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## Smartphone Apps: A Patient's New Best Friend?

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The end of the 20th century saw the introduction of the internet. Approximately two decades later, the internet has been strongly adopted by every segment of public society. In 2013, 74.4% of all United States households reported internet use, with 73.4% reporting a dedicated high-speed internet connection (1). Specifically, the general public has gravitated toward the internet through their smartphones. Smartphones are powerful devices that combine the conventional functions of a mobile phone with advanced computing capabilities. These devices allow users to access software applications (apps) (2–4). From instant messaging to mobile banking, photography to gaming, apps allow users to perform various functions quickly and easily. Also, these users are growing: as of October of 2015, 68% of Americans use smartphones (up from 35% in 2011) (5). It should come as little surprise that, among the many functions that users perform with the smartphone, managing their health would be on the top of the list. As of 2014, 62% of smartphone owners had used their phones to look up information about a health condition (6).

Clinicians have correctly identified smartphone apps as the next arena in which they should have a presence. Adult users who own a smartphone used that device for a monthly average of 37 hours and 28 minutes in 2014, increased from 23 hours and 2 minutes per month 2 years ago. Although most of these adults use apps focused on leisure, social networking, and/or entertainment, a growing body of literature suggests that a robust number of adults use medical-related apps (7–9). Data from Price Waterhouse Coopers indicate that one in three adult smartphone users have downloaded and used a health-related app (8). That translates into approximately 46 million smartphone owners who use apps to monitor their health (*e.g.*, exercise, diet, or weight). That number grew by 18% from a year earlier (10). Many medical practitioners and other health care workers are also using apps as part of their professional practice (11).

We are now experiencing a sea change in the patient-doctor relationship as patients take more control over their own bodies (taking blood sugar or BP measurements, *etc.*) and more teleconsultations with a physician do not result in a clinic visit. Mobile technologies enable the monitoring of more organ systems, and it is perhaps just a question of time before we can control the entire body in this way (12).

In this issue of the *Clinical Journal of the American Society of Nephrology*, Ong *et al.* (13) make a strong

case for the usefulness of a smartphone app to help patients manage complex medical conditions. The smartphone app targeted four behavioral elements in patients with CKD stage 4 or 5, it targeted BP, medication management, symptom assessment, and tracking laboratory results. Prebuilt, customizable algorithms provided real-time personalized patient feedback and alerts to providers when predefined treatment thresholds were crossed or critical changes occurred. User adherence was high (>80% performed at least 80% of recommended assessments) and sustained. The mean reductions in home BP readings between baseline and exit were statistically significant (systolic BP,  $-3.4$  mmHg; 95% confidence interval [95% CI],  $-5.0$  to  $-1.8$  and diastolic BP,  $-2.1$  mmHg; 95% CI,  $-2.9$  to  $-1.2$ ). Notably, 27% with normal clinic BP readings had newly identified masked hypertension. Also, 127 medication discrepancies were identified, and 59% (75) represented a medication error that required an intervention to prevent harm. In exit interviews, patients felt more confident and in control of their condition; clinicians perceived patients to be better informed and more engaged (13).

These results provide a strong rationale for a randomized, controlled trial. More than one half of the digitally naïve patients found their natively programmed app beneficial in managing their BP and medications and helpful in recognizing symptoms and understanding abnormal test results (13). Although their investigation is a proof of principle study, their results highlight broader considerations when integrating smartphone technology with health care (13).

The Tobacco, Exercise and Diet Messages Trial was a parallel group, single-blind, randomized clinical trial that recruited 710 patients with proven coronary heart disease between September of 2011 and November of 2013 from a large tertiary hospital in Sydney, Australia. Patients in the intervention group ( $n=352$ ) received four text messages per week for 6 months in addition to usual care. Text messages provided advice, motivational reminders, and support to change lifestyle behaviors. Patients in the control group ( $n=358$ ) received usual care. Messages for each participant were selected from a bank of messages according to baseline characteristics (*e.g.*, smoking) and delivered *via* an automated computerized message management system. The program was not interactive. LDL cholesterol level, systolic BP, and body mass index at 6-month follow-up were all significantly lower in the intervention group compared with in the

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control group (difference in LDL cholesterol level,  $-5$  mg/dl; 95% CI,  $-9$  to  $0$ ; difference in systolic BP,  $-7.6$  mmHg; 95% CI,  $-9.8$  to  $-5.4$ ; difference in body mass index,  $-1.3$ ; 95% CI,  $-1.6$  to  $-0.9$ ). The duration of these effects and hence, whether they result in improved clinical outcomes remain to be determined (14).

Multidisciplinary teams (MDTs) are now gaining preference over single-provider care in delivering health care to patients, especially those with complex medical conditions (15). Although MDTs include patients, they (patients) have been the weakest link within the team. Without easy access to their personal medical information and with limited scientific expertise, the most important members of the MDT are often observers. Apps, like the smartphone app by Ong *et al.* (13), have the real potential of transforming patients from mere observers into active participants and collaborators and potentially, drivers for their health care. Armed with their medical information, simple statistical analyses, and predefined algorithms that serve the purpose of increasing their scientific understanding of their condition, patients can actively participate as a fully informed participant in their MDT meetings. The app does not convert the patient into a full-fledged medical professional. Still, the study by Ong *et al.* (13) suggests that they are better informed and that the quality of their face to face interactions with other members of the MDT improves when using the app.

The new health care paradigm encourages patients to access their medical data wherever they are, discuss such data with their physicians, decide their treatment plans with their physicians, and learn about their discharge plans. Health Information Technology can support these requirements, but accessibility and mobility issues must be solved. Today, hospitalized patients look for health information regarding their conditions with smartphones and tablets, and some hospitals even provide the hardware and the connectivity for the same. Smartphones or tablets can be used effectively for all of the above purposes (16).

Perhaps inadvertently, this investigation introduces us to the next generation clinician extender (13). In our continued search to find more cost-effective ways to deliver improved health care, smartphone apps are poised to make a meaningful entry into this new model of health care. The app by Ong *et al.* (13) and particularly, the preprogrammed customizable feedback alerts have the capacity to function as one's personal clinician extender or advisor. Available year-round, 24 hours a day, and 7 days a week, these alerts offer real-time information that not only educates the patient but can help them take the next steps toward better management of their disease. Although preliminary, today's medical apps may become the forefathers of on-demand clinician extenders.

With innovative digital technologies, cloud computing, and machine learning, the medicalized smartphone is going to change many aspects of medical care. The new health care paradigm encourages patients to access their medical data wherever they are and discuss such data with their health care team. Patients are actively encouraged to formulate treatment, discharge, and/or follow-up medical plans with their provider(s). Apps can support these expectations. Apps can help patients individualize and take more control over the health care that they receive.

Taking it a step farther, on the basis of the concept of internet of things, smartphones have the ability to personalize one's own health big data, with the user being alerted proactively (*e.g.*, an alert advising the user that the manner in which the user is running led to injury in 30 other people with a relatively similar profile) on the basis of their fitness and historical medical or genetics history along with a server-based knowledge repository to create this level of near-real-time decision support. Eventually, similar to other people-finding apps, users could create their own virtual support group on the basis of certain settings that they may choose (17). Perhaps it is only a matter of time before app-driven patient empowerment becomes the standard of one's care (12,16).

Although investigators, such as Ong *et al.* (13), continue to work through the technical and programmatic challenges of app development, providers may have to shoulder the burden of app distribution (or lack thereof) and ensure that privacy requirements for health care data are met. The old axiom "if you build it, they will come" (or in the case of app development, "if you code it, they will download") may not always be true. Socioeconomic disparities in CKD are fairly strong, irrespective of how socioeconomic status is measured, with low socioeconomic status associated with low eGFR (odds ratio [OR], 1.41; 95% CI, 1.21 to 1.62), high albuminuria (OR, 1.52; 95% CI, 1.22 to 1.82), low eGFR/high albuminuria (OR, 1.38; 95% CI, 1.03 to 1.74), and renal failure (OR, 1.55; 95% CI, 1.40 to 1.71) (18). This may become an issue with more generalized usage of apps given that smartphone ownership is lower (at 50%) with lower income ( $< \$30,000$  per year) compared with 84% in adults with higher income ( $\geq \$75,000$  per year). Similar distribution exists across educational status, with smartphone ownership at 52% among adults with high school education or less compared with 78% among adults with college or higher education. However, smartphones may allow for greater digital equity given that internet accessibility is more available only *via* smartphones among adults with high school education or less and those with lower incomes (19). In the National Cancer Institute's Health Information National Trends Survey, mHealth use was proportional to the socioeconomic status and overall health of the patient and inversely proportional to patient age (20). Kidney health providers are rightfully concerned about these relationships, because their patients are generally of lower socioeconomic status and suffer from more medically complex comorbidities than their contemporaries. As our patients live longer with kidney disease, their adoption of mHealth tools drops; in one study, the drop was 4% for every 1 year that a patient ages (21). These trends indicate that any programmatic solution must be accompanied by a distribution strategy to increase patient acceptance and use of health care-related apps.

Ironically, to fully harness the power of smartphones and apps in health care, we must simultaneously look forward while firmly planting our footing into the honored tradition of caring for our patients. We must not forget or worse, ignore the cherished value of the in-person provider-patient visit or importantly, the provider-patient relationship. It rests on the shoulders of clinicians to integrate new technology with the time-tested traditional doctor-patient interaction. This interaction was, is, and should continue to be an honor for those of us who have the privilege of caring for

patients. Many of us will rely on those who are on the leading edge of creating and using technology to shepherd such technology into health care as a supplement of and not a replacement to this privilege.

#### Disclosures

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