Chapter 41: Sana Platform

Eric Winkler

Take-home messages:

- Technology can play an important role in the delivery of care but should not be assumed to improve outcomes.
- Health care technology should be sensitive to the needs of all individuals and entities that might be impacted by its use.
- Introduction of technology into a health care system must be done in a manner that allows accurate assessment of its impact.

Introduction

This chapter highlights a number of issues and considerations that may arise during the design, implementation, and deployment of mobile and related technologies as part of a health care solution. The Sana mobile health software platform, hereinafter the Sana platform, is used to illustrate the issues and present a framework for discussion.

Background

Increasing the limited access to health care for populations that have traditionally been underserved requires addressing a large number of challenges. For the developers of Sana, the advent of mobile technology and, in particular, an increased presence of mobile data networks provided an opportunity to leverage mobile technology to address these challenges, not the least of which is an uneven concentration of skilled clinicians among patient populations. Uneven concentrations can be caused by a number of factors, including geographic location, economic status, and culture, and are often magnified in developing regions where the ratio of skilled providers to the general population may be low to begin with. The Sana platform was thus conceived and developed as a mobile health platform designed to: 1) provide decision support to locally available and often less skilled community health workers, 2) capture, transmit, and archive both simple and complex medical data, and 3) allow bidirectional communication between remote workers and highly skilled specialists. Figure 41.1 shows a simple graphical representation of the platform.

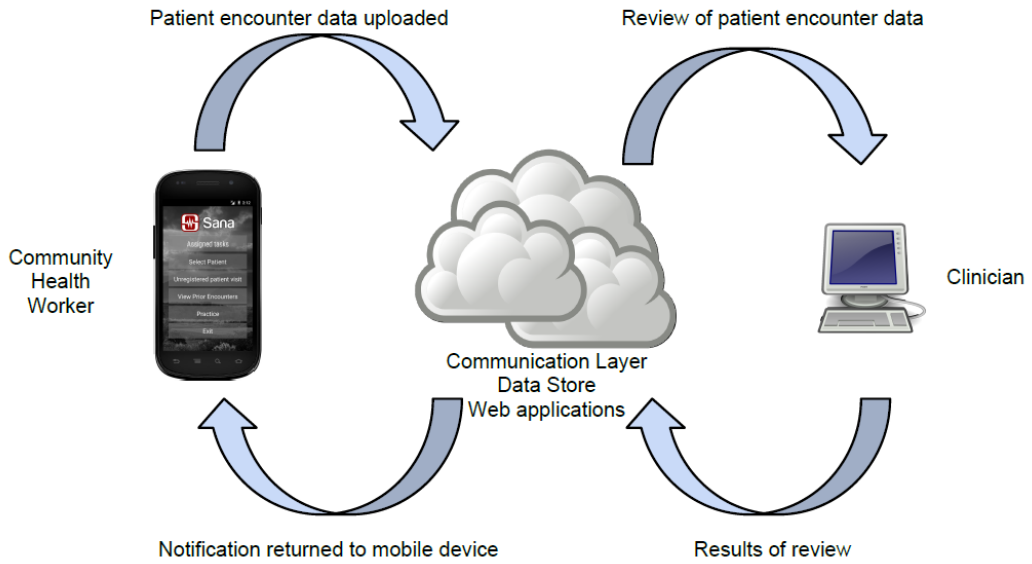

Figure 41.1
Components and flow of information between clinicians and remote workers in the Sana platform.

Design Principles

The developers of Sana never assumed that injection of new technology, or even use of an existing technology in a new way, would, in and of itself, automatically translate to better outcomes, however limited the currently available care might be. The broader design goals of the platform instead focused on how well it addressed issues related to quality, usability, availability, adaptability, and sustainability. Subsequent sections will delve into how these broader topics translate into more concrete design and discuss implementation issues that deserve further consideration. Although the Sana platform was not the only attempt to apply mobile technology to health care, the discussion in this chapter will assist the reader in developing or evaluating mobile or other technologies that may be applied to health care solutions.

Quality

One of the primary concerns when applying any software tool to health care must be whether that tool improves the clinical outcomes. A mobile application that collects and transmits data or provides decision support does not inherently do anything to alter the course of a disease. The mobile application must therefore be viewed as one component of that health care value chain, which includes the personnel and facilities of the larger system. The Sana platform was therefore deliberately designed to have physicians and community-based health workers

(CHWs) as end users. The physicians provide the content of the software and assist with the design of the information system, with the CHWs as the interface of the delivery system. The design of the system addresses precisely how the data is going to be collected, transmitted, stored, and reviewed; how diagnostic and therapeutic decisions are going to be informed; and how impact is going to be measured. Within the context of quality improvement, accurate data is key, as data is the foundation of a learning health care system. The digitalization of the care process facilitates not only evaluation and monitoring of the health system but provides an opportunity to build the knowledge base on best practices as they apply to the local patient population. It is also important to consider the general software quality. Ultimately, a poor quality product—including one that is difficult to use or unreliable—will result in end-user dissatisfaction and, at minimum, a reluctance or, at worst, refusal, to use the product. From a software development perspective, avoiding this problem entails following a number of standard best practices for producing high-quality software.

Usability

Here, usability is discussed from the perspective of end users as well as the organizations that deploy the information system. For end users, usability pertains to the experience with the application. Specific examples of usability issues include the ease of navigation and the appearance of the interface but may also include general responsiveness, clarity of the application content, and the degree to which use integrates into previously established workflows. Applications which are difficult to use for any reason will deter adoption.

For the mobile application in the Sana platform, one issue that requires particular attention with respect to usability is how to reduce any use barriers experienced by the CHWs who would be the primary end users. From that perspective, it is important to challenge any assumptions that may exist about the end users. It is not inconceivable that the user base of a mobile application will include individuals with limited or even no prior experience using smartphones. This has been observed in pilot studies where the Sana platform has been deployed.[1] In such a scenario, screens crowded with a large number of inputs and complicated navigation options could prove difficult for these users. Guidelines that the Sana mobile application has followed for assisting these types of users include single prompts per screen, larger fonts for the prompts, simple forward and back buttons to navigate between prompts, and a minimal set of navigation options from the main application screen. Furthermore, any text or visual cues in the application must be displayed in a manner appropriate for the local dialect or culture. Figures 41.2 through 41.5 show examples of the main navigation screen and sample questions from a simple surgical follow-up questionnaire when run on

the Sana mobile application, including images captured and returned using the device camera app.

Figure 41.2
Navigation menu of the Sana mobile application.

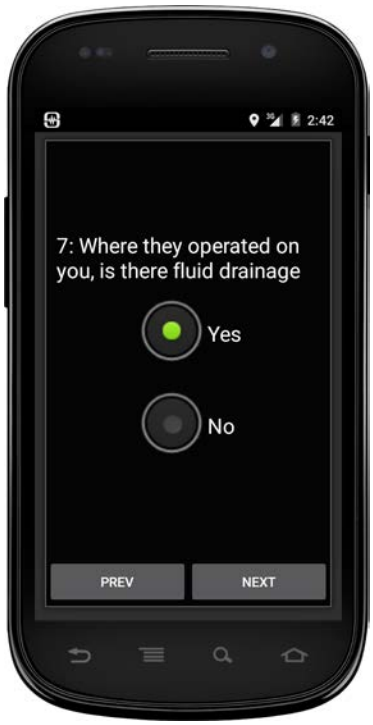

Figure 41.3
Prompt for recording the presence of fluid drainage at a surgical site in the Sana mobile application.

Figure 41.4
Prompt for recording the color of fluid drainage at a surgical site in the Sana mobile application.

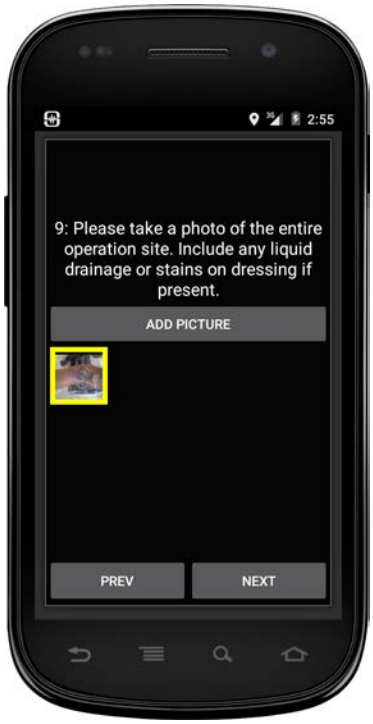

Figure 41.5
Mobile interface displaying images of a surgical site in the Sana mobile application.

In contrast, physicians who would be reviewing patient data are likely to be familiar with browser-based applications and their concerns will be different. The primary issue then becomes providing an interface with the least disruption to their workflow. The solution adopted by the Sana platform was to introduce a queue of cases requiring review and a single web page interface for reviewing the data and providing a diagnosis or recommendation into an electronic medical record (EMR) system which provides the backend or data store of the system. Figures 41.6 and 41.7 provide examples of a more feature rich physician web-based interface.

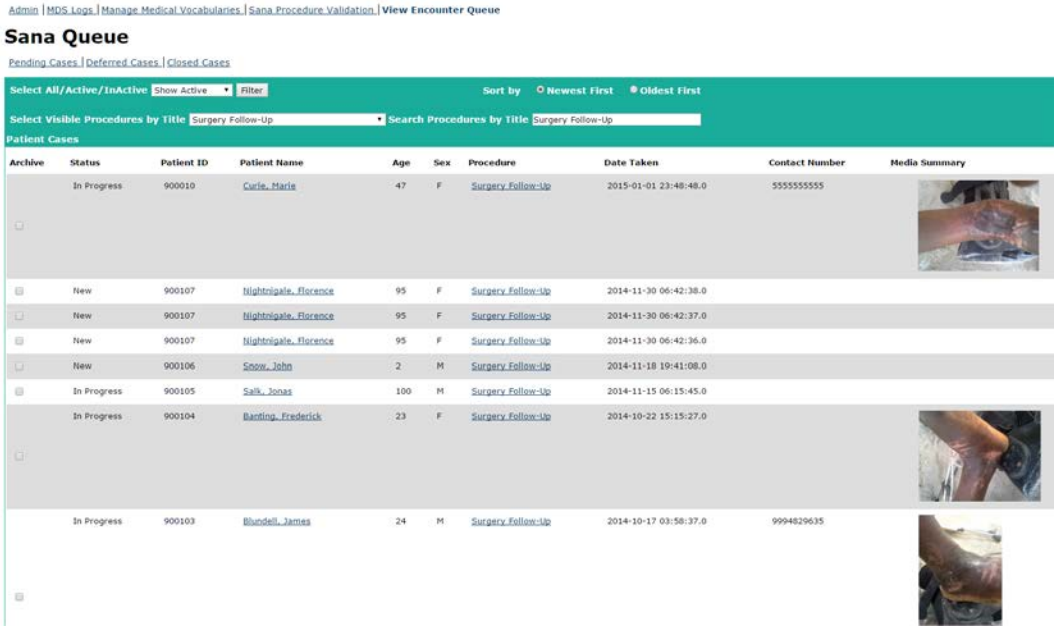

Figure 41.6
List of patient visits requiring review when accessed in a web browser and rendered by the Sana OpenMRS Module.

Figure 41.7
Detailed view of the data captured during a surgical follow up visit as rendered by the Sana OpenMRS Module.

The default EMR for the Sana platform is OpenMRS. More recent versions of the Sana platform also include an alternative web application for browser-based data access in lieu of the more feature rich default EMR. The important point from the perspective of the Sana platform design was the introduction of a middleware layer that allowed integrating other EMR or backend components based on which provided features appropriate to the setting where it is deployed. This type of design provides more flexibility in presenting users such as physicians or researchers with a visualization that may be more contextually appropriate—e.g. longitudinal patient care versus research. Figures 41.8 and 41.9 show a simpler web-based interface.

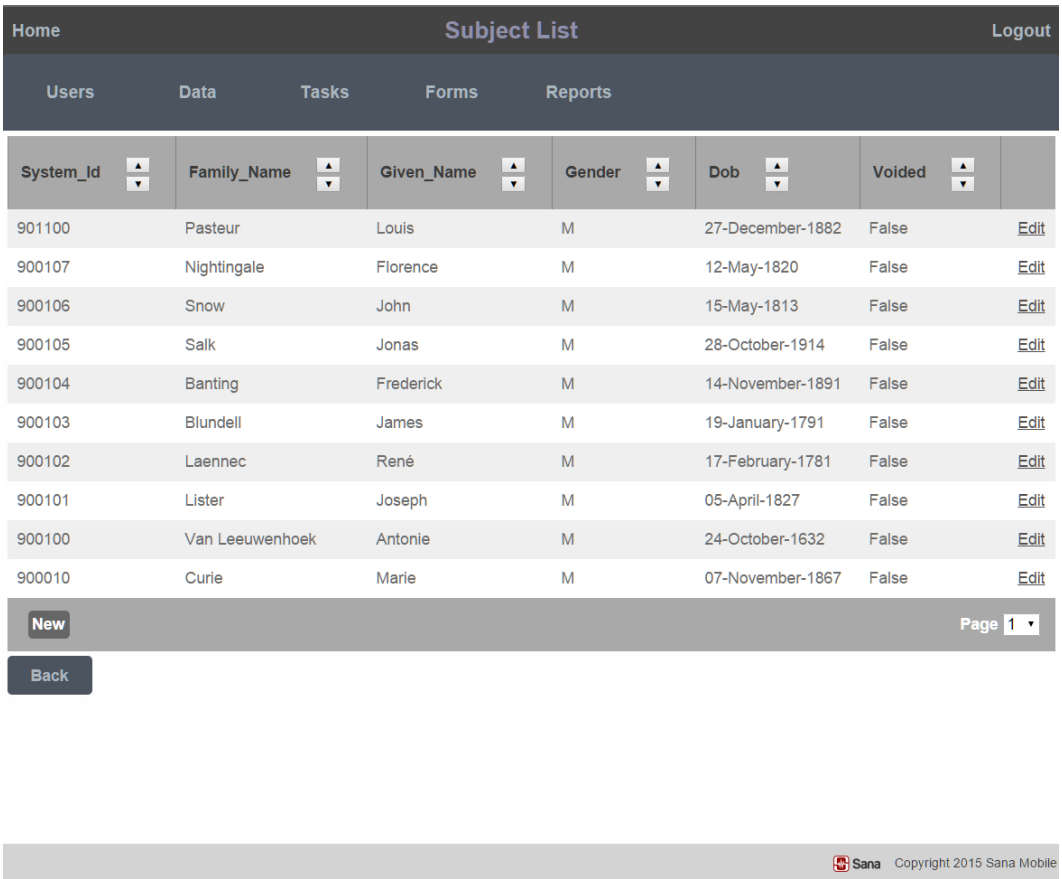

Figure 41.8
An alternative rendering of a list of patients using the web frontend included within the Sana middleware.

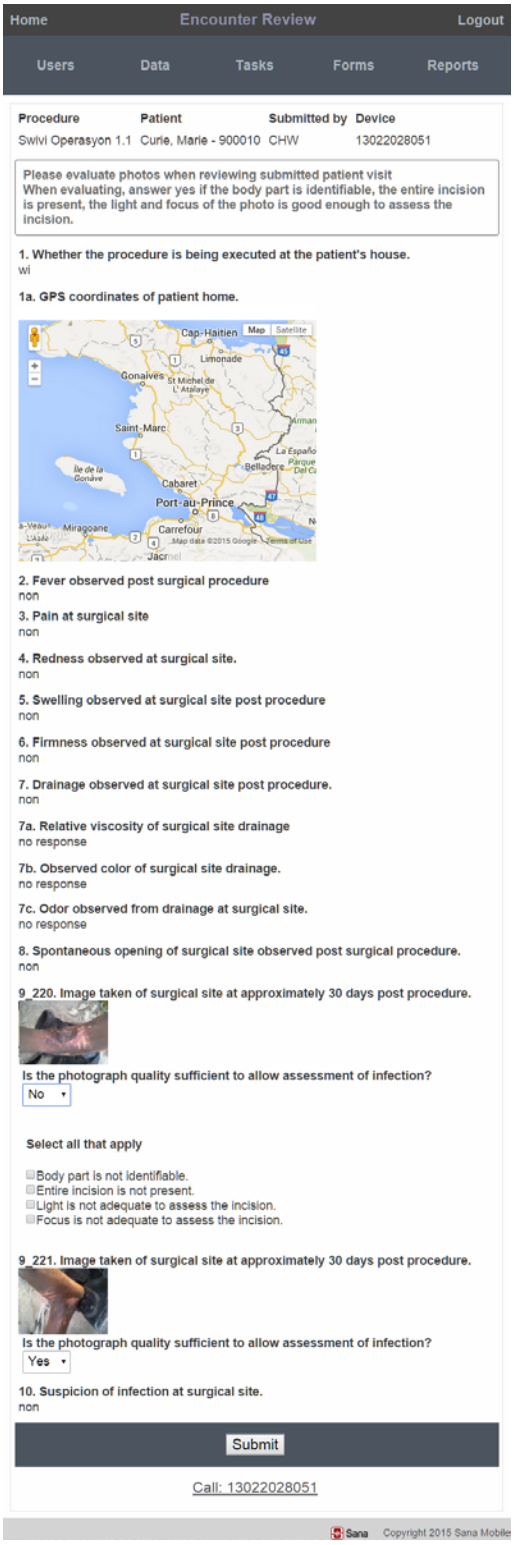
Home
Encounter Review
Logout
Users
Data
Tasks
Forms
Reports
Procedure
Patient
Submitted by
Device
Swivi Operasyon 1.1
Curie, Marie - 900010
CHW
13022028051
Please evaluate photos when reviewing submitted patient visit
When evaluating, answer yes if the body part is identifiable, the entire incision is present, the light and focus of the photo is good enough to assess the incision.
1. Whether the procedure is being executed at the patient's house.
wi
1a. GPS coordinates of patient home.
Cap-Haitien
Limonade
Gonaives
St Michel de L'Atalaye
Saint-Marc
Cabaret
Port-au-Prince
Miragoane
Carrefour
Jacmel
2. Fever observed post surgical procedure
non
3. Pain at surgical site
non
4. Redness observed at surgical site.
non
5. Swelling observed at surgical site post procedure
non
6. Firmness observed at surgical site post procedure
non
7. Drainage observed at surgical site post procedure.
non
7a. Relative viscosity of surgical site drainage
no response
7b. Observed color of surgical site drainage.
no response
7c. Odor observed from drainage at surgical site.
no response
8. Spontaneous opening of surgical site observed post surgical procedure.
non
9_220. Image taken of surgical site at approximately 30 days post procedure.
Is the photograph quality sufficient to allow assessment of infection?
No
Select all that apply
Body part is not identifiable.
Entire incision is not present.
Light is not adequate to assess the incision.
Focus is not adequate to assess the incision.
9_221. Image taken of surgical site at approximately 30 days post procedure.
Is the photograph quality sufficient to allow assessment of infection?
Yes
10. Suspicion of infection at surgical site.
non
Submit
Call: 13022028051
Sana
Copyright 2015 Sana Mobile

Figure 41.9
An alternative rendering of a detailed view of the data captured during a surgical follow up visit using the web frontend included within the Sana middleware.

On the organizational level, the usability considerations relate to the server applications and infrastructure for receiving and storing the data. Complex installation procedures and maintenance that require skills that may not be available to the organizations present a significant barrier to adoption. That gets at the crux of why the decision was made for the Sana platform to include all of the components required for a complete frontend-to-backend system comprised of a mobile client, a middleware layer for communications, and an EMR or other backend. Such a design affords control of the software requirements, versions, and other related issues that could complicate installation.

Availability

The notion of availability is applied here to two distinct areas: availability of the software itself and availability of the services provided by the software. With respect to the availability of the software, the issues involved include any direct cost of the software along with along with any costs associated with the hardware required to run it. For the Sana platform, the strategy to reduce direct software costs was to adopt an open source license for any software developed directly by the organization and only integrate externally developed components that were also available under an open source license. Without going into the nuances of the various open source licenses, the basic idea is that the source code for the software is freely available. That is not to say that open source software is without costs. Developers, systems administrators, and the hardware required to run the software all have associated costs. Rather, open source software avoids some of the up front and continuing costs associated with proprietary software. Open source software also has the benefit of not being reliant on the third-party vendor for every modification and customization. This is of particular importance with the Sana platform given that every deployment has required software modifications to adjust to local context. The availability of required hardware is also an important consideration. The design of the Sana platform was intended to address this for both the mobile and server side components by including software that could be run on fairly modest hardware. Software that could only be run on the latest or high-end hardware introduces a significant barrier. On the mobile end, the choice of using Android-based mobile devices provided a reasonable compromise between the cost of the devices relative to the minimum requirements of the features needed in the software. Less expensive mobile phones are available but lacked a number of the smartphone features required to enable most of the application's functionality. When deciding what mobile

platform to choose, it is worth looking at the relative market penetration of devices running that platform in the areas where the app will be deployed. At the time the Sana mobile app was developed, Android-based devices were the most prevalent globally. That might change in the future; flexibility of the operating system should be considered moving forward.

The server side components of the software platform were chosen and developed with the idea that they could be installed and run on a PC device with modest hardware. For larger scale deployments, higher end server hardware would be required, but it could be assumed that larger deployments would be capable of allocating greater resources for such hardware. Regardless of the size or scope of the deployment, one of the primary concerns that must be addressed when developing server side applications is maximizing the availability of services those applications provide. As an example, server downtime can easily result from unreliable power supply to locally maintained hosts. While that particular issue is more directly addressed by the larger infrastructure associated with the deployment, solutions can include providing backup power supply or using cloud based hosting such as Amazon Web Services for server side applications. It is worth commenting here that there are demonstrable benefits to using cloud based hosting. These include relieving local organizations of the burden of maintaining the power supply to the equipment and physical security of the equipment. However, cloud-based services do introduce other concerns, particularly privacy issues around sensitive medical data. In summary, both locally maintained and cloud based hosting have benefits and drawbacks. Our experience with the Sana platform has been that the context of the deployment will dictate which is the better approach.

Solutions can also be more software-specific such as how the software handles network transmission issues. One of the assumptions when the Sana mobile app was designed is the unreliability of the cellular data network. The mobile application should therefore be capable of providing most features even when the network is unavailable, essentially running in an offline mode. While an offline mode has advantages for data upload, it does not allow for real-time decision support. For the mobile client of the Sana platform, the approach was to have data collected by the app cached on the cellphone and uploaded using a retry-on-fail approach. Furthermore, additional features were included in the mobile client to detect when network services become available and process any pending uploads. Given the requirement that devices operate in areas with poor connectivity, one of the challenges is how to handle data stored in very large binary files such as images. The typical approach for uploading an image would be to attach it to an HTTP POST request. The drawback with that approach is that any interruption of the connection would require resending the entire POST. The Sana platform initially worked around that issue by breaking up larger files into

smaller individual segments that could be reassembled, a process referred to as packetization. This feature is the prelude for what would become the Sana middleware component that provides an intermediate cache between the mobile clients and the final data destination, typically an EMR system. In addition, the middleware layer introduces multiple routes for communicating data and acts as a conduit to external services such as SMS gateways and email delivery services. The reasons for choosing one particular transmission route over another may include cost, privacy issues, and reliability of the service. As a case in point, SMS networks often have broader coverage than cellular data networks. However, the cost per message for SMS when compared to email is typically higher.

Adaptability

The success of a platform in addressing future needs is fundamentally a question of how it adapts to an increasing number of use cases and users. For increased user volume, this translates to the need for additional storage, available processing power, and network bandwidth. While those are somewhat outside of the direct scope of the Sana platform components, they are important to consider at the outset of a project. Adapting to unanticipated use cases that require additional features is a more challenging problem but can be addressed by adopting what are generally considered good software design and development practices. Concepts like separation of concern and modular design contribute to minimizing the need to rewrite, or reengineer, large portions of a software product when adapting it to additional use cases. For example, the plugin architecture on the Sana mobile client allows for launching external applications directly from within a procedure, which is the normal flow of prompts presented to the mobile user. Mobile applications that communicate with, and are specific to, external point of care devices can thus be written independently of the main Sana app and yet integrate into the normal workflow. The Sana middleware layer provides a comparable mechanism in that it can also interface with various EMR backends. The basic approach being that as long as an EMR, or other backend, provides a standard set of web services for sending data to and from it, the middleware simply needs to be provided with a mapping of any differences in the representation of data objects in the two systems.

Sustainability

Sustainability of the system depends upon a number of factors but relies mostly on the local stakeholders. As it pertains to the technical components, sustainability refers to continued maintenance of systems, troubleshooting, modifications to existing software, and training end-users. One of the most important factors for sustainability is developing the local technical infrastructure in the form of skilled human resources to support the project, assuming this

infrastructure does not already exist. There is no single best way to build those resources if they are not available, and a discussion of that topic is outside the scope of this chapter.

The other major consideration for the sustainability of a project is the cost of the technical infrastructure necessary for maintaining the project. This cost can become quite significant during scale-up. For example, there is a cost differential per message sent through SMS versus email that is magnified if the project expands to cover a larger patient population. Other examples of costs include the data plan for cellular service, usage charges if deploying on cloud-based services, electrical power cost if hosting the project on a server, and the cost of replacing or acquiring new mobile devices.

Summary

This chapter presented a number of design, implementation, and deployment issues using the Sana platform as an example. It is by no means an exhaustive presentation of all the issues that may arise or of all the potential solutions. Instead, it is hoped that the information provides insight into some key areas of software and information systems development.

Discussion questions:

- What do you consider to be the most significant impact mobile technology has had on health care, for better or worse?
- What health care challenges do you believe present an opportunity that could be addressed at least in part through the introduction of mobile technology?
- What would you anticipate to be the most significant barriers to the success of such an introduction and how might they be addressed?

References

1. Matousek, Alexi et al. “Community health workers and smartphones for the detection of surgical site infections in rural Haiti: a pilot study.” The Lancet 385 (April 2015): S47.

