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

Francesco Checchi, Abdihamid Warsame, Victoria Treacy-Wong, Jonathan Polonsky, Mark van Ommeren, Claudine Prudhon

WEBAPPENDIX

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Annex 1: Search strategy for the review

In order to identify studies of methods for public health information collection in crises, we searched PubMed using Medical Subject Heading Terms (MeSH) and keyword search strategies with various combinations of relevant search terms (war, humanitarian, disaster, emergency, method, survey, surveillance, epidemiology, demography, data collection, information). We reviewed abstracts with a time range from 2000 to 2015. We also perused abstracts from relevant journals including *Disasters*, *PLoS Currents Disasters, Conflict and Health, Population Health Metrics and Prehospital and Disaster Medicine.*

Annex 2: Issues with survey sampling designs for crisis settings

As shown in Table 1, in crisis settings population-based sample surveys are often the main method available to generate key programmatic data, or to document the war's health impacts retrospectively when these impacts cannot be exhaustively measured in real-time through facility-based data or media and witness reports alone.

At the same time, surveys in crisis settings must produce information quickly and with realistic staffing, resource and logistics requirements.[1] Compromises in terms of sample size and design must therefore be made. Because reliable, updated lists of individual people or households (required for simple or systematic random sampling) are rarely available in crisis settings, surveys typically default to a multi-stage cluster design, whereby, in the simplest two-stage case, the sampling universe is divided into large "primary" sampling units (PSUs) such as camp sectors or villages, of which the approximate relative population size is known; and a given number of clusters (typically 25-50 for most applications in emergencies) of households or individuals are distributed among the PSUs, proportionally to each PSU's size.[2] At the PSU level, households or individuals within clusters (typically 15-30 per cluster) are sampled through a variety of methods, ranging from the more laborious segmentation (whereby a portion of the PSU is fully mapped out, enabling systematic sampling) to various so-called random walk processes (whereby a starting point for each cluster is selected at random within the PSU, and households are visited around this point through a rule of proximity).[3] Spatial sampling using maps[4] or satellite imagery can also be considered to select cluster or even individual household locations, but tends to under-sample populated areas (i.e. is not self-weighting).

Numerous limitations of cluster designs used in emergencies have been described, largely concerning bias in selection of households or people within clusters.[5] More fundamentally, the robustness (stability) of point estimates and estimated errors arising from the relatively small cluster sample sizes used in emergencies is far from established. The characteristics being measured, such as mortality, vaccination status or anthropometric indices, can be very homogeneously or heterogeneously distributed within the population depending on the scenario. Limited, setting-specific simulation studies have suggested that for nutritional status >25 clusters are generally sufficient to produce robust estimates[6], while for local vaccination decision-making >10 may be adequate.[7] However, more simulation studies are needed to fully explore sampling requirements across a range of plausible spatial distributions of different population characteristics requiring measurement.

A daunting, as yet insufficiently explored problem concerns how to select robust samples in urban settings, increasingly the theatre of humanitarian operations and presenting challenges such as multi-occupancy buildings and physical obstacles to random sampling walks. Sampling nomadic populations is also an ongoing challenge.[8]

Hoping to reduce sample size requirements, survey designs based on lot quality assurance sampling (LQAS) have recently been proposed for humanitarian applications including malnutrition prevalence[9] and vaccination coverage[10] estimation. These designs however have been criticised for failing to validate critical assumptions or incorrectly specifying statistical hypothesis tests.[11]

Annex 3: The role of rapid assessments

In the first days after an acute emergency occurs, carrying out rapid field assessments can provide mostly qualitative information to ground-truth the gravity of living conditions and identify specific high-priority needs that might not have been evident through desk-based secondary data review. In camp settings where the population is easily accessible, some quantitative data can and should be collected, including a rapid population estimate and access to services such as water and sanitation, provided that assessors have basic field data collection and management skills.

A multitude of rapid assessment questionnaires and protocols have been used in past emergencies[12,13], converging in recent years towards UN-led crisis-wide multi-sector assessments, the current iteration of which is the Multi-Sector Initial Rapid Assessment (MIRA).[14] These assessments rely on mainly non-representative sampling and reports of key informants, but nevertheless collect and produce mainly quantitative rather than qualitative information. There is limited evidence that these assessments improve or indeed guide humanitarian interventions[15], and that the benefit of generating any quantitative data outweighs the harm of data being obfuscatingly inaccurate. Moreover, many assessments after recent sudden onset disasters have been completed 30-50d after disaster onset.[12]

One recently developed and simple survey-based assessment tool, HESPER, generates information on priority perceived needs (thereby giving more voice to beneficiaries) and, unlike other rapid assessment questionnaires we are aware of, its reliability has been measured in different populations.[16,17] As such, it should be used more prominently in crises, both to establish initial needs, and to monitor changes in perceived needs over time.

Annex 4: Health management information systems for emergencies

Routine health management information systems (HMIS), namely paper-based or electronic collection and analysis of facility- and programme-level data in order to plan health services and monitor their quality, can fulfil most data needs on disease (other than epidemic alert), services functionality and effectiveness as per our suggested framework. Government HMIS typically deteriorate during crises.

The UNHCR has developed its own, open-access Health Information System for refugee (or potentially non-displaced) populations under its mandate, which, despite challenges with data completeness, has the potential of producing globally comparable data on essential public health service indicators, with explicit reference to relevant Sphere standards.[18]

Leading agencies such as Médecins Sans Frontières or the International Committee of the Red Cross often operate their own health services outside government structures, and thus develop independent HMIS. Others such as Save the Children or the International Rescue Committee tend to support existing health structures, but also default towards adopting parallel information systems in order to ensure data are available for their internal reporting and monitor specific humanitarian health services (e.g. management of acute malnutrition) not covered by government HMIS.

Within any given crisis, a cacophony of HMIS thus co-exists, often not inter-operable in software terms and generating different indicators and/or age and gender stratifications.[19] Critically, these systems may have little compatibility with the government HMIS, whose functionality is often neglected despite agencies' nominal commitment to strengthen all pillars of the health system.

Annex 5: Methods to estimate affected population size - brief description and comparison of the main available methods

Description of methods

__Residential structure tally combined with estimate of mean structure occupancy__

There are various ways of counting the number of residential structures or shelters: flyover with aerial observation and photography; very high-resolution satellite imagery and walk-about or drive-through processes. Aerial views and satellite images can provide perspectives on settlement patterns, and help establish the scope of the disaster affected area.[20-22] Walk-about / drive-through processes enable the cross-checking of a map from various sources and perspectives, and triangulating information in order to avoid bias and misinterpretation.[20]

The mean structure or shelter occupancy is then measured through a sample survey (simple random, systematic or cluster).[23] The total population is obtained by multiplying the total number of shelters by the mean occupancy figure. The confidence interval reflects sampling error in the mean occupancy estimate.

Alternatively, mean occupancy could be assumed based on estimates previously obtained from similar populations and settlement patterns: error in the estimate can be partly quantified by resampling from a distribution of plausible occupancy values.[22]

Total population is given by multiplying the number of structures or shelters by the mean occupancy.

__Total surface area estimate combined with estimate of population density__

Transect sample (an area sampling method)

The affected area is mapped through Geographical Positioning System (GPS) devices and the surface area calculated.

Next, a straight line of known length is randomly traced through the affected area. A width is established (typically 10 metres). The researcher walks along the transect line and counts the number of shelters within the 10m width of the line, while also carrying out a census of people living in these same shelters within the transect. Dividing the total number of people counted within the transect by the area of the transect (length x width) yields an estimate of population density that is assumed to capture the heterogeneity of settlement patterns across the community.

A rough population estimate can then be extrapolated by multiplying population density by total surface area.

Quadrat method (an area sampling method)

The affected area is mapped and the surface area calculated.

A grid is then overlaid onto the map, and a random or systematic sample of blocks (quadrats) is selected from within the grid (Figure A1). The number of people living within each of the selected blocks is counted so as to obtain a measure of mean density. A typical problem encountered by this method is the so-called "edge effect" of shelters straddling the boundary of a sampled block, usually resolved through a systematic rule.[24,25]

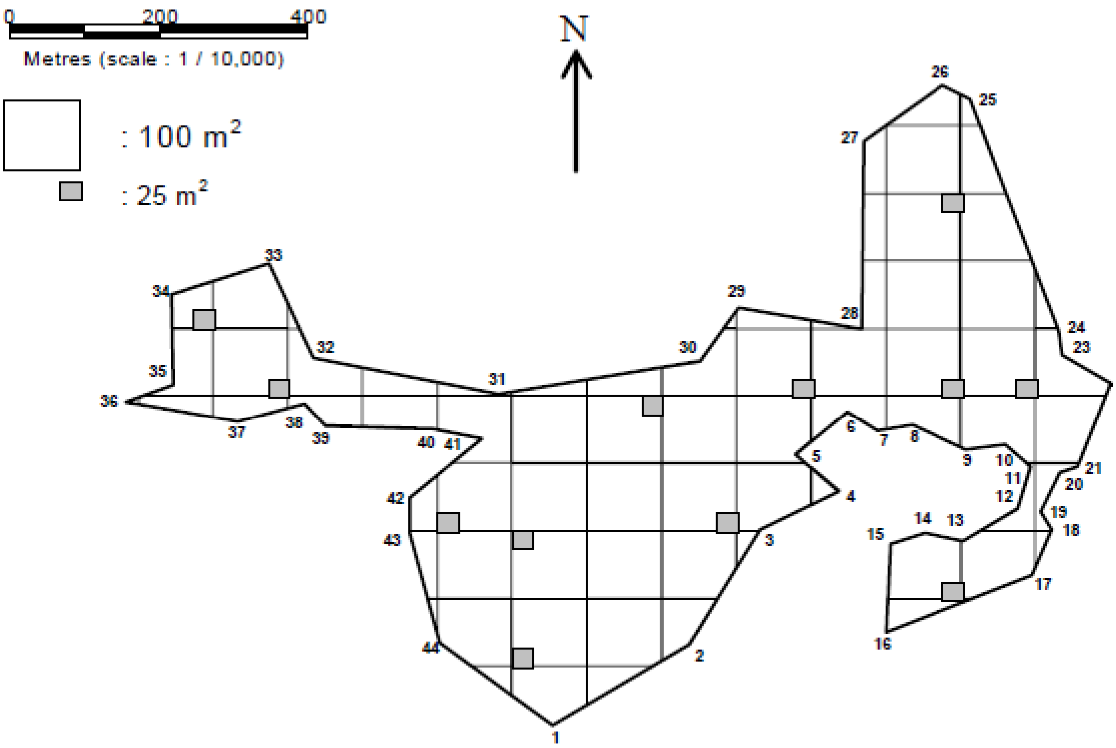

Figure A1. An example of a gridded map with a sample of blocks to be sampled. Reproduced from Brown et al.[26]

Because populations are rarely distributed homogeneously throughout a settlement, an improvement over the above method in order to improve precision is to stratify the sample of blocks by settlement pattern.[26]

Finally, the estimate of density is multiplied by the total surface area to derive total population.

T-square method (a distance sampling method)

The modified T-square method estimates population based on distance between shelters and their mean occupancy.

Firstly, the affected area is mapped and the surface area calculated.

A number m of sampling points, typically 60, is then selected within the area using computer software (either randomly or systematically).[24-26] The T-square method requires two distances to be measured at each sampling point.[27] From each starting point the distance (d1) to the nearest shelter is measured; standing at this shelter, the distance (d2) to the next nearest shelter falling within a half-plane situated on the other side of the half-plane 'T' is measured" (Figure A2).[25] The occupants in both shelters are counted.

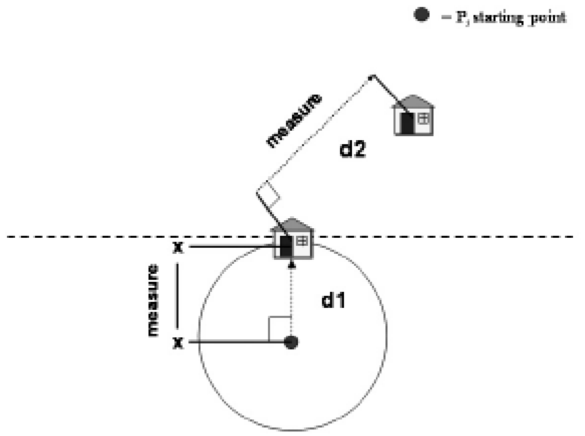

Figure A2. Measurement of distances between shelters for the T-square method. Reproduced from Grais et al.[25]

The main statistical assumption for the T-square method is that the spatial arrangement of structures is completely random. In statistical terms this is described as a spatially homogeneous Poisson process.[27] The ratio of distances, d1 to d2, depends on this spatial distribution pattern. The statistical robustness of the T-square method is verified through two tests. The first is to see if the spatial arrangement pattern is indeed random or non-random (as in clumped or uniform). If the distribution is non-random then a key statistical assumption of the method is violated and the method is prone to bias. If the sample is random, then a second test is applied to decide whether accurate confidence intervals around the estimate can be computed.

Based on the above two tests, one of two alternative formulas is applied to d1, d2 and m in order to compute the mean area “belonging” to each structure.

Lastly, the total surface area is divided by the mean area per structure to obtain the total number of structure, which is the multiplied by the mean number of people per structure (based on the 2m structures visited) to estimate population size.

Spatial interpolation method

The spatial interpolation method attempts to estimate the unknown value of a point using the known values of surrounding points.[28] It is based on the assumptions that things closer together are more similar than things further apart, and that an estimate of how similar things are can be used to extrapolate to the unknown points.

First, the affected area is mapped and the surface area calculated.

A number of sampling points is then selected (e.g. 50) from across the total surface area (randomly or systematically). A standard circumference around each point is established (e.g. 25m radius). The distance between each point and all the shelters within the circle around it is measured, and the number of occupants in each shelter is recorded.

The set of population densities from each sampled circle are then displayed in a semi-variogram (which demonstrates how similar they are). The actual population density estimate is computed through a spatial smoothing (Kriging) technique applied to the non-sampled area on the basis of the observations within the sampled circles.

Finally, density multiplied by the total area gives the population estimate.

Qualitative or convenience methods

Community estimates

Key members of the community (elders, traditional leaders) give their population estimate via focus groups or in-depth interviews.

Delphi method

As an improvement over the above, a group of experts (e.g. an expert in the area of complex emergencies, a researcher with knowledge of population estimation, persons with local knowledge and understanding of the population) go through several rounds of anonymous information exchanges to make an educated guess on the population size, and reach a consensus opinion.

Triangulation of existing data sources

There may be a wealth of already published/available information about population figures prior to the emergency e.g. local administrative records. These can be merged and cross-checked to provide an overall picture.

Flow monitoring

This method is based on monitoring and quantification of populations moving into or away from certain locations. Observers need to be located at key entry/exit points. The population can be estimated from the population flow per defined time-period. This method assumes that the population is moving en masse to a given location and requires advance knowledge of the displacement.

Using programme activity data

Population counts from water/food distribution points can theoretically be used, but these assume that the entire population has access to the service and that sufficient amounts are being provided.

More reliably, vaccination data from a mass campaign followed by a coverage survey can be used. This method relies on the assumed population age distribution. For example, the total number of children under 5y old vaccinated against measles during a campaign can be divided by estimated campaign coverage to derive the total number of children under 5y old: this can then be divided by the proportion of the population in this age group to estimate the total population.[29,30]

Other methods

Capture-recapture method

This method is adapted from ecology. Two teams walk independent routes of varying distance (determined according to the size of the geographical area) around the settlement, adopting a random and constantly shifting direction. All the shelters the teams encounter along their routes are counted, their occupants tallied, and assigned a unique identifier so as to identify them in both teams' databases. Based on the degree of overlap in the two databases, and using capture-recapture statistical principles, the total number of people can be estimated.[24,31,32] Use of three random routes provides greater accuracy, though higher statistical complexity.

Tracking population movement with mobile phone network data

All mobile phones have a subscriber identity module. When a phone call is made, a phone tower connects the call to the mobile phone network. Mobile phone networks routinely register data that can track the geographical location of active mobile phones. Mobility patterns of each mobile phone within the area of the phone tower coverage can then be analysed.[33,34]

Comparison of evidence-based methods

Based on studies reviewed, we could identify only six methods out of the above for which formal validity and feasibility tests have been conducted. We present in Table A1 below key findings and considerations arising from these published evaluations.

Table A1: Comparison of six rapid population estimation methods, which have been assessed for validity and feasibility.

Method	Number of tests	Context of field test	Validity	Feasibility			Future potential
				User-friendliness	Context	Requirements	
Structure count via satellite imagery, with occupancy estimate	11 [22,23]	Displaced populations	Achieved reasonable precision if individual structures are distinguishable and there is no major barrier to visual analysis (clouds or vegetation).	Entire analysis can be done remotely based on imagery alone, though intelligence from site would improve accuracy	Serious limitations in urban settings (connected or multilevel buildings), and camp settings where shelters share same roof or tarpaulin.	Access to real-time very high resolution satellite imagery. Support of imagery analysis unit to process images and tally structures.	Satellite imagery increasingly available. Could be automated.
Quadrat	4 [24-26,28]	Emergency setting	Provided accurate estimates.	Easy to implement in the field. E-POP software available for sampling and analysis (need not be done at field level).	Useful in enclosed camp settings.[25]	Access to population. Accurate mapping. Accuracy with counts, prone to duplication and omission errors. Local language skills.	Among first options to be considered.
T-square	3 [24,25,28]	Stable urban population	Provided accurate estimates, unless the population was very heterogeneous (clustered) which resulted in substantial underestimation.	Complicated to conduct and difficult to understand, requires training. E-POP software available for sampling and analysis (need not be done at field level).	More efficient than area sampling methods when shelters are sparse and widely scattered. Applies to any context in theory, but underlying statistical assumptions can only be verified after data collection.	Access to population. Accurate mapping. Ability to measure accurately, highly sensitive to measurement error. Local language skills.	Examples of how to optimise the method further have been identified.[27]
Spatial interpolation	1 [28]	Stable	Provided inaccurate estimate.	Method practically easier to conduct than T-Square, and comparable to quadrat.	May apply to any context, but effect of heterogeneity in settlement patterns not fully explored.	Access to population. Accurate mapping. Proficiency in geographic	Although less precise, its potential practical ease warrants further

Method	Number of tests	Context of field test	Validity	Feasibility			Future potential
				User-friendliness	Context	Requirements	
						analysis software. Ability to measure accurately, prone to measurement error. Local language skills.	investigation.
Capture-recapture	1 [24]	Stable	Excellent precision and accuracy in simulations. However, the method cannot easily be adapted to emergency settings and large sites specifically due to the huge sample size needed (typically > 10% of total population).[24]				May have future applications in urban areas, or with hidden population groups.
Tracking population movement with mobile phone network data	1 [33]	Natural disaster / outbreak	Less suitable in areas where mobile phone use and mobile radio coverage are low. Less precise in areas with low tower density, Dependent on frequency of calls. Dependent on prevalence of individuals using more than one SIM card. Although mobile phone networks are relatively resilient to external shocks, major disasters can affect power supply, destroy towers, and cause a complete loss of functionality. Limited possibilities for people to charge their mobile phones can cause bias.[33,34] Some population groups have lower than average phone use (e.g. elderly and children). If these groups have different movement patterns results would be biased.			Done remotely. Support of analysis unit specialised in geography and mobile phone data. Access to mobile phone network data.	Unclear, but holds sufficient promise to warrant further investigation.

Annex 6: Review of public health information availability in recent crises

Geographical scope and period

We wished to describe the extent to which our proposed set of minimum public health information services have been implemented during the initial acute emergency phase of recent crises, both armed conflict and natural disaster related.

Due to resource and time constraints, we included in the review any new sudden- or slow-onset crises that reached a certain critical size threshold (see criteria below) during the years 2010 to 2015 inclusive, anywhere in the world, excluding natural disasters in countries with highly developed national response capability (specifically, Japan and China). We reviewed public health data collected during the 6 month period following the date when a given crisis attained the critical size (the actual period covered by this review thus spans until mid-2016)

Criteria for inclusion of crisis events

We adapted our definition of a crisis event from that provided by the SAGE Working Group on Vaccination in Humanitarian Emergencies[35]. We considered any of the following conditions, occurring alone or in combination, as defining a crisis:

1. Sudden unplanned displacement of a large proportion of the population away from the place(s) of habitual residence and into any settlement;
2. Direct exposure of a civilian, non-combatant population to new or exacerbated and sustained episodes of armed conflict resulting in reduced access to health care, disrupted water supply and sanitation, food insecurity, and/or any other breakdown of critical state functions;
3. A sudden deterioration of nutritional status is impending or has already occurred;
4. Natural or industrial (including nuclear) disaster resulting in temporary homelessness, disruption to critical public services, increased risk of injury and/or exposure to the elements for a substantial proportion of the population;
5. Sudden breakdown of critical administrative and management functions, within the public and/or private sector, due to any reason, resulting in large scale disruption of public health and/or other critical public functions.

Among any crisis events fulfilling one or more of the above conditions, we only included in the analysis those that were estimated to directly affect 500,000 persons or more and directly have caused 1000 or more deaths at any point during the period 2010-2015; these arbitrary thresholds were set to ensure our review would be feasible given resources available. While ongoing armed conflict crises in countries such as Afghanistan and Colombia also met the above size criteria, we included in the analysis only “new” crises, or regional emergencies superimposed onto ongoing crises (e.g. famine in southern Somalia, exacerbated conflict in the eastern Democratic Republic of Congo; displacement in northern and western Iraq) that would have required establishment of a dedicated humanitarian response and coordination mechanism. This was done to hone down on the availability of information during the initial crisis response period, when arguably this information is most needed.

The start date for our 6mo analysis period was determined by when a given eligible crisis actually reached both of the above size thresholds (population affected and direct death toll). In the instance that the thresholds were reached between publication of any two situational reports, the mid-point date between the two reports' publication dates was taken as the analysis starting date.

Criteria for eligibility of public health information

Table A2 below outlines criteria we used to determine whether a given public health information service was indeed implemented and available with the recommended timeliness, as per Table 2 in the main paper.

In general, while conducting the review we found that information was fragmented and often secondary in nature, e.g. we found references to documents or estimates but were unable to locate or access the primary data collection reports, assuming these existed. Because of this, we relaxed the criteria for eligibility of information (Table A2, column 2) beyond the theoretical requirement (Table A2, column 1): for example, we sometimes could not determine clearly when the EWARS system became operational, but decided nevertheless to report whether an EWARS system was indeed activated within the first 6mo, if this information was available.

Table A2. Criteria determining eligibility of information for inclusion in this analysis.

Minimum information requirement	Criteria for analysis eligibility	Analysis notes
Multi-sector Initial Rapid Assessment (MIRA) published within 14d.	MIRA report available.	We also tried to roughly compute the proportion of the population covered by the assessment, as a measure of data coverage. To do this, whenever possible we considered the affected population estimate closest to the date of MIRA data collection.
4W database and map in place within 24h and updated at least every week.	4W (or 3W in settings like Syria where the identity of agencies was omitted for security reasons) exercise updated any time within the 6mo analysis period.	
Health Resources Availability Monitoring System (HeRAMS) system initiated within 1mo.	HeRAMS done during first 6mo.	As above, whenever possible we tried to compute data coverage (as proportion of all public health facilities included in the survey).
Multi-indicator survey of mortality, acute malnutrition, vaccination coverage, health services utilisation, feeding practices, done at least once within first 2mo and updated at least every 3mo.	Based on a sample survey or prospective community-based surveillance: allowed for different indicators being collected through separate data collection exercises (e.g. death rate through surveillance, vaccination coverage through a survey). Data includes at least one of	Information for each core indicator presented separately. For each indicator, we attempted to roughly quantify data coverage as the cumulative proportion of the crisis-affected population that had been represented at least once within the sampling frame of an eligible survey (or within

	the following core indicators: crude death rate, under 5 years death rate, prevalence of global acute malnutrition, measles vaccination coverage. At least one estimate of any of the above indicators obtained any time within the 6mo analysis period (based on the date on which data collection ended).	the catchment area of a community-based surveillance system).
Simple EWARS epidemic surveillance system activated within 2 weeks.	EWARS system operational, as defined by production of epidemiological bulletins.	As above, we tried to compute the population covered by the system.
Participatory assessment of local perspectives on mental health and psychosocial problems, resources and coping done within first 2mo.	Report of any such assessment, if done any time within the first 6mo.	

Search strategy

Crisis events

We compiled an initial list of crises from the WHO Emergency Risk Management and Humanitarian Action[36] and EM-DAT[37] websites, and the Uppsala Conflict Database[38] for armed conflicts specifically. Further emergencies were extracted from the Reliefweb[39] and the United Nations Office for Coordination of Humanitarian Affairs (OCHA)[40] websites. The Reliefweb, OCHA and Internal Displacement Monitoring Centre (IDMC)[41] websites were accessed to review situation reports and thereby determine the date when each disaster had surpassed the critical size thresholds and hence met criteria for inclusion.

Overall, 155 sudden-onset natural disasters were identified as having occurred in the 6 year review period and having affected more than 500,000 people. Of the latter only 10 caused greater than 1000 deaths, of which one occurred in Japan (2011 earthquake and tsunami) and two in China (2010 earthquake, 2010 floods). Overall, therefore, we included in the analysis the following 6 natural disaster crises: Haiti earthquake (2010), Pakistan floods (2010), Philippines tropical cyclone Washi (2011), Philippines tropical cyclone Bopha (2012), India floods (2013), Philippines tropical cyclone Hayan (2013), Nepal earthquake (2015).

Further searches resulted in 11 mainly armed conflict-related crises meeting size criteria in the following countries: Syria (for this analysis' purpose, split into government-controlled areas, opposition-controlled or contested areas and refugee settlements in nearby countries); South Sudan; Central African Republic; Myanmar (Rakhine, Kachin and Northern Shan states), Democratic Republic of Congo (North Kivu); Mali (northern region); Somalia (South-Central zone); Nigeria (northern region); Iraq (western and northern regions); Yemen (country-wide); and Ukraine (eastern region, Crimea).

Information availability

We first sought information on whether public health information services were implemented for each of the crises reviewed by reviewing grey literature reports and situation analyses on the Reliefweb and IDMC websites, as well as by doing a variety of Google key word searches looking for .doc, .docx, .ppt, .pptx and .pdf document formats.

Information on 4/3W and HeRAMS exercises was collected by consulting any available national health cluster websites. OCHA and Inter-Agency Standing Committee[42] websites were consulted for information on MIRA reports, while the WHO website was searched for EWARS information. WHO, UNICEF and CE-DAT[43] websites were also searched for information on core indicators (mortality, acute malnutrition, vaccination coverage).

In order to attempt to fill numerous data gaps and verify as much as possible whether lack of information identified in the above search actually meant that no data were collected, we systematically contacted health cluster coordination staff or WHO Department of Emergency Risk Management and Humanitarian Response staff responsible for specific countries.

We concluded that data were not collected when neither the desk-based search nor contacts with informants identified any evidence of this. When the desk-based search identified no information but no suitable informant could be contacted, we categorised service implementation as unknown / none identified.

Results for armed conflict crises are shown in Tables A3a and A3b, and for natural disasters in Table A4.

Table A3a. Availability and timeliness of minimal public health information during the first 6mo of large armed conflict related crises, 2010-2013.

Country		**Syria**			**South Sudan**	**CAR**	**Myanmar**	**DRC**	**Mali**	**Somalia**
Main sub-locations affected		Opposition-held or contested areas	Government-controlled areas	Refugees in neighbouring countries	Countrywide	Countrywide	Rakhine, Kachin, Northern Shan states	North Kivu	Northern region	South-Central zone
Date crisis passed size threshold		Jul 2011	Jul 2011	Jan 2013	Dec 2013	Dec 2013	Jun 2013	Dec 2012	Mar 2012	Jul 2011
4W database	Implemented	no	no	?	yes	yes	yes	no	yes	yes
	Timely (first 24h)		(Nov 2012)		no (Apr 2014)	yes	no (Nov 2013)	(Jul 2013)	no (Jun 2012)	yes
	Data coverage				80-99%		80-99%		80-99%	60-79%
MIRA	Implemented	no	no	no	yes	yes	yes	?	?	no
	Timely (first 14d)	(Mar 2013)			yes	no (Jan 2014)	yes			
	Data coverage				<20%					
HeRAMS	Implemented	no	no	no	no	yes	no	?	no	no
	Timely (first month)	(Jul 2014)	(Oct 2013)			no (Apr 2014)	(Feb 2014)		(Dec 2013)	
	Data coverage					80-99%				
Crude death rate	Implemented	no	no	yes†	yes	no	no	yes	?	yes
	Timely (first 2 months)			yes	no (Jun 2014)			no (May 2013)		yes
	Data coverage			20-39%	<20%			<20%		40-59%
Under 5y death rate	Implemented	no	no	yes†	yes	no	no	yes	?	yes
	Timely (first 2 months)			yes	no (Jun 2014)			no (May 2013)		yes
	Data coverage			20-39%	<20%			<20%		40-59%
Global acute malnutrition prevalence	Implemented	no	no	yes	yes	yes	no	yes	yes	yes
	Timely (first 2 months)	(Jun 2013)		yes	yes	yes		no (May 2013)	no (Jun 2012)	yes
	Data coverage			40-59%	40-59%	<20%		<20%	<20%	40-59%
Measles vaccination coverage	Implemented	no	no	?	yes	?	?	yes	?	yes
	Timely (first 2 months)				no (Apr 2014)			no (May 2013)		yes
	Data coverage							<20%		40-59%

Country		**Syria**			**South Sudan**	**CAR**	**Myanmar**	**DRC**	**Mali**	**Somalia**
Main sub-locations affected		Opposition-held or contested areas	Government-controlled areas	Refugees in neighbouring countries	Countrywide	Countrywide	Rakhine, Kachin, Northern Shan states	North Kivu	Northern region	South-Central zone
Date crisis passed size threshold		Jul 2011	Jul 2011	Jan 2013	Dec 2013	Dec 2013	Jun 2013	Dec 2012	Mar 2012	Jul 2011
EWARS	Implemented	no	no	yes	yes	yes	yes	yes	?	yes
	Timely (first 2 weeks)	(Sep 2013)	(Sep 2013)	yes	no	yes	yes	yes		no (Jan 2012)
	Data coverage			20-39%	<20%	<20%		80-99%		
Psychosocial assessment	Implemented	?	?	yes	?	?	?	?	?	?
	Timely (first 2 months)			yes						
	Data coverage									

Dates in parentheses indicate when a public health information services that was not timely according to our criteria is actually known to have first taken place.

† No survey done to our knowledge, but camp prospective surveillance data considered acceptable in lieu.

Table A3b. Availability and timeliness of minimal public health information during the first 6mo of large armed conflict related crises, 2014-2015.

Country		**Nigeria**	**Iraq**	**Ukraine**	**Yemen**
Main sub-locations affected		Northern states	Northern and western governorates	Crimea, Donbass region	Country-wide
Date crisis passed size threshold		May 2014	Jun 2014	Jun 2014	May 2015
4W database	Implemented	yes	yes	yes	yes
	Timely (first 24h)	no (Oct 2014)	no (Aug 2014)	no (Jul 2014)	no (Sep 2015)
	Data coverage		100%		100%
MIRA	Implemented	yes	yes	yes†	no
	Timely (first 14d)	yes	yes	no (Sep 2014)	
	Data coverage	100%	60-79%	<20%	
HeRAMS	Implemented	no	no	no	no
	Timely (first month)				
	Data coverage				
Crude death rate	Implemented	no	yes	no‡	yes
	Timely (first 2 months)		no (Sep 2014)		no (Aug 2015)
	Data coverage		<20%		20-39%
Under 5y death rate	Implemented	no	yes	no	yes
	Timely (first 2 months)		no (Sep 2014)		no (Aug 2015)
	Data coverage		<20%		20-39%
Global acute malnutrition prevalence	Implemented	yes	yes	no	yes
	Timely (first 2 months)	yes	no (Sep 2014)		no (Aug 2015)
	Data coverage	100%	<20%		20-39%
Measles vaccination coverage	Implemented	yes	yes	no	yes
	Timely (first 2 months)	yes	no (Sep 2014)		no (Aug 2015)
	Data coverage	100%	<20%		20-39%

Country		**Nigeria**	**Iraq**	**Ukraine**	**Yemen**
Main sub-locations affected		Northern states	Northern and western governorates	Crimea, Donbass region	Country-wide
Date crisis passed size threshold		May 2014	Jun 2014	Jun 2014	May 2015
EWARS	Implemented	no	yes	no	yes
	Timely (first 2 weeks)		no (Nov 2014)		yes
	Data coverage		40-59%		60-79%
Psychosocial assessment	Implemented	yes	no	no	?
	Timely (first 2 months)	no (Aug 2014)			
	Data coverage	<20%			

Dates in parentheses indicate when a public health information services that was not timely according to our criteria is actually known to have first taken place.

† A shorter multi-sector Humanitarian Situation Monitoring exercise was done by OCHA in Jul 2014.

‡ Monitoring of people killed and injured was done from the start of the war, but does not include non-war injury deaths, and its coverage is unclear.

Table A4. Availability and timeliness of minimal public health information during the first 6mo of large natural disaster related crises, 2010-2015.

Country (disaster)		**Haiti (earthquake)**	**Pakistan (floods)**	**Philippines (cyclone)**	**Philippines (cyclone)**	**India (floods)**	**Philippines (cyclone)**	**Nepal (earthquake)**
Main sub-locations affected		Country-wide	Khyber Pakhtunkhwa, Punjab, Sindh, Balochistan, Gilgit-Baltistan provinces	Northern Mindanao region	Davao, Mindanao	Assam state	Visayan islands	Central Nepal, 14 districts
Date crisis passed size threshold		Dec 2010	Aug 2010	Dec 2011	Dec 2012	Jun 2013	Nov 2013	Apr 2015
4W database	Implemented	yes	yes	yes	?	?	yes	yes
	Timely (first 24h)	yes	yes	no (Jan 2012)			yes	no (May 2015)
	Data coverage	80-99%		60-79%				100%
MIRA	Implemented	yes	yes	yes	?	?	yes	no
	Timely (first 14d)	no (Feb 2011)	yes	yes			yes	
	Data coverage	80-99%	60-79%					
HeRAMS	Implemented	no	yes	no	no	?	yes	no†
	Timely (first month)		no (Nov 2010)				no (Oct 2014)	
	Data coverage		80-99%				80-99%	
Crude death rate	Implemented	yes	?	yes	?	?	?	?
	Timely (first 2 months)	yes		no (May 2012)				
	Data coverage	<20%		60-79%				
Under 5y death rate	Implemented	yes	?	yes	?	?	?	?
	Timely (first 2 months)	yes		no (May 2012)				
	Data coverage	<20%		60-79%				
Global acute malnutrition prevalence	Implemented	yes	?	yes	?	?	yes	?
	Timely (first 2 months)	no (Apr 2011)		no (May 2012)			no (Mar 2014)	
	Data coverage	40-59%		60-79%				
Measles vaccination coverage	Implemented	yes	?	yes	?	?	yes	?
	Timely (first 2 months)	no (Apr 2011)		no (May 2012)			no (Mar 2014)	
	Data coverage	40-59%		60-79%				
EWARS	Implemented	yes	yes	yes	?	?	yes	yes
	Timely (first 2 weeks)	yes	yes	yes			yes	yes
	Data coverage	40-59%	40-59%				80-99%	

Country (disaster)		Haiti (earthquake)	Pakistan (floods)	Philippines (cyclone)	Philippines (cyclone)	India (floods)	Philippines (cyclone)	Nepal (earthquake)
Main sub-locations affected		Country-wide	Khyber Pakhtunkhwa, Punjab, Sindh, Balochistan, Gilgit-Baltistan provinces	Northern Mindanao region	Davao, Mindanao	Assam state	Visayan islands	Central Nepal, 14 districts
Date crisis passed size threshold		Dec 2010	Aug 2010	Dec 2011	Dec 2012	Jun 2013	Nov 2013	Apr 2015
Psychosocial assessment	Implemented	yes	?	?	?	?	yes	yes
	Timely (first 2 months)	no (Sep 2010)					yes	yes
	Data coverage							40-59%‡

Dates in parentheses indicate when a data exercise that was not timely according to our criteria is actually known to have first taken place.

† However, information on damage to health facilities was available within 1 week of the earthquake.

‡ A more geographically representative assessment (80-99% population coverage) was published 5 months into the crisis.

References

1. Bostoen K, Bilukha OO, Fenn B, et al. Methods for health surveys in difficult settings: charting progress, moving forward. *Emerg Themes Epidemiol* 2007; **4**(13).
2. Bilukha OO. Old and new cluster designs in emergency field surveys: in search of a one-fits-all solution. *Emerg Themes Epidemiol* 2008; **5**: 7.
3. Working Group for Mortality Estimation in Emergencies. Wanted: studies on mortality estimation methods for humanitarian emergencies, suggestions for future research. *Emerging Themes in Epidemiology* 2007; **4**: 9.
4. Myatt M, Norris A, Guerrero S, Guevarra E. Summary of Coverage Assessment Methods. http://www.validinternational.org/coverage/summaryCoverage.pdf, accessed 21 August 2015.
5. Brogan D, Flagg EW, Deming M, Waldman R. Increasing the accuracy of the Expanded Programme on Immunization's cluster survey design. *Ann Epidemiol* 1994; **4**(4): 302-11.
6. Binkin N, Sullivan K, Staehling N, Nieburg P. Rapid Nutrition Surveys: How Many Clusters are Enough? *Disasters* 1992; **16**(2): 97-103.
7. Minetti A, Riera-Montes M, Nackers F, et al. Performance of small cluster surveys and the clustered LQAS design to estimate local-level vaccination coverage in Mali. *Emerg Themes Epidemiol* 2012; **9**(1): 6.
8. Hemelein K, Eckman S, Murray S. Sampling Nomads: A New Technique for Remote, Hard-to-Reach, and Mobile Populations. *Journal of Official Statistics* 2014; **30**(2): 191-213.
9. Deitchler M, Deconinck H, Bergeron G. Precision, time, and cost: a comparison of three sampling designs in an emergency setting. *Emerg Themes Epidemiol* 2008; **5**: 6.
10. Pezzoli L, Andrews N, Ronveaux O. Clustered lot quality assurance sampling to assess immunisation coverage: increasing rapidity and maintaining precision. *Trop Med Int Health* 2010; **15**(5): 540-6.
11. Bilukha OO, Blanton C. Interpreting results of cluster surveys in emergency settings: is the LQAS test the best option? *Emerg Themes Epidemiol* 2008; **5**: 25.
12. Garfield R, Blake C, Chataigner P, Walton-Ellery S. HPN Network Paper 69: Common Needs Assessments and humanitarian action. London: Overseas Development Institute. , 2007. http://www.odihpn.org/documents/networkpaper069.pdf, accessed 11 August 2015.
13. Weiss WM, Vu A, Tappis H, Meyer S, Haskew C, Spiegel P. Utilization of outpatient services in refugee settlement health facilities: a comparison by age, gender, and refugee versus host national status. *Confl Health* 2011; **5**: 19.
14. Inter-Agency Standing Committee. Multi-Sector Initial Rapid Assessment Guidance. Geneva: IASC, 2015. http://cpwg.net/wp-content/uploads/sites/2/2015/03/MIRA_revision_Jan2015.pdf, accessed 23 August 2015.
15. Gerdin M, Chataigner P, Tax L, Kubai A, von Schreeb J. Does need matter? Needs assessments and decision-making among major humanitarian health agencies. *Disasters* 2014; **38**(3): 451-64.
16. Semrau M, van Ommeren M, Blagescu M, et al. The development and psychometric properties of the Humanitarian Emergency Settings Perceived Needs (HESPER) Scale. *Am J Public Health* 2012; **102**(10): e55-63.
17. World Health Organization, Kings College London. The Humanitarian Emergency Settings Perceived Needs Scale (HESPER): Manual with Scale. Geneva: WHO, 2011. http://whqlibdoc.who.int/publications/2011/9789241548236_eng.pdf, accessed 11 July 2015.
18. Haskew C, Spiegel P, Tomczyk B, Cornier N, Hering H. A standardized health information system for refugee settings: rationale, challenges and the way forward. *Bull World Health Organ* 2010; **88**(10): 792-4.
19. Thieren M. Health information systems in humanitarian emergencies. *Bull World Health Organ* 2005; **83**(8): 584-9.
20. Robinson C, Rowley E, Bolton P, Weiss W, Singh K. Demographic Methods in Emergency Assessment. A guide for practitioners. Baltimore: Centre for International Emergency, Disasters and Refugee Studies, Johns Hopkins University Bloomsberg School of Public Health, 2003.
21. Bjorgo E. Using very high spatial resolution multispectral satellite sensor imagery to monitor refugee camps *International Journal of Remote Sensing* 2000; **21**(3): 611-6.
22. Checchi F, Stewart BT, Palmer JJ, Grundy C. Validity and feasibility of a satellite imagery-based method for rapid estimation of displaced populations. *Int J Health Geogr* 2013; **12**: 4.
23. Checchi F, Grundy C. Satellite imagery for rapid estimation of displaced populations: a validation and feasibility study. Final project report. London: London School of Hygiene and Tropical Medicine, 2012.

http://crises.lshtm.ac.uk/files/2012/11/LSHTM_sat_imagery_pop_estimation_REPORT_FINAL.pdf, accessed 20 August 2015.
24. Espié E. Evaluation of three methods for estimating population. Bordeaux: Université Victor Segalen; 2000.
25. Grais RF, Coulombier D, Ampuero J, et al. Are rapid population estimates accurate? A field trial of two different assessment methods. *Disasters* 2006; **30**(3): 364-76.
26. Brown V, Jacquier G, Coulombier D, Balandine S, Belanger F, Legros D. Rapid assessment of population size by area sampling in disaster situations. *Disasters* 2001; **25**(2): 164-71.
27. Bostoen K, Chalabi Z, Grais RF. Optimisation of the T-square sampling method to estimate population sizes. *Emerg Themes Epidemiol* 2007; **4**: 7.
28. Pinto A, Brown V, Chan K, et al. Estimating Population Size Using Spatial Analysis Methods. In: Lai PC, Mak ASH, eds. GIS for Health and the Environment. Berlin: Springer; 2007: 271-87.
29. Telford J, Gibbons LK. Counting and Identification of beneficiary populations in emergency operations: registration and its alternatives. London: Overseas Development Institute, 1997.
30. United Nations High Commissioner for Refugees. Registration: A Practical Guide for Field Staff. Geneva: UNHCR, 1994.
31. Luan R, Zeng G, Zhang D, et al. A study on methods of estimating the population size of men who have sex with men in Southwest China. *Eur J Epidemiol* 2005; **20**(7): 581-5.
32. World Food Programme. Desk Review: Estimating population size in emergencies. Rome: WFP, 2006. http://reliefweb.int/sites/reliefweb.int/files/resources/1A1CB3E6D037A387C12572BF00363C1F-wfp-coordination-Dec06.pdf, accessed 21 August 2015.
33. Bengtsson L, Lu X, Thorson A, Garfield R, von Schreeb J. Improved response to disasters and outbreaks by tracking population movements with mobile phone network data: a post-earthquake geospatial study in Haiti. *PLoS Med* 2011; **8**(8): e1001083.
34. Lu X, Bengtsson L, Holme P. Predictability of population displacement after the 2010 Haiti earthquake. *Proc Natl Acad Sci U S A* 2012; **109**(29): 11576-81.
35. World Health Organization. Vaccination in acute humanitarian emergencies: a framework for decision making. Geneva: WHO, 2013. http://apps.who.int/iris/bitstream/10665/92462/1/WHO_IVB_13.07_eng.pdf, accessed 18 July 2015.
36. World Health Organization. 2015. http://www.who.int/hac/crises/en/, accessed 18 July 2015.
37. Centre for Research on the Epidemiology of Disasters. EM-DAT: The International Disaster Database. Brussels: CRED, 2015. http://www.emdat.be/database, accessed 7 July 2015.
38. Uppsala Conflict Data Program. UCDP Battle-Related Deaths Dataset v.5-2015. http://www.ucdp.uu.se/, accessed 7 July 2015.
39. Reliefweb. 2015. http://reliefweb.int/, accessed 18 July 2015.
40. United Nations Office for the Coordination of Humanitarian Affairs. 2015. http://www.unocha.org/, accessed 18 July 2015.
41. Internal Displacement Monitoring Centre. 2015. http://www.internal-displacement.org/, accessed 18 July 2015.
42. Inter-Agency Standing Committee. 2015. https://interagencystandingcommittee.org/, accessed 18 July 2015.
43. Altare C, Guha-Sapir D. The Complex Emergency Database: a global repository of small-scale surveys on nutrition, health and mortality. *PLoS One* 2014; **9**(10): e109022.