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Preparing routine health information systems for immediate health responses to disasters

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During disaster times, we need specific information to rapidly plan a disaster response, especially in sudden-onset disasters. Due to the inadequate capacity of Routine Health Information Systems (RHIS), many developing countries face a lack of quality pre-disaster health-related data and efficient post-disaster data processes in the immediate aftermath of a disaster. Considering the significance of local capacity during the early stages of disaster response, RHIS at local, provincial/state and national levels need to be strengthened so that they provide relief personnel up-to-date information to plan, organize and monitor immediate relief activities. RHIS professionals should be aware of specific information needs in disaster response (according to the Sphere Project's Humanitarian Minimum Standards) and requirements in data processes to fulfil those information needs. Preparing RHIS for disasters can be guided by key RHIS-strengthening frameworks; and disaster preparedness must be incorporated into countries' RHIS. Mechanisms must be established in non-disaster times and maintained between RHIS and information systems of non-health sectors for exchanging disaster-related information and sharing technologies and cost.

Keywords Disasters, health information systems, health planning

KEY MESSAGES

- Health planning should include as routine the planning for health services delivery in, and their responses to, common disaster situations in the country or region.
- Health policy makers should be aware of the need for strengthening Routine Health Information Systems (RHIS) to support immediate disaster responses.
- Health staff and managers, who develop and maintain RHIS, should understand disaster-specific information needs and how to prepare RHIS for early disaster response.

Introduction

When a disaster strikes, the first-line lifesaving disaster response usually comes from local volunteers and people affected by the disaster (PAHO 2000c; IRIN 2005; WHO 2010a). Considering the significance of local capacity during the first few days of disaster response, information must be available to personnel on the ground to rapidly design a disaster response and develop an action plan. Prompt planning for health relief activities requires access to existing pre-disaster baseline data on health services and programmes (VanRooyen and Leaning 2005). Access to this data and its analysis can fast-track the planning and implementation of the immediate response.

Despite the crucial role of information in a disaster response, pre-disaster baseline health data are often not available where and when needed in the immediate aftermath of a disaster, or during the early stages of a prolonged disaster (Guha-Sapir and van Panhuis 2009). Many disaster response evaluations have revealed that the information needs of humanitarian organizations in planning their response are unmet, but there has been little emphasis on the inadequate capacity of countries' health information systems to meet those needs (de Ville de Goyet and Morinière 2006; IFRC 2006; Thompson *et al*. 2006; Turner *et al*. 2008; IASC 2010).

Although Routine Health Information Systems (RHIS) exist in many resource-poor countries, their operational capacity is often sub-optimal (Sauerborn and Lippeveld 2000; AbouZahr and Boerma 2005; Aiga *et al*. 2008; Chan *et al*. 2010). Efforts to strengthen country RHIS have been a focus of development assistance internationally (AbouZahr and Boerma 2005; Shibuya *et al*. 2005; Chan *et al*. 2010). The World Health Organization (WHO) has compiled a list of key resources including standards, guidelines and assessment tools of Health Information Systems (HIS) (WHO 2008). Among these resources are two key frameworks: the Health Metrics Network's (HMN) framework for general health information systems assessment (HMN 2008) and the Performance of Routine Information System Management (PRISM) framework for RHIS performance (Aqil *et al*. 2009). Both frameworks provide guidance on input, processes and outputs of health information systems.

There are well-defined international standards for disaster response, including the aspects of health services and systems, water supply, sanitation, hygiene promotion and nutrition in *The Sphere Handbook* (The Sphere Project 2011) (see Box 1). For each of these standards, there are also well-defined indicator sets which need to be used for planning, implementation, monitoring and evaluation of the response at various points in post-disaster time. These key indicators demand particular information from HIS—whether pre-existing HIS or one developed specifically for the disaster response.

Despite these details in *The Sphere Handbook* and the many other papers and guidelines which cover various topics on health-related information in humanitarian emergencies (Brès 1986; Guha-Sapir and Lechat 1986; Lechat 1990; Guha-Sapir 1991; Médecins Sans Frontières 1997; Noji 1997; Wetterhall and Noji 1997; WHO 1999; Granger 2000; Maxwell and Watkins 2003; Checchi and Roberts 2005; Connolly 2005; Landesman 2005; Mathew 2005; Thieren 2005; McDonnell *et al*. 2007; OCHA 2009; Walsh *et al*. 2009; Cottrell and King 2010), there has been limited analysis of the role of RHIS in disaster responses and how to increase RHIS capacity to support disaster planning.

Based on this analysis the authors posed the research question: how should RHIS be adapted to meet the needs of disaster preparedness and response? This article identifies the areas where RHIS need to be capable of supporting the first-line health response to disasters at the level of international best practice. The article focuses on health staff and managers, who develop and maintain RHIS, and highlights specific information needs, analysis, access and dissemination required to enable local and national emergency and public health teams to mount an adequate response to disasters.

Box 1 HIS-specific content of *The Sphere Handbook* (The Sphere Project 2011)

- Key indicators with guidance notes for 'Health Information Management' standard: 'The design and delivery of health services are guided by the collection, analysis, interpretation and utilisation of relevant public health data.'
- A checklist of information required by the health system and services in preparation for disaster response.
- Examples of mortality and morbidity surveillance reporting forms.
- Formulas for calculating required mortality and morbidity rates and health services coverage levels.

Search strategy and selection criteria

We conducted a literature search between March and August 2010 to identify existing literature on the role and use of health information and health information systems in disaster preparedness, response and monitoring and evaluation. The search was conducted through electronic databases, the main ones being the PubMed database (1951–March 2010) and Google Scholar. The search terms in PubMed were 'health information systems disasters', and 461 articles were identified from the PubMed database. English-language articles identified from this initial search were screened for specific and detailed content on health information in disaster situations, and such articles were selected for more detailed review. This included scrutinizing for content in the areas of 'frameworks for health information systems in disasters/emergencies', 'health information needs and sources of information in disasters', 'health information system competencies required in disaster situations' and 'how to make health-related information accessible immediately after a disaster' and with any specific reference to low- and middle-income countries. In addition, we undertook a focused review of both the reference lists of articles reviewed through the formal literature review process and a targeted search of disaster-related websites such as the Emergency Events Database (EM-DAT) and the United Nation's Office for the Coordination of Humanitarian Affairs (OCHA) and specific journals such as '*Disasters*' and '*Pre-hospital and Disaster Medicine*'. In this paper, the PRISM framework is used to guide the analysis and discussion, and the HMN framework is referenced as required (e.g. data sources).

Data needs

The more rapidly a disaster occurs, the more urgently baseline and post-impact information is needed. Even in disasters which start slowly and are prolonged, baseline information such as population-at-risk cannot be collected within a short time-frame, and hence must be available on an on-going basis prior to the disaster. For analysis in this paper, data needs are grouped according to the rapidity of onset of the disasters: sudden onset and rapidly abating disasters and insidious onset and prolonged disasters (Guha-Sapir 1991). This paper will focus on natural disasters with sudden onset, such as flash floods, cyclones, earthquakes and tsunamis.

Public health impacts of disasters and post-disaster health needs vary with the type of disasters (Table 1) (Lechat 1976; Lechat 1990; Guha-Sapir 1991; Noji 2000; PAHO 2000a). Accordingly, data needed to predict and manage these health problems will also vary (Box 2). Thus, developers and managers of RHIS need to account for the data required for the health aspects of the common types of disasters in their regional area or country. Using this approach and based on the data sources section of the HMN framework (HMN 2008), we have developed a summary table that identifies a range of data required for disaster responses which need to be accessed from pre-disaster RHIS (Table 2). The availability and accessibility of this information at different levels of the health system depends on various factors, including the nature of the disaster, the extent of destruction by the disaster, socio-economic context of the affected area, characteristics of the affected population, condition of the existing infrastructure (e.g. health facilities, communications and roads) and functioning of the existing health system including HIS.

In the aftermath of a disaster, information is also needed on post-disaster health problems and priorities, remaining sources of health care, coverage of remaining public health programmes including vector control programmes, post-disaster human resource and other health system capacities, and post-disaster status on 'water supply, sanitation and hygiene promotion' and 'food security and nutrition' (Table 3).

Data, collected from sources and through methods as shown in Tables 2 and 3, are used in decision making to allocate appropriate resources in the required quantity at the right time (Guha-Sapir and Lechat 1986), with the ultimate goal of preventing further mortality and morbidity in the immediate post-impact phase. Information on characteristics of disaster victims and data regarding the time, place, circumstances and mechanism of disaster-related mortality and morbidity during the immediate and secondary post-impact phase are useful not only for needs assessment and planning, but also for evaluation of relief programmes to inform future disaster responses (Guha-Sapir and Vogt 2009). In this article, we use the definition of 'immediate post-impact' phase as approximately 'the first 48 hours' and 'secondary post-impact' phase as '3–10 days following the incident' (Guha-Sapir and Vogt 2009), noting that there are some variations on these definitions (Neal 1997).

Table 1 Examples of common health needs in different types of disasters

Injuries or illnesses	Types of disasters
Bronchitis and burns	Volcanic eruptions
Near-drowning and respiratory illnesses	Floods, tsunamis and cyclones
Crush injuries	Earthquakes
Increased risk of communicable disease outbreaks	Disaster situations with population displacement, high population density and decline in sanitation and hygiene measures

Sources: PAHO (2000d); Jones (2006); Redmond (2005); Wilder-Smith (2005); WHO (2010a).

Health information system processes

In order to meet data needs for immediate disaster response, data collection platforms and data processes must be strengthened. This may mean reaching beyond the normal health-sector data sources in order to provide the type of data and data linkages required, e.g. data on water resources and water-related diseases, the nutritional status of children under-5 and food supply and security. The PRISM framework (Figure 1) identifies technical, organizational and behavioural factors which affect RHIS processes (Aqil *et al*. 2009). These processes are data collection, transmission, processing, analysis, presentation, quality checking and feedback, and should be standardized pre-disaster by establishing procedures and protocols which are feasible to operate in disaster settings.

The following is an overview of the factors influencing RHIS processes. Adequate numbers of competent staff, sufficient supplies and suitable infrastructure are required to design and maintain an effective information system. Providing legislative

Box 2 Data needs considerations linked to the nature of disaster and likely health outcomes

- In disasters such as earthquakes and landslides, survivors of the direct impact must be rescued and given emergency care in the first 6–12 hours (Guha-Sapir and Carballo 1999), and hence immediate mobilization of resources is crucial (PAHO 2000c). Relevant information must be available within a few hours after the disaster to prevent further mortality, and rapid assessment must be done expeditiously. Having baseline data available will accelerate and assist the assessment process.
- The risk of acquiring communicable diseases varies by type of disaster (Toole 1997), and to predict the likelihood of 'outbreaks' and increases in these diseases, health authorities (local, provincial/state and national) and humanitarian organizations need to access information on the seasonal and geographical occurrence of infectious diseases, and implement early surveillance and preventive measures and reduce the risk (PAHO 2000d; Wilder-Smith 2005).
- Data on the size of population at risk are essential in estimating the disaster impact from health aspects (Guha-Sapir 1991; Noji 1997; Checchi and Roberts 2005) and this baseline data must be disaggregated by age, sex, socio-economic status and vulnerability to common disasters in their area.

Table 2 Pre-disaster data sources and collection methods in disaster response

Data required for disaster response	Pre-disaster data sources/collection methods[a]
Demographic-related data Mortality data	Census and civil registration from National Statistics and Planning Office Provincial/state and district government offices
Pre-existing health status Pre-existing health problems and priorities Population groups with specific health needs	Patient, family and facility health records in routine health management information systems from point-of-care services Health service reports from provincial/state and local health offices Mortality and morbidity reports from the National Statistics Office
Pre-disaster sources of health care	Health facility surveys from Ministry/Department of Health Resource and administrative records from provincial/state and local health offices and government councils
Coverage of public health programmes	Routine public health activity records and programme reports from provincial/state and local health offices
Vector control	Programme records/reports from vertical programmes (e.g. the Global Fund's Malaria Programme)
Health system capacities (including availability of health professionals and health financing)	Health service records from health facilities Health service reports from provincial/state and local health offices Resource and administrative records from provincial/state and local health offices and government councils Health facility surveys and National Health Accounts or National Health Plans and Budgets from Ministry/Department of Health
Community health volunteers and community-based organizations	Registration records and training records/reports from local health offices and government councils
Determinants of health	Population surveys [e.g. Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS), and Household Income and Expenditure surveys] from research institutions and Government Departments including the National Statistics Office
Behavioural data (hygiene practices)	Behavioural surveys from research institutions, public health offices, non-governmental organizations (NGOs), etc. Knowledge of local health staff
Water supply Excreta and waste management	Administrative records and Water and Sanitation reports from Water Boards, local government councils and local public health offices (in some countries)
Food security	Food security and livelihoods reports from sectors other than health sector (e.g. Ministry/Department of Livestock and Agriculture), research institutions, NGOs and the United Nations (UN) agencies [e.g. the Food and Agriculture Organization (FAO)]
Nutritional status	National nutrition surveys and MICS from government departments and research institutions Health service reports from provincial/state and local health offices
Community vulnerability (e.g. housing, transportation, age, gender, disability, migrant status) (Morrow 1999) Community resources (e.g. shelter, social network groups)	Maps containing vulnerability and resources information, collected, presented and regularly updated during routine collaborative community health activities between local health department and the community, such as immunization Above maps reported to and available at the higher-level health and administrative authorities

Source: [a]HMN (2008).

and funding structures for those requirements demands commitment and support from government and high-level health authorities (McDonnell *et al*. 2007). RHIS should be designed to aid health workers and decision makers throughout the data processes and not to burden health workers with data collection and reporting. Hence, in designing RHIS, technical and organizational factors to be considered include involving users in the system design and testing (McDonnell *et al*. 2007), avoiding complex reporting forms and procedures, implementing user-friendly information technology, setting up appropriate channels for timely information flow, establishing linkages between data producers and data users, and providing appropriate training. It is expected, as a result, that health workers will become motivated, confident and competent in HIS tasks (Aqil *et al*. 2009). These factors will be explored in more depth in the disaster context in the following sections.

Data collection

Both routine data sources and disaster-specific data collection methods are listed in Tables 2 and 3. Ensuring the utility of an RHIS for disaster applications requires unique ways of strengthening data-collection processes. For example, a protocol on post-disaster data collection and rapid assessment (including appropriate sampling methods) (Frankel 1994) must be established before the disaster strikes (Noji 2000). Procedures for getting data from the various data sources detailed in Tables 2 and 3, and triangulation of data from these sources, must be identified and detailed in the rapid assessment protocol. The operational capacity of HIS, including availability of baseline information, must be tested during disaster preparedness drills. Baseline information must be updated annually or biannually (Guha-Sapir and Lechat 1986). Disaster management plans of hospitals and other health facilities must have health

Table 3 Post-disaster data sources and collection methods in disaster response

Data required for disaster response	Post-disaster data sources/collection methods
Extent of disaster destruction Remaining health and other resources	Aerial observation through satellite and low-flying aircrafts/helicopters Transect walk by rapid assessment team
Estimated mortality	Observing body count, new graves and burial grounds (Checchi and Roberts 2005)
Affected population's needs on health, water and sanitation, nutrition and food supply	Key informant interviews, other participatory research methods, population-based quantitative surveys (with the involvement of community and other stakeholders)
Injury or illness pattern Proportional mortality Case fatality rate Type and volume of immediate medical relief needed Appropriateness of relief given	Health service reports Disease surveillance system, such as Early Warning, Alert and Response System (EWARS)
Financial budget and expenditure for disaster response in health sector	An account of budget and expenditure for disaster response in health sector, compiled by the national information management unit and through cluster co-ordination mechanism Financial tracking sheets submitted and compiled at organizational level, sector level and national level

information management as a component and must identify ways of quickly retrieving data for immediate disaster response and developing and implementing the procedures to do so. Post-disaster reduction in staff and subsequent redirecting of staff can lead to a situation where they are given unfamiliar tasks; therefore, clear concise instructions for conducting important tasks (including RHIS tasks) should be developed and available to all staff (Walsh *et al*. 2009).

There are specific data-collection needs for the management of immediate medical relief. Mass casualty management involves triage, the process by which health workers or triage officers at the disaster site determine transportation priority and admission to the hospital or health unit, and clinicians at the hospital or health unit assess patient needs and priority for medical care (PAHO 2000c; Sutiono *et al*. 2010). An RHIS requirement in this triage process entails assigning and identifying patients with standardized triage tags, which should be a part of routine emergency care pre-disaster, and ensuring familiarity with this process and tags by all medical staff (PAHO 2000c).

In situations where patients need to be transferred from one hospital to another, health workers should have ready access to information on referral networks and procedures and the availability of hospital resources at the receiving end (Box 3) (Lam 2006). The Pan American Health Organization (PAHO 2000c) developed an example of data collection and display format and process, which can aid health authorities in planning emergency medical resources. Such examples of formats and processes need to be adapted to suit a particular country's context and disaster-related data needs.

However, in resource-limited settings facing overwhelming needs for information and response in a disaster, such an individualized approach (i.e. patient centric) is not often practical (Guha-Sapir 1991). Minimum health data collection in these cases involves mortality and morbidity surveillance reporting of the disaster-affected population. Examples of these data collection and reporting forms can be found in *The Sphere Handbook* (p. 341–5) (The Sphere Project 2011) and Médecins Sans Frontières' *Refugee Health Manual* (p. 365–78) (Médecins Sans Frontières 1997). These forms were designed for use in developing countries and have been used in these countries during disaster response. More detailed forms can be found on the US Centers for Disease Control website (CDC 2008). These forms can be incorporated into routine data collection and reporting of notifiable diseases in non-disaster times, so that data collection and reporting of casualties, diseases and deaths can be started within a few hours after a sudden-onset disaster and health staff will be familiar with the processes and formats.

Managing a disaster requires health products, supplies and equipment for relief. Ensuring the availability of a site/region-specific up-to-date inventory of supplies from the logistics management information systems as part of the RHIS is an important design feature to consider (PAHO 2000f). Every country should develop an essential medicine and equipment list for disaster situations, informed by international standards, e.g. WHO's Interagency Emergency Health Kit (WHO 2006) and the United Nations Population Fund's (UNFPA) Inter-Agency Reproductive Health Kits for Use in Crisis Situations (UNFPA 2008), tailored to the local availability of medicines and the country's common disaster types (WHO 2010b; WHO India, no date). This list provides the standard against which a review of viable medicines and operational equipment in stock can be made. This review will give information on whether the supplies match the needs for immediate disaster response, and the locations and accessibility of these supplies before more supplies are ordered for the increased demand due to disaster.

Data transmission (communications)

Another important part of HIS is the communication of data to and from the data sources and data users. These communication channels (such as the cluster mechanism described later in the 'information management' section of this paper) should exist between the health sector and other sectors to quickly access information most likely to be collected by non-health sectors, e.g. between Ministry/Department of Health and Ministry/Department of Meteorology to share early natural disaster warnings for preparation for and early response to disasters (Parker 1999; Ardalan *et al*. 2009). The channels should also include local, state/provincial and national governments. Considering the significant role of and contributions

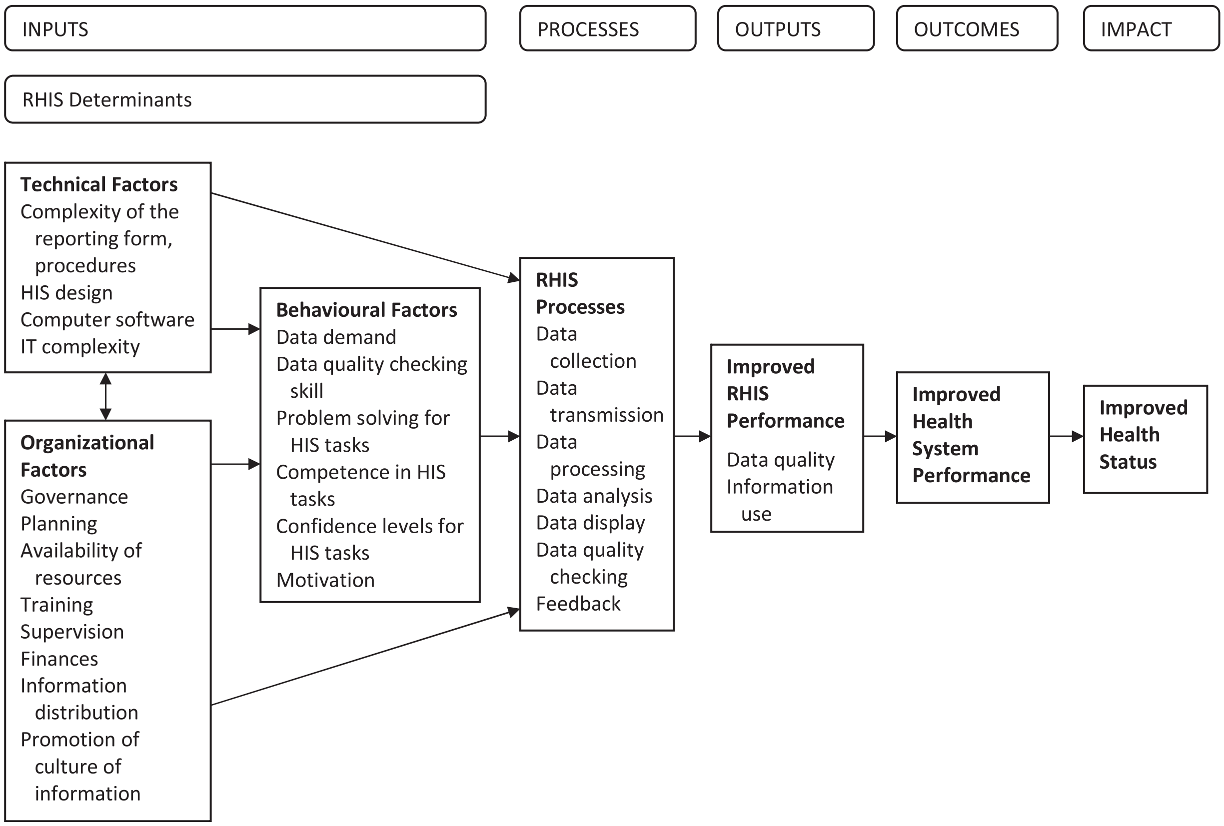

Figure 1 The PRISM (Performance of Routine Information System Management) framework. (*Source*: Reproduced from Aqil *et al*. 2009, p.220)

from non-governmental and community-based organizations in disaster management, it is also important to establish functioning communication channels or two-way data sharing/reporting mechanisms between these organizations and the government's public health departments during pre-disaster times (Bolin and Stanford 1998; Buckland and Rahman 1999).

A major challenge in post-disaster data transmission is that routine communication channels are often non-operational during and immediately after a sudden-onset disaster. This may affect the timely availability of data (e.g. casualty numbers, extent of workload) to the disaster health response team, and data transmission to the response co-ordinators from 'on the ground' health facility staff who remain operational. Ideally, disaster response requires affordable and portable communications which are independent of terrestrial systems or power lines and which can be set up within a few hours at any place (Wood 1996; Qiantori *et al*. 2010; Sutiono *et al*. 2010).

Options exist for the use of different telecommunication technologies in disaster situations, ranging from high frequency radio to satellite communication systems, taking into consideration issues such as electrical power and legislation (Wood 1996; Lam 2006). Pre-disaster agreements should be made between health sector and telecommunication authorities for the use of available communication technologies for data transmission during and after disasters (PAHO 2000e). Even if these communication systems cannot be allocated for civilian use in pre-disaster time due to political, legal or financial reasons, one option is to make arrangements for the use of police or military telecommunication resources for disaster relief, depending on the country's context and the government's commitment and policy. Disaster preparedness activities as part of the HIS at all levels of the health system should include identifying appropriate telecommunication technologies to invest in and establishing pathways to use telecommunication resources from other sectors.

Technology in high-income countries has taken emergency relief to the level of providing emergency care through telematic support (Garshnek and Burkle 1999; Huffer *et al*. 2004; Doarn *et al*. 2006). Telecommunication systems for emergency relief purposes are designed to withstand adverse conditions and feature mobility, rapid set-up and land-line independence (Garshnek and Burkle 1999), and transmission of real-time health data can be achieved by making use of those systems if they already exist. Telematic support is not limited to high-income countries. There is evidence of its use in developing countries in areas such as telemedicine, epidemiological surveillance and health programme management, and potential for its expansion (Mandil 1995; Zhao *et al*. 2002). Further trials, like the one in Indonesia (Sutiono *et al*. 2010), will be useful in application of telematics in disaster relief in developing countries. Where terrestrial and cellular networks fail, global mobile satellite telecommunication systems such as Inmarsat® will allow communication through lightweight mobile equipment which can be used throughout the world. However, the cost should be considered and legislation for use in a particular country when needed should be in place before the disaster (Staffa 1994).

Where there is no available telecommunications, transportation plays a key role in communicating essential health data,

Box 3 Example of disaster health referral process

Out of necessity, two nurses in Texas developed a patient tracking form to record patient information and track patients' location as they were referred for services during Hurricane Katrina. This form was later modified as the ambulance dispatch form before Hurricane Rita's arrival. Data in this form could be entered into a searchable database, which acted as a single source of relevant information required for health care providers, referral facilities and concerned family members. Successful coordination of care for 2400 patients (with the exception of only two requests) during Hurricane Rita demonstrated the success of this tracking process, which had the potential to develop into a state-wide tracking system.

Source: Adapted from Anon (2005, p. 141–43).

and is undertaken in conjunction with other relief activities, however with greatly reduced efficiency (Tripartite Core Group 2008). Thus, it is also important for the health sector to identify and establish links with potential resources for transportation (PAHO 2000e).

Data processing and quality checking

Data processing and compilation can occur on-site for local use or at the health administrative levels higher than the reporting unit. Depending on the scale of the disaster and the country's context, relief co-ordination units or disaster information management units will be positioned at district, provincial (state) and/or national level (Kauffmann and Krüger 2010). Ideally, at these co-ordination levels, data from rapid assessment surveys, secondary data sources and all reporting health units (starting from village level) will be checked, collated and integrated into a database before being analysed together with data from other sectors. It is important at this stage to identify, confirm and correct duplication of data, determine the coverage and completeness of data, and conduct plausibility reviews of the data, including triangulation and independent verification (Tripartite Core Group 2008). These data processing and reporting procedures, and paperwork and database formats, must be standardized in a protocol pre-disaster; appropriate technology, infrastructure and equipment must be in place to efficiently carry out these activities; and staff must be trained on processing data.

Quality checking of data involves assessing whether the data collected meet the information needs for disaster management (relevance of data); whether information is available at the time it is needed (Aqil *et al*. 2009); whether the data are useful to those collecting and reporting the data; whether the data collected are acceptable to health workers and community workers (McDonnell *et al*. 2007); whether there is consistency of data within a dataset, between the datasets and over time; what proportion of the disaster-affected area and populations are covered by data collection; whether the data are disaggregated by sex, age, socio-economic status, ethnicity, etc.; and whether the data are accessible, but secure (HMN 2008).

As the quality and functioning of HIS affects the quality of data, annual or biannual evaluations of the HIS should be undertaken to assess whether the system is sufficiently prepared for disaster response. Evaluation of HIS comprises the 'information use' assessment at facility, district or higher level, 'data quality' assessment at facility level, information system mapping, facility/office assessment, management assessment, and organizational and behavioural assessment (as described in *PRISM Tools*) (Aqil and Lippeveld 2010).

Data analysis

Modelling (to predict and estimate disaster-related morbidity and mortality and plan for disaster response), hazard analysis and vulnerability analysis (Figure 2) are unique variations of HIS data analysis required to ensure timely disaster response. To support this type of analysis, active collaboration is required between personnel from different disciplines such as epidemiology, demography, anthropology, meteorology, sociology and engineering in natural disaster-related research (Noji 1997; Allen and Katz 2010). It may not be possible for every country to develop some of these estimates; however, regional and global collaboration to ensure access to models and technology, and the skills to develop these models, are important. For example, occurrence of disasters like cyclones and tsunamis can be predicted (Groeve *et al*. 2010), and if the data are analysed, shared and utilized, the effects of such natural disasters can be reduced or mitigated despite their sudden onset. Additionally, more advanced Global Information Systems, mathematical modelling technology and demographic techniques will need to be developed to promptly approximate disaster impact on morbidity and mortality.

The data analysis component of HIS must be designed to fulfil its purposes of issuing warnings on the risk of arising diseases and other health conditions, setting priorities for action with available resources, identifying the most appropriate and efficient ways to respond, planning for an effective response and monitoring the effectiveness of the response. The WHO-facilitated Early Warning, Alert and Response System has been used in developing countries to conduct such surveillance and response activities (WHO Myanmar 2010, 2011).

Data presentation

Data for disaster management often need to be presented differently from mainstream RHIS outputs (Endsley 2010). During the pre-disaster phase, data obtained from hazard and vulnerability analyses can be presented on a map which shows terrain, houses, buildings, roads and other infrastructure. Ready access to this map-based information enables efficient rapid assessment and consequently prompt disaster response, as post-impact information such as extent of damage and population movements can be integrated into the existing pre-disaster maps. Charts and graphs assist decision makers in timely assimilation of information into response. An information package containing pre-disaster data (as stated in the

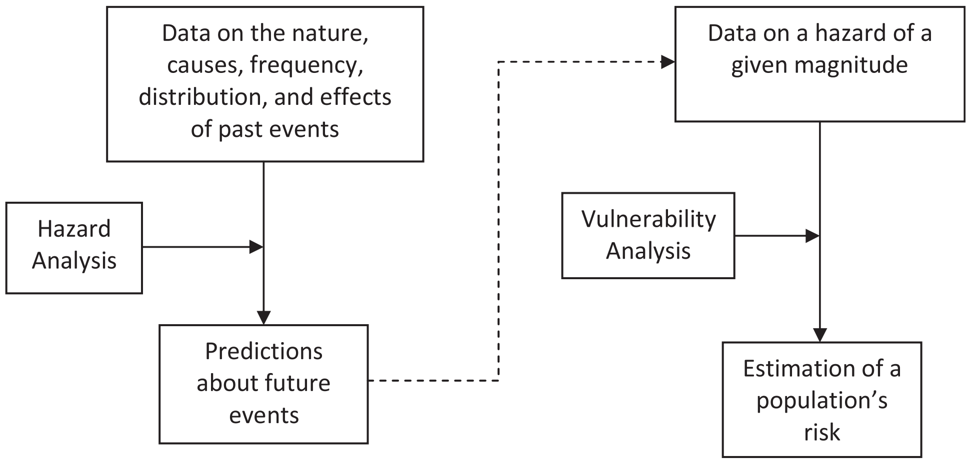

Figure 2 Hazard analysis and vulnerability analysis. (*Source*: Adapted from Noji 1997)

online supplementary material for this paper) should be compiled and kept for easy retrieval at the time of disaster (PAHO 2000b).

Technologies can assist in this form of data presentation. Maps generated using geographic information systems (GIS) and remote sensing technologies will not only assist in rapid assessments but also facilitate further data analysis and decision making such as resource allocation, planning and co-ordination of support (Kaiser *et al*. 2003). Basic geo-referenced data including co-ordinates of hot spots, health facilities and community organizations, or satellite images showing major topological features and predicted disaster impacts (e.g. lava flows or flood prone areas), must be included in RHIS (Chronaki *et al*. 2007; Shaikh 2008; Win 2010). In this area, the geo-referenced data and capacities may be within other sectors, or more regionally based groups such as PreventionWeb (2010) and the UN Office for Coordination of Humanitarian Affairs (OCHA 2011). These groups have been developing resources for public domain access, especially for resource-poor countries. Ensuring the establishment and continuity of access to these resources as part of the RHIS infrastructure is an important step.

Feedback

A critical component in ensuring appropriate and timely responses to disasters is two-way communication flow: between field health units and higher-level health units (Kauffmann and Krüger 2010). Feedback from the field should be provided on duplication, complexity of reporting, logistical issues, workload and training requirements for the HIS in the disaster setting (WHO 2004). Higher-level health units should give feedback on the timeliness and accuracy of data collected, and on analysis of the data. Staff with expertise to assess practices in data analysis, utilization and dissemination can be appointed to feed back on the quality of these practices and support lower-level staff in developing the capacity to assess their own work. If all of these feedback procedures are established and running in RHIS, and the culture of data use and feedback is supported, staff will be already accustomed to these practices when it comes to disaster response.

Cross-cutting theme: human resources

Public health professionals with an epidemiological background should be trained pre-disaster as part of the RHIS capacity in the timely analysis of disaster-related data and must be available for consultation at the time of disaster (McDonnell *et al*. 2007). A national team of public health staff, especially those with knowledge, experience and skills in responding to disasters, must be identified, organized and provided with ongoing capacity development in data collection techniques and use of related IT tools in pre-disaster times, for rapid assessment and disaster response (Lechat 1979; Guha-Sapir and Lechat 1986). Data on these human resources should be maintained in the RHIS (Gerardi 2006), and include details on name, age, gender, location of residence and work, qualifications and special competencies (e.g. midwifery, surgery, mental health). Those included should range from community-based health workers, clinical staff, laboratory technicians, pharmacists, logisticians, health managers and planners. Additionally, having a national database of available key resource persons (able to undertake a rapid disaster-impact assessment) will assist the process of responding to the disaster in a more timely manner.

Information management in practice

While the governments of developed nations lead and co-ordinate disaster response in their countries (e.g. through a disaster management committee), many developing countries lack the capacity to solely manage the response. It is common in the latter for UN agencies to assume the role of the lead agencies for humanitarian response, most often in partnership with national government departments or national/local authorities and with the involvement of other humanitarian actors, depending on the country context and the scale of the disaster.

In late 2005, the cluster approach was introduced by the Inter-Agency Standing Committee (IASC) of the key UN and non-UN humanitarian actors, 'as a mechanism that can help to address identified gaps in response and enhance the quality of humanitarian action' (Inter-Agency Standing Committee 2006). It is 'a system of sectoral coordination with designated lead organizations' (Steets *et al*. 2010), conducted mainly through intra- and inter-cluster co-ordination meetings with the involvement of UN and non-UN humanitarian actors and government agencies (relevant to each sector) as cluster members. The clusters or sectors are led by agencies such as the United Nations Children's Fund (UNICEF) for the nutrition sector or WHO for the health sector. At the country level, relevant, accurate and timely data are required in clusters' activities, especially in ensuring needs assessment and analysis, planning and strategy development, application of standards, monitoring and reporting, identification of critical gaps, and co-ordination of humanitarian actors to fill in these gaps (IASC 2006). Thus, the more detailed the population and disaster-related data and the easier it is available from RHIS, the more effective it is in planning, monitoring and co-ordination of the disaster response within the health sector.

Where existing information and co-ordination systems are weak and disaster impact overwhelms the local capacity, post-disaster data can be collected, compiled and analysed through the cluster mechanism at the country, state/provincial and local levels. Data may be obtained from the existing information systems or newly established information management mechanisms. The cluster approach aims to share information and facilitate its use at these various levels. All clusters should have information management focal points (IASC Working Group 2008). For cross-cutting information-management services and tools intended for inter-cluster co-ordination (and also supporting intra-cluster operation), agencies like UN-OCHA set up an information management network covering these various levels and all sectors, and provide technical support and a structural mechanism to improve availability and use of information (OCHA 2005; Kauffmann and Krüger 2010). One example of a product from an information management network is the 'Who does What Where (3Ws)' database and maps. The information management mechanisms should build on and strengthen the country's existing information systems, including RHIS, rather than establish parallel information systems (IASC Working Group 2008; MIMU 2011a). Care should be taken not to duplicate data collection activities of cluster leads and those of the information management units (Kauffmann and Krüger 2010).

The *IASC Cluster Approach Evaluation (2nd Phase) Synthesis Report*, based on studies in six developing countries, stated the benefit of information management through the cluster approach as 'designated space for information sharing and dissemination, which leads to an improved understanding of the humanitarian situation'. The evaluation also found improved coverage of needs, reduced duplication of activities and increased ability of humanitarian actors to learn from each other (Steets *et al*. 2010). However, problems still remain, such as insufficient details in 3Ws data for village-level activities, still-existing duplication of activities (despite the reduction), poorly facilitated co-ordination meetings, costly information technology and lack of institutional memory (Steets *et al*. 2010).

Case study

Here, one of the above six countries, Myanmar, is chosen as a case study to discuss the practicality of information management in sudden-onset natural disaster settings, and the strengthening of the existing information system along the process in developing countries. To discuss these issues, the Myanmar context is briefly explained, and three specific examples are given: (1) customizing information products by implementing affordable information technology, (2) strengthening disease surveillance through the cluster approach, and (3) providing data transmission solutions.

Myanmar, with a Human Development Index Rank of 149 (out of 181), was hit by Cyclone Nargis in May 2008 (Tripartite Core Group 2008; UNDP 2011). At this time, the Myanmar Information Management Unit (MIMU)—the key part of the UN-led information management network—and contingency planning process were in the early stages of development (Turner *et al*. 2008). However, one IASC evaluation of the disaster response identified positive outcomes in the establishment of an information system (mainly through MIMU) and in data production and dissemination, despite the data vacuum early in the response (Kauffmann and Krüger 2010). Another IASC evaluation assessed that the contingency planning process provided a platform for the cluster mechanism, resulting in timely appointment of cluster leads, which managed and shared information available from the MIMU, the government and other humanitarian actors (Turner *et al*. 2008).

Initially in the response, MIMU's products, such as 3Ws data, did not meet the user needs to the level they required (Kauffmann and Krüger 2010). However, MIMU customized the products over time to meet user needs (MIMU 2011b). An example of this is shown in Box 4.

One of the Health Cluster's information management activities was strengthening the disease surveillance system in response to the cyclone. The government's existing notifiable disease reporting system did not include coverage of newly-emerged health services of international and local non-governmental organizations in response to the cyclone. WHO, as the Health Cluster lead, facilitated an Early Warning, Alert and Response System. This system filled in the gap in disease surveillance by collecting, integrating, analysing and disseminating data from these organizations and the government's health system (UN Health Cluster/WHO 2008; WHO Myanmar 2010, 2011).

To assist in data transmission, the Emergency Telecommunication Cluster via UNICEF provided internet connection to other humanitarian actors where there was practically no internet access before the cyclone (Kauffmann and Krüger 2010). From the personal experience of one of the authors of this paper (EA), it provided a useful alternative means of communication between their field offices and headquarters despite the limited internet access and weak communication links.

There are still issues remaining in information production of the MIMU and information management through the cluster approach; however, marked improvements had evolved over the period of cyclone response and rehabilitation. If these improvements are stored in the 'institutional memory' as Steets *et al*. (2010) pointed out, more improvements can be built upon the previous ones in strengthening production, dissemination and use of information. The strengthening efforts may take one step at a time, although a strategic plan must be laid out to avoid piecemeal changes.

Box 4 Using affordable Information Technology in disaster management: Myanmar Information Management Unit (MIMU)

Issue:
In the aftermath of Cyclone Nargis, humanitarian agencies needed unique identifications (IDs) of the towns and villages in the cyclone-affected region for intra- and inter-agency response activities. These unique IDs are called Place Codes. The Ministry of Home Affairs, the Government of Myanmar, had published a list of standard names of the places at different levels of the administrative hierarchy; however, duplicate names and different ways of spelling in the names made the use of unique IDs essential in data collection and analysis. Although the standard names and unique IDs were stored and matched in MIMU's Place Code database, previously it lacked data on coordinates (latitude and longitude) of the places, which were required for mapping activities and spatial analyses in humanitarian response.

Objectives:
The objectives in addressing the above issue were: 'to collect coordinates directly into a database that stores unique IDs and names of the places; and to enable multiple users (from various humanitarian agencies) to view and update the data'.

Process:
The free version of Google Earth was installed on users' computers. Windows-Appache-MySQL-PHP (WAMP) server, which was also free, was installed on the administrator's computer and served as the web server to the users. Coordinates were obtained by panning the selected village feature on an overlay map in the Google Earth to get to the fixed centre-mark of the view. At the same time, the village name could be selected from a drop-down list on the web browser, and the user could update the coordinates for the village in the database.

Benefits:
Using place codes allows humanitarian actors to merge/compare and analyse their data with other organizations' data, and hence it promotes information sharing and cooperation among the organizations (Win and Aung 2010). Place codes and coordinates have been updated not only in the disaster-affected area, but also in other areas of the country, including the border region (MIMU 2011c). Such data is useful in generating 3Ws maps down to the village level for planning, monitoring and coordination of humanitarian and development activities in all states/divisions of Myanmar (MIMU 2011a).

Source: Adapted from Win (2010).

Conclusion

This paper has identified data needed for disaster preparedness and response that should be considered when countries are developing, assessing or strengthening their RHIS. The PRISM framework has been applied in strengthening RHIS in developing countries; and disaster-affected developing countries have used disaster-specific data processes as stated in this paper. This has demonstrated the feasibility of implementing disaster-responsive RHIS in developing countries.

Having acknowledged the inadequate RHIS capacity in resource-poor countries and also the unavailability of data for disaster response, the RHIS processes described may appear sophisticated and not applicable in these countries. However, RHIS assessment and subsequent strengthening (using the PRISM conceptual framework and associated instruments) in countries like Uganda, Pakistan and Haiti set examples for other developing countries in evaluating and strengthening their RHIS (Aqil *et al*. 2009). There is evidence in Uganda that HIV/AIDS service indicators were integrated in the RHIS during its strengthening (Aqil 2008). This is encouraging, indicating that similar action to incorporate disaster management components into RHIS is feasible in developing countries in disaster prone areas.

Resources and funding are required to strengthen a health system component, and strengthening an RHIS is no exception. Translation of the approaches proposed in this paper in any particular country will depend heavily on the government and donor commitment. Disaster response will be more effective and efficient for the government, donors and humanitarian agencies if disaster preparedness and response is integrated into the mainstream RHIS rather than forming a parallel information system that is established when a disaster strikes.

The changes required to increase the functionality of the RHIS for disaster response will also strengthen its capacity to act as a tool for health systems strengthening. This broadening of application of the RHIS and its increased cost-efficiency should be used by health programme managers to advocate for increased and sustained support for RHIS investment. Architects of RHIS and their reforms should consider adaptations of the system to meet disaster response requirements, as identified in this paper. Humanitarian agencies internal and external to countries must consider the use of RHIS data in their health and disaster assessment.

In these times of tight controls on health finances from sources such as government budgets and donors, finding ways to increase the efficiency and utility of one of the health systems building blocks, namely RHIS, with some reduction in new investment costs, is a necessity. The strengthening and use of RHIS to meet at least immediate health information needs for disaster planning and response is one way of achieving these outcomes, in addition to increasing the effectiveness of disaster responsiveness and preparedness.

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Conflict of interest

The authors declare that they have no conflict of interest.

Supplementary Data

Supplementary data are available at *Health Policy and Planning* Online.

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