5.2 Crowdsourcing to gather data

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5.2.1 Learning objectives

To understand the fundamentals of crowdsourcing and its relevance to Health EDRM, including:

1. What crowdsourcing is;
2. How crowdsourcing differs from related terms;
3. Strengths and limitations of crowdsourcing;
4. Things to consider when designing a study that would use crowdsourcing to gather data.

5.2.2 What is crowdsourcing?

Crowdsourcing, which is a method to harness the knowledge, creativity, or sheer manpower of a large number of people at once, has existed as a concept for hundreds of years, although the term itself was only coined a decade ago *(1–5)*. The term 'crowdsourcing' first emerged in a *Wired Magazine* article, and was described as a method of outsourcing tasks to an undefined, and generally large number of people using an open call. A commonly cited, classic example demonstrates the power of crowd wisdom in guessing the weight of an ox at a fair (Case Study 5.2.1). In the past decade, uses of crowdsourcing in research and practice have increased greatly, although many authors still feel the method is underutilized and underexploited *(6–9)*. This chapter explores the potential of crowdsourcing to help with research relevant to Health EDRM.

5.2

Case Study 5.2.1
A historical example of crowdsourcing

In 1907, Francis Galton wrote an article in *Nature* describing an experiment he conducted in Plymouth, West of England, where a crowd was invited to judge the weight of an ox. Some 787 votes were collected, and the average of these was incredibly close to the actual weight of the ox – within 1% of the real value *(10)*. Indeed, Buecheler et al. argue that individuals are biased towards the correct answer and that, because of this, if one million people contributed to solving a problem using crowdsourcing there would be a 97.7% likelihood that the crowd would arrive at the correct answer *(11)*.

Although technology is not a requirement for crowdsourcing, advances in technology have facilitated the impact and feasibility of crowdsourcing as a method. For example, at least 70% of the world's population has access to a mobile phone *(12)*. These devices can collect photo, video, acoustic, gyroscopic (measuring orientation), accelerometric (measuring acceleration), and proximal information, and can also be paired with external sensors such as air pollution sensors, or a wearable device such as a "smart watch" that will collect both gyroscopic and accelerometric information to track fitness by combining speed and location *(13)*. Mobile phones can also produce geographic information system (GIS) data (see Chapter 4.8), which are especially valuable in emergency situations *(14)*. Advances in artificial intelligence (AI) and machine learning algorithms provide new ways of processing the large amounts of data obtained through crowdsourcing (for example through receipt of many submissions, or through wearable sensors or mobile phone data).

Crowdsourcing can provide answers to questions that may be impossible or not feasible to answer otherwise by considerably lowering operational and data collection costs, while exponentially increasing sample size, and enabling researchers to receive data in real time *(14–20)*. As research in disaster situations faces time, funding, and logistical constraints – including staff and equipment – crowdsourcing may offer a desirable alternative or complement to traditional research methods *(8, 15, 21–28)*. However, as the crowd is often self-selected, there are concerns about the generalizability of samples. In cases where the information requested is sensitive, security and data protection issues also need to be considered. Efforts need to be made to design studies that can combat false submissions (from malicious contributors, for example, or if on a platform such as Amazon Mechanical Turk, malicious workers). Finally, concerns about the representativeness of the sample when crowdsourcing studies have very few contributors doing most of the 'work' or access to technology, age, and other demographic factors may affect who is able to contribute *(14, 29)*.

There are several different models of crowdsourcing, as well as similar and overlapping terms. While there is disagreement on the scope, categories, and types of models of crowdsourcing *(4)*, four basic and comprehensive categories emerge: crowd processing, crowd rating, crowd solving and crowd creation. These are outlined below.

Crowd processing
Crowd processing is the use of large numbers of people to process information independently, which become partially aggregated for quality assurance. This is described as a 'divide and conquer' approach. Examples of these include ReCAPTCHA, GalaxyZoo and the BioGames example provided later in this chapter.

Crowd rating
Crowd rating is the use of large numbers of people to vote or provide their opinion (such as TripAdvisor or Hollywood Stock Exchange).

Crowd solving
Crowd solving is the use of a large numbers of people to solve a problem, where the best submission is the 'winner.' Example of this are FoldIt, Crowdmed and Innocentive.

Crowd creation
Crowd creation *(30)* is the use of large numbers of people to co-create, such as Threadless.

In addition to the above four categories, crowdsourcing needs to involve a clear call for submissions or tasks, which can be voluntary or remunerated, and is usually conducted using some technology to enable low-cost and speedier data transmission. The crowd can be formed of laypersons or experts, but who the study is targeting should be decided for each problem. Responses may be aggregated or could be compared against each other in competition form. A comprehensive description of types of crowdsourcing can be found elsewhere *(4)* and some of the relevant terminology is shown in Table 5.2.1.

Table 5.2.1 Terms related to crowdsourcing and their definitions

Term	Definition
Participatory epidemiology	Using participatory methods in epidemiology, which could range from designing the study to participatory methods in data collection (the latter would likely be in line with crowdsourcing) *(31)*.
Wisdom of the crowd (that is, collective intelligence)	A phrase coined by Surowiecki *(32)*, describing a form of crowdsourcing that relies on having an intelligent crowd and follows four 'rules' to ensure crowd intelligence: diversity, aggregation, decentralization and independence. Not all crowdsourcing requires a wise crowd, but all 'wisdom of the crowd' activities are crowdsourcing.
Citizen science	Non-professionals conducting science-related activities *(33)*. While crowdsourcing refers to *how* the activity is conducted, citizen science refers to *who* is doing it, and *what* they are doing. Often, crowdsourcing and citizen science are performed in tandem.
Health 2.0	The use of Web 2.0 technologies to actively participate in one's health *(33)*. These could facilitate crowdsourcing (for example, through using wearable sensors to transmit data en masse), but may also be used individually for personal tracking.
Open-sourcing or peer production	Open sourcing is the development of data or materials that will become freely available, where there is often no clear 'call' to work. In crowdsourcing, an organization would initiate the work *(15)*.
Outsourcing	Crowdsourcing can be defined as a niche form of outsourcing *(2)*. However, unlike outsourcing more generally, there is no contract for crowdsourced work *(9)*.

5.2.3 Use of crowdsourcing in health research and emergency situations

Although, as noted above, some have argued that crowdsourcing has not been used to its full potential *(5–9)*, there are several notable examples that show the power of this innovation.

For instance, BioGames, uses the power of large crowds and gamification to analyse malaria smears. An online game, accessible via an Android device or computer, was created. The game has players 'kill' malaria parasites on blood smears using a syringe and collect healthy cells, after a short tutorial. Gamers have been able to reach 99% accuracy *(34–35)*. An educational version of this game was also created, which used a diagnostician to provide feedback to the gamers. In this version, gamers were more easily able to identify infected cells than healthy ones. The authors suggest that in future, gamers or machine-learning algorithms could pre-screen positive or negative marked cells and send questionable ones to experts for diagnosis *(36)*.

The OpenZika Project called for people around the world to volunteer their spare computing power, helping the project run simulations of potential drug candidates for Zika *(37)*. By using computing power from volunteers around the world, this project ran 92 000 simulations. All data from this project is open access.

Crowdsourcing is often used for disease surveillance in emergency settings (Chapter 2.2). Several open-source participatory epidemiology programmes exist, including Frontline SMS and Ushahidi. Participatory epidemiology is the use of people to gain epidemiological data (and is, by definition, a form of crowdsourcing). Frontline SMS enables users to request needs, such as supplies and logistical challenges, via SMS. It has been used in Malawi, Burundi, Bangladesh, and Honduras. Ushahidi creates individual reports using web, SMS, and email, which are classified, translated and geotagged *(19–20, 38)*. Ushahidi was initially created to respond to election violence in Kenya, but has since been used in many countries around the world, and most famously, to respond to the aftermath of the Haitian earthquake, as described in Case Study 5.2.2.

Case Study 5.2.2
The use of Ushahidi in Haiti

In January 2010, a 7.0 magnitude earthquake struck Haiti causing mass destruction in populous areas. Ushahidi, an open-source crowdsourcing platform, was deployed within four days of the earthquake. It provided vital information to responders. Ushahidi opened an SMS service for Haitians to text their needs, including food, aid, and medical needs, to a free SMS number, which was visualized geographically using cell phone tower triangulation, Google Earth, and Google Street Maps. Reports were triaged, and volunteers were able to text back. Translation was done by volunteers. Over 25 000 text messages were received. Of these, almost 3 600 were actioned, most relating to needs for vital services *(20, 39)*.

Other recent examples of Ushahidi's use include reporting violence after the US election, sharing geolocation information for flood help in Chennai, reporting earthquake damage in Puebla, Mexico using geolocation and photos, and tracking logistics after a terrorist attack *(38–41)*

In humanitarian or disaster relief settings, perhaps the most common use of crowdsourcing is for mapping. Ushahidi, Frontline SMS, Missing Maps and Humanitarian Open Street Maps either create maps for disaster preparedness or are able to work with crowdsourced maps (such as Open Street Maps) to enhance mapping capabilities, and to use these in coordinating a response. In many countries prone to disasters, there may be a lack of accurate maps containing basic geographic information, so efforts to create accurate maps in advance can be essential to responding effectively (see Case Study 5.2.3) *(38, 41)*.

Case Study 5.2.3
Open Cities for disaster risk management in Nepal

In addition to being one of the countries most exposed to natural hazards, the majority of houses in Nepal's capital, Kathmandu, do not meet minimum requirements for earthquake safety. As a proactive approach, local stakeholders in Nepal began using Open Street Map in 2012 to collect exposure data and map schools and health facilities. In Kathmandu 2256 schools and 350 health facilities were mapped. In April and May 2015, two high magnitude earthquakes hit Nepal. While these halted the initial Open Cities project, the existing information was crucial in informing humanitarian responders and supporting recovery efforts *(42)*.

MoBuzz, a participatory epidemiology application to combat dengue in Sri Lanka, is a good example of a multi-component crowdsourcing application. It uses predictive surveillance, civic engagement and health communication to reduce the exposure of the Sri Lanka population to dengue. The application uses predictive technology and machine learning algorithms to determine weather, vector and human data and produce hotspot maps for public and health officials. Civilians are engaged to report breeding sites, symptoms and bites, which are in turn reflected on the hotspot map. Finally, this information is communicated widely to the public and health officials *(43)*. Similar campaigns to this, or that reported more recently by Bartumeus and colleagues *(44)*, could be employed in emergency situations using this as a model.

Geographical sciences have also used crowdsourcing and these applications could be easily adapted for use in Health EDRM. One application, Sapelli, has successfully used citizen science and crowdsourcing to map poaching in sub-Saharan Africa through icon interfaces on a smartphone application *(45–46)*. The Sapelli application is icon-based and suitable for use by people with low literacy. It, or a similar application called CyberTracker *(47)*, and their underlying participatory methodology, could be tailored to report a variety of relevant health outcomes, such as disease monitoring, water and sanitation hygiene risk factors, or violence.

5.2.4 What to consider when designing a study using crowdsourcing

When designing a research study that will use crowdsourcing, there are several factors to consider, as discussed below.

Crowd composition and crowd knowledge
It is important to consider what type of crowd is needed to conduct the task. For example, the task might require specialist knowledge (such as when gathering expert or specialist opinion), or might rely on information from laypersons. Health-related crowdsourcing exercises requiring specialist knowledge include Innocentive or Crowdmed, where complex pharmaceutical or medical problems are crowdsourced by a large crowd, and the winner is rewarded with a large sum of money. Laypersons can be extremely accurate at problem solving or conducting crowd processing tasks, such as in the case of BioGames, or for GIS solutions that require large numbers of people to report and map locations, such as OpenStreetMap. It is also important to consider the diversity of the crowd that is likely to be obtained. The more diverse the crowd, the higher the probability of obtaining a 'smart' crowd *(32, 48)*.

Platform to host the call
It is important to consider the platform to host the call (or semi-open call, if choosing an expert call) for crowdsourcing submissions. Globally several platforms exist to reach laypersons, such as Amazon Mechanical Turk and Crowdflower, and other software such as Ushahidi is at least partially open-source *(38, 41)*. If people affected by the emergency are being targeted, it will be important to consider whether they are able to access the platforms without difficulty (for example, they may have limited access to mobile phones or computers with internet connections). Applications that can be considered include SMS (which may be most appropriate for those impacted), specialist data collection tools (such as using Open Data Kit) for first responders, or OpenStreetMaps for remote helpers. Finally, it is important to consider whether the data generated from the chosen platform is comparable with current data management and storage systems, and whether these can be merged if desired (*49)*.

Crowd accessibility
The accessibility of the crowd is an important consideration. For example, the crowd may be located in a hard-to-reach area. If the target population is difficult to access, this may be challenging when advertising the call using word of mouth, online advertising or targeted enrolment. There may be barriers to entry, such as cultural sensitivities, or challenges related to reaching specialist communities with the needed knowledge (for example, diaspora communities with the ability to read messages from the affected population).

Remuneration
Crowdsourcing in humanitarian settings primarily uses volunteered information. However, the use of platforms such as Amazon Mechanical Turk to process tasks (such as annotating images) may require some remuneration to the crowd. If members of the crowd are to be paid for their contribution, it is important to consider that the study or programme may receive many submissions over a short period of time and a pilot study may be helpful for adequately predicting and budgeting for submissions.

Desired output

As with any research study, a study or programme that will use crowdsourcing needs to have a clear question or purpose (Chapter 3.5). This would include careful consideration of the type of task and the best way to combine submissions (for example, aggregation or selection of the best submission). There may be ethical issues (Chapter 3.4) relating to the sensitivity of the data to be collected (for example, data on violence experienced, corruption) and care will be needed in how such data are collected, processed, stored and analysed.

Advertising the call

When considering the advertisement of the call it is essential to ensure that the right crowd is reached effectively. The call could be issued through a mass media campaign, word of mouth, or targeted enrolment – it should be considered which of these is most likely to reach the target population. Important factors include literacy, local customs and culture, and the reach of different media modalities.

Study design and analysis

In determining whether crowdsourcing is appropriate for a particular study, the balance between precision, speed and cost must be considered. It is also important to be confident that crowdsourcing is an appropriate way to generate a reliable answer to the research question.

Quality Assurance

Methods for quality assurance in crowdsourcing studies differ from those in traditional studies. Often, it is important to obtain multiple measurements of the same thing, and to triangulate these to verify one another. In addition, surveys might need to include questions designed specifically to identify 'malicious participants' (such as those who are answering survey questions at random).

5.2.5 Conclusions

Crowdsourcing is a method that uses crowds to solve problems, whether it be through harnessing knowledge of large numbers of people, capitalizing on a group of people's unique positioning to a problem (for example, through GPS-tagged submissions), or the sheer volume of a crowd and its ability to process information at a rapid scale. Existing crowdsourcing platforms are available, such as Ushahidi. Designing a programme, response or study that uses crowdsourcing will require initial thought and understanding of the questions being answered, the population forming the crowd (and how best to reach them), and whether it is the optimal method, considering trade-offs such as precision in reporting to time and cost. Crowdsourcing has been used in disaster response, and examples from outside the humanitarian context can be adapted to Health EDRM. When it is the appropriate methodology, crowdsourcing can reduce costs and improve response time, making it particularly well suited to emergency or humanitarian situations.

5.2.6 Key messages

- **Although crowdsourcing is still a nascent field, it has huge potential for Health EDRM *(4, 5, 50).***
- **Crowdsourcing can be a low-cost, rapid alternative to traditional data collection methods.**
- **There are several different problems that crowdsourcing can be used to solve, including crowd processing, crowd rating, crowd solving, and crowd creation.**
- **Several open-source applications exist which can be used for crowdsourcing studies.**

5.2.7 Further reading

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