

# Issues in TECHNOLOGY Innovation

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## How Mobile Devices are Transforming Healthcare

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### EXECUTIVE SUMMARY

**M**obile technology has expanded dramatically around the world. According to the Cisco Visual Networking Index, global mobile data traffic has doubled for the fourth year in a row. And looking toward the future, the report estimates that “global mobile data traffic will increase 18-fold between 2011 and 2016”. By the end of that time period, it is projected that **there will be 10 billion mobile devices in use around the world.**<sup>1</sup>



Getty Images, Jose Luis Pelaez

Along with 3G and 4G, these advances have had a huge impact on many walks of life. The utilization of smart phones and tablets has transformed communications, commerce, and entertainment, among other fields. Their emergence has improved service delivery, empowered consumers, businesses, and entrepreneurs, and changed the way in which people access information and make transactions.

Now this technology is poised to alter how health care is delivered, the quality of the patient experience, and the cost of health care.<sup>2</sup> Mobile technology is helping with chronic disease management, empowering the elderly and expectant mothers, reminding people to take medication at the proper time, extending service to underserved areas, and improving health outcomes and medical system efficiency. In this report, I focus on mobile health innovation around the world. As part of our Mobile Economy Project, I review adoption of innovative examples of m-health, its impact on service delivery and medical treatment, and how mobile devices are saving money in the health care system.

## The Rise of mHealth Initiatives

### Issues in Technology Innovation

The Center for Technology Innovation at Brookings has launched its inaugural paper series to seek and analyze public policy developments in technology innovation.

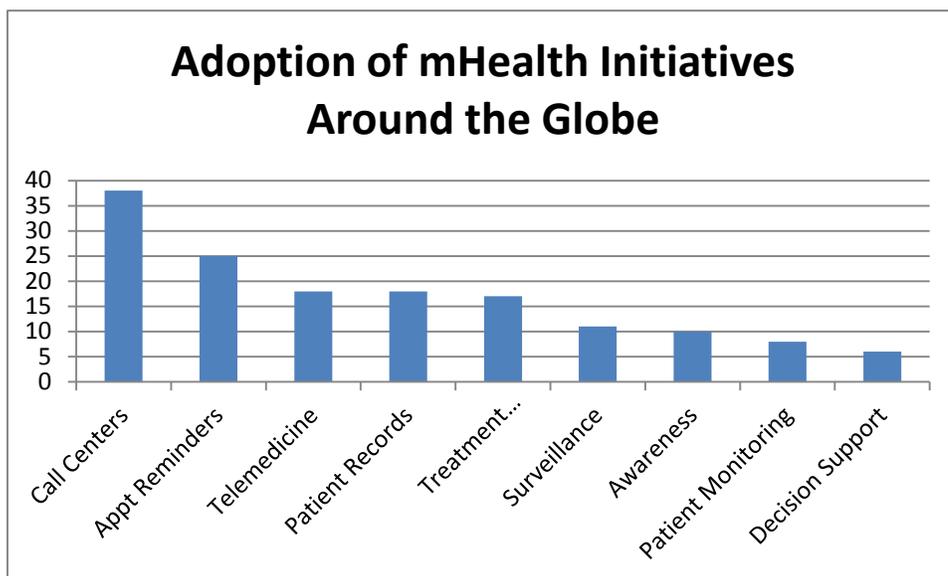
### The Center for Technology Innovation

Founded in 2010, the Center for Technology Innovation at Brookings is at the forefront of shaping public debate on technology innovation and developing data-driven scholarship to enhance understanding of technology's legal, economic, social, and governance ramifications.

### Mobile Economy Project

The Mobile Economy Project examines how the rapid expansion of mobile technology around the world is transforming economic opportunity for millions.

There has been an explosion of mHealth activities around the world. A 2011 global survey of 114 nations undertaken by the World Health Organization found that mHealth initiatives have been established in many countries, but there is variation in adoption levels.<sup>3</sup> The most common activity was the creation of health call centers, which respond to patient inquiries. This was followed by using SMS for appointment reminders, using telemedicine, accessing patient records, measuring treatment compliance, raising health awareness, monitoring patients, and physician decision support.



Not surprisingly, there were big differentials between developed and developing nations. Africa had the lowest rate of mHealth adoption while North America, South America, and Southeast Asia showed the highest adoption levels. A number of countries have initiatives in the pilot stage or have informal activities that are underway.

Member states reported their biggest mHealth obstacles were competing priorities, budgetary restrictions, and staff shortages. Concerns over privacy and data security also were cited as barriers to effective implementation. Most countries are implementing mHealth through various types of public-private partnerships.

## Managing Chronic Diseases Through Remote Monitoring and Mobile Devices

Chronic disease management represents the greatest health care challenge in many locales. Remote monitoring devices enable patients with serious problems to record their own health measures and send them electronically to physicians or specialists.

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Remote monitoring technologies could save as much as \$197 billion over the next 25 years.

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This keeps them out of doctor's offices for routine care, and thereby helps to reduce health care costs.

A Brookings Institution analysis undertaken by economist Robert Litan found that **remote monitoring technologies could save as much as \$197 billion over the next 25 years** in the United States.<sup>4</sup> He found that cost savings were especially prevalent in the chronic disease areas of congestive heart failure, pulmonary disease, diabetes, and skin ulcers. With around the clock monitoring and electronic data transition to care-givers, remote devices speed up the treatment of patients requiring medical intervention. Rather than having to wait for a patient to discover there is a problem, monitors identify deteriorating conditions in real time, and alert physicians.

Real-time management is especially important in the case of chronic diseases. In the area of diabetes, for example, it is crucial that patients monitor their blood glucose levels and gear their insulin intake to proper levels. In the "old days" based on face-to-face encounters, patients had to visit a doctor's lab or medical office, take a test, and wait for results to be delivered. That process was expensive, time-consuming, and inconvenient for all-involved. Having to get regular tests for this and other conditions is one of the factors that drive up medical costs.

However, it is possible to use remote monitoring devices at home that record glucose levels instantaneously and electronically send them to the appropriate health care provider. Patients are using "Gluco Phones" that monitor and transmit glucose information to caregivers while also reminding patients when they need to undertake glucose tests. This puts people in charge of their own test-taking and monitoring and keeps them out of doctor's offices until they need more detailed care. It is estimated that over 11 million Americans use home monitors for their glucose. Health authorities believe there are over 24 million diabetics in the United States, and the disease is the seventh leading cause of death.

Researchers at the University of Massachusetts Medical School have developed remote monitoring devices called iHeal for substance abusers. Individuals wear sensors that monitor skin temperature and nervous system activities associated with drug cravings. When combined with self-reported stress levels, the devices transmit data to health providers trained to look for risky behavioral and physiological patterns and provide various types of text, video, and audio interventions designed to discourage drug use. Physicians report positive reactions from participants in residential treatment programs deploying the system.<sup>5</sup>

A study of a smoking cessation program relying upon mobile devices found some positive benefits. Researchers identified 47 different applications designed to stop smoking. These apps counted the number of cigarettes smoked, suggested visualizations designed to encourage people to quit smoking, or employed quota systems or calculators that sought to reduce smoking levels. The project found "some promise" in text messaging interventions in smoking, but also documented that many apps needed to connect to outside resources, such as health clinics or counseling services. The authors suggested that app developers adhere more closely to public health guidelines on smoking cessation.<sup>6</sup>

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In Mexico, diabetes is the biggest chronic health care problem. Public health data indicate that the disease has “increased 25% over the last seven years and that 14% of the population with diabetes is younger than 40 years old.”<sup>7</sup> In addition, it is estimated that over 15 percent of adults living near the U.S./Mexico border are diabetic.

A clinical study begun in November 2011 proposes to examine how 3G wireless internet access can be used in diabetes management to improve patient care for marginalized communities. Health care workers in Tijuana employ a mobile application to interact with patients. Participants can use the application to access videos and health education on diabetes self-management and send interactive questionnaires to health care workers. Patient’s responses are sent through their 3G mobile phones, making them instantly available in a database for the health care providers to review and follow up. Alerts are sent when patients report significantly out of range indicator levels or when the system identifies lack of adherence to appointments tests or classes.

Another example of remote monitoring in regard to chronic diseases is found in China. Qualcomm’s Wireless Reach™ in partnership with Life Care Networks and the Community Health Association of China, has deployed an electrocardiogram sensing handset that records 30 seconds of heart data and transmits that information electronically to the 24-hour Life Care Networks Call Center in Beijing. That facility has over 40 physicians and the wireless monitors enable remote diagnosis to patients in underserved areas and provide real-time feedback to those with cardiovascular diseases. Cardiovascular diseases kill 3 million individuals annually in China, and those outside the major cities have difficulty getting access to medical care.<sup>8</sup> The impact this program has had on improving health care earned it a Computerworld Honors Laureate award for 2012.

HIV/AIDS is the big public health challenge in Kenya, with 6.3 percent of the adult population diagnosed with HIV. The delivery of Antiretroviral Treatment (ART) is a key component of the government’s strategy to reduce HIV/AIDS-related morbidity and mortality, which can be compromised due to ineffective records management. But through 3G wireless technology, reductions in the administrative burden on health care workers and improvements in patient care could be achieved by strengthening pharmaceutical management systems for ART. According to evaluation analysis, “the percentage of facilities completing reports at the time of dispensing increased 70%.” In addition, “the average time spent on delivery of reports to KEMSA (the Kenyan Medical Supplies Agency) was reduced from eight hours to five minutes.”<sup>9</sup>

Pilot projects in India and Sri Lanka have found mobile devices very helpful in monitoring outbreaks of Dengue Fever. In the world before mobile communications, it generally took the provinces 15 to 30 days to report data on disease outbreaks to central authorities. The time lost here slowed treatment responses and aggravated the spread of infectious diseases. However, with the onset of mobile and digital

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communications, the wait time on infectious diseases has dropped considerably.<sup>10</sup> Through the Real-Time Biosurveillance Program relying on mobile devices, public health authorities use data mining techniques to look for “anomaly detection” in disease patterns. Areas reporting major outbreaks receive additional resources for diagnosis and treatment, and this helps to limit the spread of the disease.

A review of 13 evaluation studies of mobile devices and physician practices in the area of reading electrocardiographs or computerized tomography scans found three benefits: 1) physicians with access to mobile devices responded more promptly to reading medical test results, 2) there were fewer errors in medication prescription and hospital discharging, and 3) doctors showed improved data management and record-keeping practices.<sup>11</sup>

Indeed, error avoidance is one of the primary strengths of mHealth. A study of nurses relying upon handheld devices found that **16 percent said the mobile equipment had helped them avoid at least one error in clinical treatment** while another six percent indicated it had enabled them to avoid errors on multiple occasions.<sup>12</sup> These positive findings demonstrate that mHealth has the ability to improve service delivery and save money in health care.

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Sixteen percent said the mobile equipment had helped them avoid at least one error in clinical treatment.

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### Helping the Elderly and Expectant Mothers

One of the biggest problems for elderly patients is forgetting to take their prescription drugs. It is estimated that only 50 percent of patients take their medication as prescribed.<sup>13</sup> Either they forget to take the drug or they do not take it at the time or dosage set by their physician. This means that we lose half of the benefit of prescription drugs through human error. This costs the systems billions in negative health outcomes.

Mobile technology has the potential to help with this and communications problems. Patients no longer need to visit doctors’ offices to be reminded to take their medicine. They can get personal reminders via e-mail, automated phone calls, or text messages. Text4Baby is a mobile application for pregnant women. It sends text messages in English and Spanish on how to handle various stages of pregnancy and problems that come up. This site has signed up 281,000 new mothers in the United States.<sup>14</sup>

In South Africa, a physician worried that his patients did not always take the prescribed Rifafol medicine for their tuberculosis. He knew that for the drug to be effective, people had to take the pill on a consistent basis. Otherwise, it would have little effect. So the doctor set up a text messaging service called “On-Cue Compliance” for each of his patients that sent them a daily SMS in English, Afrikaans, or Xhosa. Over the six-month course of treatment, his service would send a message at a pre-determined time each day reminding them to take Rifafol.

In the United States, Dynamed Solutions provides “HealthTrax” software that reminds patients to take medications, set up appointments, and track compliance with medical instructions. This and other types of “virtual health assistants” are

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particularly helpful with those suffering from chronic illnesses. These individuals need to keep close track of their medical condition and stay in touch with their caregivers. The software is integrated with electronic medical records and can store information in patient's personal records.

In Bangladesh, maternal mortality is the biggest killer. And neonatal deaths comprise more than half (57 percent) of fatalities under the age of five. To improve patient awareness, its doctors launched a Mobiles4Health initiative that provides how to take care of expectant mothers during pregnancies, early warning signs of possible infant problems, the benefits of family planning, and breast feeding best practices.<sup>15</sup>

Dr. Robert Schwarzberg of Sensei Corporation has developed a mobile "coaching app" for chronic disease sufferers. Using a subscription model, it offers "weight loss advice [and] virtual coaching on issues, including diabetes and blood pressure-control".<sup>16</sup> It tracks physical activity and body mass numbers. Based on the person's goals, it suggests food choices based on desired caloric intake and lessons on lifestyle and weight loss.

Portsmouth Regional Hospital has a service designed to shorten patient waiting time for the emergency room. Patients can text "ER" to a designated number and get the anticipated wait time to see a doctor or nurse. This reduces waiting time and provides people with the time estimates they need.<sup>17</sup>

A review of 25 studies on voice and text messaging interventions in care management found significant benefits. In examining research on medical reminders sent to 38,060 individuals, researchers documented improvements "in compliance with medicine taking, asthma symptoms, stress levels, smoking quit rates, and self efficacy. Process improvements were reported in lower failed appointments, quicker diagnosis and treatment, and improving teaching and training."<sup>18</sup>

There were links to health outcomes through a combination of remote sensors and physical activity reminders. A study of a physical activity program in the United Kingdom found that real-time mobile feedback combined with wrist-worn accelerometers monitoring physical activity yielded positive results. **Those getting virtual interventions showed an increase of 2 hours and 18 minutes per week in physical activity** and lost 2.18 percent more body fat than a control group.<sup>19</sup>

The popularity of Apple's iPad tablet has spawned a number of popular medical applications for mobile devices. Among its most widely-used apps are ones by Airstrip Cardiology that enable physicians to view electrocardiograms, an app by 3D4Medical.com called Skeletal System which shows the human bone system, Orca Health's EyeDecide MD which has optometrical information, and MIM Software's Mobile MIM, which shows various types of medical imaging.<sup>20</sup>

Overall, the Apple iTunes store has over 12,000 apps related to health care.<sup>21</sup> And it is estimated that **there are over 40,000 mobile health applications** across multiple platforms and that 247 million people have downloaded a health app.<sup>22</sup> While the impact of this growing market is still to be determined, it signals significant consumer interest in mHealth.

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## Extending Rural Access

Access to medical care in rural areas is a challenge in every country around the world. Nearly every nation has disparities between urban and rural areas. Health care providers and specialists are more likely to be located in densely-populated jurisdictions because that is where hospitals and advanced equipment are found.

Japan has a number of remote areas that are distant from urban centers. Some of them are located on sparsely-populated islands or in mountainous areas far from major cities. To improve access to medical care, Medical Platform Asia gave the 300 residents of rural Hokkaido 3G wireless devices that record and transmit blood pressure, weight, and distance walked through pedometers. Doctors examine the incoming data and make medical recommendations to each individual. Already, there have been substantial improvements in patient awareness on issues such as blood pressure management (awareness went from 50 to 100 percent during the pilot project) and the importance of being pro-active about medical care (engagement rose from 70 to 100 percent).<sup>23</sup>

In China, rural doctors have been given mobile devices which can access electronic health records and health treatment data bases. This allows physicians to see patient health information and learn how to treat common problems. If necessary, clinicians are also able to remotely consult with specialists in urban systems. In Hebei Province, 150 rural doctors are using the system, which has helped them serve approximately 300,000 patients.<sup>24</sup>

In India, rural-dwellers gain access to medical care far from their home towns through video conferencing. Using broadband connections, doctors geographically remote from patients can examine them and diagnose particular problems. In countries where physicians are in short supply in rural areas, this enables those in under-served locales to get medical treatment.<sup>25</sup>

Singapore has a mobile health application called Health Buddy that provides a list of medical symptoms and possible treatments, along with tips and videos on ways to promote good health. Patients can ask specialists detailed questions about particular illnesses and who they should see for medical care. The app provides access to SingHealth, the government health portal with over 40 different medical specialties that are available.<sup>26</sup>

In Malawi, Josh Nesbit of Medic Mobile developed software that allowed health workers to text in medical information for rural patients. Rather than spend hours commuting to clinics, they could get quick diagnosis on routine symptoms and suggested treatments. According to him, “within six months of the system going live, the number of patients being treated for tuberculosis doubled, more than 1200 hours in travel time were eliminated, and emergency services became available in the area for the first time.”<sup>27</sup>

In Bangladesh, 90 percent of childbirths in rural areas occur outside of hospitals or health care clinics. After the launch of a mobile birth notification system, that calls

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health clinics when labor starts asking for a midwife, 89 percent of births now take place with trained health workers in attendance.<sup>28</sup> Researchers at Johns Hopkins University have extended this model through an mCare initiative. It schedules prenatal care visits for expectant mothers, helps during childbirth, and checks in after childbirth to deal with any health issues.

These applications make doctors more efficient because they don't have to be in the physical presence of a patient to judge his or her condition. Digital technology allows people to overcome the limitations of geography in health care and access information at a distance. This makes it possible for patients to get a second opinion without visiting another physician by sending that person relevant medical tests. If a personal conference is required, doctors can use video conferencing to speak to patients located in another city or state.

Research by the Telnor Group has found that **mHealth can reduce the costs of medical care among the elderly by 25 percent**, double access to physicians by those living in rural areas, and improve tuberculosis treatment compliance by at least 30 percent.<sup>29</sup>

## Overcoming Policy and Regulatory Barriers

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Many patients want to employ digital and mobile technologies in their medical care. For example, 77 percent in a national survey said they would like to get reminders via e-mail from their doctors when they are due for a visit, 75 percent want the ability digitally to schedule a doctor's visit, 74 percent would like to use e-mail to communicate directly with their doctor, 67 percent would like to receive the results of diagnostic tests via e-mail, 64 percent want access to an electronic medical record to capture information, and 57 percent would like to use a home monitoring device that allows them to e-mail blood pressure readings to their doctor's office.<sup>30</sup>

A number of people, however, are worried about the privacy and security of mobile devices and wonder whether increased reliance on handheld devices will compromise the confidentiality of their medical information.<sup>31</sup> They fear the loss of a smartphone or tablet that contains personal material and are concerned that their medical information might end up in the hands of employers or private individuals.

But to move forward with mobile technology, providers must overcome barriers in terms of reimbursement policy, regulation, and research.<sup>32</sup> In many countries, neither public nor private insurance plans cover mHealth applications. Physicians, for example, often are not reimbursed for e-mail or phone consultations, the use of text messages, or data gathered through remote monitoring devices. Reimbursement policy is skewed in favor of face-to-face medical treatment over digital or mobile applications. This limits physician interest in and reliance upon innovative treatment and reduces the benefits of the mHealth revolution.

There needs to be policy changes that recognize the new landscape of medical care and the benefits of remote monitoring devices, preventive medicine, text reminders to take medication, and electronic consultations. Unless physicians are

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reimbursed for these practices, they will be less likely to make use of innovative techniques.

The mobile revolution has raised issues in terms of government regulation of medical devices and diagnostic tools. In the United States, the Food and Drug Administration (FDA) has responsibility for ensuring that medical devices are safe and beneficial. With prescription drugs and expensive imaging systems, the FDA requires clinical trials proving effectiveness and lack of harm through adverse conditions in order to approve usage.

If patients rely on home monitoring devices to transmit blood pressure data, should there be an accuracy requirement in the data transmission? Or if there are mobile apps that enable physicians to read electrocardiograms or CT-scans on handheld devices, should governments regulate the app to insure effectiveness?

In 2011, the FDA published draft guidelines that said “the interpretation of imaging scans on a mobile device could be affected by the smaller screen size, lower contrast ratio and uncontrolled ambient light of the mobile platform”.<sup>33</sup> Agency officials indicated that they would look at apps with an eye towards these considerations and also evaluate the marketing claims made on behalf of mobile applications and physician decision support protocols developed to help diagnosis and treatment.

One of the issues the FDA is grappling with is whether to regulate medical screening and diagnostic tools. In a Federal Register posting in February, 2012, the agency said it was “aware that industry is developing new technologies that consumers could use to self-screen for a particular disease or condition and determine whether a particular medication is appropriate for them. For example, kiosks or other technological aids in pharmacies or on the Internet could lead consumers through an algorithm for a particular drug product. Such an algorithm could consist of a series of questions that help consumers properly self-diagnose certain medical conditions or determine whether specific medication warnings contraindicate their use of a drug product.”<sup>34</sup> The agency indicated that use of these types of algorithms could save money because it would free consumers to self-diagnose for common problems and therefore save unnecessary trips to a doctor’s office.

It is clear based on this review that more research is required to link mobile technology to health outcomes. There is considerable data demonstrating positive results for user satisfaction, reductions in wait time, improving attendance at medical appointments, and significant cost savings. But we need more information demonstrating the connection to health outcomes, such as drops in infant mortality, reductions in the spread of infectious diseases, and positive treatment of chronic illnesses. Those are the ultimate objectives on health care and researchers need to focus more on outcomes.<sup>35</sup>

The mobile revolution is limited by the need to overcome economic, organizational, and technology disparities across nations. Research by Patricia Mechael and colleagues at the Columbia University Center for Global Health and Economic Development has identified several sources of inequity: treatment

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compliance, disease surveillance, health information systems, point-of-care support, health promotion, disease prevention, and emergency medical response.<sup>36</sup>

These issues make it difficult for people in all nations to share in the benefits of the unfolding technology revolution. Countries that have made progress in developing mHealth should transmit their best practices to other nations so that the latter can understand ways to move forward. That would help more people to unleash the potential of their mobile devices and gain the virtues of new technologies.

## The Economic Impact of mHealth

In short, mobile health clearly has expanded in number and type of initiatives. It is expected to become a multi-billion dollar field by 2017. According to a report from PwC, **annual revenues are projected to reach \$23 billion worldwide.** This includes \$6.9 billion in Europe, \$6.8 billion in Asia, \$6.5 billion in North Americas, \$1.6 billion in Latin America, and \$1.2 billion in Africa.<sup>37</sup>

Remote monitoring will comprise about two-thirds of this market as doctors and patients use these devices to manage chronic illnesses. With the ubiquity of mobile devices both in developing and developed countries, there have been innovations in awareness, prevention, diagnosis, and treatment. Mobile technology is especially helpful in regard to chronic health diseases because it frees physicians from routine office visits while still providing data on patient conditions. This helps doctors focus office care on those requiring more detailed medical assistance.

A study of the U.S. wireless industry by Roger Entner found that mobile devices improve worker productivity in four ways: 1) reducing unproductive travel time, 2) improving logistics, 3) enabling faster decision-making, and 4) empower small businesses and improving communications. He estimated that the industry increased productivity by \$33 billion in 2011 alone. One-third of this gain (\$11.2 billion) came from the medical area. Entner projected **productivity gains of \$305.1 billion over the next 10 years in medicine.**<sup>38</sup>

Econometric modeling shows a significant tie between mobile penetration and economic development. Mobile communications contribute 0.39 percent to Gross Domestic Product growth in the developed world.<sup>39</sup> Others have suggested a bigger effect of 0.59 percent added to national growth.<sup>40</sup> By easing communication, improving service delivery, and reducing transmission errors, mobile devices contribute positively to economic growth and to the benefit of countries around the world.

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Projections are productivity gains of \$305.1 billion over the next 10 years in medicine.

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