Use of Mobile Devices, Social Media, and Crowdsourcing as Digital Strategies to Improve Emergency Cardiovascular Care

A Scientific Statement From the American Heart Association

Cardiac arrest, acute myocardial infarction (AMI), and stroke affect millions of people in the United States annually.[1] Despite significant advances in medical treatments for these conditions, they remain a major public health problem and a leading cause of morbidity and mortality.[1] A critical common element in optimizing care and outcomes for these conditions is the timely recognition of symptoms and initiation of treatment. For example, rapid initiation of cardiopulmonary resuscitation (CPR) is associated with improved survival from cardiac arrest.[2] Similarly, early recognition and presentation after onset of symptoms of AMI and ischemic stroke enable implementation of critical therapies such as primary angioplasty and thrombolysis, which are known to improve outcomes.[1] Indeed, the "Chain of Survival" for emergency cardiovascular and cerebrovascular care (ECCC) starts with prompt identification of the condition and early activation of the healthcare system to rapidly initiate care.[3]

Unfortunately, despite national efforts that include public education initiatives and clinical practice guideline recommendations from entities such as the American Heart Association (AHA), major gaps remain in the timely identification of symptoms and initiation of ECCC.[4–6] As one example, studies of out-of-hospital cardiac arrest (OHCA) have consistently noted delays in the initiation of bystander CPR.[7] For AMI, there have been advances in the provision of timely primary angioplasty for ST-segment elevation myocardial infarction (STEMI), as reflected by significant improvements in door-to-balloon times.[8] However, the time from patient symptom onset to seeking care for possible myocardial infarction has not improved significantly.[9,10] Similarly, for stroke, there continue to be advances in door-to-needle times, but stroke symptom recognition and seeking of treatment by patients and their families remain a major barrier to timely stroke care.[11–16] Public and clinician education efforts alone are not sufficient to reduce gaps and unnecessary variation in time, which suggests a need for new strategies to address this challenge.

One promising area to improve ECCC is the use of digital tools and digital strategies such as mobile devices, social media, and crowdsourcing. The AHA has identified digital strategies as an important factor to help achieve the 2020 goals of improved cardiovascular health. Other organizations are also supporting study in this area through requests for applications and funding opportunities.[17–19] The Institute of Medicine report entitled "Strategies to Improve Cardiac Arrest Survival: A Time to Act" also recommends accelerating "research on the evaluation and adoption of cardiac arrest therapies" and specifically calls for health services research related to "the use of innovative technologies (e.g., mobile and social media strategies…)."[20] To date, however, there has been limited rigorous research and implementation of such strategies to improve ECCC and patient outcomes.

The broad public availability and utilization of digital platforms suggests an important opportunity to leverage digital strategies to improve ECCC and patient outcomes through more timely recognition and treatment. Social media has more than a billion users who share information, including posts, status updates, and

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location identification.[21] These online exchanges also frequently include visual sharing of images, photos, and videos. Much of this social traffic is occurring on mobile devices such as phones, which have become a ubiquitous piece of modern technology, with >285 million American mobile subscribers.[22] More than 50 million of these devices are smartphones, capable of advanced wireless services and connection to the Internet to run hundreds of thousands of mobile applications (mobile apps).[22–24] Other mobile devices (eg, watches, contact lenses, glasses, clothing sensors) are also gaining traction for general use and monitoring of health.[25–29] Crowdsourcing represents an emerging application that has been used to access and mobilize millions of people to contribute to the advancement of science.[30,31]

Digital strategies such as the use of mobile devices, social media, and crowdsourcing can provide the public with information in an accessible format that is personalized; specific to language, geography, and skill set; context specific; and "just in time." Information can be in the form of a mobile app with medical information and links to health resources or images or videos with relevant health content.[32–34] Because of the transactional nature of social and mobile data, information can also be instantly updated and facilitate a dialogue or visual exchange between public individuals and the health system (eg, emergency medical personnel or healthcare providers).[35] Importantly, these interactions and means of knowledge exchange can be tracked digitally and monitored to facilitate assessment of their effectiveness. Crowdsourcing can be used to engage large, diverse groups of people to participate in research, study digital strategies, connect networks in emergencies, and raise awareness about health conditions, including emergency cardiovascular conditions.[30,31,36–38]

However, building a mobile app, developing content on a social media site, or launching a crowdsourcing initiative does not mean that these tools or approaches will be adopted or will be effective in improving patient health or health systems. The structure of data used across digital tools also varies, and there is a need for guidance on how this information could be better organized and optimized for collection and analysis. The potential for applying these tools to improve health and health care is compelling but requires evidence of their effectiveness and could be limited by issues related to privacy and patients' willingness to provide access to their specific data. There is also a potential for unintended consequences because of factors such as inaccurate information being provided via digital tools or inequitable access to this information; thus, there is a need for rigorous research on the use of digital strategies for ECCC, to ensure safety and effectiveness.

Accordingly, the goals of this scientific statement are to (1) describe potential applications of mobile devices, social media, and crowdsourcing as digital strategies for emergency cardiovascular conditions; (2) summarize and provide illustrative examples of existing studies that have used digital strategies for aspects of cardiac arrest, AMI, and stroke care; and (3) identify gaps in evidence and identify key challenges for advancing the field of digital strategies as healthcare interventions to improve outcomes for patients with emergency cardiovascular conditions. This statement principally focuses on the current scientific knowledge, as well as limitations and opportunities for leveraging mobile devices, social media, visual sharing, and crowdsourcing to augment ECCC. This statement is intended to guide future research agendas in this evolving area and provide guidance to the AHA and other public and scientific entities as they direct resources to improve care and outcomes of patients with emergency cardiovascular conditions.

TOP THINGS TO KNOW

- Because of their broad availability and advanced technological capabilities, digital tools such as mobile devices, social media, visual media, and crowdsourcing have great potential to improve the timely recognition, treatment, and outcomes of emergency cardiovascular conditions.
- Unfortunately, there is generally a lack of scientific evidence to date to support the effectiveness and safety of specific digital strategies to improve ECCC.
- There is increasing interest from consumer groups, funders (eg, research funding entities and foundations), health systems, and other stakeholders to evaluate and optimize the use of digital strategies to improve care delivery and health outcomes. Emergency cardiovascular conditions are important clinical foci for these strategies, given the potential to improve patient outcomes by enhancing the timeliness of ECCC.
- The use of digital strategies in ECCC should be evaluated in similar fashion to other medical interventions, including by formal assessments of evidence to inform clinical practice guideline recommendations about which strategies should be implemented by health systems and other stakeholders on the basis of priority areas of focus, such as the 6 domains of healthcare quality identified by the Institute of Medicine: safety, efficacy, patient centered, timely, efficient, and equitable.[39]
- The use of digital strategies as healthcare interventions can have unintended consequences (eg, incorrect information, medical errors, or higher costs). This reinforces the need for rigorous research on the effectiveness and safety of digital strategies for emergency cardiovascular conditions.
- Mobile devices can enhance emergency medical services (EMS) systems, such as by supporting medical

dispatch communication with bystanders through the use of advanced location tracking (eg, global positioning systems), text messaging, and real-time video and photo capabilities. There remain important research questions with regard to the effectiveness of such approaches.

- Digital tools can be used to collect data about people (eg, people with emergency cardiovascular conditions and bystanders), health systems, and other factors important for studying the presentation and management of these conditions across populations. Data quality and access remain important issues for the optimal utilization of digital tools to improve care and outcomes.
- Mobile devices that are capable of tracking and transmitting various biometrics signals (eg, heart rate, respiration rate, fall detection, activity, body posture) could assist in early detection of acute cardiovascular conditions. The use of such data to potentially improve ECCC is an important focus for research.
- Social media platforms offer promise as research tools for studying networks, posted health information, and data dissemination related to emergency cardiovascular conditions.
- Visual sharing (videos, pictures) can enhance just-in-time education of the public to potentially improve early recognition of symptoms and early response for emergency cardiovascular conditions.
- Crowdsourcing can enhance development and maintenance of research databases with information about emergency cardiovascular conditions related to guidelines, emergency resources, training, and emergency response. Data quality, access, and optimal use of this approach are critical areas for evaluation.

MOBILE DEVICES

Mobile devices include smartphones, tablet computers, digital cameras, and wearable devices including glasses,[40] watches, activity monitors, clothing,[41] and contact lenses.[42] Mobile phones are becoming ubiquitous in most developed and developing countries. More than 90% of Americans have a mobile phone, and more than half of these are smartphones.[22,43] Because smartphones are able to perform many of the functions traditionally accomplished with a stationary computer and have global positioning system functionality, Bluetooth and wireless connectivity, motion-sensing capabilities, and proportionally large screens optimized for the presentation of video and Internet content, their potential as a digital strategy to connect people with resources and knowledge to improve care of emergency cardiovascular conditions is significant. Mobile device apps can provide support such as educational information about signs and symptoms at the time of an emergency event and facilitate bidirectional information exchange between a dispatcher and a bystander or a healthcare provider with another provider.

A prior scientific statement focused on use of mobile technologies for cardiovascular disease prevention, whereas the present statement focuses on applications for critical cardiovascular conditions in the acute setting.[44]

Mobile Devices and Cardiac Arrest

Although calling 9-1-1 to activate local professional emergency response services is critical, the median time interval from 9-1-1 call to arrival at scene is often >5 minutes. In many North American communities, professional responders will require >8 minutes to get an automated external defibrillator (AED) to the patient.[45] Historically, when a cardiac arrest occurs in the out-of-hospital setting, one can only hope that a trained, willing, and skilled bystander is in the immediate vicinity and that a working, publicly accessible AED is available. More recently, mobile device–based strategies have started to emerge that have the potential to improve the integration of citizens with the more traditional EMS response to cardiac arrest.[46]

CPR Education

Mobile devices provide a new avenue for educating the public and healthcare providers about basic life support and the importance of early CPR. Interactive mobile videos and games aim to expand the audience for CPR education and engage a new generation of potential rescuers. For example, the LifeSaver App was developed in the United Kingdom in partnership with the European Resuscitation Council.[47] This interactive video walks users through dramatic first-person video depictions of OHCA and other emergencies, requiring the user to guide the resuscitation as it unfolds.[47] In a study from South Korea, investigators used interactive video to provide training after a traditional classroom CPR course. Study participants were sent text message reminders to encourage them to watch the refresher video on their phone outlining the key points of CPR. Skills in the refresher video group were compared with those of a group of graduates who received no refresher video on their phones. Skill retention was significantly improved in the video refresher group.[48] Overall, there are only limited examples of research in this area to date. Additional research is needed on the use of mobile devices and apps to enhance CPR education, with a goal of higher bystander CPR rates and more timely activation of EMS.

Real-Time CPR Coaching and Feedback for Bystanders

Mobile technology provides new modalities for "just-in-time" knowledge translation for CPR when an opportunity for bystander resuscitation presents itself. Traditional real-time CPR coaching for bystanders has largely been limited to verbal CPR instructions provided by 9-1-1 call takers.[49] Some have evaluated audio CPR instructions on a mobile phone for trained and untrained rescuers during a simulated cardiac arrest. They observed that the delivery of mobile phone audio instructions was associated with improved chest compression rate, depth, and hand placement and fewer chest compression pauses compared with no audio instructions.[50] It has been hypothesized that this interaction could be augmented with video instruction delivered on a mobile device. Several simulation studies have suggested that the addition of video to the interaction between bystander and call taker can improve CPR quality.[51–54] Future research needs to determine whether video augmentation of the interaction between dispatchers and bystanders is feasible and translates into improved CPR quality and survival for patients with OHCA.

Many mobile devices contain sensors that can detect acceleration in various planes. Several apps take advantage of the output from these sensors to provide motion-sensing–based CPR-quality feedback.[55] By placing the mobile device between the hands of the rescuer or on the chest of the patient during compressions, the app measures the vertical acceleration associated with the compression cycle and provides feedback on rate, depth, and CPR fraction relative to benchmarks. It is possible that having to place the device between the hands and the chest could impair high-quality chest compressions. With the advent of new wearable devices, particularly smart watches, this technical limitation can be addressed. The outputs from mobile device CPR feedback require more study to validate the measurements and determine efficacy among lay people and healthcare providers with respect to improved CPR quality.

A mobile phone app was also used in Stockholm, Sweden, to alert volunteers within 500 meters of a cardiac arrest victim to respond and initiate CPR. In this randomized, controlled trial (RCT), the primary outcome was bystander CPR initiation before arrival of EMS.[56] The intervention group consisted of volunteers dispatched to patients with cardiac arrest, and the control group was volunteers not dispatched. The outcome was that the bystander CPR rate was 62% (188/305) in the group with the mobile app alert and 48% (172/360) in the no-app group. The results from this RCT demonstrate the ability to take advantage of the ubiquity and functionality of mobile phones for life-saving purposes.

There are also mobile device apps available that provide real-time CPR guidance independent of the 9-1-1–call-taker interaction. For example, the First Aid White Cross app provides video examples of CPR with metronomic guidance that a bystander could watch before or during an actual resuscitation.[58] In a clinical trial using this app, 64 volunteer lay rescuers were randomized to using the app versus not using the app during a simulated cardiac arrest scenario. The group using the app had a better compression rate than the group that did not use the app, but use of the app was associated with a delay to starting chest compressions and calling 9-1-1.

These latter studies importantly use robust RCTs in the evaluation of mobile device apps for management and treatment of ECCC. Rigorous study of digital strategies as health interventions is critical to proving both their effectiveness and their safety, as well as to building the scientific evidence base for their implementation.

Localizing, Retrieving, and Operating AEDs

Bystander use of an AED has been associated with improved survival for patients who experience OHCA.[60] Unfortunately, AEDs are rarely used.[60,61] In one large series involving >13 000 OHCA from the Resuscitation Outcomes Consortium, AED use occurred in only ≈2% of cases.[60] In the Cardiac Arrest Registry to Enhance Survival (CARES) database, AED use is reported in ≈ 4% of cases.[61] Barriers to AED use by bystanders include issues related to proximity and availability at the time of an arrest, access to known nearby AEDs, prior training, and willingness and capability in using the AED.[62–64]

Several mobile apps use data from AED registries to help bystanders find the closest AED and report new AEDs.[65,66] Some apps also have enhanced features such as augmented reality to guide users to the nearest publicly accessible AED.[67] Using the mobile device's built-in camera, users can view the real world with locations of AED overlaid by the app. In this way, bystanders can look around at the real world through the camera of their smartphone, and when the smartphone is being viewed in the direction of a registered AED, an icon will appear on the screen of the mobile device overlaid on the video output of the camera. By tapping on the AED icon, users in specific geographic locations can see information about AED locations, including distance from current position, building name, and precise location details.[67]

In prior work, the use of a mobile AED map with the locations of nearby AEDs in Osaka, Japan, was evaluated against trying to find an AED without use of the map.[68] Forty-three volunteers were randomized to use of the mobile map or not after being provided with simulated OHCA episodes. Although the mobile AED app was associated with reduced travel distance to an AED, a significant reduction in time to AED retrieval was not demonstrated. Several challenges with the user interface for the map were identified as potential barriers. Mobile AED maps are limited by the quality of the data supplied (eg, accurate AED locations) and the ease of use of the app.

Early Recognition of Cardiac Arrest

Mobile devices and wearable technology present a potentially novel avenue to aid in recognition of unwitnessed cardiac arrests and facilitate earlier intervention. Research is needed to determine the feasibility of using mainstream mobile devices or wearable technology to detect unwitnessed cardiac arrests, facilitate early intervention, and improve survival. There might also be an opportunity to use these devices in the study of early warning for sudden cardiac arrest. Emerging wearable technologies are capable of communicating various biometrics signals, including heart rate, respiration rate, fall detection, stress, skin temperature, activity, caloric burn, and body posture, to a mobile device.[69] This technology could facilitate remote signal analysis and monitoring and trigger an automated call to 9-1-1 under prespecified conditions (eg, patient consent, heart rate=0, fall detection, or body motion= 0). The effectiveness, safety, and cost-effectiveness of such interventions are a research priority.

Mobile Devices and AMI Care

The time interval between symptom onset and coronary reperfusion is associated with mortality in patients with STEMI.[70] Much emphasis has been placed on improving STEMI systems of care so that this time interval is minimized and outcomes are optimized for these patients.[71] To date, this emphasis has largely focused on improving EMS and hospital processes of care (eg, door-to-balloon time strategies for immediate percutaneous coronary intervention for STEMI patients). There has been less emphasis, and little success to date, in reducing the time between AMI symptom onset and healthcare system activation and treatment. Mobile device apps are potential novel interventions to improve timely care and outcomes for patients with AMI.

Public health education campaigns have been implemented to empower patients and family members to recognize the symptoms of ACS and seek healthcare access quickly after symptom onset. Unfortunately, these efforts have been largely unsuccessful. There are various symptom-checker mobile apps available that provide differential diagnoses based on self-reported symptoms, but none could be identified that were specifically designed to assist patients, their families, or public bystanders in recognizing the symptoms and signs of AMI. Moreover, there is a paucity of research on the effectiveness of such apps with regard to earlier symptom detection and activation of EMS response.

Mobile devices have been developed for the acquisition, storage, and transmission of ECGs.[73] Some require the user to purchase a smartphone case with 2 leads integrated within the structure.[74] ECGs can then be acquired through finger contact on the case leads or by pressing the smartphone against the chest. This novel electrocardiographic acquisition technique represents a potentially new avenue for interaction between the patient and emergency providers, but feasibility and clinical efficacy studies are needed. Transmission of smartphone electrocardiographic recordings to the emergency dispatcher or other providers in the STEMI system of care could potentially improve system efficiency and reduce delay to treatment by providing a definitive diagnosis earlier in the timeline.

For healthcare professionals, the acquisition of prehospital 12-lead ECGs by paramedics and other prehospital personnel is associated with shorter delays from medical contact to reperfusion.[75] This process facilitates rapid prehospital triage, destination planning, early activation of the cardiac catheterization laboratory, and reduction in hospital-based delays to definitive treatment.[76,77] Over the past few decades, there have been many studies demonstrating the feasibility of transmitting prehospital 12-lead ECGs from an ambulance to interventional cardiologists at the regional STEMI center so that a collaborative decision can be made about destination and prehospital catheterization team activation. Early studies used fax technology over cellular networks, which was associated with significant technical challenges. More recently, investigators from the STAT-MI study (ST-Segment Analysis Using Wireless Technology in Acute Myocardial Infarction) demonstrated the feasibility of sending prehospital 12-lead ECGs directly from Bluetooth-connected monitors to the smartphone of an on-call interventional cardiologist.[78] The system involved the automatic transmission of the ECGs acquired by the paramedics in portable document format (PDF) via e-mail. The cardiologists were paged simultaneously by the system to announce the e-mail. In a study conducted in Japan, emergency department personnel sent pictures of 12-lead ECGs via their smartphones to interventional cardiologists for interpretation.[79] They demonstrated that compared with the standard method of transmitting with a fax machine, the smartphone method was associated with a reduction of ≈1.5 minutes in transmission to decision time. Nonetheless, research on this topic remains limited, including the use of evolving mobile technologies for electrocardiographic acquisition and interpretation, as well as integration with other data to achieve more timely diagnosis and treatment of AMI. This area of focus could be evaluated by use of an RCT to compare time to therapy for people with enhanced mobile capabilities compared with those without.

Mobile Devices and Stroke

Early recognition of acute stroke is a key component of optimized stroke care.[80] The effectiveness of fibrinolytic therapy for acute stroke is highly time sensitive.[81,82] Patient delay in the recognition of stroke and seeking care has been recognized as a major barrier to optimal treatment of acute stroke.[11–14,16] Mobile devices may be used to help lay people and healthcare providers identify stroke, encourage activating an emergency response, and facilitate stroke risk assessment.[83–86] The American Stroke Association launched the "Spot a Stroke F.A.S.T." campaign, which included Internet-based video public service announcements and a free app for mobile devices.[87,88] The app guides users through an assessment for signs of stroke and includes a short video demonstrating stroke symptoms. There is also an integrated 9-1-1-calling feature that can be activated if stroke is suspected. This highlights the potential for use of mobile devices as mobile recognition aids. However, validated data regarding effectiveness when used by lay users are still lacking.

Telemedicine consultation, called *telestroke*, is an increasingly common method by which hospitals that lack on-site personnel can access acute stroke expertise on demand. Several investigations have demonstrated the feasibility and reliability of these systems with respect to the immediate assessment of stroke patients for fibrinolysis.[89] Remote supervision of fibrinolysis for acute ischemic stroke by telemedicine or telephone before transfer to a regional stroke center has been shown to be feasible and safe but is recommended by guidelines only within centers using high-quality dedicated videoconferencing equipment.[90]

Given the videoconferencing functionality of many mobile devices, several investigators have explored the feasibility and reliability of their use for telestroke consultation. Two smartphone apps were tested in this capacity in 2 studies.[91,92] Both used the free FaceTime videoconferencing app on the iPhone to assess stroke patients. In both investigations, agreement between 2 physician assessors of patients with stroke was quantified. For each patient in the study, 1 physician determined the National Institutes of Health Stroke Scale directly from the bedside of the patient while the other used a video feed from the FaceTime app to score the patient from a remote location. Both studies demonstrated good interrater agreement between the local physician and the remote physician for most elements of the National Institutes of Health Stroke Scale. Kappa scores in both studies were similar to earlier investigations that measured interrater reliability between 2 bedside assessments and those that reported assessments with more traditional fixed videoconferencing equipment. Both studies also demonstrated that remote video assessments of stroke patients with the iPhone and FaceTime was feasible and had high user satisfaction.

Demaerschalk et al[93] explored the use of a smartphone app to view radiological images over the Internet in a prospective study. This study was conducted via a telestroke network in Arizona and used a mobile app that supports the typical hub-and-spoke model. In this context, a "hub" vascular neurologist viewed noncontrast brain computed tomography scans from patients presenting with acute stroke to "spoke" hospitals. The study investigators demonstrated excellent agreement between hub vascular neurologists viewing the computed tomography images remotely on smartphones and spoke radiologists viewing the images on a standard picture archiving and communication system with respect to assessment for fibrinolytic drug contraindications. Retrospective analyses have also demonstrated excellent agreement between a picture archiving and communication system and smartphone image assessment with respect to intracranial hemorrhage and early ischemic changes.[94] Work with a mobile app in Japan called i-Stroke that transmits both clinical and radiographic information has also demonstrated similar feasibility.[95] Although an RCT could evaluate time to therapy using a mobile app compared with not using a mobile app for stroke care, no identified studies included actual thrombolysis evaluation and treatment of subjects. Studies using mobile telemedicine from a moving ambulance have also encountered many technical challenges.[96] Thus, there remain significant open questions with regard to the effectiveness and safety of mobile phone–based digital strategies to support timely stroke care.

Challenges and Opportunities for Mobile Devices and ECCC

The examples provided in this section from the published literature demonstrate potential applications for mobile devices to improve ECCC and outcomes. Because this area is evolving rapidly, these examples likely represent only a fraction of the mobile devices and apps being created, pilot tested, and implemented in this area, yet there remains a paucity of formal research evaluation of mobile devices with regard to ECCC. This is a medical research priority, because mobile devices and apps continue to proliferate.

There are challenges in using mobile devices for ECCC and research. Some mobile apps are designed to guide patients, whereas others are meant to guide healthcare providers; however, access is generally open. With such open access to the creation and broad distribution of apps for health care, the risk for misinformation is significant. Consider the potential harm that could be caused by an AED-locating app that has inaccurate AED location information or a CPR training mobile interactive video that demonstrates an incorrect chest compression technique.

The risk of harm related to a faulty app will vary depending on the content of the app, the intended patient population, the user audience, and the diffusion of the app among the public. These risks beg the question of whether mobile device apps for medical education or treatment should be regulated. The US Food and Drug Administration does not plan to regulate all mobile apps, only those that are deemed to be highest risk.[97] This includes any apps that effectively transform mobile devices into medical devices. This has relevance for emergency cardiovascular conditions for which some apps might serve as diagnostic tools (eg, ECG and interpretation) or facilitate an intervention (eg, defibrillation). The regulation of mobile apps for health care is certain to be an evolving field, and as the number of apps increases, the feasibility of regulation will need to be reconsidered. Regulators will be required to respond to the rapidly changing landscape of available functionalities and resultant risks associated with mobile technology (eg, smartphones and other devices) and health-related apps.

For mobile devices to realize their potential in accomplishing more timely recognition and treatment for emergency cardiovascular conditions, future work should focus attention from feasibility studies to research focused on their effectiveness, with a specific focus on comparison to usual care, improvement in mortality and nonmortality outcomes, and assessment of cost-effectiveness.

Mobile devices also offer a unique opportunity to rapidly connect patients with information over time or in a just-in-time scenario, thus connecting people with resources where and when they need them. In addition, this connectivity represents a new opportunity in ECCC for data tracking, targeted information messaging, and measurement of resource dissemination. Research that explores this aspect of mobile device apps for ECCC and conditions should be an additional area of focus.

Going forward, the healthcare community has a unique opportunity to develop innovative methods for evaluating and vetting mobile devices so as to empower users to make informed decisions concerning which to download and which to avoid. Future areas of research focus for ECCC include provision of guidance for healthcare providers to enable them to stay abreast of the mobile literature and best practices for approaches to discussing, prescribing, and monitoring mobile apps with patients.

The vast amount of information that can be collected from mobile devices (eg, changes in speech that suggest stroke, photos/videos of symptoms [eg, agonal breathing, an ECG that demonstrates AMI, resuscitation performance]) or that can be provided by mobile phones (eg, AED maps, audible CPR instructions, stroke/AMI symptom descriptions) represents a rapidly growing field of discovery for ECCC.

SOCIAL MEDIA

Social media includes websites and apps that enable users to create and share content or to participate in social networking. To date, >50% of the US population has a Facebook account (the highest-traffic site), and users spend billions of hours a month on social media sites.[21,98] For many, the Internet is used primarily to access social networks.[99] In this section, we define social media as "forms of electronic communication through which users create online communities to share information, ideas, personal messages, and other content" and social networking sites (eg, Facebook, Twitter, Foursquare) as "online platforms that facilitate creating and maintaining relationships among people who share particular interests, activities, locations, backgrounds, or real-life connections."[100]

In addition to the broad reach of social media, another feature that makes it potentially important for research to improve ECCC is the quantity of data. Several billion bits of data are generated from social media sites every day. These data are in the form of text, photos, videos, likes, shares, check-in's, and other mediums that facilitate information exchange. Also, social media is used widely across groups with varying demographics and geographic locations. On some social media platforms (eg, Twitter), blacks, Latinos, and those in urban populations are overrepresented relative to the general population.[101,102]

For many health conditions (eg, depression, cholera, epilepsy, concussion, migraine), social media and social networks[103] have been used to study health and health behaviors,[104–107] as well as implement interventions to improve health outcomes. As an example, the power of harnessing social networks for obesity has been described in an AHA scientific statement.[108] For public health emergencies, social media and social networks have been used for surveillance and to link individuals with health needs with resources.[109–112] For cardiovascular disease, language used on social media has also been used to predict county-level heart disease mortality across the United States.[113]

The hyperconnectivity of social media can facilitate rapid access to educational materials, feedback, data exchange, and tracking in the service of improving the timeliness of ECCC. In the following subsections, we review applications, challenges, and opportunities for using social media–based strategies for ECCC and conditions. Please note that social media platforms that focus exclusively on visual sharing (eg, YouTube) are discussed in the subsequent section.

Public Education and Engagement

One application of social media is the dissemination of health information, such as prevention and healthy lifestyle choices, risk factors, symptoms, or how and when to respond to potential symptoms and signs of emergency cardiovascular conditions. One prior study of health-related groups on Facebook identified that cardiovascular disease–related groups (along with cancer) had the highest number of users.[114] Compared with other common health conditions, an increased number of Facebook pages dedicated to support for stroke patients have also been reported.[115] In this context, social platforms can potentially be harnessed for both data push and pull. The data push can be in the form of patients posting symptoms and health information, whereas pull can be for those seeking information. Such approaches have not been studied for ECCC to date.

Data quality is a potential major challenge to the effectiveness of such interventions and could exacerbate unintended consequences. Information on social media is clearly not generated uniformly, and variability exists in the intended uses, generators of content, and accessibility of accurate educational content. One study of tweets about resuscitation reported that when using select search words (AED, cardiac arrest, sudden death, defibrillator, and CPR), 25% of the messages were actually relevant whereas 75% were referring to nonresuscitation-specific content (eg, CPR=Colorado public radio), which reflects the signal-to-noise challenge with social media. Of the relevant resuscitation tweets (n=15 324), most of the data represented information seeking (71%), but personal sharing through patient narratives and posts about medical conditions (eg, real-time reports of CPR in progress) and symptoms (active chest pain) was also present (29%).[116] Access to online health communities, networks, and platforms that curate content about health represents easily accessible resources for identifying patient insights regarding care and disease management. There is a clear need for research on social media and ECCC to inform how such platforms can be used to improve care and patient outcomes.

Social media can be used to enhance public campaign efforts; public health campaigns like "Freeze the Stroke," "Hands-Only CPR," "The Heart Truth," "Call Fast, Call 911," and others have reached hundreds of thousands of people.[117–119] The AHA #WeAreHeart social media ambassador program was generated to facilitate social sharing of heart health messages through individuals' social media accounts.[120] The National Wear Red Day, a program of the National Institutes of Health, created Facebook and Twitter pages with regularly posted content (eg, text and images) about heart health while also encouraging users to share similar content.[121] Specific hashtags and blog content were also generated to facilitate public engagement and interaction.

The Defibrillator Design Challenge was a research project and awareness campaign at the intersection of public health, public art, and resuscitation. The project used social media and crowdsourcing to generate artwork, slogans, and designs that could raise awareness about cardiac arrest, AED locations, and AED education.[36,122] The Challenge was hosted on a Web- and mobile-compatible platform and primarily used Facebook and Twitter to engage people to create virtual designs and educational messages concerning AEDs that could make them more visible and ideally more likely to be used. Because AEDs can be inconspicuous and difficult to locate, the intent of the designs was to make the physical devices more noticeable so the public would be more aware of AED locations.[64,123,124] This project had >13 990 unique website visitors, and designs were shared >48 250 times on Facebook and Twitter.[36] However, at this point, the effectiveness of such social media efforts to improve care and public health remains uncertain. This remains a future research direction for ECCC.

Community Consultation for Research

Another novel use for social media is as a means of achieving community consultation and public disclosure.[125–127] This has been applied to cardiac arrest and trauma-related research involving exception from informed consent. Requirements are in place for community consultation and public disclosure, yet how to best achieve broad outreach has not been well defined. Traditionally, this has occurred via town hall meetings, advertisements, and phone-based surveys with various degrees of engagement. One prior study described a social media–based strategy for community consultation and public disclosure for 2 large Resuscitation Outcomes Consortium clinical trials: the Continuous Chest Compression Trial and the Hypotensive Resuscitation Trial.[128] Using Facebook advertisements, the study authors generated short interactive text that directed viewers to websites with study details and options to opt out of the study. For both trials, Facebook advertisements were targeted at >500 000 Facebook users 15 to 44 years of age in Alabama and subsequently displayed on the site >15 million times. Of the >1000 individuals who clicked on the study advertisement, only 1 elected to opt out of the study. Although not specific to the use of digital strategies for the training, recognition, or treatment of emergency cardiovascular conditions, this study demonstrated the potential for using social media to disseminate information to the public about these conditions. Evaluation of individual communities with novel strategies for consultation and comparison to similar communities without these strategies could be instructive.

Prior work has defined 4 areas for consideration that can guide future research in studying how to optimize the use of social media for community consent.[125] These include understanding the format of the social media platform of interest, identifying how that format can be related to the goals of outreach, determining whether the intended audience for outreach is the same audience reached by the selected social media platform, and determining how to quantify and evaluate the outreach efforts using available metrics from the social media platform.

Education for Providers

In addition to using social media as a tool for public education and awareness, some studies have evaluated uses of these approaches for clinicians and healthcare providers. Takao et al[95] reported on the use of a mobile technology in combination with Twitter to facilitate consultation

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regarding stroke and rapid exchange of clinical information, images, and treatment recommendations. Using these digital tools, this group reported on the ability of the system to support knowledge exchange for time-critical management of patients with stroke symptoms.

Another study described using several social media platforms (eg, Twitter, blogs, and podcasts) to facilitate education and information exchange about targeted temperature management for post–cardiac arrest patients.[129] In this study, the authors were able to generate commentary and communication from >1100 people from 60 countries via an online global journal club about a targeted temperature management study by another group.[130] Using several tracking approaches, they also reported the following: >20 Facebook likes, >330 000 Twitter impressions, and >100 YouTube video views. Through social media, the authors also reported their ability to query journal club participants about adoption of targeted temperature management at their specific institutions to understand the direct impact of research on implementation and actual practice.

Challenges and Opportunities for Social Media and ECCC

Despite the potential for social media to enhance the treatment and management of emergency cardiovascular conditions, research in these areas is sparse, with primarily descriptive studies that lack an intervention or evaluative component. The use of social media platforms also requires consideration of the demographics of the target patient or community audience and the demographics of the social media site. The metrics of the number of Facebook "likes," retweets, and so on, are not always interpretable and suggest a snapshot of engagement that may not be longstanding or meaningful. Because one person can view things multiple times, the numbers can sometimes be exaggerated. An abundance of misinformation in social media data also exists, and verification of data and data sources can be challenging. Subject privacy is also of utmost importance, and careful calibration and use of these tools to ensure security for protected health information is crucial. This is also particularly relevant for healthcare providers who might post information on public sites about patients or view information about patients on these sites in the context of research or care provision.[131] These barriers could play a role in the limited research and evaluation of social media applications for treatment of emergency cardiovascular conditions.[132]

Nonetheless, existing social platforms have the infrastructure to facilitate rigorous study designs that allow for consent, patient privacy, data verification, and long-term monitoring. They offer an opportunity to gain real-time patient feedback and an evaluation of how patients interact with networks regarding health. Increasingly, there are also requests for proposals from funding organizations (eg, National Institutes of Health, Agency for Healthcare Research and Quality, foundations) that call for research to study the opportunities to harness social media for insights about health behaviors, as well as the treatment and management of disease.[17–19] Social media and social networks are already being studied and used for a spectrum of health conditions,[113,133–138] and there are a host of research questions that could be asked to test these approaches for emergency cardiovascular conditions (Table). Guidance also exists to develop research protocols for review by organizations that evaluate issues related to ethics, privacy, and patient protection.[139]

VISUAL SHARING

Visual sharing, defined as the sharing or "posting" of photos and videos to public websites where they can be viewed and shared again, is an integral component of social media and used by nearly two thirds (62%) of adults who access the Internet.[140] The volume of content on these platforms (eg, YouTube, Flickr, Instagram, Pinterest) is substantial. YouTube, for example, is the dominant visual sharing website with ≈60 hours of content uploaded each minute, 4 billion pages uploaded daily, and 100 million people taking some form of social action on the site.[141]

Although the concept of creating videos and images for education has been applied for decades and is not itself unique, what differentiates the current attention to visual sharing is the public accessibility, ease of creating content, instant sharing capability, and diversity of image content that did not exist a decade ago. The significant increase in use is also thought to be attributable to the ubiquity of mobile devices with photo, video, and Internet capabilities.

There is significant potential in using visual sharing for ECCC to improve education, awareness, and action of patients and bystanders in an emergency. For healthcare providers, visual sharing could enhance communication and clinical practice. To realize the potential for visual sharing requires that posted images are high quality, accurate, readily available, secured against unwanted sharing, and if patient specific, obtained with consent. This section reviews potential applications (ie, public education, surveillance, transmission of clinical data, measuring behavioral change) and challenges of using visual sharing platforms for ECCC.

Public Education

To date, there are thousands of photos and videos on visual sharing platforms that relate to cardiac arrest, AMI, and stroke. The content is diverse and includes images about prevention, warning symptoms, treatment, patient narratives, and more. Data on these sites are generated by both laypeople and professional organizations and

Table. Potential Directions for a Research Agenda for Emergency Cardiovascular Conditions and Digital Strategies

Emergency Cardiovascular Condition	Digital Strategy	Research Questions
Cardiac arrest	Mobile	• Can mobile AEDs and multiway communication between EMDs, professional responders, bystanders, and patients improve outcomes for SCA patients by enabling faster time to first shock, mobile CPR, and real-time teaching and feedback? • If intrinsic defibrillation capabilities can be integrated into mobile devices or mobile device attachments to essentially allow many people to have a device with defibrillator capabilities with them often, will this improve OHCA outcomes? • How will wearables such as glasses, watches, and computerized clothing provide new opportunities for early recognition and management of OHCA? • Can we develop an effective method of detecting unwitnessed cardiac arrest with integrated mobile device sensors so that automated 9-1-1 calls and defibrillation can be safely coordinated? • How best can we use the mobile device to empower all bystanders to deliver high-quality CPR and defibrillation while ultimately improving survival for victims of OHCA?*
	Social	• What is the role of social media in connecting and facilitating information exchange for a currently loosely connected network of cardiac arrest survivors and trained and willing responders?*
	Visual	• Can visual sharing platforms facilitate real-time coaching and debriefing for CPR and AED use by EMDs with bystanders or bystanders with other bystanders?
	Crowdsourcing	• Can crowdsourcing and location-based service platforms be optimized to develop accurate up-to-date AED registries in urban and rural environments across the world? • Can crowdsourcing be implemented to improve bystanders' willingness and ability to perform CPR when needed?
AMI	Mobile	• Can mobile devices and apps strengthen community systems of care for patients with suspected ACS? Can mobile devices accurately detect electrocardiographic abnormalities with built-in ECG technology? What criteria are needed for these electrocardiographic sensors, and who is the correct recipient for abnormal tracings? How should these remote sensors be monitored and what (if any) is the appropriate compensation model and for what level of provider?* • Can mobile devices be used by providers to accurately determine the best reperfusion destination and strategy based on real-time data from the patient, GPS, traffic conditions, hospital readiness, and historical regional reperfusion times?
	Social	• How can online social networks provide social support for patients with acute cardiovascular conditions? Do social ties translate to online social networks? Are they protective? • How will large databanks that collect information about heart health from EMRs and social media (eg, Health eHearts) contribute to the prevention and treatment of patients with ACS?*
	Visual	• Can visual platforms reduce gaps in patient symptom onset for AMI and time to presentation to a healthcare facility?
	Crowdsourcing	• Can crowdsourcing of bystanders to aid a patient with AMI reduce time to medications (eg, aspirin) or door-to-balloon time for STEMI?*
Stroke	Mobile	• Could mobile phone apps help people correctly identify the stroke warning signs in a stroke patient, enable a rapid 9-1-1 activation, and collect and transmit video and detailed information on location, stroke onset, and medical history?* • Can apps that integrate accelerometers and motion sensing in mobile devices detect falls or abnormal gait associated with stroke onset, and then confirm the diagnosis by automatically assessing a patient's responsiveness to commands? These apps could then alert EMS or nearby networks that can provide rapid assistance if a stroke diagnosis is confirmed.*
	Social	• Can automated analysis of social network activity be used to detect social isolation or behaviors consistent with poststroke depression or low medication adherence? Can social networks be leveraged to improve self-care and engagement in healthy behaviors that can reduce stroke risk factors?
	Visual	• Can visual sharing platforms improve stroke recovery through personalized training videos on activity and physical, occupational, or speech therapy? Can visual content improve stroke symptom recognition and reduce time to seek care?*

(*Continued*)

Table. Continued

Emergency Cardiovascular Condition	Digital Strategy	Research Questions
Stroke, continued	Crowdsourcing	• Can crowdsourcing both facilitate education about stroke symptoms and allow for long-term tracking of public education and response in this area? • Can crowdsourcing help solve several of the key challenges in stroke prevention, treatment, and recovery? Can we engage others to identify new methods for measuring functional outcomes after stroke in a reliable but cost-effective manner? Can we find alternative ways to conduct low-cost, large, pragmatic clinical trials of prevention or recovery interventions, substituting a crowdsourced alternative to traditional CROs? Can we encourage submission of de-identified but detailed phenotypic data along with their DNA sequencing from patients all over the world to large, protected databases to enable massive genome-phenome association studies?

ACS indicates acute coronary syndrome; AED, automated external defibrillator; AMI, acute myocardial infarction; app, application; CPR, cardiopulmonary resuscitation; CRO, contract research organization; EMD, emergency medical dispatch; EMR, electronic medical record; EMS, emergency medical services; GPS, global positioning system; OHCA, out-of-hospital cardiac arrest; SCA, sudden cardiac arrest; and STEMI, ST-segment–elevation myocardial infarction.

*Denotes questions identified as priority areas of focus by the writing group.

can serve as tools for general education or in the midst of an emergency event.[142]

Ensuring that the health information communicated by the photos and videos is accurate is an important challenge for using visual sharing to improve ECCC.[143] For example, an analysis of the credibility of YouTube videos related to AMI found a large number were irrelevant, and only 6% included complete information about AMI.[144] Videos that included personal narratives and personal experiences about AMI were more likely to have a lot of views and generate engagement (eg, rating of like/dislike or posting of comments). Similarly, an analysis of the source, content, and quality of YouTube videos related to CPR (n=104) found the majority of videos were inaccurate and missed vital steps in high-quality CPR.[145] In several videos, scene safety assessment was omitted (65%), incorrect chest compressions were provided (64%), and incorrect recommendations for a pulse check occurred (10%). These examples underscore the potential for unintended consequences in using visual sharing for ECCC and thus reinforce the need for rigorous evaluation of such interventions.

One potential use of photos and videos for ECCC is to communicate health messages for diverse audiences that may speak different languages or have varying degrees of literacy. One prior study evaluated the availability and quality of CPR videos on the Internet for Spanish-speaking populations and identified >50 videos.[146] Although the presence of these videos suggests opportunities for communicating messages across different communities, many of the videos were of low quality. Similar studies of accessibility of visual sharing to non–English-speaking populations are currently lacking for AMI. Ensuring broad accessibility to health information for non–English-speaking people is important from both a global perspective and in the United States, where this population is growing dramatically and currently exceeds 30 million people.[147] This reinforces the need for more research on this potential application of visual sharing.

Surveillance and Direct Visualization

One of the advantages of visual platforms is that the content is dynamic and can be updated regularly. This offers promise for changing content as new scientific data becomes available.[148] Prior work evaluating resuscitation-specific videos showed that the majority were not consistent with recommended guidelines, but the flexibility of visual platforms suggests that this can be amended.[142] It is therefore a specific challenge for this area to ensure that older content is archived and newer evidence-based data are displayed prominently.

Videos and photos also offer an opportunity for visual assessment of practices (eg, CPR provision, AED use, recognition of AMI and stroke symptoms) and objective measurement of technique, delivery, and patient response.[149] Images shared on the Internet could serve as a novel opportunity to better understand where an intervention is needed in changing public and healthcare providers' response to cardiovascular emergencies.[150] These represent targets for future research on the use of visual sharing to improve ECCC.

Enhancing Emergency Medical Dispatch

Video capture and transmission technology within most mobile devices allows for the possibility of video linkage between a 9-1-1 caller and an emergency medical dispatcher. Such a system could "enhance the 911 system to create a faster, more flexible, resilient, and scalable system that allows 911 to keep up with communication technology (eg, voice, photos, videos, text messages) used by the public."[151] Although not incorporated in many communities at this time, it offers the promise of application of visual sharing to improve ECCC, because the recognition of cardiac arrest by emergency medical dispatchers has been identified as a barrier to optimized dispatch-assisted CPR.[152,153] Visual assessment of the patient and the caller by the emergency medical dispatcher could enhance early recognition of emergency cardiovascular conditions to optimize EMS assignment and deployment. Therefore, this represents another priority research topic area.

Transmission and Exchange of Clinical Data

Visual sharing has the potential to enhance sharing of clinical data among healthcare providers. The promise of such directed sharing has been demonstrated with prehospital diagnosis of STEMI, prearrival hospital notification, and resultant decreased time to reperfusion.[154] In a similar fashion, sharing of patient pictures (ie, facial droop) or brief video clips (eg, aphasia) and other clinical data points suggestive of stroke could facilitate prehospital activation of stroke teams or transfer of patients to stroke centers.[155]

Visual sharing is complicated, however, by concerns about patient privacy and liability for content generators. This is particularly important if devices that enable visual sharing are lost, images are transmitted to an unintended third party, or those who manage the content do not have protocols for image storage and destruction.

Challenges and Opportunities for Visual Sharing and ECCC

Much of the effectiveness of visual sharing is currently evaluated by metrics such as views, "shares," "hits," and comments. Although these proxy measures can yield large numbers that suggest significant engagement, they do not inform whether the viewer learned from the video or whether the care of patients with emergency cardiovascular conditions was improved. Since 2012, the AHA has released several 1-minute online videos as part of its Hands-Only CPR campaign. These videos, which highlight the need to call 9-1-1 in the event of a sudden cardiac arrest and demonstrate how to do compression-only CPR properly, have cumulatively generated >3.3 million views. In 2015, public service announcements aimed to increase people's awareness of sudden cardiac arrest and the need for bystander CPR were viewed >520 million times. During American Stroke Month (May 2014), the American Stroke Association website had >1.8 million page views.

To achieve the full potential of visual sharing for ECCC, research on whether views translate into improved early recognition, appropriate treatment, and patient outcomes is needed. For example, research could determine whether views of social media pertaining to stroke lead to demonstrable improvements in knowledge about stroke warning signs, recognition of these signs, and appropriate action in response to stroke warning signs. Research in the setting of cardiac arrest might include evidence that views of visual postings on CPR are related to rates of bystander CPR in a community. Similarly, research might determine whether visual postings related to AMI can address the persistent gap in the time from patient symptom onset to seeking care. Demonstrating a relationship between social media viewing and better recognition, treatment, and outcomes of emergency cardiovascular conditions could provide a meaningful way to track the impact of readily accessible visual sharing materials on behavioral change and patient outcomes.

Additional challenges relate to the massive amount of data in visual sharing platforms. Increasingly, software is being developed to extract data from images; however, little of this effort has focused on healthcare uses broadly or ECCC specifically. There is also an ongoing need to enhance the availability and accuracy of ECCC-related content on visual sharing platforms. Up-to-date reliable information about how and when the public should respond needs to be easy to locate and apply. Research on best methods to make content accessible and applicable when needed is a priority to address this challenge.[112] Furthermore, similar standards should apply for healthcare providers using secure visual sharing for healthcare information and delivery. The ability to track and improve accessibility of accurate information on visual platforms for different populations with various learning styles and backgrounds is also needed.

The AHA, medical professional societies, and other credible entities should be encouraged to provide visual sharing tools about ECCC that are regularly updated and consistent with the most recent guidelines. These should also enable consumers to critically review information posted on visual sharing platforms to facilitate effective healthcare decision making. Directly linking viewership of photos/videos with actual recognition (eg, stroke symptoms), response (eg, 9-1-1 call), process measures (eg, time to evaluation), and outcomes could also enhance the utility of visual sharing platforms for clinical practice.

CROWDSOURCING

The exponential growth of the Internet has created the potential to optimize individuals and groups for specific services, such as crowdsourcing.[156] Crowdsourcing represents an approach to collecting ideas, data, and services from a large group of people rather than those who might conventionally participate in a task. The traditional model in science involves an expert in a particular area developing research questions and then systematically testing them on individuals or populations. Crowdsourcing represents a collective effort of problem solving to answer a challenge.[157–159] It allows for a participatory culture that can harness the collective intelligence of the masses on an open platform.[30]

Social media has enhanced crowdsourcing, allowing individuals and groups to reach other individuals or groups in real time and in large numbers. This approach can lead to not only new research questions but also nuanced ways of asking research questions and approaches to answering them. In the current era of connectedness, in which endless information is digitally accessible and knowledge exchange occurs rapidly and often effortlessly, patients can potentially collaborate with healthcare providers to drive science.

Health-related crowdsourcing has been used in multiple contexts, including problem solving, data processing, monitoring, and surveying.[31] The following section evaluates the potential use of crowdsourcing for improving care in the event of cardiac arrest, AMI, and stroke. Crowdsourcing not only has the potential to educate the general public about emergency cardiovascular conditions, but it can also potentially support public engagement to respond and take action, thereby enhancing ECCC.

Crowdsourcing for Cardiac Arrest Care

Although not previously described as "crowdsourcing," the concept of engaging lay citizens to help execute medical tasks to improve patient outcomes has had an important impact on ECCC. A principal example is bystander CPR and AED use. As noted previously in this statement, timely initiation of bystander CPR and AED use are associated with improved outcomes after OHCA. The broad prevalence of public CPR and AED training creates an environment in which lay citizens can have a critical role in the chain of survival.[2] More recently, emergency response programs using smartphones that activate the public to engage as early medical responders have been implemented. A group in the Netherlands was among the first to study solicitation of volunteers to be notified via text message when a suspected cardiac arrest was nearby.[160] This study demonstrated that responders can be activated and can arrive on the scene before traditional EMS. Another program, PulsePoint, began in 2011 with a mobile device application that integrates volunteer citizen responders with local emergency dispatch systems.[65] When an emergency call taker suspects a cardiac arrest in a public location, the PulsePoint program automatically identifies all mobile devices running the app within ≈400 m of the event. Those potential responders receive an alert on their phone followed by a map display showing the location of the cardiac arrest and the locations of nearby AEDs. As of May 2016, PulsePoint was operating in 1549 communities across the United States and Canada. The system has activated 24 100 PulsePoint responders on 9547 suspected cardiac arrest events. More than 750 000 people have downloaded the app (Richard Price, MPA, president, PulsePoint Foundation, oral communication [telephone call], May 2016). Others are developing similar systems with enhanced features in other countries such as Japan and Sweden.[161–163] Future initiatives could also allow responders (or even patients) to alert others in their geographic proximity of a need for help.[164,165] With the advent of sensors and wearable devices that track biometric data, early warning symptoms could also trigger nearby networks for early response. These applications are high priorities for future ECCC research.

As another example, the MyHeartMap Challenge, which focused on improving AED awareness and location specificity, used crowdsourcing, social media, and gaming to engage the public to find and report AEDs.[166] The project first piloted the task of crowdsourcing the public to look for and validate the location of AEDs using a mobile, location-based app, Gigwalk.[167] In a subsequent project, participants were able to download the MyHeartMap app on their smartphone or register via the Internet. The goal of the project was to have participants take a picture of AEDs in a defined urban area and upload the picture and AED location to the crowdsourcing platform to create a map for EMS and bystander use. The project generated >8000 hits and had >1400 AED submissions, 99% of which were validated. This project laid the groundwork for future challenges in other cities.

Crowdsourcing for AMI and Stroke Care

Although crowdsourcing has begun to be used for aspects of cardiac arrest care, there exists untapped potential for using similar approaches to help with early recognition and treatment of AMI and stroke. Public education and dissemination of research about these conditions could be enhanced through crowdsourcing. Similar to the PulsePoint initiative for public response to cardiac arrest cases, programs could be developed for AMI and stroke. The lay public could assist with symptom recognition and early connections with EMS, potentially leading to faster treatment and improved outcomes. Social norming to promote a culture of response could help to actualize this potential. Currently, we learn about medical conditions after the event has occurred. In the future, real-time notifications and alerts could promote a collective coordinated response in AMI and stroke emergencies. These potential applications of crowdsourcing to improve early AMI and stroke care are ECCC research priorities.

Crowdsourcing Development and Vetting of ECCC Practice Guidelines

The AHA and the International Liaison Committee on Resuscitation (ILCOR) have used crowdsourcing to garner ideas and support from healthcare and lay providers concerning guideline updates and areas of interest for focused scientific statements. This was done for the 2010 International Consensus on CPR and ECC Science With Treatment Recommendations (CoSTR) and applied with the 2015 CoSTR.[168,169] The ILCOR site is set up to garner feedback and comments from the general public on their Scientific Evidence Evaluation and Review System (SEERS) with the hope of providing greater transparency and allowing broader participation in the guidelines development process.

Crowdsourcing to Support Research Through Crowdfunding

Crowdfunding is defined as "the practice of soliciting financial contributions from a large number of people especially from the online community."[170] It has been used to raise funds for a range of medical illnesses and injuries such as traumatic events or diseases spanning from the more common to the very rare, yielding, for example, >$8.8 million from patients and others on one such site, GiveForward.[171] The AHA and other organizations are beginning to explore applications for engaging crowds in this area. In this context, the AHA has partnered with MedStartr to fund innovations targeted at meeting their 2020 Impact Goal of improving cardiovascular health for all Americans. Additionally, a group focused on messaging that concerns stroke, the Power To End Stroke campaign, has used crowdfunding to raise funds to market its message.

Crowdsourcing funds could be used for specific needs such as public AED programs, for educational projects such as CPR training among high-risk communities, to spread new campaigns such as Spot a Stroke F.A.S.T., or for other ECCC-related research initiatives. Crowdfunding can also be used to fund medical research for these diseases, and numerous platforms exist to help researchers raise funds for potential breakthroughs in science.[172,173]

Crowdsourcing: Challenges and Opportunities

Crowdsourcing has great potential but is not without limitations. There are many concerns regarding lack of validity of the data entered, the inexperience of those inputting and analyzing the data, and the possibility of propagation of false or "bad" data.[174] It could be undesirable to activate a crowd to respond to a resuscitation that was occurring at a private residence, to a non-arrest, or to retrieve an AED that was no longer at a presumed location. This could theoretically create liability issues for the individual or group reaching out to the crowd. Data accuracy is vital, and techniques should be applied to strengthen data quality measurements and determine an algorithm for calculating the reputation of crowdsourcing participants.[174]

Despite the challenges, crowdsourcing has immense potential for enhancing both public and provider response for ECCC. There are many research questions that could be answered via crowdsourcing to improve outcomes from cardiac arrest, myocardial infarction, and stroke (Table): Could rates of bystander CPR be improved solely by crowdsourcing bystander CPR response? Could door-to-balloon times be decreased solely by crowdsourcing when someone is experiencing an AMI? Can educational campaigns driven by social media and crowdsourcing improve stroke response? The determination of how to best use these interventions to engage the lay public and healthcare providers will depend on the ingenuity and innovation of those willing to study the impact of this approach on the education, outreach, and care of emergency cardiovascular conditions.

CONCLUSIONS

Timely recognition of symptoms and initiation of treatment is central to the chain of survival for ECCC, including cardiac arrest, AMI, and stroke. Digital strategies represent novel interventions to potentially improve care delivery and patient outcomes for emergency cardiovascular conditions. Well-designed prospective scientific trials could evaluate the use of digital technologies to improve areas such as bystander CPR rates for cardiac arrest, door-to-balloon time for myocardial infarction, or early recognition of symptoms for stroke. This scientific statement focused on current scientific knowledge, as well as limitations and opportunities, for using mobile devices, social media, visual sharing, and crowdsourcing in relationship to ECCC. Digital strategies represent a rapidly evolving field, both in terms of evolving technologies that potentially can be applied as interventions to improve ECCC and in terms of the growth of research in this field. As such, this scientific statement will likely need frequent updating to reflect the current state of the science for digital strategies and ECCC.

Nonetheless, an overarching finding of this statement is that although digital tools have tremendous potential, there is a paucity of scientific evidence for their effectiveness in improving ECCC to date. Moreover, there is potential for unintended consequences, such as incorrect information being provided via mobile apps or social media. Therefore, a key conclusion of this statement is that there is a clear need for rigorous research on digital strategies for ECCC, to build the scientific evidence base for their effectiveness and safety. As with more traditional medical therapies and interventions, rigorous research is needed to understand how digital strategies can be harnessed to have the greatest impact for improving outcomes for cardiovascular emergencies.

Fortunately, there is significant and growing interest among stakeholders, ranging from consumer groups to healthcare systems to research funding agencies, in evaluating digital strategies to improve healthcare delivery and patient outcomes. Accordingly, this statement emphasizes key research questions for the future for mobile devices, social media, visual sharing, and crowdsourcing interventions for ECCC. It is hoped that this will inform the AHA and other public and scientific entities as they direct resources to improve care and outcomes of patients with emergency cardiovascular conditions. If so, digital strategies could realize their potential as disruptive innovations in health care that directly translate into improved healthcare delivery and patient outcomes.

FOOTNOTES

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

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CLINICAL STATEMENTS AND GUIDELINES

DISCLOSURES

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Reviewer Disclosures

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*Modest.

REFERENCES

1. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, Das SR, de Ferranti S, Després JP, Fullerton HJ, Howard VJ, Huffman MD, Isasi CR, Jiménez MC, Judd SE, Kissela BM, Lichtman JH, Lisabeth LD, Liu S, Mackey RH, Magid DJ, McGuire DK, Mohler ER 3rd, Moy CS, Muntner P, Mussolino ME, Nasir K, Neumar RW, Nichol G, Palaniappan L, Pandey DK, Reeves MJ, Rodriguez CJ, Rosamond W, Sorlie PD, Stein J, Towfighi A, Turan TN, Virani SS, Woo D, Yeh RW, Turner MB; on behalf of the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics—2016 update: a report from the American Heart Association [published correction appears in *Circulation*. 2016;133:e599]. *Circulation*. 2016;133:e38–e360. doi: 10.1161/CIR.0000000000000350.
2. Abella BS, Aufderheide TP, Eigel B, Hickey RW, Longstreth WT Jr, Nadkarni V, Nichol G, Sayre MR, Sommargren CE, Hazinski MF. Reducing barriers for implementation of bystander-initiated cardiopulmonary resuscitation: a scientific statement from the American Heart Association for healthcare providers, policymakers, and community leaders regarding the effectiveness of cardiopulmonary resuscitation. *Circulation*. 2008;117:704–709. doi: 10.1161/CIRCULATIONAHA.107.188486.
3. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: the "chain of survival" concept: a statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. *Circulation*. 1991;83:1832–1847. doi: 10.1161/01.CIR.83.5.1832.
4. O'Gara PT, Kushner FG, Ascheim DD, Casey DE Jr, Chung MK, de Lemos JA, Ettinger SM, Fang JC, Fesmire FM, Franklin BA, Granger CB, Krumholz HM, Linderbaum JA, Morrow DA, Newby LK, Ornato JP, Ou N, Radford MJ, Tamis-Holland JE, Tommaso CL, Tracy CM, Woo YJ, Zhao DX, Anderson JL, Jacobs AK, Halperin JL, Albert NM, Brindis RG, Creager MA, DeMets D, Guyton RA, Hochman JS, Kovacs RJ, Kushner FG, Ohman EM, Stevenson WG, Yancy CW. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines [published correction appears in *Circulation*. 2013;128:e481]. *Circulation*. 2013;127:e362–e425. doi: 10.1161/CIR.0b013e3182742cf6.
5. Field JM, Hazinski MF, Sayre MR, Chameides L, Schexnayder SM, Hemphill R, Samson RA, Kattwinkel J, Berg RA, Bhanji F, Cave

DM, Jauch EC, Kudenchuk PJ, Neumar RW, Peberdy MA, Perlman JM, Sinz E, Travers AH, Berg MD, Billi JE, Eigel B, Hickey RW, Kleinman ME, Link MS, Morrison LJ, O'Connor RE, Shuster M, Callaway CW, Cucchiara B, Ferguson JD, Rea TD, Vanden Hoek TL. Part 1: executive summary: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2010;122(suppl 3):S640–S656. doi: 10.1161/CIRCULATIONAHA.110.970889.
6. Ovbiagele B, Goldstein LB, Higashida RT, Howard VJ, Johnston SC, Khavjou OA, Lackland DT, Lichtman JH, Mohl S, Sacco RL, Saver JL, Trogdon JG; on behalf of the American Heart Association Advocacy Coordinating Committee and Stroke Council. Forecasting the future of stroke in the United States: a policy statement from the American Heart Association and American Stroke Association [published correction appears in *Stroke*. 2015;46:e179]. *Stroke*. 2013;44:2361–2375. doi: 10.1161/STR.0b013e31829734f2.
7. Travers AH, Rea TD, Bobrow BJ, Edelson DP, Berg RA, Sayre MR, Berg MD, Chameides L, O'Connor RE, Swor RA. Part 4: CPR overview: 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation*. 2010;122(suppl 3):S676–S684. doi: 10.1161/CIRCULATIONAHA.110.970913.
8. Bradley EH, Herrin J, Wang Y, Barton BA, Webster TR, Mattera JA, Roumanis SA, Curtis JP, Nallamothu BK, Magid DJ, McNamara RL, Parkosewich J, Loeb JM, Krumholz HM. Strategies for reducing the door-to-balloon time in acute myocardial infarction. *N Engl J Med*. 2006;355:2308–2320. doi: 10.1056/NEJMsa063117.
9. Moser DK, Kimble LP, Alberts MJ, Alonzo A, Croft JB, Dracup K, Evenson KR, Go AS, Hand MM, Kothari RU, Mensah GA, Morris DL, Pancioli AM, Riegel B, Zerwic JJ. Reducing delay in seeking treatment by patients with acute coronary syndrome and stroke: a scientific statement from the American Heart Association Council on Cardiovascular Nursing and Stroke Council. *Circulation*. 2006;114:168–182. doi: 10.1161/CIRCULATIONAHA.106.176040.
10. Rawles J. Magnitude of benefit from earlier thrombolytic treatment in acute myocardial infarction: new evidence from Grampian Region Early Anistreplase Trial (GREAT). *BMJ*. 1996;312:212–215.
11. Fonarow GC, Zhao X, Smith EE, Saver JL, Reeves MJ, Bhatt DL, Xian Y, Hernandez AF, Peterson ED, Schwamm LH. Door-to-needle times for tissue plasminogen activator administration and clinical outcomes in acute ischemic stroke before and after a quality improvement initiative. *JAMA*. 2014;311:1632–1640. doi: 10.1001/jama.2014.3203.
12. Lackland DT, Roccella EJ, Deutsch AF, Fornage M, George MG, Howard G, Kissela BM, Kittner SJ, Lichtman JH, Lisabeth LD, Schwamm LH, Smith EE, Towfighi A; on behalf of the American Heart Association Stroke Council, Council on Cardiovascular and Stroke Nursing, Council on Quality of Care and Outcomes Research, Council on Functional Genomics and Translational Biology. Factors influencing the decline in stroke mortality: a statement from the American Heart Association/American Stroke Association. *Stroke*. 2014;45:315–353. doi: 10.1161/01.str.0000437068.30550.cf.
13. Schwamm L, Fayad P, Acker JE 3rd, Duncan P, Fonarow GC, Girgus M, Goldstein LB, Gregory T, Kelly-Hayes M, Sacco RL, Saver JL, Segrest W, Solis P, Yancy CW. Translating evidence into practice: a decade of efforts by the American Heart Association/American Stroke Association to reduce death and disability due to stroke: a presidential advisory from the American Heart Association/American Stroke Association. *Stroke*. 2010;41:1051–1065. doi: 10.1161/STR.0b013e3181d2da7d.
14. Birbeck GL, Cui X, Zingmond DS, Vickrey BG. Intravenous tissue plasminogen activator for acute stroke in California: recipients and resources. *Cerebrovasc Dis*. 2004;17:341–343. doi: 10.1159/000078091.
15. Sug Yoon S, Heller RF, Levi C, Wiggers J. Knowledge and perception about stroke among an Australian urban population. *BMC Public Health*. 2001;1:14.
16. Greenlund KJ, Neff LJ, Zheng ZJ, Keenan NL, Giles WH, Ayala CA, Croft JB, Mensah GA. Low public recognition of major stroke symptoms. *Am J Prev Med*. 2003;25:315–319.
17. Agency for Healthcare Research and Quality website. Funding announcements. http://www.ahrq.gov/funding/fund-opps/. Accessed June 10, 2015.
18. Robert Wood Johnson Foundation website. Funding opportunities. http://www.rwjf.org/en/grants/funding-opportunities.html. Accessed June 10, 2015.
19. National Institutes of Health website. Funding. http://grants.nih.gov/grants/guide/index.html. Accessed June 10, 2015.
20. IOM (Institute of Medicine). *Strategies to Improve Cardiac Arrest Survival: A Time to Act*. Washington, DC: National Academies Press; 2015.
21. Duggan M, Ellison N, Lampe C, Lenhart A, Madden M. Social media update 2014. Washington, DC: Pew Research Center; January 2015. http://www.pewinternet.org/2015/01/09/social-media-update-2014/. Accessed June 10, 2015.
22. Smith A. U.S. smartphone use in 2015. Washington, DC: Pew Research Center; April 2015. http://www.pewinternet.org/2015/04/01/us-smartphone-use-in-2015/. Accessed June 10, 2015.
23. Smith A. Americans and their cell phones. Washington, DC: Pew Research Center; August 2015. http://www.pewinternet.org/2011/08/15/americans-and-their-cell-phones/. Accessed June 10, 2015.
24. Smith A. Smartphone adoption and usage. Washington, DC: Pew Research Center; July 2015. http://www.pewinternet.org/2011/07/11/smartphone-adoption-and-usage/. Accessed June 10, 2015.
25. Jadad AR, Fandiño M, Lennox R. Intelligent glasses, watches and vests…oh my! Rethinking the meaning of "harm" in the age of wearable technologies. *JMIR Mhealth Uhealth*. 2015;3:e6. doi: 10.2196/mhealth.3565.
26. Årsand E, Muzny M, Bradway M, Muzik J, Hartvigsen G. Performance of the first combined smartwatch and smartphone diabetes diary application study. *J Diabetes Sci Technol*. 2015;9:556–563. doi: 10.1177/1932296814567708.
27. Ianchulev T, Minckler DS, Hoskins HD, Packer M, Stamper R, Pamnani RD, Koo EY. Wearable technology with head-mounted displays and visual function. *JAMA*. 2014;312:1799–1801. doi: 10.1001/jama.2014.13754.
28. Clifton L, Clifton DA, Pimentel MA, Watkinson PJ, Tarassenko L. Predictive monitoring of mobile patients by combining clinical observations with data from wearable sensors. *IEEE J Biomed Health Inform*. 2014;18:722–730. doi: 10.1109/JBHI.2013.2293059.
29. Zheng YL, Ding XR, Poon CC, Lo BP, Zhang H, Zhou XL, Yang GZ, Zhao N, Zhang YT. Unobtrusive sensing and wearable devices for health informatics. *IEEE Trans Biomed Eng*. 2014;61:1538–1554. doi: 10.1109/TBME.2014.2309951.
30. Brabham DC, Ribisl KM, Kirchner TR, Bernhardt JM. Crowdsourcing applications for public health. *Am J Prev Med*. 2014;46:179–187. doi: 10.1016/j.amepre.2013.10.016.
31. Ranard BL, Ha YP, Meisel ZF, Asch DA, Hill SS, Becker LB, Seymour AK, Merchant RM. Crowdsourcing: harnessing the masses to advance health and medicine, a systematic review. *J Gen Intern Med*. 2014;29:187–203. doi: 10.1007/s11606-013-2536-8.
32. Carter RR, DiFeo A, Bogie K, Zhang GQ, Sun J. Crowdsourcing awareness: exploration of the ovarian cancer knowledge gap through Amazon Mechanical Turk. *PLoS One*. 2014;9:e85508. doi: 10.1371/journal.pone.0085508.
33. Bevelander KE, Kaipainen K, Swain R, Dohle S, Bongard JC, Hines PD, Wansink B. Crowdsourcing novel childhood predictors of adult obesity. *PLoS One*. 2014;9:e87756. doi: 10.1371/journal.pone.0087756.

34. Kovic I, Lulic I. Mobile phone in the chain of survival. *Resuscitation*. 2011;82:776–779. doi: 10.1016/j.resuscitation.2011.02.014.
35. Skorning M, Bergrath S, Rörtgen D, Beckers SK, Brokmann JC, Gillmann B, Herding J, Protogerakis M, Fitzner C, Rossaint R; Med-on-@ix-Working Group. Teleconsultation in pre-hospital emergency medical services: real-time telemedical support in a prospective controlled simulation study. *Resuscitation*. 2012;83:626–632. doi: 10.1016/j.resuscitation.2011.10.029.
36. Merchant RM, Griffis HM, Ha YP, Kilaru AS, Sellers AM, Hershey JC, Hill SS, Kramer-Golinkoff E, Nadkarni L, Debski MM, Padrez KA, Becker LB, Asch DA. Hidden in plain sight: a crowdsourced public art contest to make automated external defibrillators more visible. *Am J Public Health*. 2014:104:2306–2312.
37. Kamel Boulos MN, Resch B, Crowley DN, Breslin JG, Sohn G, Burtner R, Pike WA, Jezierski E, Chuang KY. Crowdsourcing, citizen sensing and sensor web technologies for public and environmental health surveillance and crisis management: trends, OGC standards and application examples. *Int J Health Geogr*. 2011;10:67. doi: 10.1186/1476-072X-10-67.
38. Kim AE, Lieberman AJ, Dench D. Crowdsourcing data collection of the retail tobacco environment: case study comparing data from crowdsourced workers to trained data collectors. *Tob Control*. 2015;24:e6–e9. doi: 10.1136/tobaccocontrol-2013-051298.
39. Institute of Medicine. *Crossing the Quality Chasm: A New Health System for the 21st Century*. Washington, DC: National Academies Press; 2001. https://www.nationalacademies.org/hmd/~/media/Files/Report%20Files/2001/Crossing-the-Quality-Chasm/Quality%20Chasm%202001%20%20report%20brief.pdf. Accessed June 10, 2015.
40. Glauser W. Doctors among early adopters of Google Glass. *CMAJ*. 2013;185:1385. doi: 10.1503/cmaj.109-4607.
41. Hoi-Jun Y. Your heart on your sleeve: advances in textile-based electronics are weaving computers right into the clothes we wear. *IEEE Solid State Circuits Magazine*. 2013;5:59–70.
42. Lee MS, Lee K, Kim SY, Lee H, Park J, Choi KH, Kim HK, Kim DG, Lee DY, Nam S, Park JU. High-performance, transparent, and stretchable electrodes using graphene-metal nanowire hybrid structures. *Nano Lett*. 2013;13:2814–2821. doi: 10.1021/nl401070p.
43. Duggan M. Cell phone activities 2013. Washington, DC: Pew Research Center; September 2013. http://www.pewinternet.org/2013/09/19/cell-phone-activities-2013/. Accessed June 10, 2013.
44. Burke LE, Ma J, Azar KM, Bennett GG, Peterson ED, Zheng Y, Riley W, Stephens J, Shah SH, Suffoletto B, Turan TN, Spring B, Steinberger J, Quinn CC; on behalf of the American Heart Association Publications Committee of the Council on Epidemiology and Prevention, Behavior Change Committee of the Council on Cardiometabolic Health, Council on Cardiovascular and Stroke Nursing, Council on Functional Genomics and Translational Biology, Council on Quality of Care and Outcomes Research, and Stroke Council. Current science on consumer use of mobile health for cardiovascular disease prevention: a scientific statement from the American Heart Association [published correction appears in *Circulation*. 2015;132:e233]. *Circulation*. 2015;132:1157–1213. doi: 10.1161/CIR.0000000000000232.
45. Christenson J, Andrusiek D, Everson-Stewart S, Kudenchuk P, Hostler D, Powell J, Callaway CW, Bishop D, Vaillancourt C, Davis D, Aufderheide TP, Idris A, Stouffer JA, Stiell I, Berg R; Resuscitation Outcomes Consortium Investigators. Chest compression fraction determines survival in patients with out-of-hospital ventricular fibrillation. *Circulation*. 2009;120:1241–1247. doi: 10.1161/CIRCULATIONAHA.109.852202.
46. Zijlstra JA, Stieglis R, Riedijk F, Smeekes M, van der Worp WE, Koster RW. Local lay rescuers with AEDs, alerted by text messages, contribute to early defibrillation in a Dutch out-of-hospital cardiac arrest dispatch system. *Resuscitation*. 2014;85:1444–1449. doi: 10.1016/j.resuscitation.2014.07.020.
47. Lifesaver: An Interactive Film by Martin Percy. https://life-saver.org.uk/. Accessed June 10, 2015.
48. Ahn JY, Cho GC, Shon YD, Park SM, Kang KH. Effect of a reminder video using a mobile phone on the retention of CPR and AED skills in lay responders. *Resuscitation*. 2011;82:1543–1547. doi: 10.1016/j.resuscitation.2011.08.029.
49. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. *Circulation*. 2001;104:2513–2516. doi: 10.1161/hc4601.099468.
50. Merchant RM, Abella BS, Abotsi EJ, Smith TM, Long JA, Trudeau ME, Leary M, Groeneveld PW, Becker LB, Asch DA. Cell phone cardiopulmonary resuscitation: audio instructions when needed by lay rescuers: a randomized, controlled trial. *Ann Emerg Med*. 2010;55:538–543.e1. doi: 10.1016/j.annemergmed.2010.01.020.
51. Johnsen E, Bolle SR. To see or not to see: better dispatcher-assisted CPR with video-calls? A qualitative study based on simulated trials. *Resuscitation*. 2008;78:320–326. doi: 10.1016/j.resuscitation.2008.04.024.
52. Lee JS, Jeon WC, Ahn JH, Cho YJ, Jung YS, Kim GW. The effect of a cellular-phone video demonstration to improve the quality of dispatcher-assisted chest compression-only cardiopulmonary resuscitation as compared with audio coaching. *Resuscitation*. 2011;82:64–68. doi: 10.1016/j.resuscitation.2010.09.467.
53. Yang CW, Wang HC, Chiang WC, Hsu CW, Chang WT, Yen ZS, Ko PC, Ma MH, Chen SC, Chang SC. Interactive video instruction improves the quality of dispatcher-assisted chest compression-only cardiopulmonary resuscitation in simulated cardiac arrests. *Crit Care Med*. 2009;37:490–495. doi: 10.1097/CCM.0b013e31819573a5.
54. Bolle SR, Johnsen E, Gilbert M. Video calls for dispatcher-assisted cardiopulmonary resuscitation can improve the confidence of lay rescuers: surveys after simulated cardiac arrest. *J Telemed Telecare*. 2011;17:88–92. doi: 10.1258/jtt.2010.100605.
55. The Zoll PocketCPR [iPhone application]. http://www.pocketcpr.com/iphone.html. Accessed June 10, 2015.
56. Ringh M, Rosenqvist M, Hollenberg J, Jonsson M, Fredman D, Nordberg P, Järnbert-Pettersson H, Hasselqvist-Ax I, Riva G, Svensson L. Mobile-phone dispatch of laypersons for CPR in out-of-hospital cardiac arrest. *N Engl J Med*. 2015;372:2316–2325. doi: 10.1056/NEJMoa1406038.
57. Deleted in proof.
58. iTunes First Aid White Cross [iTunes application]. https://itunes.apple.com/ca/app/first-aid-white-cross/id295175159?mt=8. Accessed June 10, 2015.
59. Deleted in proof.
60. 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. doi: 10.1016/j.jacc.2009.11.077.
61. 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.
62. Bogle B, Mehrotra S, Chiampas G, Aldeen AZ. Assessment of knowledge and attitudes regarding automated external defibrillators and cardiopulmonary resuscitation among American University students. *Emerg Med J*. 2013;30:837–841. doi: 10.1136/emermed-2012-201555.

63. Hazinski MF, Idris AH, Kerber RE, Epstein A, Atkins D, Tang W, Lurie K. Lay rescuer automated external defibrillator ("public access defibrillation") programs: lessons learned from an international multicenter trial: advisory statement from the American Heart Association Emergency Cardiovascular Committee; the Council on Cardiopulmonary, Perioperative, and Critical Care; and the Council on Clinical Cardiology. *Circulation*. 2005;111:3336–3340. doi: 10.1161/CIRCULATIONAHA.105.165674.
64. Haskell SE, Post M, Cram P, Atkins DL. Community public access sites: compliance with American Heart Association recommendations. *Resuscitation*. 2009;80:854–858. doi: 10.1016/j.resuscitation.2009.04.033.
65. The PulsePoint Respond mobile device application to crowdsource basic life support for patients with out-of-hospital cardiac arrest: challenges for optimal implementation. *Resuscitation*. 2015;98:20-26. DOI: 10.1016/j.resuscitation.2015.09.392.
66. University of Pennsylvania website. MyHeartMap challenge. http://www.myheartmap.org/. Accessed June 10, 2015.
67. Aed4us. http://www.aed4.us/?page=overaed. Accessed June 10, 2015.
68. 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. doi: 10.1016/j.resuscitation.2010.09.466.
69. SecuraFone [smartphone application]. http://www.securafone.com/home/. Accessed June 10, 2015.
70. O'Connor RE, Brady W, Brooks SC, Diercks D, Egan J, Ghaemmaghami C, Menon V, O'Neil BJ, Travers AH, Yannopoulos D. Part 10: acute coronary syndromes: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care [published corrections appear in *Circulation*. 2011;123:e238 and *Circulation*. 2012;125:e265]. *Circulation*. 2010;122(suppl 3):S787–S817. doi: 10.1161/CIRCULATIONAHA.110.971028.
71. Jollis JG, Granger CB, Henry TD, Antman EM, Berger PB, Moyer PH, Pratt FD, Rokos IC, Acuña AR, Roettig ML, Jacobs AK. Systems of care for ST-segment-elevation myocardial infarction: a report from the American Heart Association's Mission: Lifeline. *Circ Cardiovasc Qual Outcomes*. 2012;5:423–428. doi: 10.1161/CIRCOUTCOMES.111.964668.
72. Deleted in proof.
73. Wong CK. iPhone ECG monitoring: the gateway to the new paradigm of STEMI therapy. *Int J Cardiol*. 2013;168:2897–2898. doi: 10.1016/j.ijcard.2013.03.167.
74. AliveCor. Kardia mobile EKG [electronic device]. http://www.alivecor.com/home Accessed June 10, 2015.
75. Morrison LJ, Brooks S, Sawadsky B, McDonald A, Verbeek PR. Prehospital 12-lead electrocardiography impact on acute myocardial infarction treatment times and mortality: a systematic review. *Acad Emerg Med*. 2006;13:84–89. doi: 10.1197/j.aem.2005.07.042.
76. Aufderheide TP, Kereiakes DJ, Weaver WD, Gibler WB, Simoons ML. Planning, implementation, and process monitoring for prehospital 12-lead ECG diagnostic programs. *Prehosp Disaster Med*. 1996;11:162–171.
77. Kereiakes DJ, Weaver WD, Anderson JL, Feldman T, Gibler B, Aufderheide T, Williams DO, Martin LH, Anderson LC, Martin JS. Time delays in the diagnosis and treatment of acute myocardial infarction: a tale of eight cities: report from the Pre-hospital Study Group and the Cincinnati Heart Project. *Am Heart J*. 1990;120:773–780.
78. Dhruva VN, Abdelhadi SI, Anis A, Gluckman W, Hom D, Dougan W, Kaluski E, Haider B, Klapholz M. ST-Segment Analysis Using Wireless Technology in Acute Myocardial Infarction (STAT-MI) trial. *J Am Coll Cardiol*. 2007;50:509–513. doi: 10.1016/j.jacc.2007.04.049.
79. Ohtsuka M, Uchida E, Nakajima T, Yamaguchi H, Takano H, Komuro I. Transferring images via the wireless messaging network using camera phones shortens the time required to diagnose acute coronary syndrome. *Circ J*. 2007;71:1499–1500.
80. Gossage JA, Frith DP, Carrell TW, Damiani M, Terris J, Burnand KG. Mobile phones, in combination with a computer locator system, improve the response times of emergency medical services in central London. *Ann R Coll Surg Engl*. 2008;90:113–116. doi: 10.1308/003588408X242079.
81. Goyal M, Demchuk AM, Menon BK, Eesa M, Rempel JL, Thornton J, Roy D, Jovin TG, Willinsky RA, Sapkota BL, Dowlatshahi D, Frei DF, Kamal NR, Montanera WJ, Poppe AY, Ryckborst KJ, Silver FL, Shuaib A, Tampieri D, Williams D, Bang OY, Baxter BW, Burns PA, Choe H, Heo JH, Holmstedt CA, Jankowitz B, Kelly M, Linares G, Mandzia JL, Shankar J, Sohn SI, Swartz RH, Barber PA, Coutts SB, Smith EE, Morrish WF, Weill A, Subramaniam S, Mitha AP, Wong JH, Lowerison MW, Sajobi TT, Hill MD; ESCAPE Trial Investigators. Randomized assessment of rapid endovascular treatment of ischemic stroke. *N Engl J Med*. 2015;372:1019–1030. doi: 10.1056/NEJMoa1414905.
82. Lees KR, Bluhmki E, von Kummer R, Brott TG, Toni D, Grotta JC, Albers GW, Kaste M, Marler JR, Hamilton SA, Tilley BC, Davis SM, Donnan GA, Hacke W, Allen K, Mau J, Meier D, del Zoppo G, De Silva DA, Butcher KS, Parsons MW, Barber PA, Levi C, Bladin C, Byrnes G; ECASS, ATLANTIS, NINDS and EPITHET rt-PA Study Group. Time to treatment with intravenous alteplase and outcome in stroke: an updated pooled analysis of ECASS, ATLANTIS, NINDS, and EPITHET trials. *Lancet*. 2010;375:1695–1703. doi: 10.1016/S0140-6736(10)60491-6.
83. Nam HS, Heo J, Kim J, Kim YD, Song TJ, Park E, Heo JH. Development of smartphone application that aids stroke screening and identifying nearby acute stroke care hospitals. *Yonsei Med J*. 2014;55:25–29. doi: 10.3349/ymj.2014.55.1.25.
84. Dubey D, Amritphale A, Sawhney A, Amritphale N, Dubey P, Pandey A. Smart phone applications as a source of information on stroke. *J Stroke*. 2014;16:86–90. doi: 10.5853/jos.2014.16.2.86.
85. Feigin VL, Norrving B. A new paradigm for primary prevention strategy in people with elevated risk of stroke. *Int J Stroke*. 2014;9:624–626. doi: 10.1111/ijs.12300.
86. Parmar P, Krishnamurthi R, Ikram MA, Hofman A, Mirza SS, Varakin Y, Kravchenko M, Piradov M, Thrift AG, Norrving B, Wang W, Mandal DK, Barker-Collo S, Sahathevan R, Davis S, Saposnik G, Kivipelto M, Sindi S, Bornstein NM, Giroud M, Béjot Y, Brainin M, Poulton R, Narayan KM, Correia M, Freire A, Kokubo Y, Wiebers D, Mensah G, BinDhim NF, Barber PA, Pandian JD, Hankey GJ, Mehndiratta MM, Azhagammal S, Ibrahim NM, Abbott M, Rush E, Hume P, Hussein T, Bhattacharjee R, Purohit M, Feigin VL; Stroke Riskometer Collaboration Writing Group. The Stroke Riskometer App: validation of a data collection tool and stroke risk predictor. *Int J Stroke*. 2015;10:231–244. doi: 10.1111/ijs.12411.
87. You JS, Park S, Chung SP. Mobile message for a better stroke recognition: the new concept of national campaign. *Stroke*. 2008;39:e42. doi: 10.1161/STROKEAHA.107.506717.
88. American Heart Association, American Stroke Association. Learn more stroke warning signs and symptoms. http://www.strokeassociation.org/STROKEORG/WarningSigns/Learn-More-Stroke-Warning-Signs-and-Symptoms_UCM_451207_Article.jsp#.VzVRvZErKM8. Accessed June 10, 2015.
89. Pervez MA, Silva G, Masrur S, Betensky RA, Furie KL, Hidalgo R, Lima F, Rosenthal ES, Rost N, Viswanathan A, Schwamm LH. Remote supervision of IV-tPA for acute ischemic stroke by telemedicine or telephone before transfer to a regional stroke center is feasible and safe. *Stroke*. 2010;41:e18–e24. doi: 10.1161/STROKEAHA.109.560169.

90. Schwamm LH, Holloway RG, Amarenco P, Audebert HJ, Bakas T, Chumbler NR, Handschu R, Jauch EC, Knight WA 4th, Levine SR, Mayberg M, Meyer BC, Meyers PM, Skalabrin E, Wechsler LR; on behalf of the American Heart Association Stroke Council; Interdisciplinary Council on Peripheral Vascular Disease. A review of the evidence for the use of telemedicine within stroke systems of care: a scientific statement from the American Heart Association/American Stroke Association. *Stroke*. 2009;40:2616–2634. doi: 10.1161/STROKEAHA.109.192360.
91. Anderson ER, Smith B, Ido M, Frankel M. Remote assessment of stroke using the iPhone 4. *J Stroke Cerebrovasc Dis*. 2013;22:340–344. doi: 10.1016/j.jstrokecerebrovasdis.2011.09.013.
92. Demaerschalk BM, Vegunta S, Vargas BB, Wu Q, Channer DD, Hentz JG. Reliability of real-time video smartphone for assessing National Institutes of Health Stroke Scale scores in acute stroke patients. *Stroke*. 2012;43:3271–3277. doi: 10.1161/STROKEAHA.112.669150.
93. Demaerschalk BM, Vargas JE, Channer DD, Noble BN, Kiernan TE, Gleason EA, Vargas BB, Ingall TJ, Aguilar MI, Dodick DW, Bobrow BJ. Smartphone teleradiology application is successfully incorporated into a telestroke network environment. *Stroke*. 2012;43:3098–3101. doi: 10.1161/STROKEAHA.112.669325.
94. Mitchell JR, Sharma P, Modi J, Simpson M, Thomas M, Hill MD, Goyal M. A smartphone client-server teleradiology system for primary diagnosis of acute stroke. *J Med Internet Res*. 2011;13:e31. doi: 10.2196/jmir.1732.
95. Takao H, Murayama Y, Ishibashi T, Karagiozov KL, Abe T. A new support system using a mobile device (smartphone) for diagnostic image display and treatment of stroke. *Stroke*. 2012;43:236–239. doi: 10.1161/STROKEAHA.111.627943.
96. Audebert HJ, Boy S, Jankovits R, Pilz P, Klucken J, Fehm NP, Schenkel J. Is mobile teleconsulting equivalent to hospital-based telestroke services? *Stroke*. 2008;39:3427–3430. doi: 10.1161/STROKEAHA.108.520478.
97. McCarthy M. FDA will not regulate most mobile medical apps. *BMJ*. 2013;347:f5841.
98. Facebook statistics. 2011. https://newsroom.fb.com/company-info/. Accessed June 10, 2015.
99. Rainie L, Horrigan J, Wellman B, Boase J. The strength of Internet ties. Washington, DC: Pew Research Center; January 2006. http://www.pewinternet.org/reports/2006/the-strength-of-internet-ties.aspx. Accessed June 10, 2015.
100. Social media. In: *Merriam Webster online dictionary*. http://www.Merriam-webster.Com/dictionary/social media. Accessed June 10, 2015.
101. Mislove A, Lehmann S, Ahn Y-Y, Onnela J-P, Rosenquist JN. Understanding the demographics of Twitter users. In: *Proceedings of the Fifth International AAAI Conference on Weblogs and Social Media*. Presented at: Fifth International AAAI Conference on Weblogs and Social Media; July 17–21, 2011; Barcelona, Spain. http://www.aaai.org/Library/ICWSM/icwsm11contents.php. Accessed June 10, 2015.
102. Duggan M, Elliott NB, Lampe C, Lenhart A, Madden M. Demographics of key social networking platforms. Washington, DC: Pew Research Center; January 2015. http://www.pewinternet.org/2015/01/09/demographics-of-key-social-networking-platforms-2/. Accessed June 10, 2015.
103. Kawachi I, Colditz GA, Ascherio A, Rimm EB, Giovannucci E, Stampfer MJ, Willett WC. A prospective study of social networks in relation to total mortality and cardiovascular disease in men in the USA. *J Epidemiol Community Health*. 1996;50:245–251.
104. Sullivan SJ, Schneiders AG, Cheang CW, Kitto E, Lee H, Redhead J, Ward S, Ahmed OH, McCrory PR. "What's happening?" A content analysis of concussion-related traffic on Twitter. *Br J Sports Med*. 2012;46:258–263. doi: 10.1136/bjsm.2010.080341.
105. McNeil K, Brna PM, Gordon KE. Epilepsy in the Twitter era: a need to re-tweet the way we think about seizures. *Epilepsy Behav*. 2012;23:127–130. doi: 10.1016/j.yebeh.2011.10.020.
106. Nascimento TD, DosSantos MF, Danciu T, DeBoer M, van Holsbeeck H, Lucas SR, Aiello C, Khatib L, Bender MA, Zubieta JK, DaSilva AF; UMSoD (Under)Graduate Class of 2014. Real-time sharing and expression of migraine headache suffering on Twitter: a cross-sectional infodemiology study. *J Med Internet Res*. 2014;16:e96. doi: 10.2196/jmir.3265.
107. De Choudhury M, Counts S, Horvitz E. Predicting postpartum changes in emotion and behavior via social media. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. SIGCHI (Special Interest Group on Computer-Human Interaction). 2013:3267–3276.
108. Li JS, Barnett TA, Goodman E, Wasserman RC, Kemper AR; on behalf of the American Heart Association Atherosclerosis, Hypertension and Obesity in the Young Committee of the Council on Cardiovascular Disease in the Young, Council on Epidemiology and Prevention, and Council on Nutrition, Physical Activity and Metabolism. Approaches to the prevention and management of childhood obesity: the role of social networks and the use of social media and related electronic technologies: a scientific statement from the American Heart Association. *Circulation*. 2013;127:260–267. doi: 10.1161/CIR.0b013e3182756d8e.
109. Merchant RM, Elmer S, Lurie N. Integrating social media into emergency-preparedness efforts. *N Engl J Med*. 2011;365:289–291. doi: 10.1056/NEJMp1103591.
110. Kellermann AL, Peleg K. Lessons from Boston. *N Engl J Med*. 2013;368:1956–1957. doi: 10.1056/NEJMp1305304.
111. Chew C, Eysenbach G. Pandemics in the age of Twitter: content analysis of Tweets during the 2009 H1N1 outbreak. *PLoS One*. 2010;5:e14118. doi: 10.1371/journal.pone.0014118.
112. Seltzer EK, Jean NS, Kramer-Golinkoff E, Asch DA, Merchant RM. The content of social media's shared images about Ebola: a retrospective study. *Public Health*. 2015;129:1273–1277. doi: 10.1016/j.puhe.2015.07.025.
113. Eichstaedt JC, Schwartz HA, Kern ML, Park G, Labarthe DR, Merchant RM, Jha S, Agrawal M, Dziurzynski LA, Sap M, Weeg C, Larson EE, Ungar LH, Seligman ME. Psychological language on Twitter predicts county-level heart disease mortality. *Psychol Sci*. 2015;26:159–169. doi: 10.1177/0956797614557867.
114. Farmer AD, Bruckner Holt CE, Cook MJ, Hearing SD. Social networking sites: a novel portal for communication. *Postgrad Med J*. 2009;85:455–459. doi: 10.1136/pgmj.2008.074674.
115. Hale TM, Pathipati AS, Zan S, Jethwani K. Representation of health conditions on Facebook: content analysis and evaluation of user engagement. *J Med Internet Res*. 2014;16:e182. doi: 10.2196/jmir.3275.
116. Bosley JC, Zhao NW, Hill S, Shofer FS, Asch DA, Becker LB, Merchant RM. Decoding Twitter: surveillance and trends for cardiac arrest and resuscitation communication. *Resuscitation*. 2013;84:206–212. doi: 10.1016/j.resuscitation.2012.10.017.
117. Long T, Taubenheim AM, Wayman J, Temple S, Yu E. Using social media to reach women with the Heart Truth: 2009 update. *Cases in Public Health Communication & Marketing*. 2010;4:55–68. www.casesjournal.org/volume4. Accessed June 10, 2015.
118. Meischke H, Dulberg EM, Schaeffer SS, Henwood DK, Larsen MP, Eisenberg MS. "Call fast, Call 911": a direct mail campaign to reduce patient delay in acute myocardial infarction. *Am J Public Health*. 1997;87:1705–1709.
119. Caldwell MA, Miaskowski C. Mass media interventions to reduce help-seeking delay in people with symptoms of acute myocardial infarction: time for a new approach? *Patient Educ Couns*. 2002;46:1–9.
120. American Heart Association. #WeAreHeart. http://www.heart.org/HEARTORG/Affiliate/WSA-Social-Media-Ambassador_UCM_464089_SubHomePage.jsp. Accessed June 10, 2015.

121. National Institutes of Health, National Heart, Lung, and Blood Institute. National Wear Red Day Toolkit. http://www.nhlbi.nih.gov/health/educational/hearttruth/materials/wear-red-social-networks.htm. Accessed June 10, 2015.
122. Kilaru AS, Asch DA, Sellers A, Merchant RM. Promoting public health through public art in the digital age. *Am J Public Health*. 2014;104:1633–1635. doi: 10.2105/AJPH.2014.302088.
123. McCartney S. Why hotels resist having defibrillators. *Wall Street Journal*. February 24, 2009.
124. Leung AC, Asch DA, Lozada KN, Saynisch OB, Asch JM, Becker N, Griffis HM, Shofer F, Hershey JC, Hill S, Branas CC, Nichol G, Becker LB, Merchant RM. Where are lifesaving automated external defibrillators located and how hard is it to find them in a large urban city? *Resuscitation*. 2013;84:910–914. doi: 10.1016/j.resuscitation.2013.01.010.
125. Galbraith KL. Practical and ethical considerations for using social media in community consultation and public disclosure activities. *Acad Emerg Med*. 2014;21:1151–1157. doi: 10.1111/acem.12483.
126. Galbraith KL, Keck AS, Little C. Single-site community consultation for emergency research in a community hospital setting. *Prehosp Emerg Care*. 2014;18:328–334. doi: 10.3109/10903127.2014.882998.
127. Farina-Henry E, Waterston LB, Blaisdell LL. Social media use in research: engaging communities in cohort studies to support recruitment and retention. *JMIR Res Protoc*. 2015;4:e90. doi: 10.2196/resprot.4260.
128. Stephens SW, Williams C, Gray R, Kerby JD, Wang HE. Preliminary experience with social media for community consultation and public disclosure in exception from informed consent trials. *Circulation*. 2013;128:267–270. doi: 10.1161/CIRCULATIONAHA.113.002390.
129. Thoma B, Rolston D, Lin M. Global Emergency Medicine Journal Club: social media responses to the March 2014 *Annals of Emergency Medicine* Journal Club on targeted temperature management. *Ann Emerg Med*. 2014;64:207–212. doi: 10.1016/j.annemergmed.2014.06.003.
130. Nielsen N, Wetterslev J, Friberg H; TTM Trial Steering Group. Targeted temperature management after cardiac arrest. *N Engl J Med*. 2014;370:1360. doi: 10.1056/NEJMc1401250.
131. Chretien KC, Kind T. Social media and clinical care: ethical, professional, and social implications. *Circulation*. 2013;127:1413–1421. doi: 10.1161/CIRCULATIONAHA.112.128017.
132. Olmstead K, Barthel M. The challenge of using Facebook for research. Washington, DC: Pew Research Center; March 2015. http://www.pewresearch.org/fact-tank/2015/03/26/the-challenges-of-using-facebook-for-research/ Accessed June 10, 2015.
133. Coviello L, Sohn Y, Kramer AD, Marlow C, Franceschetti M, Christakis NA, Fowler JH. Detecting emotional contagion in massive social networks. *PLoS One*. 2014;9:e90315. doi: 10.1371/journal.pone.0090315.
134. Cobb NK, Graham AL, Byron MJ, Niaura RS, Abrams DB; Workshop Participants. Online social networks and smoking cessation: a scientific research agenda [published correction appears in *J Med Internet Res*. 2012;14:e12]. *J Med Internet Res*. 2011;13:e119. doi: 10.2196/jmir.1911.
135. Young SD, Holloway I, Jaganath D, Rice E, Westmoreland D, Coates T. Project HOPE: online social network changes in an HIV prevention randomized controlled trial for African American and Latino men who have sex with men. *Am J Public Health*. 2014;104:1707–1712. doi: 10.2105/AJPH.2014.301992.
136. Nakhasi A, Shen AX, Passarella RJ, Appel LJ, Anderson CA. Online social networks that connect users to physical activity partners: a review and descriptive analysis. *J Med Internet Res*. 2014;16:e153. doi: 10.2196/jmir.2674.
137. Mandl KD, McNabb M, Marks N, Weitzman ER, Kelemen S, Eggleston EM, Quinn M. Participatory surveillance of diabetes device safety: a social media-based complement to traditional FDA reporting. *J Am Med Inform Assoc*. 2014;21:687–691. doi: 10.1136/amiajnl-2013-002127.
138. Cameron AM, Massie AB, Alexander CE, Stewart B, Montgomery RA, Benavides NR, Fleming GD, Segev DL. Social media and organ donor registration: the Facebook effect. *Am J Transplant*. 2013;13:2059–2065. doi: 10.1111/ajt.12312.
139. Moreno MA, Goniu N, Moreno PS, Diekema D. Ethics of social media research: common concerns and practical considerations. *Cyberpsychol Behav Soc Netw*. 2013;16:708–713. doi: 10.1089/cyber.2012.0334.
140. Duggan M. Photo and video sharing grow online. Washington, DC: Pew Research Center; October 2013. http://www.pewinternet.org/2013/10/28/photo-and-video-sharing-grow-online/ Accessed June 10, 2015.
141. YouTube. https://www.youtube.com/yt/press/statistics.html. Accessed June 10, 2015.
142. Yaylaci S, Serinken M, Eken C, Karcioglu O, Yilmaz A, Elicabuk H, Dal O. Are YouTube videos accurate and reliable on basic life support and cardiopulmonary resuscitation? *Emerg Med Australas*. 2014;26:474–477. doi: 10.1111/1742-6723.12274.
143. Madathil KC, Rivera-Rodriguez AJ, Greenstein JS, Gramopadhye AK. Healthcare information on YouTube: a systematic review. *Health Informatics J*. 2015;21:173–194. doi: 10.1177/1460458213512220.
144. Pant S, Deshmukh A, Murugiah K, Kumar G, Sachdeva R, Mehta JL. Assessing the credibility of the "YouTube approach" to health information on acute myocardial infarction. *Clin Cardiol*. 2012;35:281–285. doi: 10.1002/clc.21981.
145. Murugiah K, Vallakati A, Rajput K, Sood A, Challa NR. YouTube as a source of information on cardiopulmonary resuscitation. *Resuscitation*. 2011;82:332–334. doi: 10.1016/j.resuscitation.2010.11.015.
146. Liu KY, Haukoos JS, Sasson C. Availability and quality of cardiopulmonary resuscitation information for Spanish-speaking population on the Internet. *Resuscitation*. 2014;85:131–137. doi: 10.1016/j.resuscitation.2013.08.274.
147. US Bureau of the Census. Annual estimates of the population by sex, race, and Hispanic origin for the United States: April 1, 2000 to July 1, 2006. Washington, DC: US Bureau of the Census; 2007. http://www.census.gov/popest/data/historical/2000s/vintage_2006/. Accessed June 10, 2015.
148. Mass.Gov website. Stroke heroes Act FAST. http://www.mass.gov/eohhs/gov/departments/dph/programs/community-health/heart-disease-stroke/stroke-heroes-act-fast.html. Accessed June 10, 2015.
149. Harrison D, Sampson M, Reszel J, Abdulla K, Barrowman N, Cumber J, Fuller A, Li C, Nicholls S, Pound CM. Too many crying babies: a systematic review of pain management practices during immunizations on YouTube. *BMC Pediatr*. 2014;14:134. doi: 10.1186/1471-2431-14-134.
150. Edelson DP, Litzinger B, Arora V, Walsh D, Kim S, Lauderdale DS, Vanden Hoek TL, Becker LB, Abella BS. Improving in-hospital cardiac arrest process and outcomes with performance debriefing. *Arch Intern Med*. 2008;168:1063–1069. doi: 10.1001/archinte.168.10.1063.
151. 911.gov website. Next Generation 911. http://www.911.gov/911-issues/standards.html. Accessed June 10, 2015.
152. Hauff SR, Rea TD, Culley LL, Kerry F, Becker L, Eisenberg MS. Factors impeding dispatcher-assisted telephone cardiopulmonary resuscitation. *Ann Emerg Med*. 2003;42:731–737. doi: 10.1016/S0196064403004232.
153. Vaillancourt C, Verma A, Trickett J, Crete D, Beaudoin T, Nesbitt L, Wells GA, Stiell IG. Evaluating the effectiveness

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of dispatch-assisted cardiopulmonary resuscitation instructions. *Acad Emerg Med*. 2007;14:877–883. doi: 10.1197/j.aem.2007.06.021.
154. Kerem Y, Eastvold JS, Faragoi D, Strasburger D, Motzny SE, Kulstad EB. The role of prehospital electrocardiograms in the recognition of ST-segment elevation myocardial infarctions and reperfusion times. *J Emerg Med*. 2014;46:202–207. doi: 10.1016/j.jemermed.2013.08.084.
155. DeSousa KG, Haussen DC, Yavagal DR. Strategies for streamlining emergency stroke care. *Curr Neurol Neurosci Rep*. 2014;14:497. doi: 10.1007/s11910-014-0497-x.
156. González-Ladrón-de-Guevara F, Estelles-Arolas E. Towards an integrated crowdsourcing definition. *J Inf Sci*. 2012:1–14.
157. King AJ, Gehl RW, Grossman D, Jensen JD. Skin self-examinations and visual identification of atypical nevi: comparing individual and crowdsourcing approaches. *Cancer Epidemiol*. 2013;37:979–984. doi: 10.1016/j.canep.2013.09.004.
158. Bonney R, Shirk JL, Phillips TB, Wiggins A, Ballard HL, Miller-Rushing AJ, Parrish JK. Citizen science: next steps for citizen science. *Science*. 2014;343:1436–1437. doi: 10.1126/science.1251554.
159. McCartney P. Crowdsourcing in healthcare. *MCN Am J Matern Child Nurs*. 2013;38:392. doi: 10.1097/NMC.0b013e3182a41571.
160. Scholten AC, van Manen JG, van der Worp WE, Ijzerman MJ, Doggen CJ. Early cardiopulmonary resuscitation and use of automated external defibrillators by laypersons in out-of-hospital cardiac arrest using an SMS alert service. *Resuscitation*. 2011;82:1273–1278. doi: 10.1016/j.resuscitation.2011.05.008.
161. Narikawa K, Sakamoto T, Kubota K, Suzukawa M, Yonekawa C, Yamashita K, Toyokuni Y, Yasuda Y, Kobayashi A, Iijima K. Predictability of the call triage protocol to detect if dispatchers should activate community first responders. *Prehosp Disaster Med*. 2014;29:484–488. doi: 10.1017/S1049023X14000995.
162. Yonekawa C, Suzukawa M, Yamashita K, Kubota K, Yasuda Y, Kobayashi A, Matsubara H, Toyokuni Y. Development of a first-responder dispatch system using a smartphone. *J Telemed Telecare*. 2014;20:75–81. doi: 10.1177/1357633X14524152.
163. Ringh M, Fredman D, Nordberg P, Stark T, Hollenberg J. Mobile phone technology identifies and recruits trained citizens to perform CPR on out-of-hospital cardiac arrest victims prior to ambulance arrival. *Resuscitation*. 2011;82:1514–1518. doi: 10.1016/j.resuscitation.2011.07.033.
164. NowForce. http://www.nowforce.com/. Accessed June 10, 2015.
165. My SOS Network. http://www.mysosnetwork.com/?lang=en. Accessed June 10, 2015.
166. Merchant RM, Asch DA, Hershey JC, Griffis HM, Hill S, Saynisch O, Leung AC, Asch JM, Lozada K, Nadkarni LD, Kilaru A, Branas CC, Stone EM, Starr L, Shofer F, Nichol G, Becker LB. A crowdsourcing innovation challenge to locate and map automated external defibrillators. *Circ Cardiovasc Qual Outcomes*. 2013;6:229–236. doi: 10.1161/CIRCOUTCOMES.113.000140.
167. Chang AM, Leung AC, Saynisch O, Griffis H, Hill S, Hershey JC, Becker LB, Asch DA, Seidman A, Merchant RM. Using a mobile app and mobile workforce to validate data about emergency public health resources [published online ahead of print May 10, 2013]. *Emerg Med J*. 2013;31:545–548.
168. ILCOR Scientific Evidence Evaluation and Review System. https://volunteer.heart.org/apps/pico/pages/default.aspx. Accessed April 26, 2016.
169. Morley PT, Lang E, Aickin R, Billi JE, Eigel B, Ferrer JM, Finn JC, Gent LM, Griffin RE, Hazinski MF, Maconochie IK, Montgomery WH, Morrison LJ, Nadkarni VM, Nikolaou NI, Nolan JP, Perkins GD, Sayre MR, Travers AH, Wyllie J, Zideman DA. Part 2: evidence evaluation and management of conflicts of interest: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation*. 2015;132(suppl 1):S40–S50. doi: 10.1161/CIR.0000000000000271.
170. Crowdfunding. In: *Merriam Webster Online Dictionary*. http://www.Merriam-webster.Com/dictionary/crowdfunding. Accessed June 10, 2015.
171. Sisler J. Crowdfunding for medical expenses. *CMAJ*. 2012;184:E123–E124. doi: 10.1503/cmaj.109-4084.
172. Experiment.Com [online platform]. https://experiment.Com/. Accessed June 10, 2015.
173. Consano. https:///www.consano.org. Accessed June 10, 2015.
174. Hunter J, Alabri A, van Ingen C. Assessing the quality and trustworthiness of citizen science data. *Concurr Comput*. 2013; 25:454–466. doi: 10.1002/cpe.2923.

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Use of Mobile Devices, Social Media, and Crowdsourcing as Digital Strategies to Improve Emergency Cardiovascular Care: A Scientific Statement From the American Heart Association

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