Public health information in crisis-affected populations: a review of methods and their use for advocacy and action

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Summary

Valid and timely information on various domains of public health underpins the effectiveness of humanitarian public health interventions in crises. However, obstacles including insecurity, insufficient resources and skills for data collection and analysis and lack of validated methods combine to hamper the quantity and quality of public health information available to humanitarian responders. This paper reviews available methods to collect public health data pertaining to different domains of health and health services in crisis settings, including population size and composition, exposure to armed attacks, sexual and gender based violence, food security and feeding practices, nutritional status, physical and mental health outcomes, public health service availability, coverage and effectiveness, and mortality. The paper also quantifies the availability of a minimal essential set of information in large armed conflict and natural disaster crises since 2010: we show that information was available and timely only in a small minority of cases. Based on the above, we propose an agenda for methodological research as well as steps required to improve on current use of available methods: these include setting up a dedicated inter-agency service for public health information and epidemiology in crises.

Key messages

- Timely, robust public health information is essential to guide an effective response to crises (armed conflicts and natural disasters): this encompasses establishing needs and priorities, strategic planning and deciding on appropriate service packages, and reacting in real time to insufficient health service performance or new public health threats. Public health information is also critical for advocacy and documentation purposes.
- A variety of methods exist to measure relevant aspects of demographics, public health risks, status and services in crisis settings; however, many of these methods are not strongly evidence-based

- Actual, timely application of existing methods has been very limited in recent large crises, even when considering a minimal set of essential public health information services
- Far greater investment and institutional buy-in are required to make a quantum leap from the present unsatisfactory baseline; a dedicated body may need to be established in order to undertake core functions of public health information generation and analysis in crisis settings
- The research agenda for development of more robust methods needs to be consolidated, and priorities tackled collaboratively across academic and operational agencies

Introduction

Between 2005 and 2014, an annual mean of 35 armed conflicts (range 31-40), of which 6 (4-11) major (> 1000 people killed annually) were active globally[1], directly affecting some 172 million people in 2012, the sole year for which global estimates including displaced and affected non-displaced people are available.[2] Between 2006 and 2015, a mean of 393 (range 341-462) natural disasters (geological and hydro-meteorological hazards only) occurred, affecting a mean of 169 (97-260) million people annually.[3]

In the above crises, robust, timely public health information is critical to (i) rapidly establish public health needs and priorities, and thus an appropriate package of public health services; (ii) quantify and mobilise funds and resources required to deliver this package, given the population in need and the required intensity of support to the local disrupted health system; and (iii) monitor the performance of the humanitarian response, by identifying and reacting in real-time to sub-standard quality of health services, new threats (e.g. an epidemic), gaps in service availability, and other changes (e.g. improvements in food security; reduced service utilisation). A secondary function of public health information is to enable advocacy and documentation of the crisis' impact (including for legal purposes).[4]

War and disasters, however, disproportionately occur in countries where public health information systems are already weak. Crises compound these weaknesses by further disrupting government services. Other challenges specific to crises include the short timeframe and high frequency (days or weeks) within which data must be generated so as to monitor fast-developing health events such as epidemics or detect deteriorations in malnutrition and mortality; practical or statistical limitations of data collection methods in displacement situations (discussed below); lack of readily available expertise and resources for robust data collection; and security constraints, particularly where data collection or publication are perceived as threatening by combatants.

Epidemiologists and demographers have partially developed adapted methods[5] to respond to these challenges, but it is unclear to what extent these methods are used consistently, and major methodological evidence gaps remain. Here, we distinguish the different domains of public health information in crisis settings; map existing methods against each of these domains, and review the evidence supporting their use; suggest a minimum set of public health information products during the acute phase of the crisis, and investigate their actual availability in recent crises; lastly, we propose an agenda for methods development and systemic measures to make accurate, timely public health information more consistently available in future crises.

For the purpose of this paper, our definition of crisis encompasses sudden unplanned displacement; direct exposure to armed conflict resulting in heightened public health risks and/or reduced public health services; sudden deterioration in nutritional status (as opposed to trends over multiple years); natural or industrial disaster; and/or a sudden breakdown of critical administrative and management functions in a country (see Webappendix, Annex 6 for a more detailed definition and examples). We consider both the acute and protracted phases of a crisis in this review. We omit large epidemics or pandemics from this review, since these feature very specific public health information requirements that, moreover, largely depend on the pathogen and context.

Domains of public health information

Figure 1 attempts to map the main domains of public health information that may be relevant in a crisis. An obvious starting point is quantifying the affected population and vulnerable sub-groups of interest. Figure 1 depicts the main public health risk factors that emerge in crises (red boxes), and how these act upon each other and key public health outcomes (nutritional status, morbidity) and impacts (mental health, disability, mortality), depicted as yellow boxes. Lastly, the green boxes denote humanitarian public health (water, sanitation and hygiene, or WASH; nutrition; health care) services.

The relative importance of these different information domains is highly context-dependent. For example, the public health effects of the current eastern Ukraine conflict are mainly driven by interruption of non-communicable disease (NCD) treatment, drug and alcohol addiction and mental health problems.[6] By contrast, war in the Central African Republic has mainly affected feeding practices, nutritional status, continuity of HIV and TB treatment, sexual and gender-based violence

(SGBV) frequency, mental health, reproductive and neonatal health and infectious disease burden: these effects, superimposed onto a pre-epidemiologic transition baseline of very poor health status and services, have led to far higher excess mortality[7] than in eastern Ukraine.

Below we discuss the public health relevance of each information domain.

Estimates of affected population size and composition

Accurate estimates of affected population size, including gender and broad age group breakdown, are indispensable from day one to mobilise sufficient resources, scale interventions (e.g. number of children needing vaccination), and estimate service coverage (e.g. ratio of persons per latrine).[8] Population estimates need frequent updating, particularly in highly fluctuating displaced populations. Moreover, the need to identify groups requiring specific assistance and protection (unaccompanied children, pregnant and lactating women, single-parent households, patients requiring long-term treatment continuation) is increasingly recognised: these vulnerable groups require individual-level registration and tracking.

Information on public health risk factors

Armed conflict and natural disasters directly affect health through physical injuries[9], increased risk of SGBV[10] and mental disorders.[11] Describing the typology of and extent of exposure to a crisis aids documentation and advocacy, but also helps to project needs for protection and SGBV programmes, trauma surgery and rehabilitation, community psychosocial support and management of mental disorders. Armed conflict and disasters also affect health indirectly by disrupting public health services, through reduced health system governance and funding, damage to public health infrastructure, attacks against health workers and patients, and reduced or delayed service utilisation due to insecurity.

Forced displacement, particularly into overcrowded, under-served settlements, results in greater infectious disease transmission[12], worsens mental health and carries a higher, multi-factorial SGBV risk.[13] Displacement also interrupts treatment for large cohorts of people living with HIV, TB and NCDs (e.g. dialysis, insulin). The highest death rates in recent decades have been recorded in internally displaced persons' (IDP) camps.[14] Depression prevalence is higher if people are not only crisis-affected but also displaced.[11]

Natural disasters, insecurity and displacement worsen food security (i.e. the ability to procure sufficient quantity and diversity of food) and feeding practices (how breast milk and food are used), which in turn profoundly modulate nutritional status; information on these factors enables early warning of slow-onset food insecurity emergencies and helps design food distributions, cash transfer and other food security or feeding practice interventions. Poor mental health also acts as a risk factor for inappropriate feeding and infant care practices and addiction: the latter, in turn, increases the burden of NCDs.[15]

Information on public health services

Directly quantifying the impact of humanitarian public health services (as in deaths and disability averted, or improved mental health and functioning) is unfeasible due to measurement, causal attribution and resource limitations.[16] However, impact can be inferred from three quantities: (i) service availability (whether a service exists) and functionality (whether the service is actually operational as per locally stipulated service standards: e.g. whether skilled workers, drugs and equipment are available for management of obstetric emergencies; whether water is being provided with the recommended quantity and quality); (ii) coverage (proportion of population in need that actually receives the service; e.g. vaccination coverage; proportion of cases of acute malnutrition enrolled in a therapeutic feeding programme); and (iii) quality or effectiveness (proportion of people receiving the service who are treated appropriately and actually experience its intended effect; e.g. cure rate of feeding programmes; prescribing accuracy). The following general formula expresses this relationship:

$$\text{Relative impact} = \text{functionality} \times \text{coverage} \times \text{effectiveness}$$

, where impact attains its maximum if all three quantities are at 100%.

Accordingly, geographically mapping the availability and functionality of public health services (including healthcare, WASH and nutrition), by level (inpatient, outpatient, community) and thematic area (e.g. reproductive health; excreta disposal; management of severe malnutrition), helps to establish and continuously monitor gaps: such monitoring should be carried out against an agreed package of public health services appropriate to the crisis. Where a crisis can be anticipated, preparedness measures should include updating the database of available health facilities, health human resources and thematic services across the crisis-prone region, and identifying pre-crisis gaps and inequities in health system resources (see also HeRAMS below): making this information immediately accessible to humanitarian actors helps to direct resources from the very start of the response.

Provided the service is functional, quantifying service coverage in real-time is sometimes sufficient to infer impact: for example, the proportion of households receiving an adequate soap ration needs to be measured, but the effectiveness of soap may be assumed from the evidence.

Measuring at least proxy indicators of effectiveness is necessary whenever the latter cannot be assumed: for example, the coverage of a community-based management of acute malnutrition (CMAM) programme is insufficient for monitoring: defaulting and cure rates (i.e. effectiveness) among children enrolled vary considerably across programmes, and must therefore also be quantified. The case-fatality ratio of admissions to inpatient services is also a key indicator that partly reflects service quality. Similarly, some interventions may have known effectiveness in theory, but may be used inappropriately in practice (e.g. bed nets not being used to protect the most vulnerable household members, re-sold or recycled for other purposes): when this is suspected, assessment of household-level use of the intervention may be required, for example through behavioural surveys.

Information on public health outcomes and impacts

Mental health is strongly associated with various physical health outcomes[17]. SGBV worsens mental health and reproductive health outcomes.[18] Worsening nutritional status correlates exponentially with mortality in displaced populations[19] and is an early signal of overall crisis severity[20]; in emergencies acute (wasting and oedema), rather than chronic (stunting) undernutrition, is the main emphasis of response, with children under 5y, pregnant or lactating women (and the elderly in certain contexts) as the main vulnerable groups.[21] Adults' nutrition status also requires monitoring in extreme food insecurity or famine scenarios.[22] Malnutrition leads to mortality via a vicious cycle involving increased disease susceptibility and case-fatality.[23] Accordingly, acute malnutrition prevalence estimates are critical to appropriately scale interventions ranging from nutritional therapy alone to food security and feeding practices improvement.[22] Henceforth, we use the terms malnutrition and undernutrition interchangeably, unless specified. Overnutrition (e.g. obesity) is however an emerging problem in some crisis-affected populations, and increasingly overlaps with undernutrition, warranting measurement of both.[24]

In crises, total mortality may be separated at least conceptually into its "baseline" (the counterfactual level, had the crisis not occurred) and "excess" (i.e. indirectly or directly crisis-attributable) fractions.[25] Humanitarian public health interventions are primarily intended to minimise this excess, though sometimes they may also reduce baseline mortality. Accordingly, the population crude death rate (CDR), as compared to likely baseline levels, is a core indicator of crisis severity and humanitarian impact[26]; however, the death rate among children under 5y old (U5DR) may be more sensitive to changes in conditions and may thus be a better signal of a deteriorating situation. Cause-specific mortality data are also highly relevant, as they indicate which health problems should be prioritised.

Directly crisis-attributable excess mortality (i.e. fatal injuries) has been of primary interest for advocacy, war crimes investigations and historical narrative.[27] However, roughly 80-95% of excess deaths in historical African conflicts may have been "indirect".[28] Arguably, indirect mortality is also of great forensic and advocacy relevance, particularly when combatants deliberately target civilians by obstructing assistance, destroying health infrastructure, etc. Both direct and indirect death tolls (plus long-term physical and mental disabilities) should thus be quantified to fully document crises' impacts.

Synthesising disparate information

At the needs assessment stage, information from all of the above domains only makes sense if combined with pre-crisis data on health status, disease burden and the characteristics and performance of the local health system. Evidence from similar crises should also be used at this stage to make plausible predictions of the crisis' public health effects and their severity in the absence of a response. This information and predictions should be synthesised into a public health situation analysis document, which in turn should be the basis for deciding on an appropriate package of services by thematic area, the right modality of support to the health system, the target population, and consequent resources needed (funding, staff, drugs, etc.). As the response gets underway, real-time information on different information domains, including the performance of humanitarian public health services, should be used to update the situation analysis and adjust services accordingly. For example, proportional morbidity trends may warrant a recalculation of pharmaceutical needs; an increase in the affected population may open up new gaps in service provision.

Review of available methods

Table 1 summarises available methods pertaining to the public health information domains outlined above. Each of these methods is reviewed below (see Annex 1, Webappendix for search strategy).

Methods: Affected population size and composition

Prospective demographic surveillance, consisting of initial census and ongoing (weekly, monthly) updates by community health workers, is an established approach for tracking population size and mortality (see below), but is mainly done in camps. In eastern DRC IDP camps, the United Nations

Office for Project Services (UNOPS) ran an effective demographic surveillance system.[29] In non-camp communities of the Central African Republic, by contrast, discordances were noted between weekly birth, death and migration data and repeat census exercises.[30]

Because of urgency and resource constraints, rapid population estimation methods are often required.[31] These[32] mainly fall into three approaches: (i) multiplying a ground-, aerial- or satellite imagery-based tally of residential structures with an estimate of mean structure occupancy, obtained by questioning a random sample of households or extrapolation from similar settings[33]; (ii) multiplying an estimate of the total settlement surface area with an estimate of population density, derived from transect sampling, the “Quadrat” method[34], the T-Square method[34] or spatial interpolation[35]; (iii) qualitative or convenience methods, such as community informant estimates[36], Delphi consensus[37], triangulation of existing sources[36], flow monitoring in dynamic camp settings[36], and use of programme data[36]. Other methods, relying on capture-recapture statistics[38] or population tracking using mobile phone data[39], have been proposed. Satellite imagery and crowd sourcing methods facilitated by social networks and telephony are of interest for further methods development.

Annex 5, Webappendix appraises the above methods more fully. In general, statistically robust methods require expertise in complex sampling and analysis[34], rarely available in the first weeks of emergencies. Generally, evidence is very limited in this area, precluding a clear appraisal of different methods’ accuracy under various conditions. Many humanitarian field manuals recommend methods that are not validated or based on convenience sampling[40]. Moreover, enumeration of populations, if tied or concurrent to relief distributions, can be biased by intentional over-reporting of household size, or perceived as an oppressive, disempowering practice.[41]

Methods: Exposure to armed attacks

Attacks against civilians, including killings, injuries, abductions and torture, can be measured through three broad approaches. Firstly, population surveys (see Annex 2, Webappendix) can be used to retrospectively document exposure to these events: multiplying survey-estimated attack rates by population size within the survey area (or sampling universe) yields the estimated total number of events.[42,43] Secondly, media and human rights activist reports can be systematically captured and codified to provide real-time tracking and analysis of killings and attacks, as exemplified by the Iraqi Body Count[44,45] and the Uppsala Conflict Data Program.[46] This approach does not necessarily produce accurate estimates, but offers insights into patterns and perpetrators of violence, and establishes a credible minimum total of people killed, as done for the Syria war.[47,48] Thirdly, capture-recapture statistics have been used to analyse overlap in lists of people killed or abducted and thereby estimate the true total numbers of victims. Resulting evidence has informed war crimes proceedings for Guatemala and the former Yugoslavia.[49,50]

Attacks against health workers and facilities, commonplace in settings like the Central African Republic and Syria[51], have historically been monitored by the International Committee of the Red Cross[52], though in 2012 WHO was mandated by Member States to track these as well.[53] To date only media and agency reports are being used, producing patterns but not comprehensive estimates. A related paper in this Series (Boshara et al.) reports on a method for monitoring and verifying such data in northern Syria.

All the above methods can be enriched by in-depth case studies and qualitative research to identify patterns, analyse perpetrators and better characterise the effects.

Methods: Sexual and gender-based violence

Aggregate SGBV incidence data may be collected from routine HMIS (Annex 4, Webappendix) or from registers of SGBV cases seen. The Gender-based Violence Information Management System (http://www.gbvims.com/) is active across different crises to harmonise and aggregate case reports from various sources. However, whereas high caseload indicates high SGBV frequency, sporadic cases typically reflect utilisation barriers, not low incidence.[54] SGBV burden estimations have thus relied on population surveys: in armed conflict settings these have been few, and have adopted varying questionnaires and case definitions, despite steps towards standardisation.[55] The “neighbourhood method”, whereby female respondents also provide information about sisters and close neighbours (thereby reducing sample size) yielded either similar (in Liberia)[56] or different (Uganda[57] and Ethiopia[58]) reported rates among sisters versus neighbours; Several Ethiopia respondents reported violence due to survey participation.[58] Respondent-driven sampling, whereby “seed” study participants enrol others from their social networks, has been used to quantify SGBV among migrants in Morocco[59], and holds promise. Whatever the method used, stringent ethical requirements are imperative in SGBV studies and restrict their feasibility to well-controlled settings and specialist researchers.[60] Ultimately, developing methods to rapidly quantify SGBV service uptake and understand barriers may be more practically useful than trying to measure SGBV incidence.

Methods: Food security and feeding practices

Food security assessments encompass indicators of food availability, access and utilisation[61], household vulnerability, resilience and coping, and the broad economic context. These assessments are not standardised and utilise various qualitative and quantitative methods.[62-64] Market analysis yields critical information on food security but is seldom conducted due to difficulty.[65] Early warning and surveillance systems have become more common recently, and generally analyse data on agricultural production, market prices, nutrition and underlying factors. The Famine Early Warning Systems Network[66] and the World Food Programme’s Vulnerability Analysis Mapping (VAM) unit[67] produce regular reports and alerts in a number of countries. The Food Security and Nutrition Assessment Unit in Somalia[68], established during the famine in the 1990s, pioneered combining food security and nutrition data, and its methodology of food security phase classification[69] is now used in several countries. Despite these improvements, delays in humanitarian response remain, as in the 2011 crisis in Somalia.[70] We do not discuss food security methods further in this paper, as they mostly fall outside the remit of humanitarian public health.

Indicators for assessing Infant and Young Child Feeding (IYCF) practices are well defined[71]. Achieving acceptable precision among age strata of interest (0-5, 6-9, 12-15 and 20-23 month-olds) requires surveys with substantial sample size[72]. Rapid qualitative methods can supplement information about changes in feeding practices and barriers to optimal feeding.[73]

Methods: Nutritional status

The weight-for-height (WFH) index, as Z-score deviation from the mean of a well-nourished reference population distribution, has traditionally been used to measure wasting.[74] However, Mid-Upper Arm Circumference (MUAC) has gained momentum for identifying children in need of treatment[75] since it appears to better predict mortality[76], is a good indicator of nutritional stress[77] and is easier to measure.[78] MUAC is a recommended index to screen and detect severe acute malnutrition.[75] Since MUAC and WFH do not identify the same children as wasted[79] and their overlap varies across populations,[8081] the use of MUAC alone for measuring malnutrition prevalence[82] and nutritional programme admission is currently debated.[83,84]

Kwashiorkor or oedematous malnutrition has higher case-fatality than wasting but is mostly not diagnosable through MUAC or WFH.[85] Instead, a simple bilateral thumb pressure test is used in emergencies.[86]

Cross-sectional surveys targeting children 6-59mo old are the main method currently used to estimate acute malnutrition prevalence. These surveys classify children into severely (SAM) or moderately (MAM) acutely malnourished based on bilateral oedema presence and/or WFH Z-score or MUAC cut-offs. Prevalence thresholds for benchmarking crisis severity have been proposed[87], but prevalence should also be interpreted against trends and baseline estimates where these exist. For example, Multiple Indicator Cluster Surveys[88] and Demographic Health Surveys[89], regularly conducted in developing countries, can provide useful comparisons even though they also include <6mo olds and do not assess oedema. Overnutrition prevalence is also best assessed through surveys, though including adults, with Body Mass Index as the main measure.

Despite progress in standardising anthropometric surveys[21], errors in their implementation have been frequent.[90] Poor quality has been attributed to unqualified survey staff.[91] The inter-agency SMART initiative has developed field-friendly manuals and analysis software and regularly trains humanitarian staff in survey design and implementation.[20] An algorithm for assessing survey quality[92] and plausibility checks for data accuracy have also been developed by SMART. However, application of different recommended data cleaning criteria results in substantial differences in estimated prevalence.[93]

The relatively high sample size (usually hundreds of children) required to achieve interpretable precision constrains the frequency and geographical disaggregation of anthropometric surveys, limiting their use for ongoing surveillance and geographical targeting of interventions, though low sample size (<200) could be used in small homogeneous areas to inform early emergency response.[20] More efficient sampling schemes using Lot Quality Assurance Sampling (LQAS)[94] and PROBIT statistics[95] have been proposed but seem bias-prone.[96,97] Repeat testing of sentinel communities, trend analysis of health facility nutrition data and trends in feeding programme admissions can all contribute to surveillance, but methodological questions remain concerning their use.[98,99] Generally, the interpretation of anthropometric indices as continuous variables, without converting them into binary prevalence data, would enable lower sample sizes, as suggested by unpublished data (cite Séverine Frison paper when it comes out).

Up to 20% of children admitted to feeding programmes in emergencies are under 6mo old[100], and wasting prevalence in this age group exceeds 30% in some countries.[101] Including <6mo olds in surveys has been advocated[102]. This would require higher sample size and training on specialised anthropometry equipment.

Lastly, assessing micronutrient deficiencies generally requires blood or urine samples and is seldom performed in crises, other than for anaemia prevalence.[103] Instead, their likely burden is gauged using food distribution and dietary diversity data.[104]

Methods: Physical health

Outpatient and inpatient data collection as part of routine HMIS (see Annex 4, Webappendix), complemented by drug consumption tracking, is essential to plan pharmaceutical orders and prioritise topics for in-service training and supervision (e.g. around the main paediatric or obstetric morbidities).

Epidemic alert and response, a critical function of public health services in crises, is beyond the scope of HMIS and requires ongoing facility-based syndromic surveillance of the main epidemic-prone diseases, backed up by laboratory confirmation and investigation and response procedures.[105] WHO-led Early Warning Alert and Response systems (EWARS) are systematically implemented in emergencies, but with varying delays, coverage and effectiveness.[106,107] Past EWARS have monitored various lists of syndromes/diseases with different alert and epidemic declaration thresholds, some of which (for meningococcal meningitis and malaria) are based on statistical trends, and the remainder on arbitrary decision rules.[105] These systems have arguably over-relied on weekly data transmission, and neglected immediate alert reporting through formal or informal channels, which, in Pakistan's Disease Early Warning System[108], accounted for 90% of outbreaks detected.[109] WHO guidelines now emphasise the alert function.[105] EWARS should not impose a data reporting burden additional to existing HMIS, but rather should enhance the latter by establishing epidemic preparedness plans, shared case definitions and alert thresholds, immediate phone or SMS alert communication and aggressive investigation and response. A new, highly user-friendly WHO EWARS application and field kit are now available (http://ewars-project.org/).

While HMIS data can illuminate the relative burden of HIV, TB and NCDs locally, the population's age structure and pre-crisis prevalence estimates allow for reasonable prediction of treatment requirements.[110] However, it is imperative to rapidly identify patients requiring treatment continuation for HIV, TB and priority NCDs (e.g. hypertension, diabetes, kidney disease), and monitor their treatment coverage[111], as done for HIV during Northern Uganda conflict[112], HIV, TB and other NCDs during post-election violence in Kenya[113] and HIV after the 2010 earthquake in Haiti.[114] To our knowledge no established methods exist for going about this. Recomposing pre-war treatment databases, contacting associations of people living with HIV, and inviting patients through community health and media messaging are logical options. However, in high prevalence settings where stigma is low, actively searching for patients and asking for disease status during initial refugee registration or exhaustive population counts may be warranted.

Methods: Mental health

Mental health assessments in crises used to rely heavily on mental disorder prevalence surveys.[115] However, though such surveys can be extremely valuable for advocacy and scientific progress, it is now understood that their practical value for designing interventions is greatly reduced[116] due to high variability in estimates depending on the method of assessment[11]; narrow scope (typically PTSD and depression only); a frequent lack of indicators of severity (e.g. the extent to which symptoms impact daily functioning); and delays between study planning and reporting.

Existing WHO projections[117] and meta-analysis of methodologically robust surveys (i.e. that used representative sampling and diagnostic interviews)[11] suggest average prevalence of depression and post-traumatic stress disorder (PTSD) between 15 and 20% in crisis-affected populations. These numbers more than justify delivery of mental health care. However, such care should be informed by relevant assessment.

As part of preparedness or as a first step of assessment during the crisis, a desk review of secondary data – for which a template is available[118] - should be conducted rapidly summarising pre-crisis mental health and psychosocial information about the affected population, and should include sociocultural aspects of mental health whenever services are offered by external actors. This is essential to avoid collecting unnecessary data. Such reviews – ideally systematic as done after the earthquake in Nepal[119] - are increasingly common (available on www.mhpss.net), and narrative reviews on Haiti and Syrian refugees have been widely used.[120,121].

Second, data collection on the ground should immediately start by site visits of institutions[122] to inform immediate protection and care for people with mental disabilities in institutions as their severe neglect in is common in acute emergencies[123].

Third, gaps in knowledge on local perspectives on problems, resources and coping should be filled through participatory assessment among general community members[118], people with in-depth knowledge of the community[118] or severely affected persons.[122] Results are valuable not only for the health sector but also for psychosocial activities within the protection and education sectors.

Fourth, mental health should be integrated within general health assessments by adding relevant questions to general health status surveys[122], assessments of primary health services[122], HMIS[122] and post-conflict/post disaster needs assessments focusing on recovery.[122]

Finally, mental health needs to be included in crisis-wide service availability monitoring (see below, HeRAMS) as well as specific Who What Where When (4Ws) assessments of mental health and psychosocial support activities .[124]

Methods: Service availability and functionality

The WHO and Global Health Cluster (the humanitarian cluster approach is the main coordination mechanism for crises: one cluster is usually activated for each sector of the response, e.g. health, nutrition, WASH, etc.) have developed a Health Resources Availability Mapping System (HeRAMS) method whereby, at individual health facility level, enables mapping of which specific health services are available, and identification of health system gaps and inequalities, both geographically and in terms of the package of health services provided.[125,126] HeRAMS to date has mostly been implemented as cross-sectional surveys, but should instead be used as a real-time monitoring system. A key step in HeRAMS implementation, which should arguably be carried out as part of emergency preparedness, is to update and geo-reference the database of health facilities in the crisis-affected area, also needed for HMIS and EWARS (see below). A complement to HeRAMS is the more generalist Who What Where When (4W) application, managed by OCHA, for monitoring which agencies are supporting which health and nutrition services, where.[127] Both are increasingly being rolled out to clusters globally.

Similarly, the WASH cluster has developed detailed information management tools for analysing needs, availability of services and improving targeting of interventions.[128]

Methods: Service coverage

For many services, basic coverage data can be obtained by combining HMIS or programme reports with an estimate of the service's catchment population. The Sphere standards and other guidelines suggest benchmarks of acceptable coverage. For example, an outpatient utilisation rate (new consultations per person-year) ≥ 1 is considered a proxy of good health care access, while ≥ 15 L water per person-day should be available. Such indicators rely heavily on accurate population estimates.

Assessing coverage of therapeutic feeding programmes is critical, but fraught. Typical anthropometric surveys provide imprecise estimates of coverage, as the denominator of coverage (number of SAM or MAM cases detected in the survey) is usually small. A coverage survey method that also allows investigation of barriers to treatment, relying on snowball case finding of suspect SAM cases in a systematic spatial sample of communities, is instead currently being scaled up by the inter-agency Coverage Monitoring Network.[129] However, the snowball technique is not sensitive for MAM. Alternatively, the number of SAM and MAM cases actually admitted for treatment can be compared to the population SAM and MAM incidence during the same period, but quantifying the latter is very difficult unless all children are being routinely screened, an infrequent scenario. Prevalence as measured prior to implementing a feeding programme is multiplied by a conversion factor derived from the estimated mean durations of SAM and MAM[130] so as to forward-project population incidence: however, this is extremely rough and only useful for broadly planning resource requirements.

Vaccination coverage estimates computed administratively (i.e. by tallying people vaccinated routinely or through campaigns) are straightforward, but are often upward-biased due to political and financial incentives to report positive results[131], and, in displacement scenarios, are confounded by changing denominators. Survey estimates relying on card evidence or caregiver recall are more accurate, and vaccination questionnaires can be nested within anthropometric and/or mortality surveys. More economical survey designs have been explored in order to provide the geographic granularity required to efficiently target remedial vaccination interventions such as catch-up campaigns. LQAS has been combined with cluster sampling to provide binary decisions at the very local level[132], but this method can be highly inaccurate. Traditional cluster surveys with small sample sizes may provide an acceptable alternative.[133]

Methods: Service effectiveness

Effectiveness or quality indicators need to be measured whenever interventions depend greatly on the performance of individual providers or facilities: this includes any clinical patient care, and the management and outcome of obstetric and neonatal emergencies. Functional HMIS (see Annex 4, Webappendix) can provide useful quality data, such as in-service case-fatality ratios, and agencies increasingly use software applications to monitor cure rates of therapeutic feeding programmes[134] or cholera treatment centres.However, other important indicators of quality, including prescribing accuracy, safety of assisted births or patient satisfaction, can only be collected through facility audits.

In humanitarian health, quality of care has received little attention[135], though the UNHCR has developed standardised WASH and primary health care auditing tools, as part of its TWINE data platform project.[136] Auditing data are not widely available and it is thus difficult to ascertain to what extent humanitarian healthcare is effective. This is an area of considerable neglect that, furthermore, reduces agencies' meaningful accountability to beneficiaries and ignores recent advances in healthcare governance across many health systems.

Methods: Population mortality

Births and deaths (vital events) registration has low coverage in many countries even outside crises.[137] In these countries, population mortality is estimated through demographic modelling methods that exploit census and large demographic household survey data. These methods measure long-term trends over large populations, but cope poorly with sudden shifts in death rates, high migration and unusual age-sex pyramids, common features of crisis-affected populations.[138,139]

Retrospective surveys are the mainstay of mortality measurement in crises. These elicit information from households on demographic events occurring over a specified "recall" period, aided by a local salient events calendar: CDR estimates are then constructed.[140] In addition to sampling problems (see Annex 2, Webappendix), questionnaires used for these surveys, though increasingly standardised[20], have never been validated[139], despite known biases in traumatic event recall. Generally, mortality surveys suffer from low quality of implementation and analysis[92], and their influence on relief operations is reduced by difficult inference (estimates are often imprecise, and inevitably reflect past conditions) and interpretation errors.[141] Retrospective surveys have documented mortality at a crisis-wide scale, e.g. in Darfur[142], northern Uganda[143], the Democratic Republic of Congo[144] and Iraq[145,146]. Some of these studies may have been pivotal to raising political and funding interest, but all have encountered methodological criticism[143,147]; their use seems less common nowadays.

Prospective mortality surveillance, consisting of ongoing registration of deaths and population denominator updates by community health workers, is theoretically superior to surveys as it provides data for immediate action, but suffers from under-reporting and inaccurate population estimates if done with limited supervision.[148,149] Mortality surveillance has typically been done in camps; however, a sentinel system in rural Central African Republic detected >90% of deaths after rigorous training.[30] Moreover, such systems can be integrated with other community-based activities including anthropometric screening, pregnancy registration and health promotion.

Media and activist monitoring and capture-recapture approaches have focussed solely on violent deaths (see above), and few other methods have been tested. In four different settings, a rapid method reliant on community key informants identified 55-73% of all deaths over a 60d recall period; the same study suggested that adding more informants and subjecting the different lists generated to capture-recapture analysis could achieve acceptable accuracy.[150] A few studies have estimated crisis-wide mortality in Darfur[151] and the Somalia 2011 famine[152] by combining fragmentary survey data with statistical models predicting mortality based on other crisis variables: this approach merits further development, and may be superior to single large surveys thanks to greater internal validity checks.

The above methods generate CDR or U5DR estimates, but neonatal and maternal mortality, being numerically rare, requires specific sisterhood questionnaires that collect data from women about themselves and their living and dead sisters.[153] Confusingly, the U5DR indicator derived from emergency surveys is not directly convertible into the under 5y mortality measure used to track long-term progress in development goals: the former expresses the number of children that die per unit time, out of the total population under 5y, while the latter expresses the proportion of children that survive to age 5y, out of all live births.

Lastly, cause of death information is theoretically of great operational use in humanitarian responses, but information by family members is unreliable, and current WHO verbal autopsy questionnaires, though validated[154] and aided by automated analysis software, are lengthy and require experienced interviewers. Abridged autopsy questionnaires aiming to at least attribute deaths to disease categories could prove useful.

What information should be collected, and is this happening?

What minimal information is needed to start responding?

Not all information discussed above is required before launching humanitarian interventions. Humanitarian decision-making needs to emphasise speed of response, with a no-regrets attitude. For most plausible scenarios initial priority interventions can be predicated based on the evidence base collected in previous emergencies and codified in various guidelines, and desk-based public health situation analysis relying on pre-crisis secondary data, circumstantial information and epidemiologically plausible projections. Risk assessment and situation analysis procedures for infectious and vaccine-preventable diseases have been put forward by the World Health Organization[155], and for SGBV by the Reproductive Health Response in Conflict (RHRC)

Consortium.[156] Similarly, even if data on the burden of mental disorders and SGBV are missing, known exposures such as armed attacks are sufficient to justify a basic package of mental health and SGBV services, particularly given the consistently high burden of both mental disorders and SGBV even in non-crisis settings. Much of this information can and should be compiled and widely shared as part of emergency preparedness.

As the crisis evolves, field data become increasingly important to refine interventions, detect new threats and identify failures in service provision. In Table 2, we propose minimal public health information services during the first 6mo of a new crisis: our list is broadly consistent with WHO's Emergency Response Framework[157] and standards for the Global Health Cluster under publication (F Checchi, personal communication).

Is minimal information actually available in recent crises?

We reviewed whether the above information services were implemented during the first 6mo of major, newly emergent crises that started between January 2010 and December 2015, through a desk-based search (see Annex 6, Webappendix). Where possible we also ascertained timeliness and data coverage (i.e. proportion of the population for which data were available). We omitted from the review population estimation and tracing of people in need of treatment continuation, as no reliable information could be found on methods used; and the public health indicators dashboard, as to our knowledge this has not been implemented previously. Tables A3a, A3b and A4 (Annex 6, Webappendix) present findings for armed conflict and natural disaster related crises, respectively.

This limited analysis suggests that recent practice falls considerably short of even minimum requirements. We found evidence of timely 4W information in only 2/13 armed conflicts and 3/7 natural disasters. These proportions were 4/13 and 37 for the MIRA; 0/13 and 0/7 for HeRAMS; 2/13 and 1/7 for CDR and U5DR; 5/13 and 0/7 for GAM prevalence; 2/13 and 0/7 for measles vaccination coverage; 5/13 and 5/7 for EWARS; 1/13 and 2/7 for psychosocial assessment. Removing the timeliness criterion, we found evidence of minimum information availability in about twice as many crises. In no crisis was the full set of minimum information available. Where data were collected, their coverage seemed mostly low. Notably, however, mortality and malnutrition indicators were collected despite insecurity during the 2011 crisis in south-central Somalia, thanks to the FSNAU.

In conducting our review, we found that information, even when it exists, is poorly accessible and scattered across various platforms. Tracking the evolution of public health data collection in crises seems arduous at present, unless far better knowledge management, including an open approach to publication, is implemented.

A proposed agenda for methods development and improved practice

Developing better methods

Numerous areas for improvement of current methods and development of new ones exist. In Table 3 we suggest key priorities. Moving forward on methods development will require field agencies and academics to agree on a common research agenda and plan multi-site validation studies so as ensure findings have wide applicability. [158] The current evidence gaps also result from funding neglect. Dedicated funds, such as the current Wellcome Trust and UK Department for International Development funded Research for Health in Humanitarian Crises (R2HC) scheme, are needed.

Making data collection, analysis and use more consistent

In Table 4 we recommend steps for ensuring that public health information in crises becomes more consistent. These proposals would probably require the establishment of an ambitious, dedicated, well-funded epidemiology and demography service[91], governed by the relevant coordination mechanisms (the health, nutrition and WASH clusters, under the stewardship of their respective lead agencies, WHO and UNICEF; and UNHCR for refugee settings), but probably housed within academic centres of excellence, and able to operate and communicate independently and transparently. Moreover, such a service should have a permanent presence in key countries and be linked to coordination mechanisms. It could also work to improve ethical provisions and practice for collection and management of data on the field, an ongoing issue of concern, by instituting ethics review board pre-approval of specific protocols[159] and specifying practical, feasible procedures for enhanced confidentiality and effective consent.

A few initiatives can provide useful starting points. A Health and Nutrition Tracking Service, broadly similar to the above concept and housed within WHO, was briefly active between 2008 and 2010. Currently, the Assessment Capacities Project (ACAPS) provides rapid secondary data reviews and assessment support for all crises.[160] In nutrition, initiatives to train field staff on conduct of SMART[20] and coverage[161] surveys are ongoing, and the NGO Action Contre la Faim supports their implementation. Survey repositories by the Centre for Research on the Epidemiology of Disasters have been established.[162] The inter-sectoral Information Management Working Group of the Inter-Agency Standing Committee (see https://www.humanitarianresponse.info/en/topics/imwg) has produced guidance on common operational datasets and top-line assessment and monitoring. All such initiatives risk being short-lived without high-level buy-in and coordination, and we suggest that a quantum leap in investment is required. Even once information becomes available, the extent to which humanitarian responders at different levels interpret it appropriately and translate it into commensurate action remains a major challenge. Solutions probably include more ambitious and systematic capacity building of humanitarian staff (see Table 4), and strengthened accountability and governance of humanitarian agencies and coordination mechanisms, which is beyond the scope of this paper.

Conclusions

Timely collection of quality public health information in crisis-affected populations is an ethical and deontological responsibility of the humanitarian response system, and a prerequisite for full accountability to beneficiaries and donors. Without information, public health actions risk being inappropriate, inefficient, ineffective, and impossible to evaluate.

Our review highlights areas requiring methodological advancement that warrant a focussed, globally coordinated programme of research. However, a substantial scale-up in the application of existing methods is even more pressing. Implementing our recommendations will require far greater funding investment, coordination and inter-agency efficiency of initiatives. We believe however that this investment represents a small fraction of total spend on health and nutrition in crises, and will pay for itself through improved efficiency and cost-effectiveness. Beyond this, a culture of data sharing and immediate publication of available information, uncoupled from political or fundraising considerations, will need to be promoted and adopted widely.

Acknowledgements

We are grateful to the Centre for Research on the Epidemiology of Disasters for sharing data on surveys done in crises we reviewed.

The opinions expressed in this article are those of the authors only and do not necessarily represent the decisions, policies, or views of Save the Children, WHO, or the London School of Hygiene and Tropical Medicine.

Sources of funding

The paper was written without a specific source of funding.

Conflicts of interest

We declare that we have no conflicts of interest.

Author contributions

CP reviewed nutrition and food security methods and wrote the corresponding sections of the paper. VTW reviewed population estimation methods and wrote the corresponding section of the paper. MvO reviewed mental health methods, wrote the corresponding section of the paper and reviewed availability of mental health data. AW and JP reviewed availability of other data. FC reviewed other methods and wrote additional sections of the paper. All authors reviewed drafts and provided substantial input.

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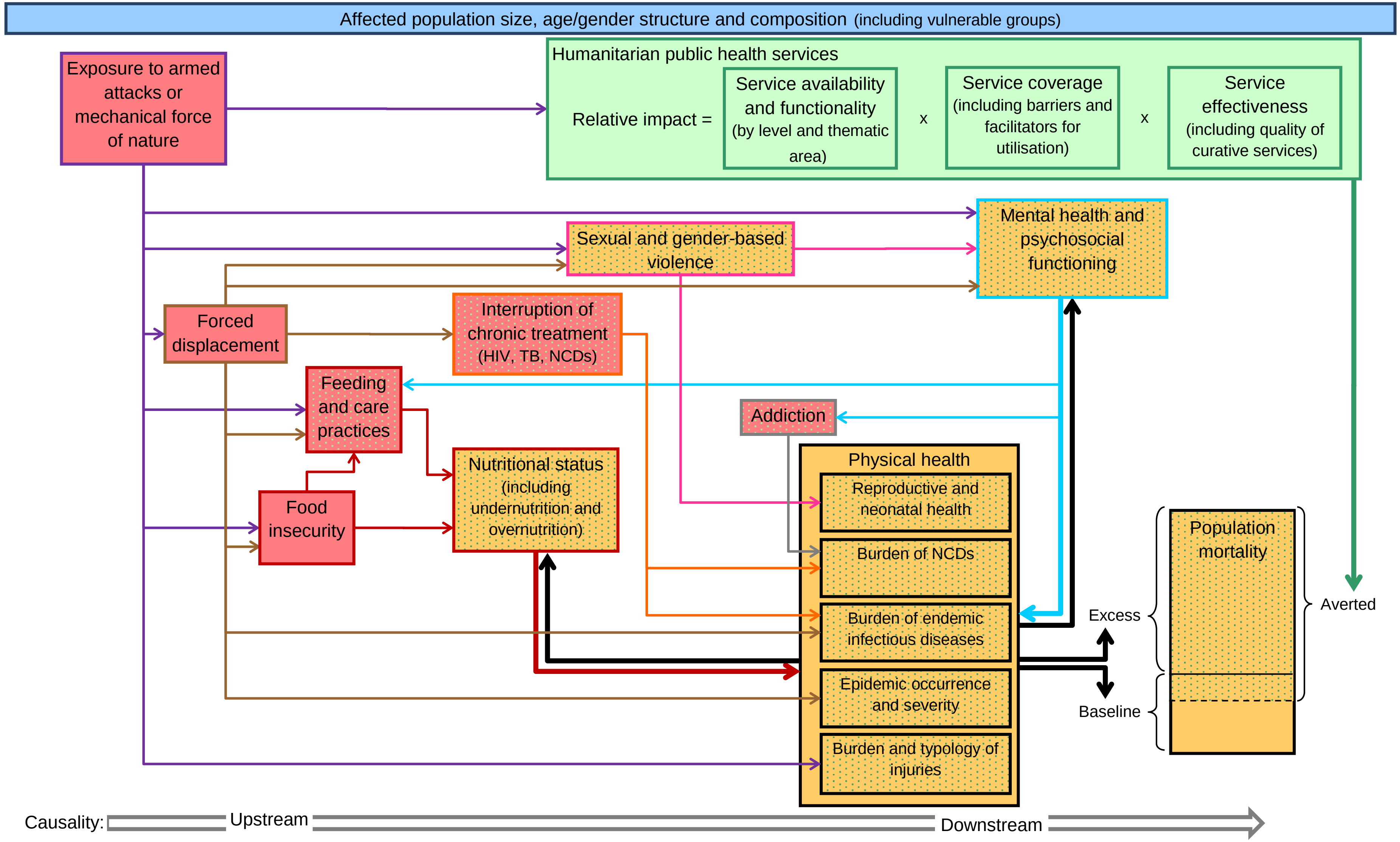

Figure 1: Conceptual framework of public health information domains in crises. Blue box = affected population size and composition. Red boxes = public health risk factors. Green boxes = public health interventions / services. Yellow boxes = public health outcomes (disease or injury) and impacts (mortality, mental disorders). Dotted boxes are those that humanitarian public health action can mitigate. Lines indicate causal effects.

Table 1: Methods available to collect different domains of public health information in crises.

Domain of information	Prospective surveillance	Population sample survey (see Annex 2, Webappendix)	Analysis of programme data	Other methods
Affected population size and composition	Community-based demographic surveillance	Residential structure tally plus structure occupancy estimation	Vaccination or nutritional screening data combined with expected age structure	Area estimation plus population density estimation Various qualitative or convenience methods
Exposure to armed attacks or mechanical force of nature	Facility-based surveillance of injuries and attacks against health	Retrospective survey of individual exposure to injury		Conflict analysis (tracking of media and other informant reports)
Sexual and gender based violence	Facility-based surveillance of SGBV cases	Retrospective survey of individual exposure to SGBV		Conflict analysis (tracking of media and other informant reports)
Food security and feeding practices		Household livelihoods, resilience and coping, food access, food consumption and feeding practices survey		Agricultural production monitoring Market analysis Household focus groups Desk-based food security risk assessment
Nutritional status	Repeated anthropometric sampling from sentinel communities	Anthropometric survey	Trend analysis from community- or facility-based anthropometric screening, and CMAM admissions	Desk-based nutritional risk assessment
Physical health	Early Warning Alert and Response Network system (EWARS) for epidemic alert and response	Survey to measure point prevalence of chronic diseases or retrospective incidence of acute disease syndromes	Analysis of facility-based morbidity and mortality data	Desk-based disease risk assessment and situation analysis Tracing and tracking of people in need of treatment continuation
Mental health	Collecting data covering serious mental health symptoms as part of general facility-based health surveillance.	Adding questions covering serious mental health symptoms to general health surveys	Analysis of HMIS morbidity data	Literature (desk) review Services mapping Participatory assessment
Service availability and functionality	HeRAMS (with updated geographical database of facilities)			Who What Where When (4W)
Service coverage		Coverage survey (vaccination,	Comparison of actual programme	Focus groups, other qualitative methods

		health services, nutritional programme, etc.)	outputs vs. target beneficiaries	for exploring service utilisation and barriers
Service quality or effectiveness			Analysis of HMIS data (e.g. on cure rates)	Facility audits and spot checks, patient exit interviews
Population mortality	Community-based demographic surveillance Passive "body count" surveillance	Retrospective mortality survey (verbal autopsies as add-on to explore causes of death)		Census (post-war) and demographic modelling Capture-recapture analysis Indirect (model-based) estimation

Table 2: Suggested minimal public health information services during the first 6mo of a new crisis. Note that the order in which services are listed does not imply a hierarchy of importance.

Public health information service	Notes	Suggested agency/cluster responsible for data collection
Public health situation analysis published within 48h of crisis onset (initial version, based on secondary data review), with fuller version (incorporating rapid field assessment findings) published within 14d.	The situation analysis should be informed by a secondary review of data on the public health status of the affected population, known disease burden and risks in the area, health-seeking and care practices, and health system functionality. This review should be available before crisis onset as part of preparedness measures, wherever a crisis appears imminent. A database of health facilities, staff and services should also be updated for preparedness purposes.	UNHCR for populations under its mandate. Health, nutrition and WASH clusters (otherwise).
4W database and map in place within 24h and updated at least every week.		UNHCR for populations under its mandate. Relevant clusters (otherwise).
Multi-sector Initial Rapid Assessment (MIRA) published within 14d, including where possible the Humanitarian Emergency Settings Perceived Needs Scale (HESPER) assessment; see Annex 3, Webappendix.	The HESPER assessment should be increasingly rolled out and arguably could serve as the main assessment method for MIRA, combined with a rigorous public health situation analysis (see above).	UNHCR for populations under its mandate. OCHA (otherwise). Health, nutrition and WASH clusters to contribute public health situation analysis and public health section of assessment methods.
Health Resources Availability Monitoring System (HeRAMS) system initiated within 1mo and updated in real-time, with openly accessible, interactive map showing geographical and thematic gaps in service provision.	If the data collection workload is a constraint, the system can initially focus only on services available and broad thematic areas. By 3mo, it should extend to monitoring human resources availability and health infrastructure.	UNHCR for populations under its mandate. Health cluster (otherwise).
Population estimation updated at least every month for dynamic displacement scenarios, or every 3mo otherwise.	The method used should be demographic surveillance in camps, and one of the evidence-based methods otherwise (see Annex 5, Webappendix).	UNHCR for populations under its mandate. OCHA (otherwise).
Multi-indicator survey of core indicators (death rate, acute malnutrition prevalence, vaccination coverage, health services utilisation rate, infant and young child feeding practices), done at least once within first 2mo and updated at least every 3mo. This service will generally be of lesser priority in well-resourced post-disaster	Stand-alone surveys are less efficient, but may be required instead, depending on the timing with and purpose for which estimates are required. Whenever possible, demographic surveillance should be considered instead of	UNHCR for populations under its mandate. Health, nutrition clusters or a technical agency, commissioned by cluster (otherwise).

scenarios, as vaccine-preventable disease risk, malnutrition and excess mortality are unlikely to increase to a measurable extent in these scenarios.	surveys, especially in camp settings.	
Simple EWARS epidemic surveillance system activated within 2 weeks. In armed conflicts, the system should also incorporate surveillance of SGBV, war injuries and attacks against health workers and services. A weekly bulletin should be issued, tracking alerts, confirmed outbreaks and actions taken.	To reduce delays and complexity, the initial system may be alert-based only, without numerical data collection. Data collection and trends analysis could be introduced after 2mo.	UNHCR for populations under its mandate. WHO, reporting to health cluster (otherwise).
Participatory assessment of local perspectives on mental health and psychosocial problems, resources and coping done within first 2mo.		UNHCR for populations under its mandate. Health, protection, education clusters (otherwise).
Active identification and construction of a database of people in need of treatment continuation (HIV, TB and top three NCDs), within 1mo and updated on a monthly basis if relevant.	NCDs should be prioritised based on a combination of local burden (prevalence) and the individual risk of missing treatment (e.g. insulin-dependent diabetes is relatively uncommon, but carries a high case-fatality if not managed continuously).	UNHCR for populations under its mandate. Health cluster (otherwise).
Public health key performance indicator dashboard activated within 1mo and updated on a quarterly basis.	Publicly available, crisis-wide and geo-referenced presentation of available estimates for a discrete set of contextually relevant key performance (availability, coverage, effectiveness) indicators (e.g. proportion of births assisted by a skilled birth attendant; L water per person-day; outpatient utilisation rate; measles vaccination coverage), compared to consensus service standards (e.g. Sphere), and clearly highlighting missing information. Source data should be taken from surveys, or on combination of programme output data with reliable population estimates.	UNHCR for populations under its mandate . Health, nutrition and WASH clusters (otherwise).

Table 3: Suggested priorities for further development of public health information data collection methods for crises.

Priority	Research aims and questions
Validation of retrospective mortality survey questionnaires	Establish how well available questionnaires capture household-level deaths, and classify them correctly in terms of time.
Abridged verbal autopsy method for proportional mortality estimation	Adapt current WHO verbal autopsy household questionnaires to rapidly but accurately classify cause of death into broad categories (e.g. injury, neonatal, maternal, chronic disease, etc.), as part of surveys or surveillance.
Assessment of robustness of survey sampling designs	Using desk-based simulation methods, test the statistical robustness (e.g. stability of estimates) of various cluster designs applied to different indicators (e.g. anthropometry, vaccination, infants and young child feeding practices, water and sanitation) and in different human settlement scenarios, with a view to establishing the most efficient sample sizes that are likely to yield robust estimates. Using a similar approach, test the validity of proposed spatial sampling designs, which are not necessarily self-weighting.
Development of sampling methods for urban settings	Using desk-based simulation and ground validation studies, test the validity and feasibility of rapid methods to survey urban populations, including urban IDPs and other less visible vulnerable groups.
Establishment of inter-rater reliability of assessment tools	The validity of any assessment is undermined if the assessment results vary by who the assessor is. With the exception of the HESPER, no emergency health assessment tools have established inter-rater reliability coefficients. Thus it cannot be excluded that current assessment results are biased by the interests, competencies and mandates of the assessors. Methods to establish inter-rater reliability will depend on exact measurement tool.
Development and validation of prospective nutritional surveillance approaches	Using desk-based simulation and ground studies, validate and optimise sample size and sampling design for existing options to carry out ongoing nutritional surveillance, including sentinel site data collection, extrapolation of facility-based growth monitoring data and repeat small-area surveys. Explore the use of statistically efficient indices, including the mean MUAC or WHZ.
Development of methods for estimating the coverage of treatment of moderate acute malnutrition	Current methods to measure coverage of nutritional therapeutic interventions are applicable only to severe malnutrition, as they rely on community informants being able to visually identify SAM cases. Explore alternative methods to rapidly estimate a denominator in need of MAM cases, and compare this with the number being treated (e.g. by measuring the ratio of SAM to MAM and combining this ratio with the current SQUEAC method for SAM coverage estimation).
Development of methods for rapid, small-area estimation of vaccination coverage	Using desk-based simulation and ground studies, validate designs for vaccination coverage measurement that require small sample sizes and yield local-level estimates, without the drawbacks of Lot Quality Assurance Sampling.
Optimisation of EWARS systems in emergencies	Further development of rapid, data-light approaches for establishment of sensitive EWARS systems in emergencies.
Development of an agreed set of minimal standards for safeguarding ethics of emergency public health data collection	For any type of public health data collection exercise done in crisis settings (especially emergency surveys, for which ad hoc ethics review is unfeasible), agree on practical standards that need to be in place to guarantee an acceptably low risk to people involved in data collection (both collectors and subjects). These standards should encompass ethics considerations for deciding whether to carry out a specific data collection exercise.

Table 4: Suggested priorities for improved collection and analysis of health information in crises.

Priority	Description
Creation and deployment of a field epidemiology, demography and public health information management service for crises	A standing service primarily devoted to rapid deployment of epidemiologists, demographers and health information managers, housed within a reputable, independent institution or academic network, should be created. The service should undertake global normative, capacity building and information synthesis work, including priorities set out below. The service should also ensure timely desk reviews of secondary data (see below). The service should draw upon sufficiently ambitious levels of pooled donor funding, with minimal restrictions on its work, with a funding model similar to that of the International Committee of the Red Cross.
Systematic consolidation, analysis and publication of secondary data as part of emergency preparedness, at least in very crisis-prone countries	Data on population, existing WASH and health services (including facility mapping), vaccination coverage, mental health, prevalence of malnutrition, feeding practices, etc. should be extracted from secondary sources, analysed and made available on a public platform. This exercise should be ongoing as part of emergency preparedness. OCHA's Common Operational Datasets initiative[163] attempts to fulfil the above function, but data coverage seems low and the scope is broad. In disaster-prone countries, this exercise should flow into risk assessment and impact scenarios, carried out jointly by disaster risk reduction and humanitarian response actors.
Consolidation and knowledge management of evidence-based methods	Evidence-based methods, protocols, training and analysis tools for each domain of information should be vetted, consolidated and made available online on a single toolbox platform, duly updated as per a regular review schedule.
Capacity building on field epidemiology and demography for researchers and information managers and, on commissioning and use of public health information for practitioners	A large cadre of researchers and information managers should benefit from in-depth capacity building on the above methods based on a single curriculum and competency framework, accredited as a post-graduate diploma. Capacity building recipients should be primarily from crisis-prone countries, with scholarships for promising graduates, and a structured career development pathway following training. Training of lower intensity, with an emphasis on decision-making, should also be offered to programme managers commissioning and interpreting data, as part of professionalisation and accreditation schemes.
Systematic estimation and tracking of affected population size and composition	Real-time population estimation should be made a key performance indicator for lead coordination agencies (UNHCR and OCHA), and the extent to which population is tracked in a timely and accurate way should be tied to a funding incentive. The above epidemiology and demography service, equipped with a dedicated real-time global satellite imagery analysis unit, should support field population estimation.
Development and roll-out of a single HMIS and EWARS platform common to all agencies	Implementation of a HMIS and activation of basic EWARS functions should be made a requirement for each agency, and a condition for funding release. A single HMIS software and data collection platform should be developed (for example, using open-source DHIS-2 software, increasingly adopted by Ministries of Health). The WHO EWARS application should be rolled out across all agencies.

Establishment and activation of a crisis-specific dashboard of key public health indicators showing performance of humanitarian response against agreed standards	In order to promote adherence to humanitarian standards (e.g. Sphere) and accountability for low performance, existing data on key indicators (e.g. death rate, health facility utilisation rate, vaccination coverage) at local or crisis-wide level should be shared on a public web platform. Core indicators across clusters have already been agreed.[164] Data sharing should be made a requirement for all agencies and tied to funding disbursement and participation in coordination mechanisms. The absence of data should be prominently flagged in the dashboard.
Establishment of a global data repository to quality-appraise, store and make openly available public health data from all crises, and generate a public health information availability, timeliness and quality scorecard for each crisis	All available meta-data on the common indicator menu, including full study reports if appropriate, should be shared with a global data repository, housed within the epidemiology/demography service. Data sharing should be a requirement and a condition for funding disbursement. The data repository should issue a real-time scorecard, crisis by crisis, combining data availability, timeliness and quality, so as to promote accountability and generate essential meta-data based on which to transparently track actual progress of the above and other initiatives.