed to the decision to engage with and train existing health care providers including TBAs in order to maximize the usefulness of existing (accepted) services in the area (134).

3.3 Research methods and evidence in humanitarian crisis

In humanitarian crises, planning and implementing research is often complicated by conflict, insecurity and access challenges and by the vulnerability of the population in focus of the research (31–33). Yet, data about mortality, morbidity, health care availability and access to care cannot be collected before or outside the crisis situation and therefore adequate and context-adapted methods to collect such data in crises are key to provide an evidence base for decisions and to steer appropriate humanitarian response. In order to ensure humanitarian action truly addresses the biggest health problems of the populations most in need, the generation of evidence, i.e., information that is able to demonstrate if an assumption holds true (1), is required in humanitarian crises (3).

An increasing number of studies has been conducted over the past decades to identify and quantify health needs of populations trapped in crises; however, repeatedly concerns have been raised over methodological shortcomings and the quality of data (32,70,71,124,139–141). A number of initiatives

have led to the use of more standardised indicators for population health such as the Sphere project (142) or the (short-lived) Health and Nutrition Tracking service housed in WHO (143) in recent years. Additionally, several initiatives are in place that aim to support the utilisation of more standardised methodologies, e.g., the SMART initiative to improve nutrition and mortality surveys (60), the WHO reference manual for vaccination coverage surveys (61) or the complex emergency database (65). The Public Health Information Service of the Health Cluster, led by WHO, outlines required population health indicators in humanitarian crises and appropriate methodologies to obtain them (17). The methods and indicators used here are based on these initiatives and standards, adapted to their context (53,54,58,66–68).

ALNAP (3) states in 2014 as their summary of a review of quality and use of evidence in humanitarian action that "despite progress over the past 20 years, there appears to be room for improvement in the quality and use of evidence in international humanitarian action"((3), p.6). The studies presented in this overview aim to contribute to good quality evidence by context-driven adaptations to improve survey methodology and HMIS- and surveillance data analysis: the survey in CAR was adapted to use a modern sampling technique based on satellite images and implemented an adapted mixed-method questionnaire to elicit more information on the context and better data about neonatal and maternal deaths (66). The survey in Liberia was adapted to use mobile-phone dialling instead of physical household visits in order to be able to implement a mortality survey at all in a setting with enforced social distancing due to the Ebola epidemic (67). The survey in Chad was a classical household survey following standard recommendations (61) to produce high-quality results (68). In Libya and on the Mediterranean Sea a high-quality analysis of HMIS data showed the richness of evidence a detailed analysis of simple HMIS systems can provide (53,54). In Bangladesh, the public health threat detection and assessment as part of the EWAR system was able to rule out a deadly HEV outbreak and illustrated how threat identification and investigation can contribute to avert further morbidity and mortality (58).

In humanitarian emergencies as elsewhere, it is required to produce and use good quality routine and research data for the benefit of the population (32). Several researchers and institutions have argued that more applied high-quality research, adapted to context in humanitarian crises is needed and should routinely be conducted to provide an evidence base for humanitarian action (16,32,144). It is hoped that the presented research provides a small contribution to advances in the measurement of population health indicators in humanitarian crises by tailoring standard methods to context and documenting these adaptations, and by using available HMIS and surveillance data in order to provide an evidence base for programme decisions and advocacy.

3.4 Evidence-based decision making in humanitarian emergencies

The research presented here did not stop at context-appropriate and skilled research design and implementation. All of the presented studies were reported in adapted formats to different audiences and all of these studies bridged the gap in research use from "knowing to doing" ((2), p.1).

For all studies a report was produced for the commissioning agency: MSF for two studies in Libya and the SAR vessel (53,54), MSF and MoH in three studies in CAR (66), Liberia (67) and Chad (68) and MoH and WHO in Bangladesh (58). The comprehensive reports included context, and methodological details including adaptations, ethical considerations, strengths and limitations as well as context-specific recommendations. For several studies, these comprehensive reports were followed by short reports and presentations to operational decision-makers and discussions for the next annual planning. Additionally, (except for the studies based on retrospective secondary data analysis on the Mediterranean Sea and Libya) the results were as well shared with the community to live up to the

accountability towards the populations under research (145,146). Feedback to the communities under research is key to empower communities to take action on their own behalf (146).

These recommendations given in the report were – to some extent – transformed into operational decisions by the commissioning agency.

In CAR, following the survey on mortality and health-seeking behaviour (66), MSF started to expand the provision of care at integrated community case management (ICCM) facilities from malaria testing and treatment only, to diagnosis and treatment of respiratory infections and diarrhoea in order to allow for effective treatment of most prominent causes of deaths in children (133). The expansion allowed the provision of simple and life-saving treatment close to where people live (90).

In Liberia, following the survey on mortality, morbidity and health-seeking behaviour (67), MSF continued health promotion activities as reservations held by the communities against healthcare facilities were substantiated by the survey with a large proportion of households not seeking care for Ebola and non-Ebola-related illnesses (67).

For the project in Libya and for the Search & Rescue project on the Mediterranean Sea, the data (53,54) confirmed anecdotal evidence already known from healthcare workers and patient accounts and strengthened the evidence base for MSF's advocacy and communication aiming to close detention centres in Libya and finding options for saver passages to Europe for migrants, refugees and asylum seekers (109,147). The analysis of tuberculosis data in Tripoli's detention centres also contributed to the continuation of MSF's tuberculosis program in Libya (53).

In Bangladesh, the investigation of a potential public health threat using enhanced laboratory surveillance (58)was able to confirm the causing pathogen, HAV. To stop the spread of HAV and to prevent other outbreaks of waterborne diseases from occurring, WSH facilities were scaled up and improved. Given the high proportion of HBV and HCV detected, it was additionally, advocated to expand detection and treatment for chronic viral hepatitis (58).

In Chad, the survey on health service provision for MHS (68) provided the foundation for MSF to start a project in the region of the survey focussing on maternal health. The project was co-created with the communities to ensure acceptability of services (134). The project was also implemented in close collaboration with existing formal and informal health care providers for pregnant women and mothers aiming to improve the quality of existing care and provide simple-to-access care close to home and a culturally acceptable way and ultimately would reduce maternal mortality (134).

However, recommended actions from the presented research did not always follow (promptly) due to competing priorities, limited resources and security constraints. In CAR, further operational research to identify reasons for the unexpectedly high maternal mortality ratio was planned but to date not implemented due to competing other priorities. Neither was a follow-up mortality survey of the whole country implemented due to persisting insecurity; the survey was planned because similarly high mortality rates beyond emergency thresholds were expected throughout the country and would have helped to prove the severity of the crisis unfolding. In Bangladesh in CXB, treatment for HBV and HBC is still limited and WHS conditions still offer room for improvement. In Chad, the start of the project in Sila region was delayed by more than a year because of operational constraints.

The Humanitarian Practice Network (4) defined evidence-based decision making in humanitarian assistance as follows "Evidence-based decision-making encompasses external evidence, expertise and beneficiaries' values and circumstances."((4), p.19). It also concludes that "financial resources and political will" ((4), p.2) are required, which also proved true for the evidence-based recommendations for the above studies.

The ALNAP review of quality of evidence in humanitarian settings suggested that providing and using evidence in humanitarian crises makes humanitarian interventions more effective, ethical and accountable (3). The presented research demonstrates that context-appropriate research designs using available HMIS and surveillance data, as well as well-conducted standard approaches and adapted methods to population-based surveys, can overcome design and implementation challenges and provide evidence for decisions making. Furthermore, the tailoring of research to operational questions, the formulation of actionable recommendations and embedding research in organisations that provide humanitarian aid ensured the evidence was used for decision-making and thus contributed to effectiveness and accountability of humanitarian aid.

3.5 Conclusion and recommendations

Analysis of HMIS and surveillance data like the studies presented above (53, 54, 58) should be conducted more routinely to identify threats as well as to inform the provision of care and broader public health responses (50). The surveys presented provide two examples of adapted survey methodologies to address implementation challenges in the field (66,67) but more research is needed to develop context-tailored approaches and better-validated survey designs that may help to obtain better population health data that is urgently needed to plan adequate interventions and monitor the performance of humanitarian response (41, 43, 63). Several researchers and institutions have argued that more applied high-quality research, adapted to context in humanitarian crises is needed and should routinely be conducted to provide an evidence base for humanitarian action (16,32,144). It is hoped that the presented research provides a small contribution to advances in the measurement of population health indicators in humanitarian crises by tailoring standard methods to context and documenting these adaptations, and by using available HMIS and surveillance data in order to provide an evidence base for programme decisions and advocacy.

3.6 Limitations

The six studies presented here provide only a snapshot of population health indicators in six different humanitarian crises and do not (intend to) provide a comprehensive overview of all population health indicators and their measurement options. Additionally, all studies were affected by methodological limitations.

The three surveys in CAR, Liberia and Chad might have been affected by recall bias and social desirability bias and information on deaths and diseases was based on reporting by the household making misclassification possible (66–68). The analysis of HMIS and surveillance data in Libya, the Mediterranean Sea and Bangladesh was hampered by data quality problems as the data was not collected for research purposes and was often incomplete or inconsistent and required substantial data cleaning prior to analysis (53,54,58).

Two of the presented studies needed to be adapted or limited in scope during implementation: The mortality survey in CAR 2020 needed to be limited to 12 out of 16 communes for reasons of security and movement restrictions (66); the mortality survey in Liberia needed to resample because the non-response was higher than anticipated (67). Such adaptations of methods and research processes in humanitarian research were described as frequent and necessary in a recent review of research in humanitarian settings (32). It was suggested that good documentation of the changes allows sharing of the implementation knowledge with the wider humanitarian and research committee (32).

Further research is needed to compare the adapted sampling methods used in CAR and Liberia (66,67) to standard methodologies and to validate questionnaires for surveys - such as the ones used in CAR (66), Liberia (67) and Chad (68) in humanitarian emergencies.

4 Summary

Improving population health is the ultimate aim of all public health interventions. The translation of relevant research findings into evidence-based, context-appropriate and feasible strategies that improve health and reduce disparities is key to successful public health interventions. However, conducting research and providing a solid basis for evidence-based decisions regarding priority interventions to improve population health is particularly challenging in humanitarian crises (4). Evidence is needed to ensure humanitarian relief reaches the groups most vulnerable and hardest affected by the crises and targets the biggest health problems to ensure maximum impact of humanitarian assistance (3,4). Providing and using evidence in humanitarian crises makes humanitarian interventions more effective, ethical and accountable (3).

Humanitarian crises are increasingly frequent and a growing number of people is in need of humanitarian aid (18,19). Humanitarian crises can be defined as events such as natural disasters, epidemics, violence or conflicts that impact on health and safety of a significant proportion of the population and threaten their human rights; the arising humanitarian needs require multisectoral external assistance (19–23). Additionally, protracted crises are becoming a more and more common phenomenon (18,25). Protracted crises continue for a longer duration and are characterised by the ongoing threat to health and wellbeing, the continuous risk of loss of livelihood and weak governance that provides little or no response to these threats (26). In addition to humanitarian crises bound to specific countries, on the Mediterranean Sea a crisis has evolved as migrants, refugees and asylum seekers aim to cross the Mediterranean in small boats to reach Europe (27).

Humanitarian response is aiming to reduce morbidity and mortality of populations affected by crises by addressing underlying factors such as provision of food, water, hygiene and sanitation (WHS) and shelter but as well by providing health care (23). The public health information required during humanitarian crises includes data about a) the health status and threats to affected populations such as estimates of mortality, major causes of morbidity and threats of epidemic-prone diseases, b) the availability of health services and resources and c) health system performance including coverage, utilisation and quality of care (17,23). Indicators of population health regarding mortality, proportional morbidity, disease trends and access to care are key to identify health needs and health risks and to monitor the success of relief programs addressing these needs (17). Additionally, these estimates are the basis for resource mobilisation and allocation and the source of advocacy efforts (17,23).

However, establishing the required indicators and consequently measuring impact of humanitarian aid and assessing the need and scope for further interventions is difficult and is only partially standardized (43,49,50,142). Following initial rapid assessments at the onset of the crisis, there are three main sources for information on population health indicators for mortality, morbidity and healthcare utilisation and quality: 1. health program data such as health management information systems (HMIS) data, 2. data from surveillance systems and 3. population sample survey data (4,17,43,50).

In the following, I am presenting six research approaches to estimate population health and health system performance for populations affected by humanitarian crises. All presented studies are based on HMIS data, surveillance data or survey data collected during crises. The objectives of the individual pieces of research were to establish population health indicators for populations affected by humanitarian crises in order to guide health service provision, broader relief efforts and advocacy strategies. This synthesis aims to demonstrate that context-appropriate research designs using available HMIS and surveillance data, as well as well-conducted standard approaches and adapted methods to population-based surveys, can overcome design and implementation challenges and allow to generate an evidence base for decision-making in humanitarian settings.

The first research piece is a population-based two-stage cluster survey on mortality and health-seeking behaviour in Ouaka prefecture in CAR in 2019 (66). The standard survey methodology was adapted with a modified questionnaire and sampling strategy (66). For the sampling, we used a dataset based on satellite imaging and building identification with artificial intelligence to select cluster starting points (76). The crude mortality rate (CMR) exceeded the emergency threshold and the maternal and child mortality were measured to be among the highest worldwide (66). Violence was the major cause of death alongside preventable diseases (66). The survey demonstrated the severity of the crisis and confirmed the program's aim to provide care closer to the community to avoid preventable deaths (66).

The second study represents an unconventional population-based mobile phone survey to estimate crude- and Ebola-associated mortality as well as morbidity and health-seeking behaviour during the Ebola outbreak in Monrovia in 2014 and 2015 (67). While the CMR did not exceed the emergency threshold, we did identify some excess mortality due to Ebola. Additionally, health-seeking behaviour showed a low utilisation rate for health services and indicated the need for improvement of access and context-adapted health messaging (67).

The third study is a retrospective data analysis of HMIS data from health facilities in detention centres for migrants, refugees and asylum seekers in Tripoli, providing insight into the living conditions and morbidities of a vulnerable subgroup in the protracted emergency that continues to unfold in Libya in 2018 and 2019 (53). Minimum standards for appropriate shelter as well as WHS were frequently not met and the health problems identified were related to overcrowding, lack of water and ventilation, and nutrition; the data contributed to advocacy efforts to end detention in Libya (53).

The fourth study is a retrospective analysis of HMIS data on disease distribution among migrants, refugees and asylum seekers on board a search and rescue vessel in the Mediterranean Sea 2016-2019 demonstrates a high proportion of journey-related illnesses as well as illnesses related to overcrowding and poor WHS conditions (54). The study gives some indication that the majority of conditions could potentially be prevented if migrants, refugees and asylum seekers had an option for a safe passage to Europe and strengthened advocacy efforts (54).

The fifth study illustrates the use of surveillance data to detect health threats during the acute humanitarian crisis in the Rohingya refugee camp in Cox's Bazar, Bangladesh in 2018 (58). After an initial increase of cases of acute jaundice syndrome detected by the early warning alert and response (EWAR) system, enhanced laboratory surveillance was implemented to identify the aetiology of the outbreak (58). The enhanced laboratory and epidemiological surveillance helped to confirm an outbreak of HAV and to rule out a (much more dangerous) outbreak of HEV (58). WHS interventions were implemented based on the finding to limit the spread of HAV and other diseases of similar transmission routes (58).

The sixth study represents a population-based survey that explores maternal health service (MHS) coverage among women living in Sila region in Chad (68). Antenatal care (ANC) was used by 58% and 22% delivered their children in health facilities and 33% received any postnatal care (68). Available ANC was often incomplete and infrequent (68). The most frequent access barriers were reported to be lack of transportation but also factors related to culture and belief (68). The results are indicating that reaching women with MHS requires improvements in infrastructure and in the quality of available care as well as community engagement to better understand local beliefs related to maternal health (68).

The studies presented in this overview aim to contribute to available evidence by context-appropriate survey methodologies and HMIS- and surveillance data analysis: the survey in CAR was adapted to use a modern sampling technique based on satellite images and implemented an adapted mixed-method questionnaire to elicit more information on the context and better data about neonatal deaths (66).

The survey in Liberia was adapted to use mobile-phone dialling instead of physical household visits in order to be able to implement a mortality survey at all in a setting with enforced social distancing due to the Ebola epidemic (67). The survey in Chad was a classical household survey following standard methods (61) to produce reliable results about MHS coverage and quality (68). In Libya and on the Mediterranean Sea a good quality analysis of HMIS data showed the richness of evidence a detailed analysis of simple HMIS data can provide (53,54). In Bangladesh the public health threat detection and assessment as part of the EWAR system allowed to rule out a deadly HEV outbreak and illustrated how threat identification and investigation can contribute to avert further morbidity and mortality (58).

The research presented here did not stop at context-appropriate research design and implementation. All studies were reported in adapted formats to different audiences and yielded actionable recommendations directly relevant to the specific humanitarian crisis to bridge the gap in research utilisation from "knowing to doing" ((2), p.1). The presented research demonstrates that appropriate research designs using available HMIS and surveillance data, as well as skilfully adapted methods to population-based surveys, can overcome implementation challenges and provide evidence for decisions making and thus contributed to the effectiveness and accountability of humanitarian aid.

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Statutory declaration

Erklärung

§ 4 Abs. 3 (k) der HabOMed der Charité

Hiermit erkläre ich, dass

- weder früher noch gleichzeitig ein Habilitationsverfahren durchgeführt oder angemeldet wurde,
- die vorgelegte Habilitationsschrift ohne fremde Hilfe verfasst, die beschriebenen Ergebnisse selbst gewonnen sowie die verwendeten Hilfsmittel, die Zusammenarbeit mit anderen Wissenschaftlern/Wissenschaftlerinnen und mit technischen Hilfskräften sowie die verwendete Literatur vollständig in der Habilitationsschrift angegeben wurden,
- mir die geltende Habilitationsordnung bekannt ist.

Ich erkläre ferner, dass mir die Satzung der Charité – Universitätsmedizin Berlin zur Sicherung Guter Wissenschaftlicher Praxis bekannt ist und ich mich zur Einhaltung dieser Satzung verpflichte.

03.01.2023

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