Supplemental Material 3. Long-form methodological guidance for implementing crowdsourcing challenge contests.

Crowdsourcing challenge contests in public health and medicine: Methodological guidance for implementation and research

Background

Traditional approaches to intervention development typically involve experts collaborating with each other to develop programs for members of key populations with limited input from the public. These approaches often lead to interventions that have limited long-term success, low potential for community-level sustainability, and/or have insufficient levels of community engagement. To address these key concerns, researchers have sought more creative approaches to engaging diverse stakeholders in public health research to improve outcomes and strengthen community buy-in. Crowdsourcing, which involves experts and non-experts collaborating to solve a problem and sharing the solution with the public, is garnering increased attention from researchers and policy-makers due to its collaborative nature and engaging methods [1]. This process encourages creativity and innovation because a large group of people can contribute diverse solutions [2].

Crowdsourcing approaches have been used to increase HIV self-testing among sexual minority men [3], map the placement of automated external defibrillators at various locations within a large county in the United States [4], and solicit ideas for interventions aimed at increasing hepatitis testing [5]. Compared to expert-driven approaches to problem-solving, crowdsourcing may have lower costs [6], produce quicker results [7], and lead to transdisciplinary solutions [8]. There are several approaches to crowdsourcing, including open contests, hackathons, open forum, and data extraction from social media platforms; however, we lack consensus in the field regarding the key stages involved in developing, implementing, and evaluating crowdsourcing processes. This lack of consensus hinders crowdsourcing research and programs in a number of ways, including limiting our ability to compare research findings across studies. In this article,

we share suggestions regarding optimal methods for conducting crowdsourcing contests in health and health research.

Stages for conducting a crowdsourcing contest

This section is divided into the steps recommended by the The Special Programme for Research and Training in Tropical Diseases (TDR) practical guide on crowdsourcing in health and health research [1], which include: determining whether crowdsourcing is an appropriate approach, organizing a steering committee for a crowdsourcing contest, engaging the community, receiving and evaluating contest contributions, sharing outputs from crowdsourcing contests, and recognizing contributors.

Stage 1. Considering the appropriateness of challenge contests

Determining which category of crowdsourcing is best suited to answer a particular research question is key to leading a successful contest. While there are no absolute requirements for crowdsourcing, its implementation may be more appropriate when certain conditions are met, including: having the ability to mobilize diverse networks, selecting a topic that can garner support among community advocates, and developing a contest that is feasible and realistic.

Categories of crowdsourcing

There are three major categories of crowdsourcing: contests, hackathons, and online collaboration systems. Contests are competitive processes in which an individual or entity presents a problem to the public to solicit creative approaches to solving the identified problem [9]. In the past, crowdsourcing contests have been used to develop health messages, inform health policy, and enhance medical diagnostics [9]. Hackathons bring together individuals for a

short amount of time with the purpose of furthering a common goal [10]. In healthcare, hackathons have been used to develop medical technologies [11] and design m-health interventions [12]. Online communities act as collaborative systems by allowing individuals to connect via a virtual platform and exchange knowledge and information [13]. Online collaboration systems have been used to develop a mobile application to train volunteers to identify, locate, and respond to people in the community who were experiencing a suspected out-of-hospital cardiac arrest within a 500 m radius of their location, resulting in a reduction of deaths from out-of-hospital cardiac arrest [14].

Contests, hackathons, and online collaboration systems vary by their organization, duration, and prize structure. When determining whether to use crowdsourcing, an individual or group should decide which approach would be the most appropriate considering a project's goals, resources, and intended outcomes. Table 1 highlights important considerations and distinguishing factors that could assist one in selecting the approach that is best suited to solve a given problem.

Table 1. Contests, Hackathons, and Online Collaboration Systems

Method	Definition	Participation Platform	Duration	Prize Structure
Contests	Open prize challenges where a call is issued to the public and then contributions are solicited and evaluated	In-person or online	Longer duration (weeks/months)	Prizes awarded
Hackathons	Events where a diverse group of individuals are brought together to advance a common goal	Usually in-person	Shorter duration (a few days)	Prizes awarded
Online Collaboration Systems	Online platforms that allow individuals to exchange and share contributions and ideas	Online	Permanent	Prizes not typically awarded

Engaging diverse networks

Crowdsourcing can be more effective in settings where there is a mechanism to engage diverse networks of individuals to contribute. In this context, "diverse networks" can be broadly defined as individuals with a wide array of economic, social, cultural, and educational backgrounds [8]. Often, crowdsourcing is able to mobilize diverse populations that are under-engaged in research, including ethnic and sexual minorities, and individuals with disabilities. If organizers do not explicitly make efforts to engage members of underrepresented populations, they run the risk of limiting the scope of a crowdsourcing activity. For example, a crowdsourcing contest that is promoted solely through an online platform may limit responses from individuals who do not have internet access. However, if the target population for the contest frequently engages in activities online, then a virtual contest may be most appropriate.

Advocates for the cause

Another factor warranting consideration is whether there are advocates for a cause within a community. Advocates are typically people who have been directly impacted by the issue or who hold a strong interest in the topic. For example, in a crowdsourcing contest focused on HIV, advocates for the cause could include people living with HIV, healthcare providers, clinical research scientists, health policy experts, and those affected individuals. Moreover, contests may achieve higher levels of participation if community members view advocates as personally invested in the cause, particularly when they have tacit knowledge, work experience, or related training.

Crowdsourcing feasibility

A final element to consider is whether the request being made of potential participants by the crowdsourcing activity is feasible with regard to the targeted crowd's ability to contribute. Crowdsourcing activities that solicit text messages, memes, images, and short videos may draw larger crowds and a higher number of contributions. Additionally, complex and deep learning algorithms can also be crowdsourced; however, participation will largely be limited to individuals or groups with highly specialized or technical skills, and would require a prize structure and governance framework to sufficiently incentivize participation given the demands of the activity. Lastly, the amount of time needed to participate in the crowdsourcing activity is another element to consider when assessing whether and what form of crowdsourcing is appropriate for a given study or program. For some potential participants, the time commitment may be a limiting factor.

For the remainder of this article, we outline the processes entailed in designing and implementing crowdsourcing contests. These guidelines are grounded in the expertise and experience of individuals who have implemented contests to address an array of issues in health and medicine.

Stage 2. Organizing a community steering committee

Upon deciding that a crowdsourcing contest is the best approach to solving a particular problem, the next stage involves convening a steering committee [1]. The main function of a steering committee is to provide leadership and guidance for the contest. While contest organizers are responsible for clarifying the roles and responsibilities of the steering committee and defining key stakeholders, the steering committee is responsible for establishing the purpose of the contest

and assisting in the creation of a call for contributions. Forming a competent steering committee is a prerequisite for running a successful crowdsourcing contest and there are a number of ways to do this. For example, during a designathon that sought to engage community members in the design of a public health program [15], the following steps were used to select and organize a steering committee: 1) identify organizations that could host the contests (e.g., a non-governmental organization or a university); 2) invite local professionals in public health, communications, design and civil society to serve on the steering committee; 3) hold regular steering committee meetings to discuss the scope, rules, and prize structure of the contest; and 4) widely disseminate the call for contributions to identify potential participants. Despite variation in this process from project to project, the following steps are generally recommended for effectively organizing a crowdsourcing contest steering committee.

Clarifying roles and responsibilities

The first step of organizing a steering committee is to identify hosts and partners of the contest. Host organizations need to have diverse networks and some communication capacity to enable coordination [1]. These networks can help distribute the call for contributions and share solutions. Health-focused crowdsourcing contests have been organized by universities, public health agencies, community-based organizations, UN agencies, and private companies. The host organization is typically responsible for the administrative and logistical aspects of the contest, including promoting the call for contributions, contacting venues, and preparing related materials. Partner organizations are not necessary, but can help to identify steering committee members and build momentum.

Clarify the purpose of the contest

The steering committee clarifies the purpose and structure of the contest. Contests are often divided into two types: outcome-oriented contests and process-oriented contests. Outcome-oriented contests usually focused on soliciting highly innovative contributions. For instance, in one study, the team used an online, multiphase crowdsourcing contest to solicit ideas regarding the development of machine learning algorithms to segment lung tumors in preparation for radiation therapy thereby addressing the global shortage of expert radiation oncologists [16]. Process-oriented contests are organized to enhance broad community engagement and reach larger numbers of people [2]. One example is CrowdOutAIDS, a participatory online policy project launched by UNAIDS that focused on developing a strategy to better engage youth in decision-making processes related to AIDS. This enabled young people to engage in an open and horizontal process by allowing them to debate issues related to HIV and sexuality [17]. Many contests have an interest in both generating a high-quality outcome and widespread engagement, but understanding the overall aim can help to shape the contest. In addition, clarifying whether the contest will be organized as a research study or an educational/engagement program is important, as research-based contests tend to place emphasis on improving knowledge on a particular topic, whereas other contests are focused on programmatic objectives.

Identify steering committee members

The steering committee should be comprised of key stakeholders who: 1) have an interest in the topic of the contest; 2) are local community members, health professionals, community-based organization (CBO) leaders, or private sector leaders [1]; and 3) have breadth and depth of experience in core disciplines or fields of interest. In addition, a steering committee should include individuals of different genders and people from different regions. Input from members

of underrepresented groups is also important in terms of organizing a steering committee [9]. For example, a contest focused on gay men and health behaviors should include gay men and healthcare providers, as well as other stakeholders, including local CBO leaders and researchers. A sample invitation letter for a steering committee is included in Appendix A.

Create a call for contributions

A well-designed call for contributions can attract potential participants and ensure that they understand the purpose and requirements of the contests, which will lead to quality contributions. The host organization typically creates an initial draft call for contributions. This draft is shared with the steering committee for feedback. The steering committee meets on a regular basis to discuss the scope, purpose, rules, and prize structures of the contest [15]. Roles and responsibilities of hosts, partners, and the steering committee are listed in Table 2.

Table 2. Different roles/responsibilities of institutions

	Roles/responsibilities
Host organization	1. Identify partner organizations 2. Identify potential steering committee members 3. Create a first draft call for contributions (including prize structure)
Partner organizations	1. Identify potential steering committee members 2. Disseminate a call for contributions
Steering committee	1. Provide leadership and guidance for the contest 2. Clarify the purpose of the contest and determine the structure of the contest 3. Provide feedback on the call for contributions; 4. Finalize the prize structure

A call for contributions first provides an overview of the contest and then clarifies its purpose. It also identifies the target audience of the contest for potential contributors. Detailed guidelines/requirements for contributions can be listed in the call for contributions, such as word limits or video file size limits. Judging criteria should be clearly described in the call for contributions. The timeline of the contest should also be highlighted, and usually includes the deadline for contributions and the date when the results will be announced. Including information on contest prizes is another essential component of a call for contributions, because an appropriate prize structure can motivate individuals to participate. In some cases, frequently asked questions (FAQs) are included in the call for contributions. In most cases, the call for contributions should avoid providing exemplars of contributions to avoid cognitive fixation [1].

Establish the prize structure

Selecting an appropriate prize structure is essential for encouraging participation and achieving outcomes [18]. The steering committee should consider what may motivate potential contributors to participate, what type of support and resources they have, and determine the level of risk associated with contributing to the contest [19]. Process-oriented contests provide a relatively large number of prizes in order to expand engagement and participation. On the other hand, outcome-oriented contests have a smaller number of larger prizes [2]. An official commendation from the contest organizers or an opportunity to receive mentorship can be excellent prizes. Unless there are teams competing for prizes, we recommend that organizers avoid cash prizes [19]. Several studies have shown that intrinsic benefits of participation like mentorship and commendation are highly valued by participants compared to extrinsic benefits like cash prizes [20]. There should also be some flexibility based on the quality of the contributions and the time

invested. For example, a steering committee may decide that two exceptional submissions both receive a first prize award.

Stage 3. Promoting the challenge contest

Community engagement can enhance communication, facilitate information exchange, and spur innovation [21-23]. We define engagement as the process of working collaboratively with relevant partners who share common goals and interests [24]. Community engagement is particularly important in crowdsourcing contests, as it facilitates more contributions and may also assist in disseminating the contest results, which could lead to the diffusion of health information among relevant stakeholders. Additionally, engagement provides stakeholders with an opportunity to contribute local wisdom and learn about their own health [25]. It enables the community to have voice and exercise their power, and holds policy makers accountable to meeting the needs of their beneficiaries [26]. When done well, community engagement builds trust between the institutions and the public. At its best, public engagement can spur systemic changes in policy or practice.

Community engagement messages

Most people are unfamiliar with crowdsourcing contests and will need a clear description of the purpose, expectations, and rules. Although there are many private companies that organize contests, we generally recommend using a simple website to communicate with potential participants about the contest. The website shows the public all information related to the crowdsourcing contest, including an overview of the contest's aims, timeline, target group,

guidelines for submissions, criteria for judging, prizes, FAQs, and partners. Infographics and short videos can help move beyond expert audiences to engage the public.

Visual media

Infographics are visualizations of data or ideas that convey information to an audience in a manner that can be easily understood [27]. Infographics require less cognitive demand compared to text, expanding the potential audience. Another advantage of infographics is that they can be easily shared within in-person or online networks. Infographics have been shown to improve individual's knowledge, particularly in low-literacy groups [28]. Examples of video approaches to communicating contest information include a whiteboard time-lapses, filmed interviews with investigators, and short animations, all of which can be effective at reaching a broad audience and drawing attention through a rich visual experience and detailed descriptions. It is easy to share videos on social media, and helps to personalize and contextualize the contest as well as inspire excitement and trust in the legitimacy of the contest. However, it requires more skills to produce and edit a video compared to an infographic.

Approaches to community engagement

In-person events

Research on challenge contests suggests that in-person events play an important role in engaging the community [29]. A study evaluating a crowdsourcing contest that used both in-person and online promotion showed participants were twice as likely to learn about crowdsourcing contests through in-person events compared to online ones [30]. Disadvantages of in-person events include needing to coordinate with the hosting institutes and to spend more time explaining the

context of the contest for a general audience. Table 3 provides examples of how in-person events could be implemented as engagement strategies for crowdsourcing contests.

Table 3. Several forms of in-person events

	Event type	**Examples**	**Contest Examples**
	*Planned smaller events*	Lab meetings, research conferences, works-in-progress meetings, seminars	Promote the contest in collaboration with a research laboratory meeting
	*Planned larger events*	Feedback session in a public space, a booth in a public space	Promote the contest at a large football stadium or sporting event
	*Locally driven events*	Co-creation workshop in coffee bars or other community spaces.	Speed-friending event at a local community-based organization

Social Media

Social media can also be used to promote community engagement related to crowdsourcing contests [31, 32]. Well-crafted social media messages can rapidly move through the internet, or go viral, and reach large groups of people. In addition, emails and newsletters can embed images and links to videos, accelerating dissemination of the call for submissions through pre-established networks. Capturing the attention of the audience is key to the effectiveness of health promotion activities. Several research studies, for example, suggest that social media posts with emotionally upbeat titles are more likely to attract readers' attention [33, 34]. Moreover, including a good quote or story from the local community can make the contest personal and spark curiosity. It is also important to highlight features that differentiate contests from each other to assist potential contributors in deciding whether to participate. For example, the opportunity for commendations and mentorship offered by one contest may be more appealing to

individuals early in their careers or for those seeking to brand their businesses, while a higher cash prize may be more appealing to those with financial motives [18].

Other promotion approaches

Concurrently, inequities built into social media networks must also be considered. People's access to social media is widely variable. Crowdsourcing contests can make accommodations for people without social media access and those who are less connected by additionally utilizing low-tech participatory approaches [35]. Low-tech ways to promote contests include text messages, radio station announcements, and word-of-mouth promotion through tribal councils and/or other local organizations.

Stage 4. Assessing contributions

Assessing contributions requires careful consideration of an array of factors pertaining to the category of contest, accessibility, and the need to identify exceptional finalists. Below we explore the various platforms for receiving challenge contest contributions and provide guidance on how to implement an effective evaluation process.

Receiving contributions

Challenge contest organizers must consider how contributions to the contest will be received: will contributions be submitted online, offline, or a combination of both? Consider the context of the contest and which options are available to contest contributors. For some contests, receiving in-person contributions may be the most appropriate option. An in-person approach is best when creating a contribution requires little time and inconvenience on the part of participants (e.g., a

contest involving a brief survey of community members' ideas on how to improve a particular health service). In-person contributions are typically solicited via 'in the moment' participation, which can involve either approaching potential contributors directly, or directing contributors to a station where trained facilitators are present to explain the contest, obtain consent, and receive submissions. Figure 1 depicts an example of the latter scenario.

Figure 1. An example of an in-person strategy for receiving crowdsourcing contest contributions. This contest sought community ideas for improving HIV clinical trials. The contest booth was stationed at a public celebration for HIV Cure Research Day. Potential participants approached the booth where a contest facilitator (shown here) explained the contest, obtained written informed consent, and collected contributions in response to the contest prompts. In this case, contest contributions were displayed as they were received in order to prompt reactions and/or additional participation from event attendees as they walked by throughout the event. Small tokens of appreciation (e.g., colorful bags of assorted candies) were offered to anyone who submitted a contribution, helping to attract further interest in the contest booth among event attendees.

Receiving contributions in-person can be a beneficial approach for many reasons, including providing potential contributors with an opportunity to ask questions about the contest and receive answers immediately. Facilitators' enthusiasm for the contest can also help to encourage a greater number of participants to engage with and contribute to the contest, as well as help build trust in the contest [1]. Additionally, facilitators can help to make the contest more accessible for persons that may otherwise experience barriers to participation; for example, they can explain contest rules, read consent forms, and record contributions for persons with literacy/language challenges or mobility issues. There are, however, some limitations to using an in-person submission platform, primarily in terms of contest resources and reach. Staffing contest submission stations will require an appropriate space and/or event in which to host the station, and facilitators will need to be trained to effectively solicit contributions from potential contributors. Additionally, if the contest is limited to receiving contributions in-person only, the potential pool of contest contributors is subsequently limited to those who happen to be in the vicinity of the contest station or booth.

For some contest topics, receiving contributions exclusively online may be the best approach, particularly when the contest requires a substantial time commitment to create a contribution, or for contests in which the solicited contribution format is most amenable to digital submission. For example, using an online receiving platform would be the most efficient choice for a challenge contest seeking video contributions, as videos can be readily uploaded and submitted from any location with internet access. An additional benefit to receiving contributions online is that recording and sorting contributions can be quickly and easily accomplished. There are,

however, some drawbacks to an exclusively online platform for receiving contributions. While online submission of contributions can make contest participation more accessible for some (e.g. persons with physical disabilities who may otherwise be missed at in-person contribution opportunities), there are still accessibility issues to consider with an online platform. For example, limiting a contest's receiving platform to only online contributions should be used with caution in regions with lower literacy levels and limited internet availability. According to a World Economic Forum report, over four billion people, mostly in developing countries, do not have Internet access [36]. There are also logistical aspects to consider when receiving contributions through an online platform. While various online channels may be used to reach broad groups of audiences for promoting the contest (e.g. advertisements linking to the contest on websites, social media platforms, newsletters, etc.), it is important to ensure there is only one online contribution receiving platform. To avoid contributions being submitted through multiple online channels (e.g. email, private messaging, etc.), ensure that all contest advertisements provide the same link for uploading contributions and clearly state that contributions should be submitted via this method. Moreover, once the contest has closed and contributions are no longer being accepted, contest organizers will need to close down the online submission form and provide a notice that the deadline for contributions has passed. This is an opportune time to additionally note the timeline for when the contest finalists will be decided and announced.

Given the potential opportunities and drawbacks of in-person and online receiving platforms, it is recommended that crowdsourcing contests include a mix of both online and in-person opportunities to receive contest contributions wherever possible [2]. For example, in-person promotional events may present an opportunity (depending on the contest topic and type of

contributions sought) to physically collect contributions from event attendees. Contest organizers can then add these contributions to those received through the contest's online receiving platform.

Organizing received contributions

Regardless of whether contributions are received in-person or online, one must keep a record of each submission. Maintaining a well-organized database of received contributions is critical not only for the process of reviewing and evaluating individual contributions, but also to obtain an overall assessment of the contest's effectiveness (e.g. number of contributions, demographics of participants, etc.). Unless a very large number of contributions is anticipated to result from your contest (which will depend on contest type) a simple spreadsheet will suffice to keep track of contributions and their subsequent evaluations. The rigor of this process is important for maintaining the trust of contributors, as well as for ease of tracking contributions and providing evaluations to judges for the evaluation process.

Evaluating contributions

Once all contest contributions are collected and the contest deadline has passed, they are then evaluated by a panel of judges to determine the finalists. There are several aspects to consider in the evaluation process.

Identify contest judges

Typically volunteers who have expertise or experience in the topic, are directly impacted by the issue, or are otherwise interested could be judges. The judging panel often consists of a mix of experts, laypersons, and members of the contest organizing committee [1]. Potential judges should be identified and approached in advance of the contest closing date to ensure a timely

evaluation process. Provide potential judges with an estimate of the time commitment that would be needed, the deadlines for providing evaluations to the contest organizers, and a summary of the judging criteria to enable them to assess their ability to commit to the judging process. Judges with a conflict of interest will recuse themselves from reviewing submissions during this stage. Estimate the number of judges needed to have a sufficiently large enough panel so that each contribution can be assessed by three independent reviewers.

Judging process

Once the panel of judges has been identified, the next step is to provide them with full instructions to evaluate contest contributions and the format for providing assessments/scores. These instructions should be developed and sent to judges before the judging process begins to expedite the evaluation process, and should include an overview of the goals of the contest, the evaluation rubric, and evaluation form. When using a point-based evaluation rubric (i.e., assigning each contribution a score on a numeric scale), it can be helpful to provide the judges with descriptions of what low, moderate, high, and exceptionally high scoring contributions would contain. Providing space on the evaluation form for judges to make optional notes or comments can also be useful if judges need to communicate additional information about the submission to the contest organizers and contributors.

The quality of crowdsourcing submissions can vary broadly, resulting in both low and high-quality contributions [9]. It is thus recommended to conduct an initial eligibility screening of all contributions in order to remove invalid, incomplete, or duplicate entries before forwarding to the judges, so that judges spend time assessing only those contributions that meet the contest criteria [1]. When there is a smaller number of contest contributions (typically fewer than 200),

panel judging can then occur after this initial screening. Ensure that a master record is kept of which contributions have been sent to which judges in order to easily consolidate evaluations as they come in from panel members. If a contest receives a large number of crowdsourcing contributions (typically greater than 200), the judging process can be conducted using the following three phase process to limit the number of contributions considered for finalist selection [1].

1) Eligibility screening: two independent judges examine the contributions based on pre-specified criteria. Invalid, incomplete or duplicated entries are deleted and do not advance to the next judging round.
2) Crowd judging: a group of laypersons evaluates each eligible contribution using an evaluation rubric. Each contribution is reviewed by three independent judges; only those contributions that meet a pre-determined evaluation cut-off (e.g. the top 10-20% of submissions) will then proceed to the final round of panel judging.
3) Panel judging: a panel of experts and non-experts individually evaluates each contribution forwarded from the previous round of crowd judging, using an evaluation rubric.

Determining the finalists

Once the judges' evaluations have been received, the contest steering committee reviews all evaluations to assess the scores and identify the contest finalists. Judges should be thanked for their assistance and notified when an announcement of the finalists will be made (see Stage 6 below on recognizing contributors). Typically, raw (unadjusted) scores are used to determine

which contributions are the top finalists, with mean score and standard deviation used to assess to assess overall contribution quality; while this information is not typically shared as a part of the dissemination strategy (see Stage 5 below), it can be a useful metric for reporting on the effectiveness of a contest to project funders or in research contexts.

Stage 5: Recognizing contributors

Recognizing contributors and organizers of crowdsourcing contests is critical to contest success and sustained stakeholder engagement. Considering that many contributors and organizers volunteer their time in order to make the contest possible, identifying an appropriate structure to recognize contributors and organizers is critical to organizing an effective crowdsourcing contest. Recognition in the context of a crowdsourcing contest can be difficult given that the organizers bring together experts, non-experts, and many other individuals who have different training backgrounds and expectations. Large variations in the time that people spend contributing to the contest further complicate matters. However, this is an important component of establishing and sustaining crowdsourcing contests. In this section, we describe how crowdsourcing contests recognize contributors, judges, and steering committee members.

Setting expectations

The first step in recognizing individuals is to establish clear expectations for all those who contribute. Among judges and steering committee members, this typically involves ensuring that potential participants are aware that their contributions would be voluntary. The amount of time required of judges and steering committee members varies, but is usually requires less than four hours in total. In explaining this commitment, we often compare it to the time required to

complete a single peer review for a research manuscript at a journal. Among contest contributors, the amount of time required to create a submission should be commensurate with the prize structure. In instances where there is uncertainty, asking individuals who make contributions to estimate the total time spent creating the submission may be helpful.

Determining appropriate recognition for those who contribute to contests is often dependent on the context and potential risks associated with publicly identifying contributors. For example, a contest in which people are asked to provide text-based suggestions regarding how to market HIV self-test kits to men who have sex with men from underserved communities may need to take into consideration local homophobia and the potential for inadvertent sexual orientation disclosure. The form of recognition is determined prior to the launch of the crowdsourcing contest and often in collaboration with key stakeholders, as well as the steering committee. Some individuals may want to participate and not be openly identified with their submissions.

Examples of recognition strategies

Table 6 provides examples of how various participants in a contest can be recognized for their contributions. Contributions to crowdsourcing contests include finalists (those whose contributions were deemed exceptional by judges), semi-finalists (those deemed good by judges), and others. Finalists may be recognized through public announcements using various platforms, including organizational websites, social media platforms, online public fora, and in-person events. There are several benefits to public announcements, including their ability to provide finalists with the opportunity to: 1) gain visibility and notoriety for their contributions towards solving a specific problem, and relatedly, improve their social status through recognition

from diverse audiences, including experts and their peers; and 2) market their skills or talents, furthering their careers. While more attention is given to contest finalists, it is important to acknowledge the efforts of all people who submitted contributions. There are a number of ways to do this, which include sending formal letters or emails notifying contributors of the contest outcome and thanking them for their efforts or listing their names on the study website or contest platform. Written feedback on submissions can also be shared with semi-finalists or finalists, depending on the nature of the contest. In any case, it is important for the steering committee to outline the approach to recognizing participants within the instructions for the contest to enable potential contest contributors to make informed decisions. Public announcements should be timely and occur shortly after the conclusion of a contest. Moreover, terms such as "winner" and "loser" are often avoided to acknowledge the hard work of all contest contributors and encourage future participation.

Table 6. **Potential forms of recognizing individuals who contribute or organize a crowdsourcing contest.**

	Prize	Public recognition	Feedback from professionals on submission	Included in publications*	Certificate of participation	Email of appreciation
Finalists	✓	✓	✓	✓		
Semi-finalists		✓	✓			
Other contributors					✓	
Judges		✓			✓	✓
Steering Committee		✓		✓	✓	✓

*If individuals meet criteria for co-authorship, they could be recognized as co-authors.

Recognizing organizers

In addition, it is also important to acknowledge the efforts of the judges and steering committee members because their participation is critical to the success of the contest. For some judges and steering committee members, a formal commendation can help with promotion and career advancement. Figure 2 shows a sample certificate that was given to a steering committee member of a challenge contest. Including selected judges and steering committee members on peer-reviewed publications that result from crowdsourcing contests can also recognize their contributions. Recognizing those who contribute and organize crowdsourcing contests is essential to their success. However, the approaches and examples that we have suggested above should be appropriate for the local context.

Figure 2. **Example certificate for judges**

Stage 6. Sharing and implementing ideas

One of the most important stages of community-engaged research projects is the process of sharing results, and there is need to emphasize the importance of dissemination beyond scientific

publication [37, 38]. The main aim of the dissemination stage in crowdsourcing contests is to share with others the knowledge produced through crowdsourcing and/or to implement crowdsourced ideas [39]. Sharing in crowdsourcing is contest-specific, and the particular audience/setting to which the information/outcome is directed may determine the sharing method. However, there are some general guidelines and key stages to follow when considering how to report and spread contest results. One of the most important things to consider when sharing outputs is the purpose of the challenge. Crowdsourcing contests vary in their mission; for example, some challenges aim to deliver an actionable outcome to a specific community. In other cases, the contest is organized simply to raise awareness with regard to a particular issue. Some barriers to effective sharing include institutional priorities and organizational culture, practical difficulties, and other technical and infrastructural barriers [40].

Rationale for sharing or not

There are several strong reasons to widely share the outputs of a crowdsourcing contest. First, crowdsourcing involves soliciting outputs from a group of individuals and sharing allows the organizers to give back to the group who made the project possible. In addition, there is an ethical obligation to share widely. Often crowdsourcing projects are supported by public funds, enroll local participants, and are sanctioned by local public authorities. The ethos of crowdsourcing contests encourages wide sharing of selected contest outputs as a way to give back to those whose efforts and collaboration made the contest possible.

Despite the strong rationale for sharing, there are also many factors that may limit this process. Some submissions to contests include private information about those who submit or other individuals, which could have consequences for participants if sharing includes identifying the

individual(s) who made contributions to the contest. For example, a social media post that clearly identifies a contest participant as gay could have implications for that individual in the context of homophobic environments. Measures must be taken to ensure that appropriate consent is obtained before sharing, as well as clear communication with contest participants regarding what information will be publicly shared post-contest. In terms of research, scientists may be concerned with widely sharing materials that may interfere with trials.

Types of sharing

At the end of a crowdsourcing contest, finalists' contributions can be shared with the public in different ways. The first stage is to specify an appropriate audience and select relevant ways of sharing. Sharing could include creating an open access websiteto display the contest results, presenting the contest results at a public meeting and inviting community stakeholders to attend, developing a white paper to inform policy, or implementing a program based on contest results. Below we describe in detail a variety of common formats for sharing contest results and the processes to consider during implementation.

Online sharing

Online sharing could encompass sharing via open access, social media platforms and/or other digital repositories. For example, a team could create a simple website reporting the contest and its results (see Table 4 for an example); exceptional entries can be archived and the link to the site shared widely with relevant networks. Oftentimes, infographics are created about key findings from the contest to be shared online using social media platforms (e.g. Facebook, Twitter and LinkedIn). There are also places to publish online without associated fees (e.g., Medium).

Table 4: The UJMT Fogarty Global Health Fellows Program Contest	
The UJMT Fogarty Global Health Fellows Program Contest employed online dissemination for contest results and outcomes using social media channels	
Contest Purpose	To increase interest in the UJMT programme by engaging UJMT partners (in-country collaborators, fellows, alumni, and others) to reflect on their experience and create messages to showcase the program. The results will be used in order to further promote the UJMT program
Target Audience	Potential applicants to the UJMT program
Sharing Platform	Facebook (https://www.facebook.com/FogartyGlobalHealthFellows)
Contest Website	http://www.seshglobal.org/UJMT-Contest

Professional conferences and journal sharing

Professional conferences and academic journals provide an avenue to share with other researchers. In this case, the contest process and outcomes would be written as a press release or research paper/communication brief in a relevant journal. Once published, the article may be shared on various social media platforms, or within relevant newsletters or email listservs. An abstract of the project can also be submitted for an oral or poster presentation at appropriate conferences or other relevant events. However, it is notable that professional society conferences and journals have limited ability to reach public audiences.

Sharing with policy-makers

Some contests are designed to directly inform health policies. For example, the hepatitis testing innovation contest identified descriptions of hepatitis approaches to support local programs and inform WHO guidelines on hepatitis B and C testing. The contest solicited descriptions and

exceptional contributions were then included as best practice cases in the 2017 World Health Organization Hepatitis Testing Guidelines [5].

Sharing through implementation

Another form of sharing the outcomes of a crowdsourcing contest is to implement the outcome of the contest or pilot programs in real settings (see Table 5 for an example). Here the key contest findings can be pitched as an idea to stakeholders in the relevant organizations.

Table 5: The diagnostics and AMR clinical case contest	
The Diagnostics AMR Crowdsourcing Contest led to the development of an educational resource that is being piloted for implementation.	
Purpose:	To create open access online learning resources on diagnostics and AMR using a challenge contest to crowdsource clinical cases on AMR/diagnostics
Target Audience:	Medical students, physicians, healthcare providers
Sharing Platform:	**CME Module**
Outcome:	Learning module was created
Contest Website	http://www.seshglobal.org/DiagnosticsAMR2018
Next steps:	Pilot finalized version of the module among physicians

Stage 7. Evaluating challenge contests

There are three primary ways in which crowdsourcing contests are evaluated: 1) qualitative/descriptive methods, 2) meta-synthesis, and 3) randomized controlled trials (RCTs). Qualitative or descriptive evaluations are typically used to assess the impact, effectiveness and/or reach of a crowdsourcing activity itself. Descriptive assessments may include of the number of

website followers, the amount of online traffic, the number of individual hits that the website receives regularly, or the number of social network connections among unique service users [5, 29, 41]. Qualitative evaluations can include thematic analysis of the content of all contest contributions, enabling the research team to examine the content of contributions to inform hypotheses or solve key problems. Qualitative evaluations tend to be more flexible, as they can be designed to be context-sensitive and specific. Meta-synthesis, which involves integrating the results of different qualitative studies on the same topic, has also been used to evaluate crowdsourcing. It is largely used to interpret the results of previous studies to provide direction for future research [42]. Lastly, RCTs are used to assess the effectiveness of crowdsourcing interventions when compared to more traditional methods. One study, for example, evaluated an online, peer support intervention designed to promote evidence-based techniques and use crowdsourcing to identify participants and solicit feedback from a wider group [43]. While considered to be the gold standard evaluation method, RCTs are often time and resource intensive. Moreover, conducting RCTs may have implications for study ethics approvals, as approved protocols may need to be amended after the selection of contest finalists and prior to trial implementation if the risks to participants were to change.

Discussion

The ultimate goal of crowdsourcing contests in health-related fields is to implement the crowd's proposed solution to a problem to effect change. Increasingly, researchers and other stakeholders are applying principles of implementation science to promote the uptake of research findings. Implementation science describes the systematic study of methods aimed at improving the integration of evidence-based practices into real work settings thereby improving the

effectiveness and quality of healthcare services [44]. Implementation research often relies upon the expertise of transdisciplinary teams comprised of diverse stakeholders, including patients, researchers, practitioners, administrators, economists, or sociologists. Similar to the purpose of RCTs of crowdsourcing methods, the evaluation of implementation science studies often focuses on examining the implementation process and its effect on the targeted evidence-based practice. Moreover, similar to crowdsourcing methods, implementation science emphasizes the importance of stakeholder input and engagement throughout study design, evaluation, and dissemination and implementation [45].

There are several key benefits to integrating crowdsourcing and implementation research approaches. First, due to its ability to engage large groups of people, crowdsourcing methods can be leveraged to increase the reach and adoption of implementation science-based interventions. Moreover, the use of participatory methods to merge implementation science strategies and crowdsourcing methods could lead to more effective interventions due to a greater emphasis on engaging and empowering key stakeholders early in the research process [46]. Such an approach could improve community buy-in, which may increase the likelihood of sustained intervention engagement over time. Considering that crowdsourcing is atheoretical, these methods have the potential to be integrated with other theoretical approaches or frameworks, including participatory methods and implementation science frameworks.

Conclusion

Crowdsourcing can be an effective tool for informing the design and implementation of public health interventions and programming. With its broad applications, ability to incite creativity and

innovation, and emphasis on engaging the public to solve complex problems, crowdsourcing has the potential to advance public health research and influence policies that may lead to notable and sustainable behavioral changes.

References

1. Han L, Chen A, Wei S, Ong JJ, Iwelunmor J, Tucker JD. Crowdsourcing in health and health research: a practical guide. Geneva: World Health Organization, 2018.
2. Pan SW, Stein G, Bayus B, Tang W, Mathews A, Wang C, et al. Systematic review of innovation design contests for health: spurring innovation and mass engagement. BMJ innovations. 2017;3:227-37. Epub 2017/01/01. doi: 10.1136/bmjinnov-2017-000203. PubMed PMID: 29576873; PubMed Central PMCID: PMCPMC5863925.
3. Tang W, Wei C, Cao B, Wu D, Li KT, Lu H, et al. Crowdsourcing to expand HIV testing among men who have sex with men in China: A closed cohort stepped wedge cluster randomized controlled trial. PLoS medicine. 2018;15(8):e1002645. Epub 2018/08/29. doi: 10.1371/journal.pmed.1002645. PubMed PMID: 30153265; PubMed Central PMCID: PMCPMC6112627 have no competing interests relevant to this work.
4. Merchant RM, Asch DA, Hershey JC, Griffis HM, Hill S, Saynisch O, et al. A crowdsourcing innovation challenge to locate and map automated external defibrillators. Circulation Cardiovascular quality and outcomes. 2013;6(2):229-36. Epub 2013/03/14. doi: 10.1161/circoutcomes.113.000140. PubMed PMID: 23481522.
5. Tucker JD, Meyers K, Best J, Kaplan K, Pendse R, Fenton KA, et al. The HepTestContest: a global innovation contest to identify approaches to hepatitis B and C testing. BMC infectious diseases. 2017;17(Suppl 1):701. Epub 2017/11/17. doi: 10.1186/s12879-017-2771-4. PubMed PMID: 29143673; PubMed Central PMCID: PMCPMC5688427.
6. Wazny K. Applications of crowdsourcing in health: an overview. Journal of global health. 2018;8(1):010502. Epub 2018/03/23. doi: 10.7189/jogh.08.010502. PubMed PMID: 29564087; PubMed Central PMCID: PMCPMC5840433 at http://www.icmje.org/coi_disclosure.pdf (available upon request from the corresponding author) and declares no conflict of interest.
7. Turner AM, Kirchhoff K, Capurro D. Using crowdsourcing technology for testing multilingual public health promotion materials. Journal of medical Internet research. 2012;14(3):e79. Epub 2012/06/06. doi: 10.2196/jmir.2063. PubMed PMID: 22664384; PubMed Central PMCID: PMCPMC3414863.
8. Boudreau KJ, Lakhani KR. Using the crowd as an innovation partner. Harv Bus Rev. 2013:60-9.
9. Tucker JD, Pan SW, Mathews A, Stein G, Bayus B, Rennie S. Ethical Concerns of and Risk Mitigation Strategies for Crowdsourcing Contests and Innovation Challenges: Scoping Review. Journal of medical Internet research. 2018;20(3):e75. Epub 2018/03/11. doi: 10.2196/jmir.8226. PubMed PMID: 29523500; PubMed Central PMCID: PMCPMC5866301.
10. Tucker JD, Day S, Tang W, Bayus B. Crowdsourcing in medical research: concepts and applications. PeerJ. 2019;7:e6762. Epub 2019/04/19. doi: 10.7717/peerj.6762. PubMed PMID: 30997295; PubMed Central PMCID: PMCPMC6463854.
11. Olson KR, Walsh M, Garg P, Steel A, Mehta S, Data S, et al. Health hackathons: theatre or substance? A survey assessment of outcomes from healthcare-focused hackathons in three countries. BMJ innovations. 2017;3(1):37-44. Epub 2017/03/03. doi: 10.1136/bmjinnov-2016-000147. PubMed PMID: 28250965; PubMed Central PMCID: PMCPMC5293858.
12. Angelidis P, Berman L, Casas-Perez ML, Celi LA, Dafoulas GE, Dagan A, et al. The hackathon model to spur innovation around global mHealth. Journal of medical engineering &

technology. 2016;40(7-8):392-9. Epub 2016/08/20. doi: 10.1080/03091902.2016.1213903. PubMed PMID: 27538360; PubMed Central PMCID: PMCPMC5681847.
13. Faraj S, Jarvenpaa SL, Majchrzak A. Knowledge collaboration in online communities. Organization science. 2011;22(5):1224-39. doi: 10.1287/orsc.1100.0614.
14. Ringh M, Rosenqvist M, Hollenberg J, Jonsson M, Fredman D, Nordberg P, et al. Mobile-phone dispatch of laypersons for CPR in out-of-hospital cardiac arrest. The New England journal of medicine. 2015;372(24):2316-25. Epub 2015/06/11. doi: 10.1056/NEJMoa1406038. PubMed PMID: 26061836.
15. Tucker JD, Tang W, Li H, Liu C, Fu R, Tang S, et al. Crowdsourcing designathon: a new model for multisectoral collaboration. BMJ innovations. 2018;4:46-50. doi: 10.1136/bmjinnov-2017-000216.
16. Mak RH, Endres MG, Paik JH, Sergeev RA, Aerts H, Williams CL, et al. Use of Crowd Innovation to Develop an Artificial Intelligence-Based Solution for Radiation Therapy Targeting. JAMA oncology. 2019;5(5):654-61. Epub 2019/04/19. doi: 10.1001/jamaoncol.2019.0159. PubMed PMID: 30998808; PubMed Central PMCID: PMCPMC6512265.
17. Hildebrand M, Ahumada C, Watson S. CrowdOutAIDS: crowdsourcing youth perspectives for action. Reproductive health matters. 2013;21(41):57-68. Epub 2013/05/21. doi: 10.1016/s0968-8080(13)41687-7. PubMed PMID: 23684188.
18. Mitchell K, Parker A, Joshi S, Goldhammer J, Anderson B. The craft of incentive prize design: lessons from the public sector2014. Available from: https://www2.deloitte.com/us/en/insights/topics/social-impact/the-craft-of-incentive-prize-design.html.
19. Ballantyne P. Challenge Prizes: A Practice Guide. Nesta: Centre for Challenge Prizes, 2014.
20. Merchant RM, Griffis HM, Ha YP, Kilaru AS, Sellers AM, Hershey JC, et al. Hidden in plain sight: a crowdsourced public art contest to make automated external defibrillators more visible. American journal of public health. 2014;104(12):2306-12. Epub 2014/10/17. doi: 10.2105/ajph.2014.302211. PubMed PMID: 25320902; PubMed Central PMCID: PMCPMC4232166.
21. Crequit P, Mansouri G, Benchoufi M, Vivot A, Ravaud P. Mapping of Crowdsourcing in Health: Systematic Review. Journal of medical Internet research. 2018;20(5):e187. Epub 2018/05/17. doi: 10.2196/jmir.9330. PubMed PMID: 29764795; PubMed Central PMCID: PMCPMC5974463.
22. Brabham DC, Ribisl KM, Kirchner TR, Bernhardt JM. Crowdsourcing applications for public health. American journal of preventive medicine. 2014;46(2):179-87. Epub 2014/01/21. doi: 10.1016/j.amepre.2013.10.016. PubMed PMID: 24439353.
23. Nguyen CD, Tahmasbi N, de Vreede T, de Vreede G-J, Oh O, Reiter-Palmon R. Participant Engagement in Community Crowdsourcing. ECIS2015.
24. Tindana PO, Singh JA, Tracy CS, Upshur RE, Daar AS, Singer PA, et al. Grand challenges in global health: community engagement in research in developing countries. PLoS medicine. 2007;4(9):e273. Epub 2007/09/14. doi: 10.1371/journal.pmed.0040273. PubMed PMID: 17850178; PubMed Central PMCID: PMCPMC1989740.
25. Tang W, Ritchwood TD, Wu D, Ong JJ, Wei C, Iwelunmor J, et al. Crowdsourcing to Improve HIV and Sexual Health Outcomes: a Scoping Review. Current HIV/AIDS reports.

2019;16(4):270-8. Epub 2019/06/04. doi: 10.1007/s11904-019-00448-3. PubMed PMID: 31155691; PubMed Central PMCID: PMCPMC6635017.
26. Liu E, Iwelunmor J, Gabagaya G, Anyasi H, Leyton A, Goraleski KA, et al. Women's global health leadership in LMICs. The Lancet Global health. 2019;7(9):e1172-e3. Epub 2019/08/14. doi: 10.1016/s2214-109x(19)30308-0. PubMed PMID: 31401998.
27. Smiciklas M. The power of infographics: Using pictures to communicate and connect with your audience: Que Publishing; 2012.
28. Dowse R, Ramela T, Barford KL, Browne S. Developing visual images for communicating information aboutantiretroviral side effects to a low-literate population. African journal of AIDS research : AJAR. 2010;9(3):213-24. Epub 2010/09/01. doi: 10.2989/16085906.2010.530172. PubMed PMID: 25860626.
29. Mathews A, Farley S, Blumberg M, Knight K, Hightow-Weidman L, Muessig K, et al. HIV cure research community engagement in North Carolina: a mixed-methods evaluation of a crowdsourcing contest. Journal of virus eradication. 2017;3(4):223-8. Epub 2017/10/24. PubMed PMID: 29057087; PubMed Central PMCID: PMCPMC5632550.
30. Zhang Y, Tang S, Li K, Tso LS, Bayus BL, Glidden D, et al. Quantitative evaluation of an innovation contest to enhance a sexual health campaign in China. BMC infectious diseases. 2019;19(1):112. Epub 2019/02/06. doi: 10.1186/s12879-019-3746-4. PubMed PMID: 30717678; PubMed Central PMCID: PMCPMC6360679.
31. Gladwell M. The tipping point: How little things can make a big difference: Little, Brown and Company; 2006.
32. Jenkins H, Ford S, Green J. Spreadable media: Creating value and meaning in a networked culture: NYU Press; 2018.
33. Baum N. Titles are terrific: creating titles that will attract attention. The Journal of medical practice management : MPM. 2014;30(3):166-7. Epub 2015/03/27. PubMed PMID: 25807616.
34. Molek-Kozakowska K. Communicating environmental science beyond academia: Stylistic patterns of newsworthiness in popular science journalism. Discourse & Communication 2017;11(1):69-88. doi: 10.1177/1750481316683294.
35. World Bank Group. World development report 2016: digital dividends: World Bank Publications; 2016.
36. Marcus A, Wong A. Internet for All: A Framework for Accelerating Internet Access and Adoption. World Economic Forum, 2016.
37. McElfish PA, Purvis RS, Stewart MK, James L, Kim Yeary KH, Long CR. Health Research Funding Agencies' Policies, Recommendations, and Tools for Dissemination. Progress in community health partnerships : research, education, and action. 2018;12(4):473-82. Epub 2019/02/12. doi: 10.1353/cpr.2018.0072. PubMed PMID: 30739901.
38. Chen PG, Diaz N, Lucas G, Rosenthal MS. Dissemination of results in community-based participatory research. American journal of preventive medicine. 2010;39(4):372-8. Epub 2010/09/15. doi: 10.1016/j.amepre.2010.05.021. PubMed PMID: 20837290.
39. Myers P, Barnes J. Starting Evaluation Findings: Disseminating the Evidence 2004.
40. Derman RJ, Jaeger FJ. Overcoming challenges to dissemination and implementation of research findings in under-resourced countries. Reproductive health. 2018;15(Suppl 1):86. Epub 2018/06/28. doi: 10.1186/s12978-018-0538-z. PubMed PMID: 29945654; PubMed Central PMCID: PMCPMC6019998.

41. Ong JJ, Bilardi JE, Tucker JD. Wisdom of the Crowds: Crowd-Based Development of a Logo for a Conference Using a Crowdsourcing Contest. Sexually transmitted diseases. 2017;44(10):630-6. Epub 2017/09/07. doi: 10.1097/olq.0000000000000658. PubMed PMID: 28876322; PubMed Central PMCID: PMCPMC5783316.
42. Wu D, Ong JJ, Ritchwood TD, Tang W, Tucker J. P157 Crowdsourcing methods to enhance HIV and sexual health services: a qualitative scoping review of evidence. Sexually transmitted diseases. 2019;95:A1-A376.
43. Morris RR, Schueller SM, Picard RW. Efficacy of a Web-based, crowdsourced peer-to-peer cognitive reappraisal platform for depression: randomized controlled trial. Journal of medical Internet research. 2015;17(3):e72. Epub 2015/04/04. doi: 10.2196/jmir.4167. PubMed PMID: 25835472; PubMed Central PMCID: PMCPMC4395771.
44. Eccles MP, Mittman BS. Welcome to *Implementation Science*. Implementation Science. 2006;1. doi: 10.1186/1748-5908-1-1.
45. Stewart RE, Williams N, Byeon YV, Buttenheim A, Sridharan S, Zentgraf K, et al. The clinician crowdsourcing challenge: using participatory design to seed implementation strategies. Implementation science : IS. 2019;14(1):63. Epub 2019/06/16. doi: 10.1186/s13012-019-0914-2. PubMed PMID: 31200730; PubMed Central PMCID: PMCPMC6570922.
46. Lyon AR, Koerner K. User-Centered Design for Psychosocial Intervention Development and Implementation. Clinical psychology : a publication of the Division of Clinical Psychology of the American Psychological Association. 2016;23(2):180-200. Epub 2016/06/01. doi: 10.1111/cpsp.12154. PubMed PMID: 29456295; PubMed Central PMCID: PMCPMC5812700.

Appendix A. **Sample crowdsourcing contest invitation letter**

Dear XXX,

We are going to hold a MSM-friendly doctor hackathon during 4-7 September in Guangzhou, China. The purpose of the hackathon is to bring together diverse individuals to develop a target prototype that links gay men and local MSM-friendly doctors (please see appendix for more details).

Given your expertise in public health (computer science, design, health communication), we would like to invite you to serve as a steering committee member. This would involve providing leadership and guidance for the contest, determining the purpose of the contest, and helping create a call for contributions. It would be a great honor to have you as one of the steering committee members. We look forward to your reply.

Best wishes,

XXX