A Crowdsourcing Innovation Challenge to Locate and Map Automated External Defibrillators

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Goals and Vision of the Program

Out-of-hospital cardiac arrest is a major public health problem that affects an estimated 300 000 people in the United States every year.[1,2] The application of an automated external defibrillator (AED) to patients who have experienced cardiac arrest has saved many lives. AEDs coupled with cardiopulmonary resuscitation can significantly improve survival from cardiac arrest from <2% to >50%.[3–5] AEDs can be used easily by untrained laypeople. When accessed and opened, most devices provide audible and visual instructions on use and how to perform cardiopulmonary resuscitation. However, AED effectiveness is extremely time dependent, and presently, in a crisis no comprehensive map of these devices exists to help bystanders find and use them.[3,6–9] Previous work from a large database of out-of-hospital cardiac arrest in the United States suggests low (4%, 1166 of 31 689) use of AEDs by bystanders.[10] An accurate, easily accessible map of AEDs could help people locate them in an emergency, either directly through smart phone applications (apps) or through communication with map-equipped 911 emergency responders.[11]

Creating such a map is challenging, and currently, there is no publicly accessible, accurate, comprehensive crowdsourced map for any region in the world. Although sending out an army of staff might allow canvassing of a geographic region, such an approach would be expensive and not clearly scalable. Furthermore, because AEDs can move locations and require maintenance, ensuring that a database of devices had valid, routinely updated data would be a difficult task.

Crowdsourcing is increasingly used to address major creative and data gathering challenges.[12–15] Crowdsourcing involves taking a task conventionally assigned to particular individuals and instead soliciting help for the task from a large group of diverse individuals (ie, the crowd). The task is often posted online to facilitate collaboration, networking, and team problem solving. Crowdsourcing is often implemented as a tournament or scavenger hunt and has the potential to attract individuals interested in the problem, likely to finish the task, and likely to contribute with the most innovative ideas.[16] Although crowdsourcing is becoming more accessible with the uptake of networked mobile phones and phone apps, as a research technique, it remains underutilized and underreported in the field of health.

We developed a crowdsourcing tournament, The MyHeartMap Challenge, to organize public reporting of AED locations throughout a major US metropolitan city. There were 3 main purposes. First, we wanted to investigate the feasibility of using crowdsourcing to collect meaningful public health data of an otherwise underutilized health technology. Second, we wanted to learn more about the locations of AEDs in a defined region and to build a serviceable inventory of AEDs for use by laypeople and municipal service providers in life-threatening emergencies. This would yield a baseline snapshot of AED locations at 1 point in time, which would serve as the foundation for building a routinely updated and maintained database of devices. The third purpose was to evaluate the process itself, including the demographics and motivations of the participants submitting crowdsourced information and the validity of submitted data.

Design of the Initiative

The MyHeartMap Challenge was a prospective crowdsourcing research project to engage the public to rapidly and accurately locate and photograph AEDs in Philadelphia County. The tournament was heavily publicized in print and radio announcements. Social media tools (eg, Facebook, Twitter, and Foursquare) were also used to disseminate information about the challenge and to create a platform for participant dialog and engagement. To participate, contestants registered as individuals or teams via a Web or mobile phone app. They photographed and collected supplemental information about identified AEDs and submitted these AED locations

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via a Web or mobile app to the project Web site. Participation was incentivized with monetary prizes and the opportunity to contribute to a database that could potentially save someone's life.

Local Challenges in Implementation

In designing the MyHeartMap Challenge, we sought to create a contest that would engage a wide range of participants to report AED locations using the Web or a mobile device. The aim was for the technology to serve as an aid rather than a hindrance and for the task to be simple, easy, and enjoyable. To reach a wide audience, we also partnered with the local newspaper to publish daily clues about AED locations either online or in print for the length of the 8-week contest. The answer to the clues was an AED location, and these were in multiple forms (word puzzles, photographs, physics equations, and diagrams).

Implementation of the Initiative

Study Timeline

The study was announced on the project Web site (http://www.myheartmap.org) in July 2011. Complete study details, data required to participate, and access to the mobile application were made available to the public at the start of the challenge. The MyHeartMap Challenge was launched at 9 AM Eastern Standard Time on Tuesday, January 31, 2012, to coincide with the start of National Heart Month and ran for ≈8 weeks, until 8 PM Eastern Standard Time on Tuesday, March 27, 2012.

Study Location

The study took place in Philadelphia, the fifth largest US city and home to Center City, the third largest downtown residential population in the United States.[17] The city covers 135 square miles and has 1.5 million inhabitants and ≈500 000 daily workers or visitors. The Philadelphia airport was included in the submission boundaries, although it spans Philadelphia and Delaware counties.

Participant Inclusion/Exclusion Criteria

All individuals over the age of 18 were eligible to participate, except members and immediate family members of the following: the investigator team, project vendors, and project sponsors.

Innovation Tournament Design

Participants were eligible for 2 different prizes: (1) a $10 000 grand prize for the individual or team who located, photographed, and submitted the most eligible AEDs in Philadelphia County in the study time frame and (2) $50 for each participant who was the first to identify each of 200 unmarked preidentified AEDs. These AEDs were selected by generating a random sample of locations from the list of devices known to the team precontest (from manufacturers or canvassing). The list of these unmarked AEDs was known only to the study team. The intent of this 2-level prize design was to encourage teams to compete for the most AEDs, to encourage speed, and to encourage participation by individuals who wanted to contribute but would not be in a position to compete for the grand prize.

Data Collection

We developed a mobile phone app functional on iPhone (Apple, Cupertino, CA) and Android (Google Inc, Mountain View, CA) platforms, which was free to participants. This app facilitated the submission of data entries. Participants could also upload submissions directly to the project Web site. To access the data entry form, participants registered online, providing their acceptance of the project rules, consent for participation, and name, e-mail address, home address, age, occupation, and motivation for participation. Teams were required to register under a team name, with the team lead member providing demographic information.

Data Elements

Only fixed location AEDs were eligible for submission—including those installed, moored, wall-mounted, or assigned to a fixed drawer, shelf, cabinet, or closet. AEDs in personal residences or unfixed locations, including police cars, fire trucks, and airplanes, were excluded.

For an AED submission to be eligible for a prize, the following data were required: building address of the AED (street number, street, city, state, and ZIP Code), building name and type (eg, school, gym), a photo of the AED taken with a mobile phone (zoomed out to show the surrounding location), a description of the AED location (eg, second floor, near the bathroom), and device functionality (ie, does the device appear to need service/maintenance?). Participants were provided with information about how to assess device functionality. To collect the GPS coordinates of the AED location, participants were prompted to activate the location-services–on feature when taking AED photos.

Optional AED data included AED manufacturer name, contact name, and e-mail of the person or organization responsible for the device; an indication of whether the AED had been used before; and notation of whether the device location was public or private (ie, limited or no public access).

All entries were automatically time stamped with the corresponding date and time of submission. Temporal patterns were evaluated relative to week, day, and time of submission. Time was collected as Eastern Standard Time.

Data Validation

The validation of previously unknown AEDs was a major challenge for the project. Data validity (ie, was an AED at the reported address) was determined by 3 approaches. First, we compared the GPS coordinates of the AED photo associated with the mobile phones with the GPS coordinates of the building location. Building location GPS coordinates were obtained from Google Maps. If GPS coordinates were not associated with the photo (ie, location services were not turned on when the photo was taken, or the photo was taken with on a non–GPS-enabled device), then the reported AED was compared with lists of locations provided prechallenge by AED device manufacturers. Reported AEDs not identified by those methods were then validated via door-to-door searches by the research team that occurred prechallenge and postchallenge.

The contest rules included the statement that if a contestant team had >0.5% of entries identified as false or inaccurate, then that team would be eliminated from the grand prize competition. False or inaccurate AEDs were considered those not at the location identified, those placed after the challenge began for the purpose of contest submission, and devices determined to be fake, counterfeit, or replicas.

Study Feedback

Throughout the contest, participants were able to provide feedback or to ask questions of the project team (study authors) or other participants publicly via the project online message board or via social media tools (eg, Facebook, Twitter, Foursquare). Questions intended only for study authors could be sent via the project e-mail.

Statistical Analysis

We present summary statistics that describe the demographics of study participants and their reported motivation(s) for participation. We used χ^2 tests to compare select subject demographics by the number of AED submissions.

Summary statistics were also used to compare submission characteristics for both individual AEDs and buildings with AEDs. The total number of submissions, total number of unique submissions, and total number of buildings are reported. For unique submissions, summary statistics are used for floor level and location characteristics. Additional optional data are presented using summary statistics as follows: maintenance, contact person, private/public, and previous use. For building-level characteristics, summary statistics are used for region of the city, building type, and number of AEDs per building.

To evaluate submission characteristics, temporal patterns and median AED submissions by day of the week and time of day were determined.

A map was created using ArcGIS (version 10.1, Redlands, CA) to illustrate the distribution of AEDs located during the study time frame.

Data validity was determined by comparing the submission photo GPS coordinates with the GPS coordinates of the reported building and data from AED locations identified pre- and postchallenge.

All statistical analyses were performed with STATA version 12, College Station, TX. The Institutional Review Board of the University of Pennsylvania approved this study.

Success of the Initiative

Results

Participant Characteristics

During the 8-week study time frame, 313 teams and individuals registered to participate. Characteristics of the 203 participants providing demographic information are reported in Table 1. Many were students (59, 31%) or employed in the medical field (42, 22%). Most (129, 64%) participants resided in Philadelphia, but those residing outside of the city represented 10 states and 3 countries. The most common identified motivation for participation was to make a contribution to an important cause (144, 71%). This was followed by other motivations: fun (117, 58%) and money (88, 43%). Older participants (>41 years old) submitted more AEDs than younger participants (18–40 years old; 1025 compared with 404, respectively; $P<0.01$).

Location and Buil\ding Characteristics

Study participants submitted 1429 AED entries. Of these, many (852, 60%) were unique nonoverlapping entries in 528 buildings; and many (376, 44%) of these were previously not known to the study team or to device manufacturers.

There were 238 devices previously known to the study team via manufacturers or previous canvassing that were not reported by study participants. Many of these devices were in very limited access areas like nursing homes, jails, special needs facilities, or restricted government buildings.

AEDs were located in almost all Philadelphia ZIP Codes (46, 94%) in areas with both high and low population density (Figure 1). They were reported in locations as follows: gyms (102, 19%), schools (85, 16%), and office buildings (57, 11%) (Table 2).

AEDs were most commonly reported on the first floor of buildings (385, 45%), near the entrance/front desk/lobby area (140, 16%), and in office spaces (44, 5%), security areas (72, 8%), and copy rooms (85, 10%) (Table 3).

Of the 200 preidentified AEDs, many (123, 62%) were located in the contest. Appendix I in the online-only Data

Table 1. Participant Demographics (n=203)

Demographics	n (%)
Home address	
Philadelphia	129 (64)
Other*	74 (36)
Age, y	
18–24	51 (25)
25–30	48 (24)
31–40	37(18)
41–50	41 (20)
>51	26 (13)
Occupation	
Administration	12 (11)
Business	11 (6)
Government	7 (4)
Medical	42 (22)
Student	59 (31)
Technical/science	17 (9)
Education	7 (4)
Other	38 (20)
Participant motivation†	
Fun	117 (58)
Cause	144 (71)
Money	88 (43)
Personal	39 (19)
Education	75 (37)

*Outside of Philadelphia, California, Delaware, Hawaii, Illinois, Massachusetts, Michigan, Minneapolis, Missouri, New Jersey, New York, International.

†Totals equal >100% because the options for the question were to check all that apply.

Supplement includes a list of the types of these locations and how often AEDs were found and reported in these areas.

AED Characteristics

Several participants provided optional data on AED access and functionality (Table 3). Many devices were identified as being in private, nonpublic locations (240, 41%). These private AEDs were less frequently identified by multiple participants. For publicly accessible AEDs, the ratio of unique entries (342) to total public entries (622) was 1.82. This is compared with private AEDs, where the ratio of unique entries (240) to total private AEDs (418) was 1.74. Several AEDs were identified as needing maintenance (12, 2%), but participants were often unable to determine on visual inspection whether the device was functioning properly or needed service (335, 48%).

Submission Characteristics

Submissions occurred throughout the study period, with the highest number of entries during the first, fourth, and eighth weeks of the study (Figure 2). Mondays had the highest number of submissions (median, 39; range, 30–51), and most submissions occurred during daytime hours 8 AM to 8 PM Eastern Standard Time (890, 72%). The distribution of entries was left-skewed, with few people submitting a lot of entries and many people submitting a few entries. AEDs were submitted by participants throughout the city, and only a few (113, 8%) of the AEDs were reported in the home ZIP Code of the participant.

Data Validation

Most submissions (1413, 99%) were validated by comparing the GPS coordinates of the photo with the GPS coordinates of the reported buildings and by comparing submissions with data of AED locations identified by the research team. No individual or team was disqualified because of submission of >0.5% of entries identified as false or inaccurate.

Challenge Feedback

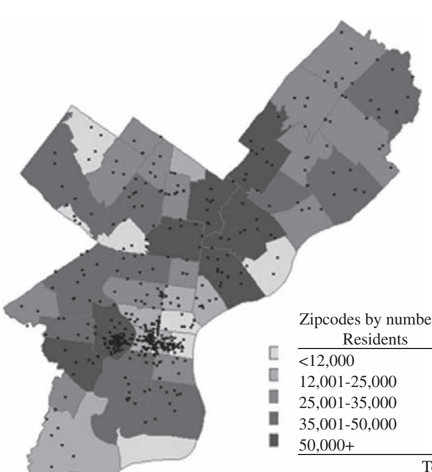
During the challenge, participants were able to provide feedback about the study via the study message board, project e-mail, or social media tools. Although some of the feedback focused on contest logistics (eg, troubleshooting associated with the mobile app), most focused on difficulties associated with the task of locating and collecting data about AEDs. Participants primarily highlighted barriers in determining whether buildings had AEDs and identifying a building employee who could locate the AED and allow the participant to visualize it. Participants also posted information about the importance of AEDs, AED training resources, and requests for social network collaboration for the project grand prize.

Summary of the Experience, Future Directions, and Challenges

This study has 4 main findings. First, a crowdsourcing innovation challenge is a feasible method for locating AEDs in a large urban city. The geographic AED location data generated represent the most comprehensive AED map within a large metropolitan US region reported in the peer-reviewed literature. Notably, this approach was useful for creating an initial baseline database of AEDs at a particular time point, which could serve as a foundation for a data repository, which could then be routinely validated and maintained over time. Using this approach, 1429 AEDs were identified throughout Philadelphia county in almost all ZIP Codes. Devices were reported on multiple floors of buildings in both easy to access public locations and hard to access private locations. Areas of the city with high-density AED coverage and low-density AED coverage were identified. Furthermore, although assessing AED device functionality via visual inspection is limited and challenging, additional data about some of the devices were also obtained, including maintenance needs and device owner contact information. This level of detail would be important for scaling this project to develop a national or international AED registry.

The study design overall aligned with the concept of the ability of the public to act as critical public health sensors or citizen scientists[18,19] and brought together the public with researchers to address an important community health challenge that would have been difficult and expensive to address without this collaborative approach.

Second, most (99%) of the AED location data obtained via crowdsourcing were able to be validated using traditional (pre- and postcontest identified AEDs) and nontraditional



Zipcodes by number of Residents	Number of Zipcodes	Number of AEDs	Average number of AEDs per 1,000 residents
<12,000	8	209	41.8
12,001-25,000	7	376	10.6
25,001-35,000	14	173	0.8
35,001-50,000	11	223	1.1
50,000+	7	314	1.9
Total	47	1295	11.24

Figure 1. Automated external defibrillator (AED) distribution by population density per ZIP Code. This map illustrates buildings with AEDs identified throughout Philadelphia County by study participants. Solid line demarcations represent ZIP Codes, and gradations of shading represent population density by ZIP Code. Circles represent individual buildings identified with AEDs.

Table 2. Characteristics of Buildings Reported to Have an Automated External Defibrillator

	n (%)
Building type (n=528)	
Bank	2 (<1)
Faith-based organization	9 (2)
Government building	4 (4)
Grocery store	8 (2)
Gym/fitness center/recreation center	102 (19)
Hospital/healthcare facility	34 (6)
Hotel	15 (3)
Miscellaneous/other	13 (2)
Office building	57 (11)
Residential	14 (3)
Restaurant	5 (1)
Retail	5 (1)
School	85 (16)
Sport stadium/theater/art/culture	28 (5)
Transportation facility	9 (2)
University	56 (11)
Missing	66 (12)

(mobile phone GPS coordinates) approaches. We saw data validity as essential to evaluate because directing someone in an emergency to an AED that did not exist could have fatal consequences. Previous crowdsourcing challenges have reported data falsification and gaming.[12] For example, the US Government Defense Advanced Research Projects Agency Network Challenge was a crowdsourcing, geolocation initiative to find 10 moored red balloons across the continental United States with a grand prize of $40 000.[12,20] The task was made even more difficult when several individuals deployed fake balloons with the intent of being misleading.[12,20] The Defense Advanced Research Projects Agency Network Challenge experience suggests the need for a robust validation approach when collecting data from the public via crowdsourcing.

Several factors may have contributed to the accuracy of data reports for the MyHeartMap Challenge. First, the monetary prizes, in total, were about half those in the Defense Advanced Research Projects Agency Network Challenge study, and the top prize was one fourth as much. Second, the rules made clear that teams would have to pay particular attention to accuracy, because they would be disqualified if they had more than a very few false entries. Third, the only way to win 1 of the 200 prizes for preidentified AEDs was to submit valid entries, because, by definition, no false entry could have been preidentified. Fourth, unlike the Defense Advanced Research Projects Agency Network Challenge, a real-looking AED may have been harder to falsify than a red balloon. Finally, and perhaps most important, the unit of study was a potentially life-saving device and not an arbitrary balloon.

This study also differed from other crowdsourcing initiatives in that participation involved a series of tasks, most with the following high search costs: finding buildings with AEDs, traveling to the building, entering the building, locating an employee knowledgeable about the AED, and then obtaining permission to access and photograph the device. In comparison, other crowdsourcing projects have required less human interaction or could be completed from a phone or computer. These included the following: locating resources in outdoor public spaces (eg, red balloons for the Defense Advanced Research Projects Agency Network Challenge),[12] solving a gene multiple sequence alignment challenge via a computer (eg, the Phylo project),[18] developing an algorithm that predicts which movies people will enjoy (eg, the Netflix Challenge),[21] and characterizing photos of galaxies captured by the Hubble telescope (eg, NASA's Galaxy Zoo).[22] Future work is needed to better understand how to optimize crowdsourcing relative to the task requirements and desired outcomes.

Table 3. Automated External Defibrillator Characteristics

	n (%)
Floor level (n=852)	
Basement	74 (9)
Lobby/main/ground/first floor	385 (45)
Floors 2–5	135 (16)
Floors >6	105 (12)
Other	16 (2)
Missing	137 (16)
Location (n=852)	
Copy room	85 (10)
Elevator	69 (8)
Entrance/front desk/lobby	140 (16)
Gym	57 (7)
Office	44 (5)
Nurse's office	16 (2)
Restroom	21 (2)
Security	72 (8)
Stairs	14 (2)
Trainer	11 (1)
Other	170 (20)
Missing	153 (18)
Maintenance (n=698)	
Yes	12 (2)
No	351 (50)
I do not know	335 (48)
Contact information available for the person(s) responsible for the AED (n=852)	
Yes	152 (18)
No	700 (82)
Access (n=582)	
Public	342 (59)
Private	240 (41)
Previous use of the device (n=518)	
Yes	4 (1)
No	157 (30)
Unknown	357 (69)

AED indicates automated external defibrillator.

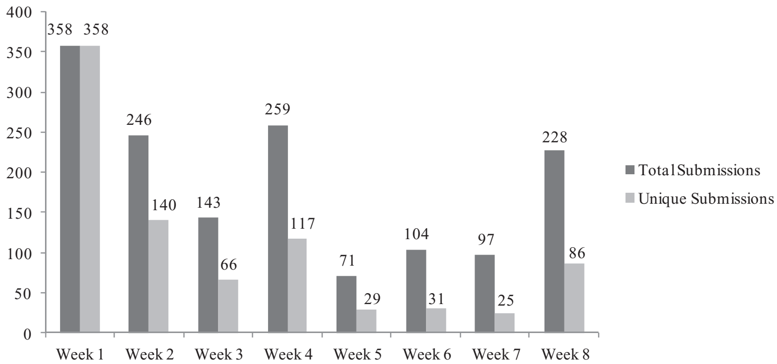


Figure 2. Total and unique automated external defibrillator (AED) submissions by week. This illustrates the number of AED submissions (total and unique) per week for the 8-week study duration. The *y* axis represents number of submissions, and the *x* axis indicates weeks.

Third, our findings suggest that a crowdsourcing approach could also be used in other cities and countries to build AED databases and maps. We provided the project mobile app and Web site freely, and both could easily be used in other regions as a data collection tool. Although monetary incentives were offered for this study, participants noted that their primary motivation for partaking in the challenge was to contribute to an important cause. A better understanding of how behavioral incentives can encourage public health data collection could be important for planning and implementing other health campaigns and initiatives. Future campaigns should also be coupled with other options to increase likelihood of AED use such as training and drilling for employers. Our contest engaged few participants to submit lots of entries and lots of participants to submit few entries. This seems consistent with a public health initiative to engage people in different ways with broad participation and exposure to the task.

Fourth, this project was unique in that we were able to collect data about crowdsourcing that could inform study design for other medical research projects. This included information about who participated and how they participated. Notably, the MyHeartMap Challenge study engaged generally older participants than predicted, with most over the age of 41, a population not traditionally targeted for mobile technology projects. The older age of participants may have been related to the perceived risk for needing an AED, knowing someone who may need an AED, or knowing a patient who has experienced cardiac arrest or a survivor of cardiac arrest. Engaging this age group could help improve awareness and ultimately device use. Our findings that AED submissions primarily occurred early during the week and during daytime hours could also help inform crowdsourcing implementation for future studies.

This study had several limitations. Although crowdsourcing allowed identification of many AEDs in Philadelphia, the true denominator remains unknown, and there may be more devices than were reported. This approach could thus represent an underestimation of AEDs in a region. Importantly, however, for this study, devices were identified by the public and therefore likely represent AEDs most visible and accessible for actual use. This study also took place in a large urban city, and there may be different engagements in suburban, rural, or international locations. The crowdsourced data for this study also provide only a snapshot of AED locations at a certain time point that could quickly become out of date. Furthermore, the in-person validation technique used was labor intensive and would be challenging to scale. Although not the aim of this study, future work will focus on continuous public engagement to routinely validate and report device locations and functionality or changes in the technology of AEDs to make them self-locating. As the public is increasingly using mobile apps like Facebook and Foursquare to check in at locations and report their whereabouts, it seems that a logical next step would involve engaging individuals already at a specific location to report on the presence, status, and functionality of an AED at the location. This would also allow several approaches for data maintenance and verification if multiple people reported this information in addition to device owners. Additionally, because the contest was promoted via traditional (radio, television, print) and nontraditional (social media, mobile media) approaches, the latter may have biased the types of participants who engaged and the type of locations where they searched for AEDs.

This study also had several strengths. Central among these is the importance of accurate AED mapping as a prerequisite for development of systems to send out the location of the nearest AED to rescuers during the crisis of a cardiac arrest. Previous work has illustrated that AEDs are lifesaving, cost-effective, and easy to use by trained and untrained people.[9,23–26,27,28] But, a nearby AED that cannot be located quickly might as well not be there at all. AED registration requirements vary by region, however, and a specific agency is not tasked with tracking and maintaining AED locations and use. This gap in our current emergency response infrastructure represents an opportunity to apply new approaches such as crowdsourcing for improving public knowledge and use of lifesaving AEDs.

Conclusions

Using a crowdsourcing methodology, we were able to engage the public to use mobile phones to identify and report AED locations in a large urban city. Submitted data were valid, were from a diverse set of locations across the city, and revealed a variety of AED densities. The data obtained represent the most comprehensive data reported in the peer-reviewed literature currently available for any US metropolitan region. These crowdsourcing approaches can be repeated in other areas of the nation and the world to support emergency efforts and to examine the distribution of AEDs. This could ensure that AEDs are located where cardiac arrests might occur and identify AED deserts where new AEDs might be placed.

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Disclosures

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References

1. Rea TD, Eisenberg MS, Sinibaldi G, White RD. Incidence of EMS-treated out-of-hospital cardiac arrest in the United States. *Resuscitation*. 2004;63:17–24.
2. Roger VL, Go AS, Lloyd-Jones DM, Benjamin EJ, Berry JD, Borden WB, Bravata DM, Dai S, Ford ES, Fox CS, Fullerton HJ, Gillespie C, Hailpern SM, Heit JA, Howard VJ, Kissela BM, Kittner SJ, Lackland DT, Lichtman JH, Lisabeth LD, Makuc DM, Marcus GM, Marelli A, Matchar DB, Moy CS, Mozaffarian D, Mussolino ME, Nichol G, Paynter NP, Soliman EZ, Sorlie PD, Sotoodehnia N, Turan TN, Virani SS, Wong ND, Woo D, Turner MB; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics–2012 update: a report from the American Heart Association. *Circulation*. 2012;125:e2–e220.
3. Hallstrom AP, Ornato JP, Weisfeldt M, Travers A, Christenson J, McBurnie MA, Zalenski R, Becker LB, Schron EB, Proschan M; Public Access Defibrillation Trial Investigators. Public-access defibrillation and survival after out-of-hospital cardiac arrest. *N Engl J Med*. 2004;351:637–646.
4. Weisfeldt ML, Everson-Stewart S, Sitlani C, Rea T, Aufderheide TP, Atkins DL, Bigham B, Brooks SC, Foerster C, Gray R, Ornato JP, Powell J, Kudenchuk PJ, Morrison LJ; Resuscitation Outcomes Consortium Investigators. Ventricular tachyarrhythmias after cardiac arrest in public versus at home. *N Engl J Med*. 2011;364:313–321.
5. Valenzuela TD, Roe DJ, Nichol G, Clark LL, Spaite DW, Hardman RG. Outcomes of rapid defibrillation by security officers after cardiac arrest in casinos. *N Engl J Med*. 2000;343:1206–1209.
6. Rea TD, Olsufka M, Bemis B, White L, Yin L, Becker L, Copass M, Eisenberg M, Cobb L. A population-based investigation of public access defibrillation: role of emergency medical services care. *Resuscitation*. 2010;81:163–167.
7. Aufderheide T, Hazinski MF, Nichol G, Steffens SS, Buroker A, McCune R, Stapleton E, Nadkarni V, Potts J, Ramirez RR, Eigel B, Epstein A, Sayre M, Halperin H, Cummins RO; American Heart Association Emergency Cardiovascular Care Committee; Council on Clinical Cardiology; Office of State Advocacy. Community lay rescuer automated external defibrillation programs: key state legislative components and implementation strategies: a summary of a decade of experience for healthcare providers, policymakers, legislators, employers, and community leaders from the American Heart Association Emergency Cardiovascular Care Committee, Council on Clinical Cardiology, and Office of State Advocacy. *Circulation*.2006;113:1260–70.
8. Weisfeldt ML, Sitlani CM, Ornato JP, Rea T, Aufderheide TP, Davis D, Dreyer J, Hess EP, Jui J, Maloney J, Sopko G, Powell J, Nichol G, Morrison LJ; ROC Investigators. Survival after application of automatic external defibrillators before arrival of the emergency medical system: evaluation in the resuscitation outcomes consortium population of 21 million. *J Am Coll Cardiol*. 2010;55:1713–1720.
9. Ren ZJ, Cohen MA, Ho TH, Terwiesch C. Information Sharing in a Long-Term Supply Chain Relationship: the role of customer review strategy. *Oper Res*. 2010;58:81–93.
10. McNally B, Robb R, Mehta M, Vellano K, Valderrama AL, Yoon PW, Sasson C, Crouch A, Perez AB, Merritt R, Kellermann A; Centers for Disease Control and Prevention. Out-of-hospital cardiac arrest surveillance—Cardiac Arrest Registry to Enhance Survival (CARES), United States, October 1, 2005–December 31, 2010. *MMWR Surveill Summ*. 2011;60:1–19.
11. Sakai T, Iwami T, Kitamura T, Nishiyama C, Kawamura T, Kajino K, Tanaka H, Marukawa S, Tasaki O, Shiozaki T, Ogura H, Kuwagata Y, Shimazu T. Effectiveness of the new 'Mobile AED Map' to find and retrieve an AED: A randomised controlled trial. *Resuscitation*. 2011;82:69–73.
12. Tang JC, Cebrian M, Giacobe NA, Kim HW, Kim T, Wickert D. Reflecting on the DARPA Red Balloon Challenge. *Commun Acm*. 2011; 54:78–85.
13. Nguyen TB, Wang S, Anugu V, Rose N, McKenna M, Petrick N, Burns JE, Summers RM. Distributed human intelligence for colonic polyp classification in computer-aided detection for CT colonography. *Radiology*. 2012;262:824–833.
14. Merchant RM, Elmer S, Lurie N. Integrating social media into emergency-preparedness efforts. *N Engl J Med*. 2011;365:289–291.
15. Cooper S, Khatib F, Treuille A, Barbero J, Lee J, Beenen M, Leaver-Fay A, Baker D, Popović Z, Players F. Predicting protein structures with a multiplayer online game. *Nature*. 2010;466:756–760.
16. Brabham DC. Crowdsourcing as a model for problem solving: an introduction and cases. *Convergence: The International Journal of Research into New Media Technologies*. 2008;14:75–90.
17. McCarthy ML, Ding R, Pines JM, Terwiesch C, Sattarian M, Hilton JA, Lee J, Zeger SL. Provider variation in fast track treatment time. *Med Care*. 2012;50:43–49.
18. Kawrykow A, Roumanis G, Kam A, Kwak D, Leung C, Wu C, Zarour E, Sarmenta L, Blanchette M, Waldispühl J; Phylo players. Phylo: a citizen science approach for improving multiple sequence alignment. *PLoS ONE*. 2012;7:e31362.

19. Conrad CC, Hilchey KG. A review of citizen science and community-based environmental monitoring: issues and opportunities. *Environ Monit Assess*. 2011;176:273–291.
20. DARPA Network Challenge. DARPA.com. http://www.hsdl.org/?view&did=17522. Accessed January 27, 2013.
21. Ransohoff DF. Proteomics research to discover markers: what can we learn from Netflix? *Clin Chem*. 2010;56:172–176.
22. Clery D. Galaxy Zoo Volunteers Share Pain and Glory of Research. *Science.* 2011;333:173–75.
23. Terwiesch C, Diwas KC, Kahn JM. Working with capacity limitations: operations management in critical care. *Crit Care*. 2011;15:308.
24. McCarthy ML, Ding R, Pines JM, Terwiesch C, Sattarian M, Hilton JA, Lee J, Zeger SL. Provider variation in fast track treatment time. *Med Care*. 2012;50:43–49.
25. Terwiesch C, Diwas KC, Kahn JM. Working with capacity limitations: operations management in critical care. *Crit Care*. 2011;15:308.
26. Lu T, Xu Y, Monttinen ES, Kato N. Supplementing vitamin B6 to a low vitamin B6 diet exaggerates UVB-induced skin tumorigenesis in DMBA-treated hairless mice. *J Nutr Sci Vitaminol*. 2008;54:262–265.
27. Kang X, Xu Y, Wu X, Liang Y, Wang C, Guo J, Wang Y, Chen M, Wu D, Wang Y, Bi S, Qiu Y, Lu P, Cheng J, Xiao B, Hu L, Gao X, Liu J, Wang Y, Song Y, Zhang L, Suo F, Chen T, Huang Z, Zhao Y, Lu H, Pan C, Tang H. Proteomic fingerprints for potential application to early diagnosis of severe acute respiratory syndrome. *Clin Chem*. 2005;51:56–64.
28. Kitamura T, Iwami T, Kawamura T, Nagao K, Tanaka H, Hiraide A; Implementation Working Group for the All-Japan Utstein Registry of the Fire and Disaster Management Agency. Nationwide public-access defibrillation in Japan. *N Engl J Med*. 2010;362:994–1004.

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