Cardiac arrest, acute myocardial infarction (AMI), and stroke affect millions of people in the United States annually. Despite significant advances in medical treatments for these conditions, they remain a major public health problem and a leading cause of morbidity and mortality. 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. 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. 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.

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. As one example, studies of out-of-hospital cardiac arrest (OHCA) have consistently noted delays in the initiation of bystander CPR. 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. However, the time from patient symptom onset to seeking care for possible myocardial infarction has not improved significantly. 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. 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...).” 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...
location identification. 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. 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). Other mobile devices (eg, watches, contact lenses, glasses, clothing sensors) are also gaining traction for general use and monitoring of health.

Crowdsourcing represents an emerging application that has been used to access and mobilize millions of people to contribute to the advancement of science.

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. 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). 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.

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.
- 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
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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. 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. 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. 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. 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. 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. 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 ECC. 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. Unfortunately, AEDs are rarely used. In one large series involving >13,000 OHCA from the Resuscitation Outcomes Consortium, AED use occurred in only ≈2% of cases. In the Cardiac Arrest Registry to Enhance Survival (CARES) database, AED use is reported in ≈4% of cases. 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.

Several mobile apps use data from AED registries to help bystanders find the closest AED and report new AEDs. Some apps also have enhanced features such as augmented reality to guide users to the nearest publicly accessible AED. 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.

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. 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 (e.g., 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 unwit-
nessed 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. This technology could facilitate remote signal analysis and monitoring and trigger an automated call to 9-1-1 under pre-specified 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. 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. 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. Some require the user to purchase a smartphone case with 2 leads integrated within the structure. 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. This process facilitates rapid prehospital triage, destination planning, early activation of the cardiac catheterization laboratory, and reduction in hospital-based delays to definitive treatment. 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. 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. 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. The effectiveness of fibrinolytic therapy for acute stroke is highly time sensitive. Patient delay in the recognition of stroke and seeking care has been recognized as a major barrier to optimal treatment of acute stroke. 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 al93 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.21,38 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 networks103 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=15324), 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.54,123,124 This project had >13990 unique website visitors, and designs were shared >48250 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 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 social media for clinicians and healthcare providers. Takao et al129 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

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<th>Emergency Cardiovascular Condition</th>
<th>Digital Strategy</th>
<th>Research Questions</th>
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| 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 unwatched 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.*  
• 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? |
| 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)
can serve as tools for general education or in the midst of an emergency event.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.”\textsuperscript{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.\textsuperscript{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. In a similar fashion, sharing of patient pictures (e.g., facial droop) or brief video clips (e.g., aphasia) and other clinical data points suggestive of stroke could facilitate prehospital activation of stroke teams or transfer of patients to stroke centers.

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. 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 (e.g., stroke symptoms), response (e.g., 9-1-1 call), process measures (e.g., 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. 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. It allows for a participatory culture that can harness the collective intelligence of the masses on an open platform.

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. 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. 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. 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. 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 24100 PulsePoint responders on 9547 suspected cardiac arrest events. More than 750000 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. Future initiatives could also allow responders (or even patients) to alert others in their geographic proximity of a need for help. 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. 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. 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. 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 es-
especially from the online community. 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. The AHA and other organizations are beginning to explore applications for engaging crowds in this area. In this context, the AHA has partnered with MedStarrt 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 ECC-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.

**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. 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.

Despite the challenges, crowdsourcing has immense potential for enhancing both public and provider response for ECC. 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 ECC, 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 ECC. Digital strategies represent a rapidly evolving field, both in terms of evolving technologies that potentially can be applied as interventions to improve ECC 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 ECC.

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 ECC 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 ECC 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 ECC. 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
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*Modest.
†Significant.

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<td>Karin Przyklenk</td>
<td>Wayne State University School of Medicine</td>
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REFERENCES


5. Field JM, Hazinski MF, Sayre MR, Chameides L, Schexnayder SM, Hemphill R, Samson RA, Kattwinkel J, Berg RA, Bhanji F, Cave...
Digital Strategies to Improve Emergency Cardiovascular Care


57. Deleted in proof.


59. Deleted in proof.


72. Deleted in proof.


97. McCarthy M. FDA will not regulate most mobile medical apps. BMJ. 2013;347:f5841.


Digital Strategies to Improve Emergency Cardiovascular Care


Circulation. 2016;134:e87–e108. doi: 10.1161/CIR.0000000000000428

August 23, 2016 e107
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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

John S. Rumsfeld, Steven C. Brooks, Tom P. Aufderheide, Marion Leary, Steven M. Bradley, Chileshe Nkonde-Price, Lee H. Schwamm, Mariell Jessup, Jose Maria E. Ferrer and Raina M. Merchant

On behalf of the American Heart Association Emergency Cardiovascular Care Committee; Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation; Council on Quality of Care and Outcomes Research; Council on Cardiovascular and Stroke Nursing; and Council on Epidemiology and Prevention

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