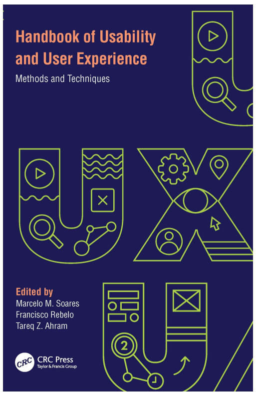

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Getting the Benefit from Connecting Health Apps to Complex Healthcare Systems

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10 Getting the Benefit from Connecting Health Apps to Complex Healthcare Systems

Ken Eason, Adam Hoare and William Maton-Howarth

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10.1 INTRODUCTION

It is estimated that there are now 325,000 digital health applications available to consumers in the UK (ORCHA 2019), supporting them in everything from exercise regimes and healthy eating to the management of every kind of health condition from diabetes to insomnia. Many of these applications are stand-alone: the consumer can use them to keep a personal check on the exercise they are taking, the calories they are consuming, etc. However, there is another class of applications that serve people who have specific medical conditions and are patients of the health services. These applications depend for their effectiveness on being connected to healthcare systems that can, for example, interpret results and provide expert guidance and care. Applications of this kind have great potential because they can provide new links for the consumer/patient to healthcare systems and render the expertise of health service professionals much more accessible. However, to develop an application that gives a good user experience of interacting with health services is a much more complex design task than the development of a stand-alone consumer product.

This chapter explores the issues to be addressed if the consumer who is a patient is to get an effective service from an application that is linked to a complex healthcare system. There is now an extensive literature that tells the troubled history of getting digital applications embedded as normal practice in health services. The history of telehealth applications is one example. Applications that enable a patient in one location to be in visual contact with clinical staff in another location have been available for many years and have been shown to be of great value to patients who may have difficulty visiting clinical professionals. However, as evaluations consistently show, it is proving very difficult to establish this kind of consultation as a normal part of health service delivery (May et al. 2003, Polisena et al. 2009) and authors such as Wyatt (2011) are left asking: "Why does telehealth fail and what can we do about it?" An extensive randomized control trial of telehealth in the UK (Steventon et al. 2012) failed to reach a definitive view observing only that there was no conclusive systemic evidence of benefits despite widespread anecdotal reporting of enormous benefit to individual patients. There are factors at work that seem to make it difficult to translate the manifest benefits of a new digital application, often demonstrated in early trials and pilots, into sustained and widespread benefits when the application is disseminated more widely in health services.

In an attempt to elucidate the barriers to the successful adoption of these applications, this chapter will review three health applications that depend for their full effectiveness on both the digital application available to the consumer/patient and on the way the application is connected to relevant health service systems. The authors have recently undertaken an evaluation of nine innovations in the English National Health Service and this included two of the case studies below (NIA 2018). The cases have been chosen to illustrate three different kinds of health applications that give rise to different but overlapping sets of issues that have to be resolved if effective and sustained services are to be delivered to patients.

10.2 A DIGITAL APPLICATION TO SCREEN FOR ATRIAL FIBRILLATION (AF)

The first case study is an example of a digital application that can be used as a stand-alone device that a consumer can use to monitor their own health but in this case is being used within a health service so that the results can be acted on by healthcare specialists.

10.2.1 The Digital Application

Many people have undetected heart problems that are only identified when they have a major problem. A particular example is that people can have undetected disruptions to their heart rhythms known as atrial fibrillation and this can lead to people having strokes. Kardia (2019) is a small, mobile digital application that enables a person to generate their own electrocardiogram (ECG) by simply pressing down on two touch pads. The system is able to analyze an ECG to detect whether there are abnormalities in heart rhythms that might indicate AF. Kardia is available as a stand-alone product and is already in extensive use by people with known heart problems who use it for regular monitoring. However, it is also possible that it could be used for more general screening: to use it for people who have no known heart condition but who might be "at risk." If early signs of AF can be detected, it should be possible to take action that would mean the person would not suffer a stroke. That would obviously provide an enormous benefit to the patient and would probably save the health service the considerable expense involved in providing long-term care for a stroke patient.

10.2.2 The Plan

In the southeast of England a trial was set up to use Kardia to screen people over the age of 65 for early signs of heart disease (NIA 2018). The aim was to locate the service in pharmacies that patients visit regularly to buy medicines, to seek advice on medication and to collect medicines prescribed to them by their local General Practitioners (GPs). If the patient was over 65, they would be offered a free ECG screening which was a quick and easy procedure. Figure 10.1 shows the overall plan for the service.

The plan was to undertake the ECG scan and to use the analysis process built-in to the application to assess whether the heart rhythm was normal or abnormal. The patient could be informed of the result and, where there were concerns, would be advised to go and see their General Practitioner. In the event of an anomaly being detected, the pharmacy assistant would also notify the patient's General Practitioner

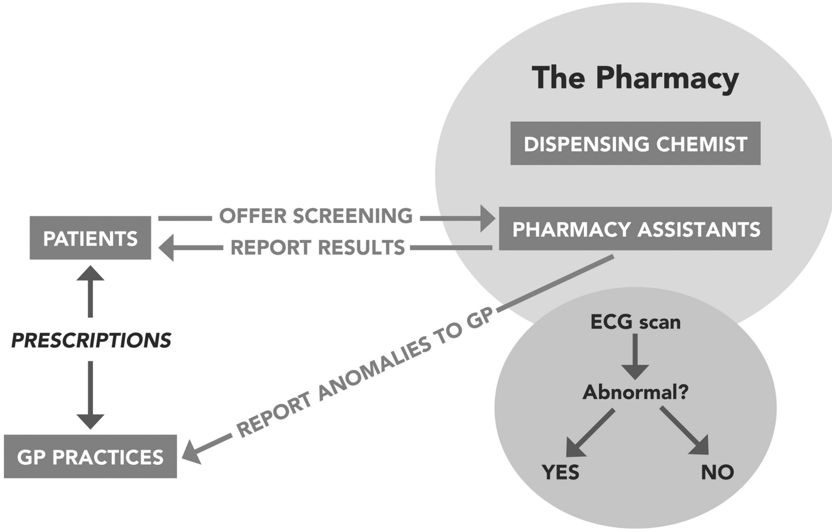

FIGURE 10.1 ECG screening in a pharmacy.

which was normal procedure in pharmacies if they noted anything of concern about the patient's health.

10.2.3 The Implementation and the Result

A trial was undertaken to assess whether patients were happy to use Kardia and whether the pharmacy assistants could capture good quality ECGs that could be analyzed for anomalies. Many patients were indeed happy and willing to take part in this process but many of the ECGs were difficult to analyze and may or may not have indicated an anomaly. Changes were made to the procedure (e.g., quieter locations for the screening, more training for the pharmacy assistants) but there remained a problem in interpreting some of the ECGs. A further problem was identified when anomalies were reported to the patient's GP. Although fully supportive of the purposes of the screening, the GPs felt it was inappropriate to refer the matter of dealing with anomalies to them. They were already overstretched in dealing with an increasing patient load and they were not equipped to undertake definitive tests for heart conditions. It was likely they would not be able to see the patient urgently and, even then, they would have to refer them to the cardiologists in the local hospital to assess whether there was an incipient heart condition. The pharmacy staff were concerned on two counts: first they may be creating anxiety in the minds of the patients and, second, the delay at the GP surgery may mean the patients would have to live with the anxiety for a considerable time. Some estimates were that it might be up to 12 weeks from the time of the screening to an appointment with a cardiologist. In these circumstances, the pharmacy wondered whether they should abandon what had seemed a very beneficial service.

10.2.4 The Revised Plan

The project team, which included pharmacists, AF specialists and an innovation testbed, did not want to abandon this beneficial service and they embarked on a wide consultation to find a way forward. A review of the pathway by which anomalous results would be processed was undertaken and, following consultations with the cardiology department of the local hospital and the local Clinical Commissioning Group (that provides the funding for local healthcare), a new system was proposed. In the new system, the cardiology department would set up a "one-stop clinic" to receive ECG traces from Kardia for their cardiologists to review for possible AF or other heart problems. If they considered there might be a problem, they would arrange an outpatient appointment for the patient at the hospital. This plan was adopted. A new computer system was introduced that enabled the pharmacy to send the ECG traces directly to the cardiology department and, when necessary, they arranged appointments to see the patients. Twenty-one pharmacies took part in a second trial in which 672 ECG traces were captured and 110 were referred to the clinic. The clinic concluded that 74 needed no further action and that meant they invited 36 patients to come for further tests. The process was reduced from a possible 12 weeks to 2 weeks.

10.2.5 Discussion

This example shows clearly that it is not enough for a digital application in this setting to be able to offer a major health benefit, to be acceptable to patients and usable by the pharmacy assistants. If the goals of confirming AF and of treating the patient in question are to be achieved, an acceptable process or "pathway" in the local healthcare system is also to be created. This is a change in the "socio-technical system" (Eason 2014, Hoare 2019) by which healthcare is delivered. In this case, it required the development of a new computer system to transmit ECG traces from Kardia to the cardiology department and changes not only to the role of the pharmacy assistants but also to the cardiologists in the local hospital. It was the realization by the project team that this was not just a technical innovation but required a revision to the existing sociotechnical system that made this possible. If a substantial review had not been undertaken and a new sociotechnical plan put in place, this promising development could have become just another innovation that did not become embedded in normal practice.

10.3 A DIGITAL APPLICATION FOR THE MANAGEMENT OF OUTPATIENT APPOINTMENTS

Many people are now actively engaged with the convenience of ordering and managing services using mobile applications. Whether ordering takeaway food, a taxi or bidding for products in online auctions, the immediacy and interactivity of apps has been embraced by a wide cross section of the public. In the context of outpatient appointments, including the problems of "did not attends" (sometimes called DNAs) and the need to manage precious resources, it would seem that a digital app that optimized appointment bookings would bring convenience to many people and make economic sense for hospitals.

It turns out that this particular application, in its requirement to integrate systemically with current ways of working, reveals some of the fundamental challenges of interoperating technology platforms and the sociotechnical nature of such change. That is, the successful adoption of such an approach is not just a matter of overcoming the technology challenges of getting different computer-based systems to share data in a meaningful way. It also requires change in the way that staff interact with the systems and with patients using them. These challenges can be better understood through the process by which the DrDoctor platform was adopted.

10.3.1 The Digital Application

DrDoctor (2019) is an online and text-based service that allows patients to confirm, cancel and change outpatient clinic bookings digitally. For patients, it means they have an application that enables them to engage quickly and easily with the outpatient clinics of hospitals to manage their appointments. For hospitals, the application means they can maximize and manage patient volume to best fit their capacity. The immediacy and interactivity of being able to offer new appointments and deal quickly with cancellations means that there is much greater flexibility in setting up and filling additional clinics and canceling clinics that become non-viable. This flexibility is not available using postal approaches to communication and it reduces the resource-intensive nature of trading appointments by telephone. Such approaches are therefore beneficial for targeting long waiting lists and more flexibly managing clinic slots. In addition, it also provides the potential for digital assessments before and after appointments, saving time for both patients and caregivers.

10.3.2 The Plan

Contact between Guy's and St. Thomas Hospital Trust (GSTT) and DrDoctor began in 2013 when the General Manager for Women's Services in Gynecology identified the high number of missed outpatient appointments (DNAs). DrDoctor was identified as a potential solution. However, the Trust was already underway with a procurement process for a text-only appointment booking solution, and DrDoctor's functionality was broader than the procurement specification.

In 2014, the General Manager for Women's Services developed a short business case that focused on the reduction of DNAs and led to GSTT piloting DrDoctor in gynecology in 2015. A small amount of funding covered the cost of the DrDoctor service as well as paying for some IT integration. The pilot provided sufficient evidence that DrDoctor reduced DNAs to justify a broader roll out across GSTT. At the same time, the Chief Medical Officer at GSTT saw the additional potential of DrDoctor to reduce the cost of postage by replacing letters with electronic communication.

10.3.3 The Implementation and the Result

The Chief Medical Officer took the Senior Responsible Officer Role (SRO) for the wider deployment of DrDoctor to all outpatient departments in 2016. A project board was assembled, including the SRO, an operations lead and a finance lead. The data from the pilot was shared with the hospital general managers and they were brought into the project board as the rollout occurred across their department. Each department and IT made funds available to deploy DrDoctor. Integration with the Patient Administration System (PAS), recruitment of clinical and admin staff and training was overseen by the general managers. The process involved:

- Integration with the PAS
- Recruitment of staff to oversee and action reporting
- Recruitment of 142 super users to maintain content and system settings
- Staff training: 224 booking clerks were trained to action patient requests

The level of functionality offered by DrDoctor was directly linked to the ability to integrate the services with the PAS. Initially the sending out of texts capability of the DrDoctor system was fully deployed across the hospital.

Dental services had begun to implement the second-stage capability offering alternative appointments by text. This was due to dental services managing their own clinics and being somewhat independent of other services in the hospital. This introduced some workforce challenges as the manual system of calling patients had to be integrated with the automated alternative appointment offers. This required a two-phase approach of incorporating all automated data into the PAS before any manual calls were made.

Much was learned in the early years about the implementation of the DrDoctor service. For example, early use demonstrated the importance of the accuracy of clinic codes, consultant codes and data generally. For this reason, GSST became proficient at data cleansing and accurate management of coding. With around 750 clinic codes alone, this was a significant aspect of the smooth working of the system. This subsystem was run by the Business Support Manager—Dental Directorate in cooperation with IT.

The PAS was under review during this period and the process of replacing it would have a direct impact upon the DrDoctor deployment. Hence, the full benefits of the DrDoctor service would not be realized until a new PAS was in place and the integration had taken place. This would take several more years pushing out the realization of the full benefits of DrDoctor to 2022 or later.

10.3.4 Discussion

Technology platforms, when introduced into care delivery, can be particularly challenging where they are not stand-alone but are required to interoperate with current systems, be that technological or workforce. This is complicated further where impacted systems are old and may be replaced or where full functionality is dependent upon developing both ends of the interoperability capability. The DrDoctor implementation is a good example of these challenges. The old PAS was only capable of supporting the first stage (texting out) of the DrDoctor capabilities. The requirements for DrDoctor to achieve full functionality provided guidance on the potential PAS system that could replace the incumbent, older system. In the meantime, the dental service was able to increase the DrDoctor functionality to include alternative clinic slots offered by text through developing the workforce to provide some of the interoperability as a manual function tied into the regular clinic management activity.

Two things are critical in being able to go on this journey:

1. That the management and resource commitment of the customer is long-term enough for the solution to evolve in terms of impact on current systems and work practices.
2. That the technology supplier is prepared to develop their offer and provide support for the staged approach which may include work on intermediate interoperability fixes.

In Section 10.5, we develop a "lock and key" model to describe the way a new technological intervention (the "key") has to engage with the current sociotechnical system (the "lock"). In this case, the intervention (DrDoctor) was not able, initially, to deliver all of its capability within the current context of the customer (GSTT in this case). DrDoctor is a "key" that is trying to fit into the "lock" of the GSTT context. To get the full benefit of the new technology, both the "key" and the "lock" need to change through a process of mutual adaptation. In this case, the adaptation of the GSTT context, notably changing the PAS, could not be done quickly and so the early use of DrDoctor was limited to "texting out" for most outpatient departments. Dental services were able to use more of the functionality of DrDoctor because it did not rely on the existing PAS, but in order to accommodate DrDoctor it had to make changes to the roles of the clinic staff and to the processes of clinic management. However, over time the goal remains to have DrDoctor fit exactly the context provided by GSTT such that the optimal functionality can be adopted. The adaptation process is not purely technological, as indicated by the changes to practice in the dental services clinic management. This model of engagement is very different to the idea of buying an "off-the-shelf solution" that works in all contexts and is plug-and-play.

There are two other factors that affected the mutual adaptation between the "key" (intervention) and the "lock" (the sociotechnical context):

1. *Push factors*: These are efforts by the technology supplier to make the key better fit the "lock."
2. *Pull factors*: These are efforts by the customer (GSTT) to adopt and engage with the "key."

In the context of DrDoctor and GSTT, these factors were critical to the level of success achieved:

- *Push factors*: DrDoctor staff took offices close to GSST in the early days of the adoption. The location of DrDoctor staff near to GSST assisted in ensuring that any problems encountered were addressed rapidly with staff available on-site. DrDoctor staff then engaged with the staged approach to interoperability with the current PAS recognizing the need to accommodate a future PAS. They focused on the long-term outcomes sought rather than the delivery of a specified technological implementation.

  DrDoctor also created a bespoke training regime for each of the different operational roles in GSST that would be affected by the implementation. Each person was trained in a series of practical sessions run by the DrDoctor team, where the departments were not only shown how to use the software but how to align their processes with the new system. During the go-live process, "super users," i.e., people in GSST already trained and working in the new way, managed the transition to DrDoctor. Weekly team meetings were held to feedback on progress and early benefits. By 2019, discussions were underway for the DrDoctor applications to develop different reports for different operational roles in order for clinic development management as well as resource management to be greatly improved.
- *Pull factors*: One of the key enablers was the cooperation between DrDoctor and lead champions within GSST in collaborating on the embedding of the technology. This required cooperation with the senior, clinical, operational and IT functions. This required several people to act as advocates for the service, primarily the Chief Medical Officer, the Program Director (Digital Patient Journey) and the Deputy General Manager (Dental Directorate). Without this advocacy within the customer, the approach would have lacked commitment and inevitably withered on the vine.

  The other key pull factor is that the lead champions and other key people in the hospital accepted the need to evolve the solution and engage with a long-term collaboration.

10.4 A DIGITAL SYSTEM TO DELIVER GENERAL PRACTITIONER SERVICES

One way in which the suppliers of digital applications can overcome the challenges of interfacing with the existing sociotechnical systems of current services is to bypass them, i.e., not just provide a technical solution but offer customers a completely new service that is based on new technical opportunities. This is the big "disruption" strategy favored by many in Silicon Valley, for example, Amazon disrupts the high street model of the retail trade by offering online retailing services and Uber offers a completely different taxi service. The two digital innovations described above are to some extent disruptive of existing services but in a major disruption approach, the technology developer creates a complete new service that constitutes radical competition to existing services. If it offers a complete service in which the digital application is an integral part, the technology supplier has an opportunity to design all the connections between the application, the social system and other forms of technology itself. It does not have to deal with the inertia caused by having to change existing systems.

10.4.1 A Disruption Approach to General Practice Services

The long history of trying to establish digital consultations between GPs and their patients was described in the introduction to this chapter. Although some progress has been made, it has proved very difficult to integrate telehealth conversations between doctors and patients into the daily procedures of General Practice clinics that are primarily based on face-to-face consultations. One way of making faster progress is to offer a new approach to General Practice. In this case, it would be a General Practitioner service in which digital consultations are the norm and face-to-face consultations are only resorted to when necessary. The third case study to be discussed has taken this approach.

10.4.2 The Digital Application

Babylon's "GP at Hand" service (2019) replaces the traditional GP service in which patients visit their local GP clinics for face-to-face consultations with a service in which they first book a video consultation with a doctor. A video or audio consultation then takes place within an hour or two of the booking. In most instances, this is sufficient for the patient to be given appropriate medical advice but, if it is necessary, arrangements can be made for the patient to have a face-to-face consultation with a doctor at a later date. The patient can access the "GP at Hand" application via their smartphone and it is available at all hours. It also offers other features such as a symptom checker that in many instances may provide sufficient advice so that even a video consultation is unnecessary.

10.4.3 The Implementation Plan

The "GP at Hand" service was launched in London in 2017. Although different in approach to normal GP practices, it was funded by the National Health Service through the Clinical Commissioning Group in the Borough of Hammersmith, which is the body responsible for funding GP services in that area. The majority of the funding for a GP service is per capita: a fixed sum of money is provided for each patient registered for the service. To use the new service, patients had to deregister from their existing GP practice and register with "GP at Hand."

10.4.4 The Implementation and the Result

An evaluation of the service in 2019 (Ipsos-MORI 2019) reported a very rapid take-up of the service. The service had 49,000 registered patients by April 2019 and was adding new patients at a rate of 500–1000 per month. It had also contracted a large workforce of qualified GPs who were attracted by the flexibility of the job: they could work part-time from home and choose the hours they worked. The evaluation showed that the service was very popular with commuters who traveled to London each day and who found it difficult to attend GP clinics near their homes during the working day. They found that, using "GP at Hand," they could get appointments very quickly and conveniently compared with the GP appointment procedures they had been used to. Although most contacts with the service led to video consultations, many patients used the symptom checker or made an audio-only appointment.

The rapid growth of the service was not, however, without problems. On many occasions the first consultation revealed the need for a face-to-face consultation and "GP at Hand" established five locations across the London area where patients could be seen by a GP. However, patients found getting an appointment was much slower than for the initial consultation and it was often inconvenient to get to the location for the face-to-face appointment. Many patients who had conditions that required face-to-face appointments concluded they were better served by the traditional GP service and 1 in 4 of the patients who had registered since July 2017 had de-registered by April 2019.

But a much bigger problem was the disruptive impact the new service was having on the traditional GP services in the London area. Patients were being recruited by "GP at Hand" from 29 GP services across London and these services found they were losing patients who were mostly young, well, working-age commuters. These were patients that GPs tended not to see very frequently and who made very limited demands on their services. The per capita basis of payment to GPs means that they rely on having a large number of their registered patients of this kind. They make few demands on the service and this compensates for the high demand made by the old, the very young and those with long-term conditions. The loss of many of the "working-age well" patients disrupted the financial base of the service: the workload stayed high but the income decreased. Because of this disruption, there have been calls (Downey 2019a) for "GP at Hand" to be refused a license to offer General Practitioner services. The company has plans to extend its operations to other major English cities such as Birmingham and Manchester and the authorities in these cities are looking carefully at the results in London in assessing whether to approve these developments. In Manchester, for example, there are also concerns that the new service may not be able to offer patients effective links into other health services such as cancer screening. A Manchester health authority spokesman (Downey 2019b) reported:

> We are not convinced that Babylon's GP at Hand model of care is sufficiently integrated with other local and national services to ensure safe and effective care for local people. Areas of concern include screening programs and safeguarding.

10.4.5 Discussion

By going beyond being a technology supplier and offering new customer services based on digital technology, "GP at Hand" has been able to avoid the immediate problems of integrating the technology with the existing sociotechnical systems in

GP practices. It has control over the social system, e.g., the roles the GPs play, other technical systems such as the appointment booking system and the process by which patients are provided with healthcare. All these aspects of the service can be integrated with the video system. However, the new service still has to interface with the larger healthcare system that it is part of and problems are emerging on many fronts as experience of its operation grows. For patients, there are problems when they need face-to-face consultations, for other GP practices there are threats to their business model and for the authorities concerned with the integration of health services for patients, there are concerns about how integration can work with a "GP at Hand" type of service. In systems terms, it seems that delivering a service rather than just new technology can avoid local sociotechnical system integration problems, in an open system such as national healthcare, there will be interfaces with the larger system that will still have to be addressed. It is instructive that there is no evidence that these issues were recognized or addressed in the initial design of the new service: for many of the stakeholders, be they patients or existing GP practices, they only become apparent once there is evidence of the service in operation.

10.5 THE ADOPTION OF DIGITAL APPLICATIONS AS EVOLUTIONARY SOCIOTECHNICAL SYSTEMS CHANGE

All three of the case studies are success stories to the extent that they are on a path toward embedding digital innovations into normal healthcare provision. However, in every case, there have been complex challenges to address to create an effective link between the new technology and the existing healthcare system. In this section, we review the nature of these challenges and explore the design methods by which they may be met.

10.5.1 The Challenges

A first target for technical design is to ensure that the direct user experience is positive and effective. However, when the new digital technology can only be effective if integrated into the existing complex health service system, there are many challenges that go well beyond the design of effective interaction between end users and the new technology. The overall sociotechnical systems challenge is that it may be necessary for the new technology to work with the existing technical systems in the health systems, for changes to be made in the social systems, e.g., changes in the work roles of people in the health services, and adjustments to be made to the processes or pathways by which work gets done. If these adjustments are not made, it is quite likely that, at worse, the new technology will not be adopted or, at best, only the features that are easy to assimilate without making changes in the existing system will be adopted.

The problems of integrating the new technology with the existing sociotechnical system can be avoided if a complete new system is designed as illustrated by the development of "GP at Hand." However, it will still have to deal with the interfaces it requires with existing systems. In a highly regulated large-scale and complex system such as a national health service, that is likely to create many obstacles to the widespread adoption of a radically new system.

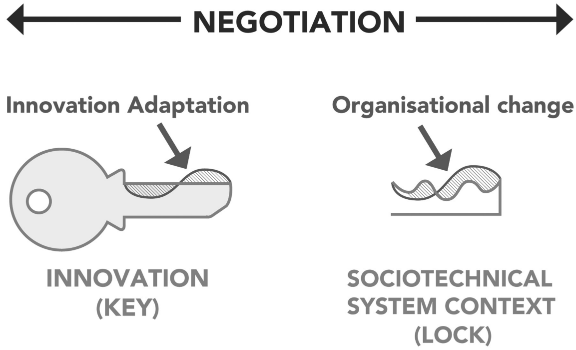

FIGURE 10.2 The lock and the key.

It is likely that most digital health applications will be adopted into existing healthcare settings as in the first two cases described above. As in these cases, successful adoption will depend upon how the interfaces between the new technology and the existing local sociotechnical system are managed. The process can be likened, as in Figure 10.2, to a "key" (the digital application) being fitted into a "lock" (the existing sociotechnical system). Initially the fit is not likely to be very good and modifications may be needed both to the "key" and the "lock" before the "key can be turned," adoption can take place and the benefits for the patient realized.

Achieving a good fit between the "key" and the "lock" involves a number of specific challenges:

- The "key" will have to be sufficiently flexible to be shaped to the needs of each application setting. While the "lock" will also need to change to accommodate the "key," it is not realistic to expect all the necessary accommodation to come from an existing system which is charged with the ongoing need to deliver care to patients. It will need to remain a viable system capable of the continuous delivery of care through any period of change and significant changes in the short term may well be too disruptive to contemplate. There will have to be mutual accommodation of changes to both the "key" and the "lock" or what sociotechnical theorists have called "joint optimization" (Herbst 1974).
- A significant challenge is the creation of a design team capable of achieving a good fit between the "key" and the "lock." It is likely that the technology supplier will provide experts who are very familiar with the technical capabilities of the "key" but they are unlikely to have detailed knowledge of the specifics of the "lock" and most certainly will not have the sense of ownership of the "lock" that the people responsible for the daily delivery of care in the existing system will have. Those who do understand the "lock," the local stakeholders, will in contrast not have detailed knowledge of the "key." Some form of user-centered design that is a partnership between

those who understand the technology and those who understand the existing systems will be necessary. Achieving a successful partnership is made all the more difficult by the fact that many of the significant stakeholders in the existing system are often very busy with their “day job” and have little time to address the challenge of implementing new technology.

- Another challenge is that it is often not initially apparent, even to the stakeholders in the existing systems, what the ramifications for the existing systems of implementing the new technology might be. The impact on direct users of the new technology might be obvious but, because the impact is on a system, there are likely to be indirect impacts elsewhere. In the case of the adoption of Kardia, for example, the impact on the jobs of the pharmacy assistants was clear but not the impact on the workload of neighboring GP practices who would have to deal with referrals. Identifying where there might be direct and indirect impacts is a precursor to undertaking design work on the “key” and the “lock.”
- A further significant challenge is that while the “key” may remain the same from one application to another, the “lock” changes on each occasion. The design challenge will be different because the local sociotechnical system will have different characteristics in each case. Furthermore, the people who own the “lock” (the local stakeholders) will also be different on each occasion and will come fresh to understanding the “key” and what needs to be done to achieve a good fit with their “lock.” There is always a strong desire to solve the problems of implementation in early pilots and then to “roll out” the new technology to lots of other sites, the assumption being that they will all need the same solution. However, as Tapscott (1982) put it in his second law of office automation:

> The ease of a pilot implementation is inversely related to the complexity of its operational extension.

In practice, each new implementation represents a new sociotechnical design challenge.

Given these significant challenges, it is perhaps less surprising that many digital health applications have struggled to become widely adopted.

10.5.2 Meeting the Challenges

Our conclusion from these case studies and many others is that in order to meet these challenges, the process by which a digital application is implemented in a health service setting needs a number of properties.

10.5.2.1 Flexibility in the Digital Application to Meet the Challenge of a Changing Sociotechnical System

We have already referred to the “lock and the key” metaphor for the sociotechnical system context and the intervention. It is important to consider the features of both the "lock" and the "key" in a broader context to better understand how to meet the challenges of technology adoption in specific contexts and across different settings.

The "Lock" (the current sociotechnical system context) is a complex mix of:

- current technology that is being used,
- the workforce deployment into operational work roles and their skills and capabilities,
- current work processes (e.g., "patient pathways" in health services) and healthcare practices,
- pressures for change from other sources, e.g., new regulations, local and national guidance, resources, tendering and procurement.

This means that the "lock" of today is an open system subject to a wide variety of influences and that it will be a different "lock" tomorrow because it is subject to many other pressures to change. It can be argued that the "lock" is never a stable component of any intervention as it is always subject to internal and external organizational factors that are constantly changing. The implication is that the search for accommodation between the "lock" and the "key" has to meet the requirements of the current "lock" and the solution has to be sufficiently flexible to be able to adapt to changes in the future.

The "Key" (the intervention) must therefore adapt to the current sociotechnical systems context and provide useful outcomes that evolve by improving its fit with the "lock." This may include meeting interoperability challenges that exhibit much more complexity than that of the initial requirement to enable the technological exchange of data between systems. The quality, completeness and meaning of the data can be significant factors determining whether different systems are able to utilize data to improve outcomes. Data cleansing is often the term used to indicate the significant work needed to make sure that data is current, accurate and complete. Technological interoperability reflects the ability for systems to communicate with each other. In the GSTT case, the older PAS was able to "write out" files of clinic data but could not import data (without significant modification) other than by manual entry. Hence, the ability to fully integrate with DrDoctor was compromised. This led to a sociotechnical solution that automated outgoing data but required manual entry of incoming data. Technological interoperability can introduce many challenges if it is limited in its ability to exchange data and also in its ability to ensure that, when connections are unavailable, the sociotechnical system recovers elegantly and does not lose data. Finally, we have also seen cases where the connection of the same record-keeping system across separate geographical regions has revealed that identical events or conditions are coded differently. Similarly, the use of free text fields can result in variations in custom and use that makes a joined-up system challenging. These challenges are often referred to as semantic interoperability. The intervention therefore, requires flexibility of approach over time to evolve the fit of the intervention with the sociotechnical context.

10.5.2.2 A Multidisciplinary Design Team

To create a good fit between the “key” and the “lock” will require the expertise and motivation of a joint team of technology suppliers and local people from the existing service. Not only do they bring complementary knowledge and expertise, but they also bring different but essential motivation to the design task. The technology suppliers provide the “push,” the desire to see the application successfully implemented, and the local stakeholders need to supply the “pull”: the energy within the existing service to find an appropriate way of gaining the benefits from the application. If we assume that the technical team is a relatively stable group that stays the same from application to application, then the main question is: “who is involved from within the existing service?” There is a widely held belief that what is needed is a “champion,” someone with some authority who can convince colleagues of the value of the application and mobilize them to get it embedded in the existing system. The evidence from the case studies and from other cases makes clear that to deal with all the potential sociotechnical issues that can arise may need many more than one champion. Many different stakeholder groups may be affected by the development, with some of them acting as gatekeepers on the progress of the intervention. This has led to the idea of “gateholders” (Hoare 2019) rather than stakeholders. Gateholders are people who must be active and positively engaged in the intervention in order for it to succeed. Identifying and managing gateholders is a key aspect of overcoming the systemic issues of complex interventions. In the Kardia case, for example, when it was appreciated that a new pathway was required to process people with suspected AF, the team that designed the new pathway included technologists, pharmacists, cardiologists, GPs and commissioners. In the case of DrDoctor, the team that managed the implementation at GSST included over time the Chief Medical Officer, the Program Director, IT staff, the managers of the Dental Directorate and the managers of other outpatient departments as the implementation reached them. Complex interventions require a clear understanding of the impact of the intervention on a range of stakeholder groups and exploration of what they require in order to engage positively with the change.

10.5.2.3 An Evolutionary Approach

There is a long history in project management of preplanning: of creating a linear program of activities at the outset of a project that is then executed to achieve the desired result. Such an approach will not be effective in the search for a fit between the “key” and the “lock.” This will be an uncertain and exploratory process for most of the people involved: they will not know at the outset what problems, what opportunities and what barriers they might encounter and they will need a design process that is much more evolutionary. It will need to be an iterative process that takes a step forward, reviews progress and then determines the next step forward. It also needs to be a learning process for both the gateholders in the existing sociotechnical system and the technology suppliers. There are well-developed methodologies that take this approach to systems change. Developmental evaluation (Patton 2010), for example, is an approach used in major social systems change programs that work through cycles of implementation, evaluation and review to move toward the implementation of sustainable change. Action research (McNiff and Whitehead 2006) in a similar way involves cycles of action followed by research to gather evidence of the result of the action followed by review and learning followed by a further round of action based on what has been learned. Following a process of this kind, the technology suppliers and the gateholders could explore the space between the digital application and the existing system to seek out the best fit between the "key" and the "lock."

A particular problem for a team that is seeking to adapt the "key" and the "lock" is that many of the problems identified in the adaptation process are not obvious until an attempt is made to change them. In the "GP at Hand" case, for example, it was only after the service had been operating for some time that many of the issues for the wider health service became evident. These discoveries are akin to repeatedly finding weak links in a chain, a process explored in the "theory of constraints" (Goldratt 1999). It is not possible to chart a path in advance from the current status to the solution desired unless these constraints are understood. Project management approaches that assume a linear path to the solution cannot do this and some form of iterative process is necessary to discover these issues and take account of them in solution delivery.

Hoare (2019) describes the process of mutual adaptation of the "key" and the "lock" as a set of activities based on a series of assumptions:

- The process is based on an action research approach that seeks to understand through iteration.
- Rather than taking a reductionist approach to breaking up the problem, the action research process engages with complexity by mapping the context of the intervention through gateholder groups and system levels (understanding the "lock") and evolving the intervention as a negotiation (the "key").
- Gateholder engagement and delivery of systemic outcomes occur through a theory of constraints-type approach to building engagement and lowering barriers to use.
- A developmental approach to evaluation is built into the approach which accepts that the final intervention cannot be fully understood up front.
- Purposeful program theory (Funnell and Rogers 2011) based on a theory of change and a theory of action provides guidance on "what" is being changed and "how" that change is implemented.

It is most likely that, following this process, the impact on the existing system will also be evolutionary. As in the example of DrDoctor, some parts of the existing system may adopt the new digital application before others. The full realization of the capabilities of the intervention may evolve through intermediate stages that deliver partial benefits. This evolutionary approach also has the advantage that it gives the wider stakeholder community time to adjust to the opportunities created by the new technology and to consider the more major sociotechnical changes that may be necessary to get the full benefit of the technological potential.

10.5.2.4 The Tools for the Job

The technology suppliers may come to the development with many tools to help them tailor the application and get it up and running in the existing system. But what tools are available to help them and the internal gateholders play their part in the development of new sociotechnical systems? There are relatively few tools "ready to hand" to help these teams engage in the search for new sociotechnical system design solutions. Many of the approaches referred to above provide methods that can be adopted for these purposes, e.g., action research and the theory of constraints. There are also many techniques that can be borrowed from related domains, for example, from the evaluation literature. Realistic Evaluation (Pawson and Tilley 1997), for example, follows the impact of a change wherever it goes in an existing system. Similarly, there are concepts in the literature on implementation science that are directly relevant, for example, Normalization Process Theory (NPT) (May and Finch 2009) that identifies the process by which an innovation can become embedded in the normal practice of an existing system. What is needed is a program to convert these approaches into practical tools for technology developers and gateholders to use as normal design practice.

There are methods that are specifically for designing sociotechnical systems, although most of these are for circumstances where the starting point is explicitly to create a new sociotechnical system, for example, Mumford (2000). In most of the cases where a new digital health application is being implemented, there is probably no initial expectation that sociotechnical change will be necessary and so techniques that help identify the extent to which there are sociotechnical issues to be addressed may be more helpful. One of the perennial problems is that there are unexpected consequences when a change is made that become barriers to development and there is a need to be able to identify these "weak links in the chain" as early as possible in the development process. In this context, we have developed a Planning for Change Framework (PfCF) (Eason and Maton-Howarth 2020) which helps people in gateholder roles make an early assessment of the impact of a proposed change on the local existing sociotechnical system, i.e., the work roles of existing staff, the other technical tools they use and the processes by which they engage with one another to get work done.

10.5.2.5 Passing on the Learning

How can the learning from one implementation of a digital health application best be conveyed to those responsible for the implementation of that application in a different location? The assumption may be that the design solution adopted in the first location can be applied directly in the second and this is often where wider dissemination can go wrong because the existing system in the new location may be different in important respects. It may be more important to pass on to the gateholders in the second location, learning about the issues that need addressing and the design processes that are necessary to achieve successful adoption, i.e., not the solutions but the process by which a fit between the "key" and the "lock" may be found.

In most circumstances, it is the team of the technology supplier that carry the learning from one implementation to another: they are usually the only common factor in the move from one location to another. However, as technology specialists, they may not be the ideal people to convey information about sociotechnical issues. It may be better if the new gateholders could meet the old gateholders and hear from them directly what they have learned. One way in which this might be done is by creating a user community forum in which the people who use an application can get together and share their learning about how best to get the benefit from it.

10.6 CONCLUSION

Many promising digital healthcare applications fail when they are used within the context of existing health services. The three cases described demonstrate why achieving success in this context can be difficult and what needs to be done to make progress. When the adoption of digital health applications involves engagement with an existing health service, the issues that need to be addressed go well beyond the technical. The cases show that to adopt the health application in a way that achieves its potential benefit, there may be many sociotechnical issues to address that involve changing both the existing sociotechnical system that delivers the health service and the new health technology application. The metaphor of a "lock" and a "key" conveys the sense of interdependence between the two: unless the health application can be embedded in the normal practice of the service delivering system, it is unlikely to achieve its promised benefits. The three cases described reveal the issues involved in seeking a fit between the existing system and the new opportunity in different ways. In the case of the use of Kardia, the "lock" had to be redesigned to cope with a new source of referrals for cardiological diagnosis. In the case of DrDoctor, only a limited part of its functionality could be used initially because of the changes that were necessary to existing systems to provide full interoperability. In the case of GP at Hand, the design of a totally new service avoided any requirement to integrate new technology with existing sociotechnical systems but experience of use has revealed many more strategic issues when the new service impacted upon the existing national health services with which it has to integrate.

In order to achieve a good fit between the new technology and the receiving sociotechnical system, there is a need, first, for flexibility in the technology and in the existing sociotechnical system so that an accommodation can be found. Second, to identify an appropriate accommodation, a design team has to be assembled that includes technical experts and gateholders who can work on sociotechnical issues on behalf of all of the stakeholders who are interested parties in the development. Third, the process by which the design team work toward solutions will need to involve exploration and learning and we need evolutionary models of change to enable these developments. Fourth, we need tools that are specifically designed for this purpose. There are few readily to hand but there are approaches in the wider literature of organizational change, evaluation and implementation that can be utilized for this purpose and can help to realize the potential of these applications. The challenge for future implementations of digital applications in healthcare services is to offer the multidisciplinary teams who find themselves, often to their surprise, engaged in the iterative development of new sociotechnical solutions a practical toolset to support their work.

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