# Strategies, Approaches and Experiences:
## Towards building a South African Digital Health Innovation Ecosystem

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***Strategies, Approaches and Experiences: Towards building a South African Digital Health Innovation Ecosystem***

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# Strategies, Approaches and Experiences: Towards building a South African Digital Health Innovation Ecosystem

*Prof Marlien Herselman & Prof Adèle Botha*

*November 2016*

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| | |
|---|---|
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# Foreword

The **digitalisation** of Healthcare Information Systems in South Africa could have an impact beyond mere access to and delivery of health services. The health landscape of South Africa offers unique challenges and for digital health to work, it has to address several major challenges pertaining to infrastructure and interoperability of all health systems. South African **investments in digital health, when conceived and managed as socially, technologically and economically sustainable innovation,** can have **implications beyond economic policy**, and may require new approaches in public management. Therefore, the **planning and building of a national infrastructure for digital health** should take stock of international experiences of building integrated systems. **Yet, substantial effort is required to plan and build a distinctly South African digital health culture that accommodates the country's diverse needs appropriately.** Success will require innovative solutions that are **sensitive to local economic, social, cultural and organisational factors**, and that are adapted to augment the broader **South African capabilities** in digital health. The **adoption and acceptance of digital health infrastructure and solutions by healthcare professionals, organisations and patients is challenging and critical for success.** A clear evaluation framework to monitor unsuccessful and successful adoption and acceptance of digital health solutions, as well as to trigger adaptive and corrective measures, must be designed from early on.

The **Digital Health Innovation Ecosystem (DHIE)** involves three interactive, complementary modules: **context,** the **innovation lifecycle** and the **users/stakeholders**. The context builds on the typology of Social, Technological, Economic, Environmental, Political and Value-based issues (STEEPV). **Stakeholders** should include, for example, patients, user communities, technology providers, payers, regulators and policymakers. **Technology** should cover **systemic views on elements** of interoperability, standards and integration of infrastructure. It should include privacy elements and big data, as well as focus on analytics and storage, and control of access. In a digital ecosystem, **users must sense or experience trust**. They must feel that they can control and increase their own access to a system. Their uptake and use are essential for such an ecosystem to work or to be regarded as a sustainable solution. For sustainability to work, the **value of a system has to be shared across groups** where there are partnerships, capacity building, good leadership and governance. **Reaching, engagement and empowerment** of low-income populations in urban and rural areas to deliver novel digital health services require **highly targeted measures**, which will require careful consideration of relatively **idiosyncratic conditions**.

The **build-up of digital health in South Africa** is not only about improving the availability, access and delivery of healthcare services, but essentially about **enhancing a**

**country's strategic capabilities to create, adapt and implement novel digital health solutions** within and by the **public and private** sectors. Platforms, technologies and solutions implemented must also be flexible enough to adjust to **future needs**. **Foresight methodologies** may propose a useful approach to construct a shared understanding of emerging possibilities. Including often-facilitated social processes, foresight methodologies propose a reforming platform for a **self-directed innovation ecosystem to emerge**. Innovation is considered to occur in an organic manner based on the **common interests of various stakeholders** and, consequently, it allows novel outcomes. In a local form these creative platforms can support the rise of an innovation-favourable culture, and help lower the barriers of local entrepreneurship.

# Preface

The purpose of the book is to provide an overview of how a Digital Health Innovation Ecosystem (DHIE) was developed based on different strategies, approaches and experiences over a period of time, and based on collaborations between the Council for Scientific and Industrial Research (CSIR) and VTT, known as the Technical Research Centre of Finland.

The book provides a realistic overview of the current South African health situation in which ICT systems are involved and related issues have to be addressed if digital health systems are to be implemented to strengthen the health system in South Africa. Digitalisation of healthcare processes is one of the key requirements in global health, and as such constitutes an obvious central issue for every government concerned with the health and well-being of its citizens. National strategies, initiatives, funding, projects, as well as consultant briefs and academic literature on the topic are increasing rapidly. Practically no serious health policymaker or professional would have missed the call to digital health action due to "social and demographic changes, the rise of chronic diseases, and the need to improve efficiency and quality of healthcare delivery" (OECD 2013).

The Finnish Ministry for Foreign Affairs played a key role in making this collaboration a reality through its financial support. The collaboration focused on two key issues: Firstly, it broadened the Finnish and South African capabilities for strategic planning of digital health innovation ecosystems, and secondly, it undertook practical and targeted work to analyse, conceptualise and build a South African Digital Health Innovation Ecosystem (DHIE), in which foresight and road mapping were applied. The dialogue between South African and Finnish research experts in innovation and community work has been important for our ability to learn how technologies can be deployed to address society-wide challenges. It is also a testimony to the importance of two-way learning between Finland and South Africa.

The context and challenges experienced in health in South Africa are outlined in **Section A,** coupled with an analysis of what elements constitute the DHIE in general. **Section B** presents the methodology that was applied, as well as the underlying philosophy and methods that contributed to the development of this high-level ecosystem. The different phases of conceptualising and developing the DHIE for South Africa, together with a graphical representation that illustrates how the concepts relate to and support one another, are also provided in the final DHIE. **Section C** presents the next steps in implementing a Mobile Health and Wellness Innovation Ecosystem in South Africa with the lessons learnt, reflections and discussions.

All the chapters were reviewed by peers and the feedback from these reviewers has been incorporated.

# Section B: Methodology applied to develop the DHIE

# Chapter 3: Applied Methodology

*Marlien Herselman & Adèle Botha*

## 3.1 Introduction

This section will address the methodology that was applied to develop the South African DHIE. Each chapter under Section B represents a specific phase in the methodology.

## 3.2 Design Science Research

The methodology applied in the exploration and design of the DHIE – known as Design Science Research (DSR) – focuses on the creation of new knowledge and the purpose of design science is "to change existing situations into preferred ones" (Simon, 1996). Design Research is research into or about design, whereas DSR mainly involves research that uses design as a research method or technique (Vaishnavi & Kuechler, 2015). DSR is a research procedure for producing innovative constructions intended to solve problems faced in the real world and, by that means, to make a contribution to the theory of the discipline in which it is applied (Lukka, 2003). Design science addresses *wicked problems* in information systems (IS) (Rittel & Webber, 1984) and is fundamentally a problem-solving paradigm. Wicked problems, as explained by Hevner and Chatterjee (2010, p. 11), relate to the ill-defined environmental contexts as well as the creativity and teamwork to produce effective solutions. DSR also addresses *messy* problems. These are characterised by "a large degree of uncertainty as to how the problem should be approached and how to establish and evaluate the set of alternative solutions" (Pries-Heje & Baskerville, 2008, p731). This description is applicable to the development of the DHIE for South Africa especially, since there are many ways to develop such an ecosystem and it should be evaluated in different contexts for different purposes.

The research methodology is grounded in the philosophy of pragmatism. Pragmatism assumes that knowledge is provisional, socially created and situated in history (Kelder, Marshall, & Perrey, 2005). Hence, theory is only deemed to be true after it has been proved to be useful – and then only in the context and the period within which it is established to be useful (Kelder et al., 2005; Levy & Hirschheim, 2012). However, the current study also applied interpretivism to understand the feedback obtained from specific case studies (Figure 3-4, 5). To a design science researcher, reality is socio-technologically enabled and knowledge is gained through the process of artefact creation (Vaishnavi & Kuechler, 2015). Hevner and Chatterjee (2010) indicate that an artefact is a man-made object created to solve a specific problem, as opposed to naturally occurring objects. The artefacts created in DSR could

involve one of the following elements (Hevner & Chatterjee, 2010; Hevner, March, Park, & Ram, 2004; Vaishnavi & Kuechler, 2013):

- *Constructs:* A construct is the term that is used to describe a problem or solution. Constructs establish the specialised language and shared knowledge of a discipline that arises during the conceptualisation of a problem and they are refined throughout the DSR cycle.
- *Models:* A model is a set of propositions or statements that describe the relationships between constructs. It could also refer to an abstraction and representation of a problem or solution and may include frameworks and guidelines. The focus of models in DSR is on their usefulness or utility.
- *Methods:* A method is a set of steps that guide the performance of tasks. Methods also represent the plan of action aimed at achieving a goal. In DSR, a method that is aimed at solving a previously known problem in a more effective way is deemed valuable.
- *Instantiation:* This is the actualisation of a construct, model or method. Instantiations demonstrate the feasibility and effectiveness of the constructs, models or methods in an environment. The digital health framework is an example of this.
- *Better theories:* The DSR can contribute to the formulation of better theories or the development of new ones. The development or evaluation of an artefact may result in a better understanding of the relationship between its elements and could potentially lead to the development of a new design theory for that artefact.

Based on these definitions, the artefact known as the DHIE, which was conceptualised in a developing context in this book, is an instantiation because it demonstrates the feasibility and effectiveness of the constructs, models or methods in an environment (Vaishnavi & Kuechler, 2015). This was actualised by demonstrating its effectiveness in a developing context (South Africa) through the mHealth and Wellness innovation ecosystem in Cape Town (Section C).

### 3.3 An Information Systems Design Science Research framework

Hevner et al. (2004) were the first authors to provide an information systems framework to show where DSR fits in. The design science research framework was proposed for the building and evaluation of IT artefacts. The framework aims to create practical knowledge for the design and implementation of solutions in a socio-technical system where Information Systems artefacts are critical means for achieving the desired outcomes of an intervention. It was therefore referred to as the Information Systems Research Framework and was later improved by Pirinen (2009), as well as by Wang and Wang (2010). Figure 3-1, adapted from Hevner et al. (2004) and Piirainen & Gonzalez (2013), indicates the relevance and rigour of DSR in information systems. It is also used as the theoretical framework that informs the conceptualisation of the digital health innovation ecosystem.

Figure 3-2 borrows the IS research framework found in Hevner et al. (2004) and overlays a focus on three inherent research cycles – relevance, rigour and design – with creativity. It also explains how each of these cycles contributes to the knowledge base of foundations and

methodologies. People, organisation and technology are three components of the environment of design research. Business needs are the driving force behind design research that causes it to remain relevant. Design research must add to the knowledge base so that it can be rigorous. The specific IS DSR cycles that have been applied are illustrated below:

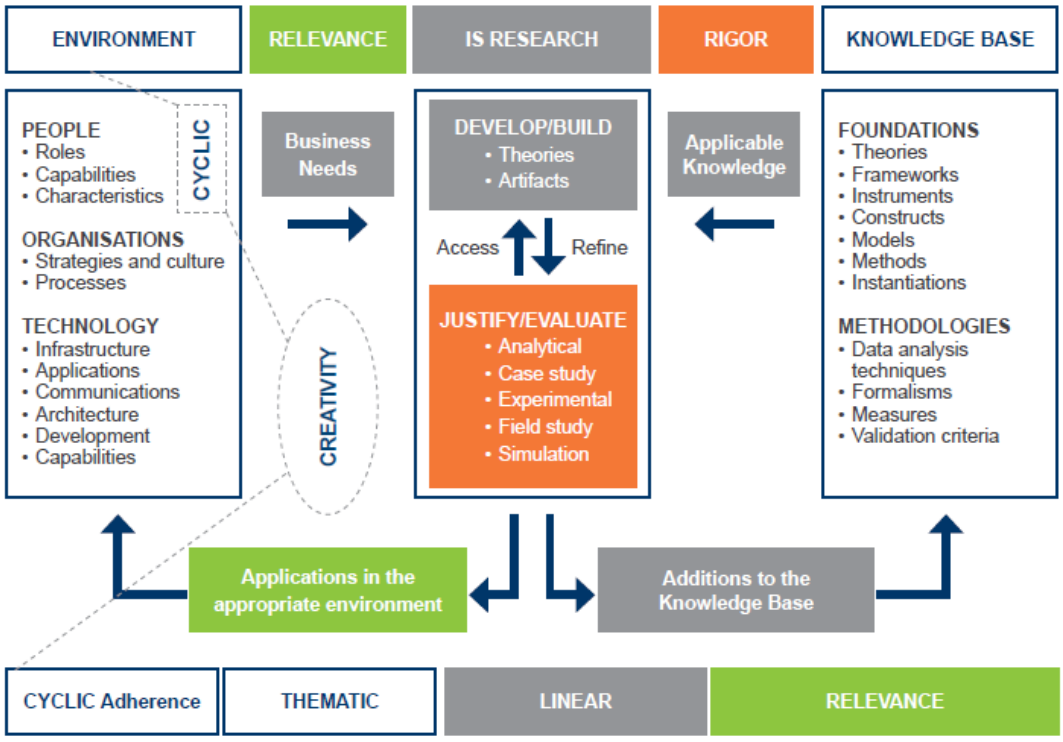


**Figure 3-1: Information Systems Framework (Hevner et al. 2004; Piirainen & Gonzalez, 2013)**

In the next paragraphs, each of these cycles is described and the way in which they informed the development of the DHIE is subsequently discussed.

### *3.3.1 Relevance Cycle*

The Relevance cycle initiates DSR with an application context that not only outlines the requirements for the research (e.g. the opportunity/problem to be addressed) as inputs, but also defines acceptance criteria for the ultimate evaluation of the research results. The output from the DSR must be returned into the environment for study and evaluation in the application domain (Hevner, 2007).

The DHIE can inform other developing countries in respect of similar initiatives where appropriate. The ecosystem would be developed for the resource-constrained context as contextualised by individual literature studies based on relevant case studies and position papers. Identified requirements were peer reviewed by experts (or published in peer-

reviewed publications) for validation and to ensure that the artefact design had a solid foundation. The individual component requirements provided the input for the design cycle and were used to collect data and evaluate the artefact.

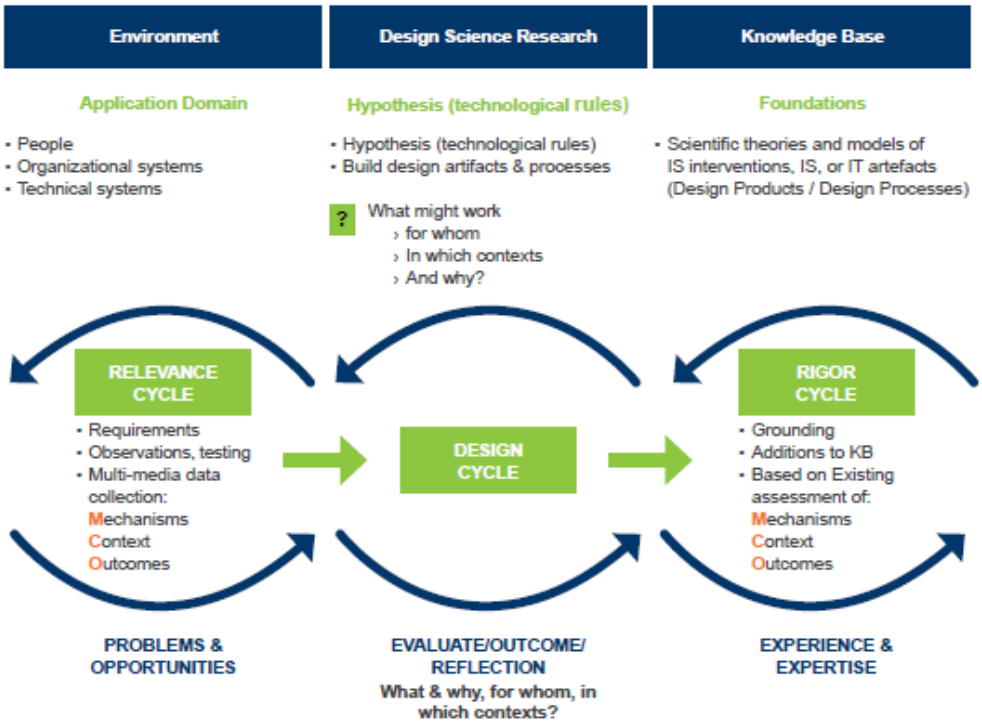


**Figure 3-2: Information Systems Design Science Research Cycles (adapted from Carlsson, 2010 & Hevner, 2007)**

### *3.3.2 Rigour Cycle*

The Rigour cycle provides existing knowledge to the ecosystem to ensure its innovation. It is contingent on the researchers to thoroughly research and reference the knowledge base to guarantee that the designs produced are research contributions and not routine designs based on the application of well-known processes (Hevner, 2007). Additions to the knowledge base resulting from the DSR will include any extensions made during the research, the new artefact (ecosystem) and all experiences gained from performing the research and field testing the artefact in the application environment (Hevner et al., 2004; Hevner, 2007). This is where the mHealth and Wellness innovation ecosystem in Section C is an example of the application of the DHIE.

Regarding the knowledge base, this study applied relevant existing digital health ecosystems and frameworks from Scandinavian countries to inform the development of a South African ecosystem. It also applied various techniques such as concept mapping to indicate how the ecosystem was developed based on a systematic literature review (see Chapter 2, Section A).

### *3.3.3 Design Cycle*

The internal Design cycle of research activities iterates more rapidly than the Relevance and Rigor cycles between the development of technological rules, the construction of an artefact, its evaluation and subsequent feedback to further refine the design (Carlsson, 2006; Hevner, 2007). Simon (1996) describes the nature of this cycle as generating design alternatives and evaluating the alternatives against requirements until a satisfactory design is achieved. In this study, the Design cycle involves the development and evaluation of the ecosystem in various workshops (see Chapter 7, Section B).

Based on recent literature that highlights the dynamic and increasingly complex nature of IS research and necessitates an agile approach to the design process, Drechsler and Hevner (2016) added a fourth cycle to the initial three-cycle view of the Design Science Research process. The additional cycle, categorised as the change and impact cycle (CI) is diagrammed in Figure 3-3.

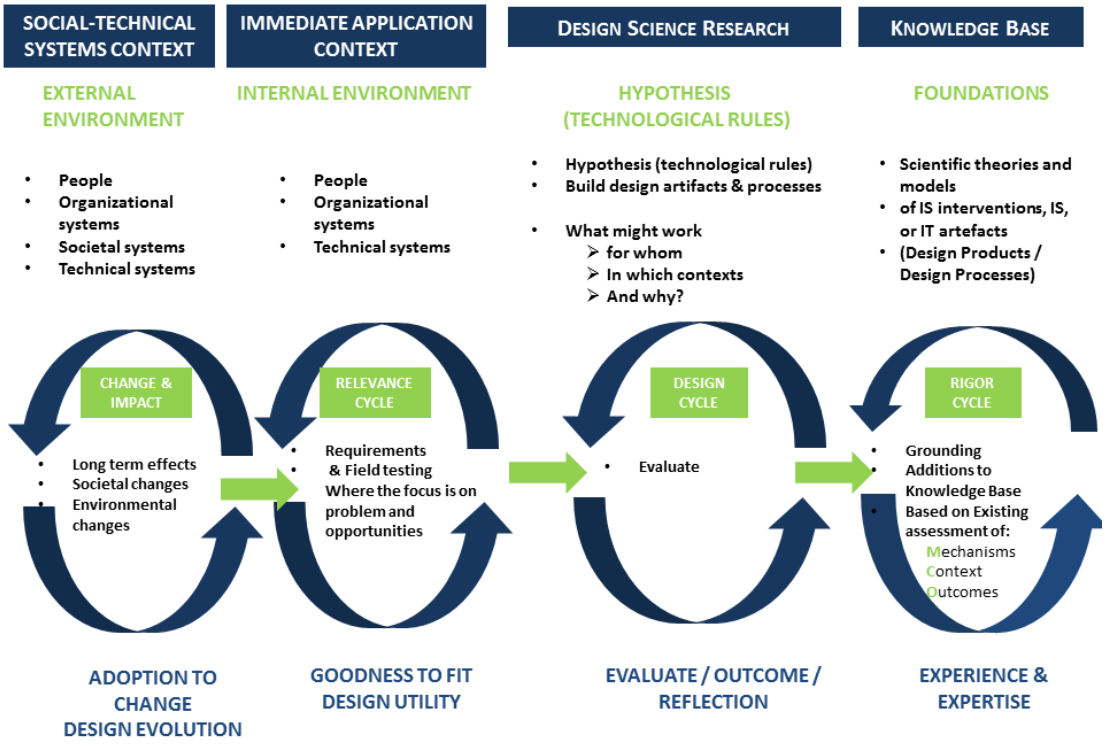


**Figure 3-3: A Four-Cycle view of Design Science Research (adapted from Drechsler & Hevner, 2016)**

The addition of a fourth cycle (referred to as the Change and Impact (CI) cycle) by Drechsler and Hevner (2016) was necessary when researchers considered the secondary or longer-term impact of the artefact in and on societal environments. During the Change and Impact cycle, Drechsler and Hevner (2016) propose to distinguish between an artefact's

immediate application context where users find themselves within their environment, and the encompassing socio-technical system within which the immediate application context is a subsystem. This cycle therefore indicates the long-term effects, as well as the unintended side-effects that a traditional artefact utility evaluation may not be designed to capture. The fourth cycle is directly relevant to the work in hand, as this is where the influence of people and systems in a specific context indicates what needs to be done to adapt or improve the artefact to have greater impact. The mHealth and Wellness innovation ecosystem which was implemented in Cape Town, South Africa, at the end of 2016, revealed what impact the DHIE has had in society and how it can support and influence the National System of Innovation in this country. It also showed its impact on the users involved during this intervention. Impact will be discussed in more detail in Section C.

### *3.4* Design Science Research Guidelines

The seven guidelines (see Table 3-1) that can be used to perform DSR in an information systems discipline as described by Hevner et al. (2004) include design as an artefact; problem relevance; design evaluation; research contributions; research rigour; design as a search process; and communication of research (Wang & Wang, 2010). These seven guidelines are widely cited in Design Science Research and thus relevant to this study. Although they serve as underlying steps in carrying out Design Science Research, their use is not mandatory but depends on the researcher who decides when and how to use each.

**Table 3-1: Design Science Research Guidelines (Hevner et al., 2004)**

| | | |
|---|---|---|
| Guideline 1: Design as an Artefact | Design Science Research must produce a viable artefact in the form of a construct, a model, a method or an instantiation. | A research-related artefact (ecosystem) was conceptualised based on knowledge gained from the application of technologies and resources in digital health in other countries and from literature. |
| Guideline 2: Problem Relevance | The objective of Design Science Research is to develop technology-based solutions to important and relevant business problems. | Based on the ICT Roadmap it was desirable to develop a conceptualisation of a DHIE to inform the implementation of digital health systems in South Africa. |
| Guideline 3: Design Evaluation | The utility, quality and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods. | The artefact was evaluated by experts in the digital health domain at various workshops. |
| Guideline 4: Research Contribution | Effective Design Science Research must provide clear and verifiable contributions in respect of design artefacts, design foundations, and/or design methodologies. | The relevant ecosystem is a novel contribution to assist health system implementers to consider specific components relevant to digital health. The ecosystem may also make some theoretical, methodological and practical contributions to eHealth in South Africa. |

| | | |
|---|---|---|
| Guideline 5: Research Rigour | Design Science Research relies on the application of rigorous methods in both the construction and evaluation of the design artefact. | Rigour will be achieved by involving researchers or practitioners from industry and academia to evaluate the relevance of the DHIE. Additions to the knowledge base have assisted in the development of the ecosystem (see Chapter 7, Section B). |
| Guideline 6: Design as a Search Process | The search for an effective artefact requires utilising available means to reach desired ends, while complying with legislation in the problem environment. | The authors scanned digital health literature to know what already existed in South Africa and used the already existing digital health literature and architectures from Finland and Estonia to develop the DHIE for South Africa. The design science process was followed to develop the ecosystem, which was then evaluated through workshops and expert reviews. |
| Guideline 7: Communication of Research | Design Science Research must be presented effectively, both to technology-oriented and management-oriented audiences. | Various presentations were made at various forums, conferences and workshops to communicate the ecosystem and get inputs from experts in the field of digital health – both in South Africa and in Finland. |

## *3.5* Design Science Research Process

Many excellent models of the research process of DSR exist (Jarvinen, 2004; Lukka, 2003; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008; March & Smith, 1995; Vaishnavi & Kuechler, 2007; Hevner, 2007) and are reported in high-impact journals. The Design Science Research Process (DSRP) applied in this research is consistent with prior literature (Hevner et al., 2004; Hevner, 2007; March & Storey, 2008) and includes six steps: problem identification; motivation; objectives for a solution; design and development; evaluation and communication. The iterative nature of the DSRP (as introduced by Peffers et al. (2008) and adapted for this study) is illustrated by the arrows between the various steps as shown in Figure 3-4. The Design Science Research Process (DSRP) as proposed by Peffers et al. (2008) will be used as basis for the current research. This process model provides a structured approach, from problem identification and statement of objectives, through an iterative process of solution development; testing and communication (see Figure 3-4).

The next section explains the six Design Science Research Processes as they were applied in this study.

### *3.5.1 Problem Identification and Motivation*

A critical review was made of related literature to identify the problem and determine the motivation for the research, identify the exact problem, and justify the value of the solution.

The act of justifying the value of a solution helps to deal with two aspects of research: it motivates the researcher and all others concerned to pursue solutions and accept the outcomes of the research, and it offers a better understanding of the reasoning behind the researcher's understanding of the problem (Peffers et al., 2008).

### *3.5.2 Objectives of a Solution*

With the specific problem identified and research well motivated, the objectives of a solution can then be deduced from the problem definition. The current study aims to develop an artefact that is expected to support solutions to problems that have not been addressed up till now (Peffers et al., 2008).

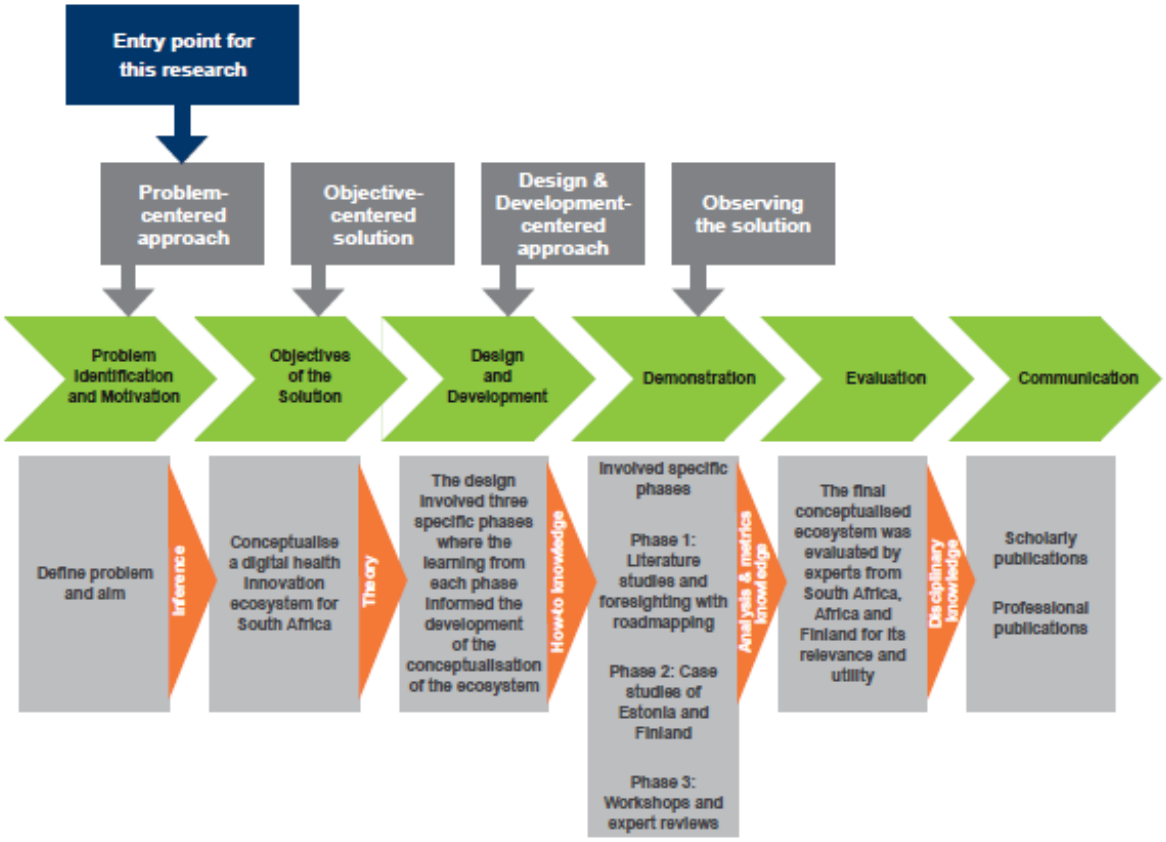


**Figure 3-4: Design Science Research Process (adapted from Peffers et al., 2008)**

### *3.5.3 Design and Development*

During this stage of the research a solution is designed, such as by developing hypotheses (technological rules) and artefacts (constructs, models, methods or instantiations) (Hevner et al., 2004). The design and development stage also involves presenting the requirements of the solution, determining the artefact's expected functionality and architecture, and developing the actual artefact and processes (Peffers et al. 2008).

### *3.5.4 Demonstration*

This stage of the research involves a demonstration of the efficacy of the technological rules and artefacts for solving the problem. It demonstrates their use in analysis, experimentation, simulation, testing, study or other relevant activities to be examined by experts.

### *3.5.5 Evaluation*

The evaluation stage involves the rigorous demonstration of the utility, quality and efficacy of a design artefact by using well-executed evaluation methods (Hevner et al., 2004). The designed solution was evaluated by experts from the eHealth, technology and SME development domains using methodologies in the knowledge base (Table 3-2). The process of evaluation by experts is known as the expert review method, since their recommendations will affect the evaluation results (Johannesson & Perjons, 2012). Using their experience and knowledge, experts review heuristically the artefact by comparing the objectives of the solution with actual observed results from the use of the artefact in the demonstration. Finally, the evaluation stage ends with the researchers iterating back to the design and development stage to incorporate expert recommendations in the final artefact.

**Table 3-2: Design Evaluation Methods (adapted from Hevner et al., 2004)**

| | | **Expert Utility Review:** Heuristic evaluation of the artefact's utility by leveraging the evaluators' experience and knowledge |
|---|---|---|
| 1. Observational | Field Study: Study artefact in depth in business environment | × |
| | Field Study: Monitor use of artefact in multiple projects | × |
| 2. Analytical | Static Analysis: Examine structure of artefact for static qualities (e.g. complexity) | ✓ |
| | Architecture Analysis: Study fit of artefact into technical IS architecture | ✓ |
| | Optimisation: Demonstrate inherent optimal properties of artefact or provide optimality bounds on artefact behaviour | ✓ |
| | Dynamic Analysis: Study artefact in use for dynamic qualities (e.g. performance) | ✓ |
| 3. Experimental | Controlled Experiment: Study artefact in controlled environment for qualities (e.g. in Cape Town, Chapter 8) | ✓ |
| | Simulation: Execute artefact with artificial data | ✓ |
| 4. Testing | Functional (Black Box) Testing: Execute artefact interfaces to discover failures and identify defects | ✓ |

| | | |
|---|---|---|
| | **Expert Utility Review:** Heuristic evaluation of the artefact's utility by leveraging the evaluators' experience and knowledge | |
| | Structural (White Box) Testing: Perform coverage testing of some metric (e.g. execution paths) in the artefact implementation | ✓ |
| 5. Descriptive | Informed Argument: Use information from the knowledge base (e.g. relevant research) to build a convincing argument for the artefact's utility | ✓ |
| | Scenarios: Construct detailed scenarios around the artefact to demonstrate its utility | ✓ |

Evaluation is an integral part of the Design Science Research Process model (Peffers et al., 2008). It should "observe and measure how well an artefact supports a solution to the problem and involves comparing the solution to actual observed results from use of the artefact in the demonstration" (Peffers et al., 2008, p.13) However, it has been argued that little guidance exists in the literature with respect to the evaluation of artefacts (Herselman & Botha, 2015; Prat et al., 2014; Shresta et al., 2014), and that methods and objectives of evaluation are fragmented and unclear (Prat, 2014).

Authors such as Prat et al. (2014) and Venable et al. (2016) have proposed evaluation design frameworks (see Table 3-3) to address this gap in the Design Science Research literature.

**Table 3-3: Frameworks for evaluation**

| Author | Approach to evaluation | Proposed method |
|---|---|---|
| Prat et al. (2014): "Artefact evaluation in information systems design research: a holistic view" | The artefact is considered to be a system that needs to be evaluated against the specific dimensions of a system (goal, environment, structure, activity, and evolution). | Use four different characteristics against which to define an evaluation method:<br>• Form of evaluation (quantitative, qualitative)<br>• Secondary participant (e.g. students, practitioners, researchers)<br>• Level of evaluation (abstract artefact, instantiation)<br>• Relativeness of evaluation (comparable artefacts or absence of artefact) |
| Venable et al. (2016): "FEDS: a Framework for Evaluation in Design Science Research" | FEDS includes a two-dimensional characterisation of DSR evaluation episodes (particular evaluations), with one dimension being the functional purpose of the evaluation (formative or summative) and the other dimension being the paradigm | Follow an evaluation design process comprised of the following four steps:<br>• Explicate the goals of the evaluation<br>• Choose the evaluation strategy/ies<br>• Determine the properties to |

| Author | Approach to evaluation | Proposed method |
|---|---|---|
| Prat et al. (2014): "Artefact evaluation in information systems design research: a holistic view" | The artefact is considered to be a system that needs to be evaluated against the specific dimensions of a system (goal, environment, structure, activity, and evolution). | Use four different characteristics against which to define an evaluation method:<br>• Form of evaluation (quantitative, qualitative)<br>• Secondary participant (e.g. students, practitioners, researchers)<br>• Level of evaluation (abstract artefact, instantiation)<br>• Relativeness of evaluation (comparable artefacts or absence of artefact) |
| | of the evaluation (artificial or naturalistic). | evaluate<br>• Design the individual evaluation episode(s) |

In general, a method of evaluation needs to suit the nature of the item that is being evaluated. Furthermore, it needs to "provide feedback for further development, and … [assure] the rigour of the research" (Venable et al., 2016, p.1). The *why*, as well as the *how*, *what* and *when* to evaluate become central to the evaluation method (Lagsten, 2011; Prat et al., 2014; Venable et al., 2016), as is evident from the frameworks outlined above.

For the purpose of this research, both of the frameworks in Table 3-3 were applied to describe the nature of the artefact's evaluation: first, FEDS was used to develop a strategy for evaluation of the artefact, and then the systems approach of Prat et al. (2014) was used to identify the properties to evaluate, as well as the appropriate method of evaluation.

### *3.5.6 Communication*

The communication stage of the research presents to researchers and other relevant bodies the research problem and its importance, the utility and novelty of the study, the rigour of the research design, and its effectiveness (Peffers et al., 2008). The research findings are published through peer-reviewed conference papers and journal articles, and rapid feedback helps to ensure the credibility of both results and research methodology.

Figure 3-5 depicts the phases of implementation as iterations where all the above were included during three phases:

The DHIE was developed in three phases as depicted in Figure 3-5:

- *Phase 1* involved the literature review on digital health as well as a foresight exercise to identify relevant future health and wellness innovations and roadmapping towards future horizons.

- *Phase 2* covered the case studies in which the health systems of Finland and Estonia were examined and experts working on these were interviewed to obtain relevant feedback on architectures and challenges.
- *Phase 3* involved workshops and expert consultations to validate and review the conceptualised DHIE prior to its becoming the final ecosystem.

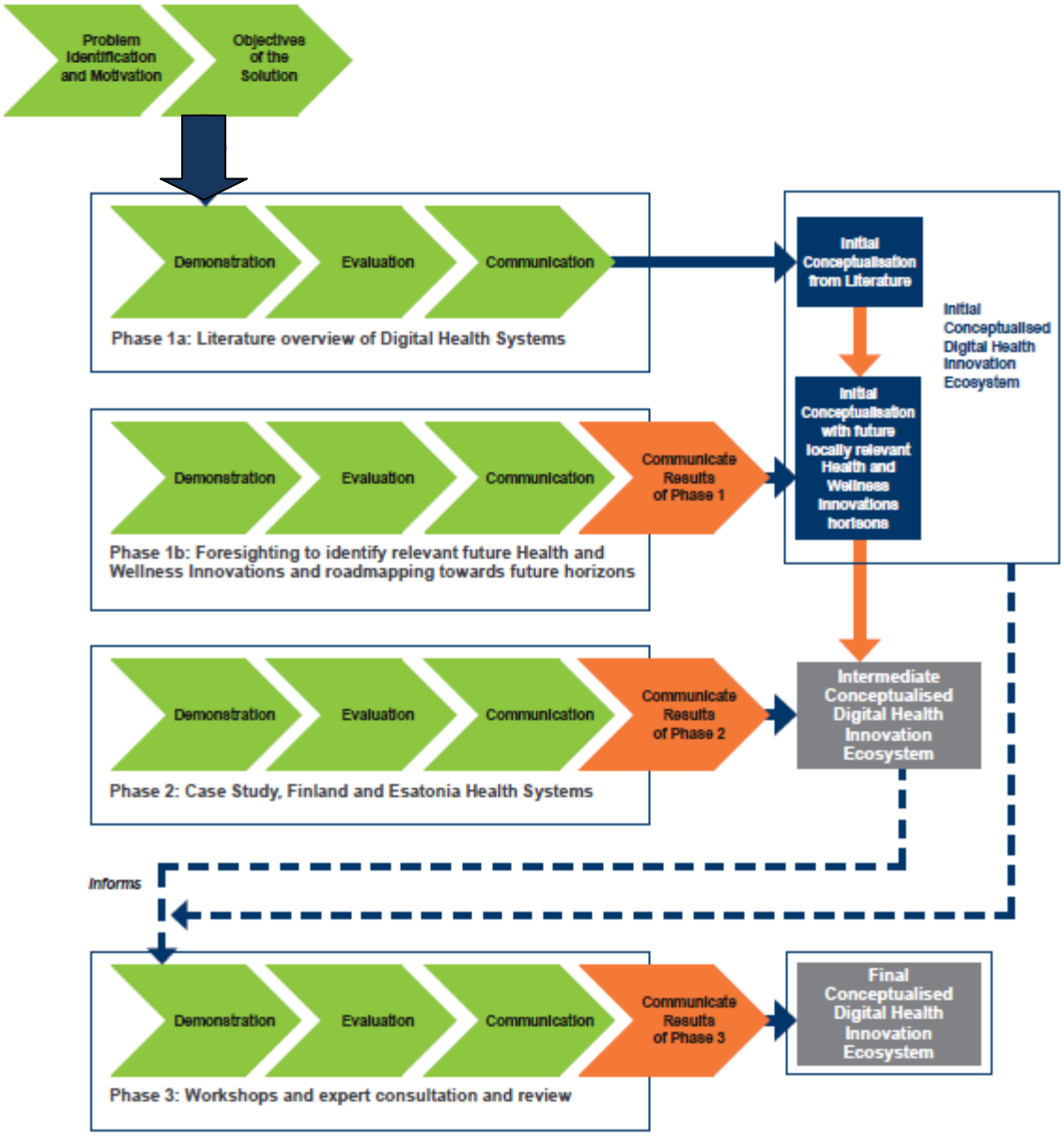


**Figure 3-5: The Design Science Research Process with multiple case studies and the deliverables from each iteration**

At the end of each subsequent phase, the DHIE was at a different level of conceptualisation. At the end of Phase 1 it was an initial ecosystem, at the end of Phase 2 it

was an intermediate ecosystem and after Phase 3 it was the final, conceptualised DHIE as can be seen from the final explanation of what this ecosystem looks like (see Figure 3-5).

## 3.6 The contributions of this work to the knowledge base

This work has made contributions on a theoretical, methodological and practical level, as will be explained next.

### *3.6.1 Theoretical contribution*

The literature and existing digital health systems from two Scandinavian countries allowed for insight and foresight to play a significant role in developing the DHIE for South Africa and to inform health strategies and the development of future health systems for the country. The design theory recalibrated the DSR approach to better accommodate the needs of the digital health environment of South Africa. The resulting artefacts can guide the implementation of similar initiatives in similar contexts.

### *3.6.2 Contribution to research methods*

The challenging environment in which digital health systems have to be implemented in South Africa provides for specific challenges relating to environmental, community and physical challenges. By using an in-depth comparative case study within the design science iterations, this project applied multiple data-gathering methods as well as multiple data sources. Data-gathering methods included expert and participant interviews, focus groups and observations. Following an iterative data-gathering process over a period of two years enabled an in-depth understanding of the social reality of the participants.

### *3.6.3 Practical contributions*

On a practical level, this initiative provided the following:

- A final DHIE that specifically suits the requirements of the health system in South Africa
- The mHealth and Wellness Innovation ecosystem, which is a practical implementation of one aspect of the DHIE in South Africa and which illustrates its utility, relevance and application potential

## 3.7 Conclusion

Design Science Research was indicated as the specific methodology that was applied to develop the DHIE. This methodology was further explained by indicating the guidelines, processes, relevance and rigour associated with it in order to build the artefact known as the DHIE.

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# Chapter 4: Phase 1a: Literature overview of health in South Africa

*Adèle Botha, Marlien Herselman, Ronell Alberts, Thomas Fogwill, Matthew Chetty & Paul Geldenhuys*

## 4.1 Introduction

This chapter provides a detailed explanation of each of the phases that were applied during the development of the DHIE (see Figure 4-1).

## 4.2 Phase 1a: Literature study of health systems in South Africa

To conceptualise the DHIE for South Africa, it was important to understand the literature on the existing local health situation, as well as to investigate some ways to address the challenges that it faces. Most of the literature was already covered in Chapter 1 (Section A) of this book. It forms part of Phase 1 of the Design Science Research Methodology (DSRM) process, but also involves some aspects of Phase 3, as will be seen later in this section. Figure 4-1 illustrates Phases 1a and 1b of the conceptualisation of the Digital Health Innovation Ecosystem (DHIE) for South Africa.

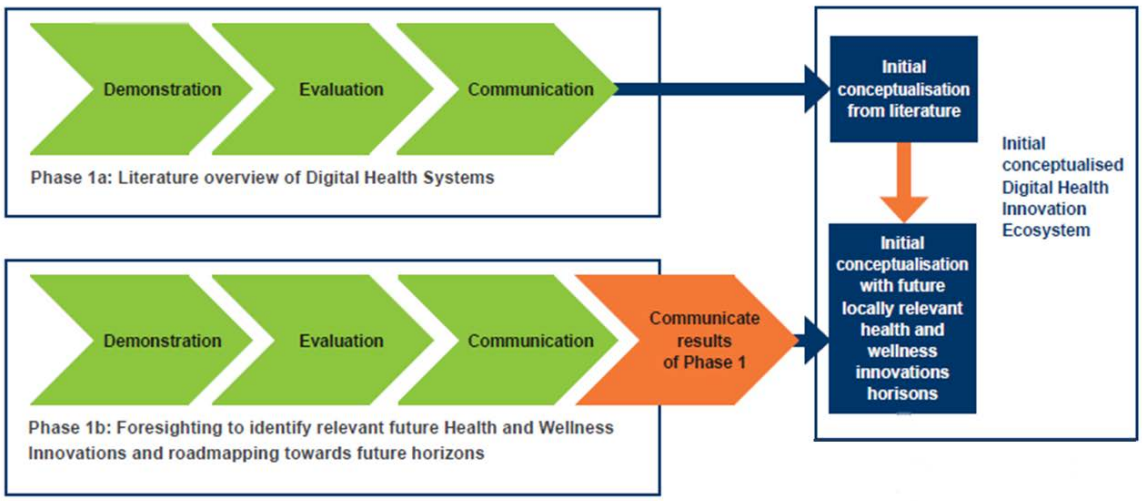


**Figure 4-1: Phase 1 – Development of the DHIE for South Africa**

Phase 1a involved a literature overview of the health situation in South Africa (see Chapter 1, Section A). A number of these realities about the health situation in South Africa will now be highlighted before an overview is provided about the two case study countries (Finland and Estonia).

### *4.2.1 South African healthcare*

According to Chapter 1 (Section A) of this report, the South African population is estimated to be 56 million (Statistics South Africa, 2016), and life expectancy is more or less 59 years for males and 63 years for females. This indicates that life expectancy in South Africa falls short of the Millennium Development Goal (MDG) target of 70 years (United Nations DESA, 2008).

Healthcare in South Africa is also divided between the public and private sectors, and significant inequities are evident between the two systems. Healthcare at the public primary care level tends to be the most overburdened of all the healthcare sectors, and hence individuals avoid it if they are able to afford private care. Public primary care is used mostly by poor non-white South Africans, and as a result, there is little crossover of patient demographics between public and private primary care (Maillacheruvu & McDuff, 2014).

Each of the nine provinces of South Africa is divided into several districts and each district is divided into sub-districts. Figure 4-2 presents the health landscape and challenges in the South African healthcare system as outlined in the National Development Plan (2011). It lists the different levels evident in the public health sector, as well as the role of each of the primary health centres (community workers and home-based care) that falls under the revitalised primary care (Chetty, 2013). The figure gives an outline of how data is transferred from the community (where it is captured by a community health worker) to the provincial hospital. In this way, primary data can rather be regarded as secondary data (Wright & Odama, 2012). The data is used to calculate the value of authority, as well as administrative, medical and care functions for patients (Wright & Odama, 2012).

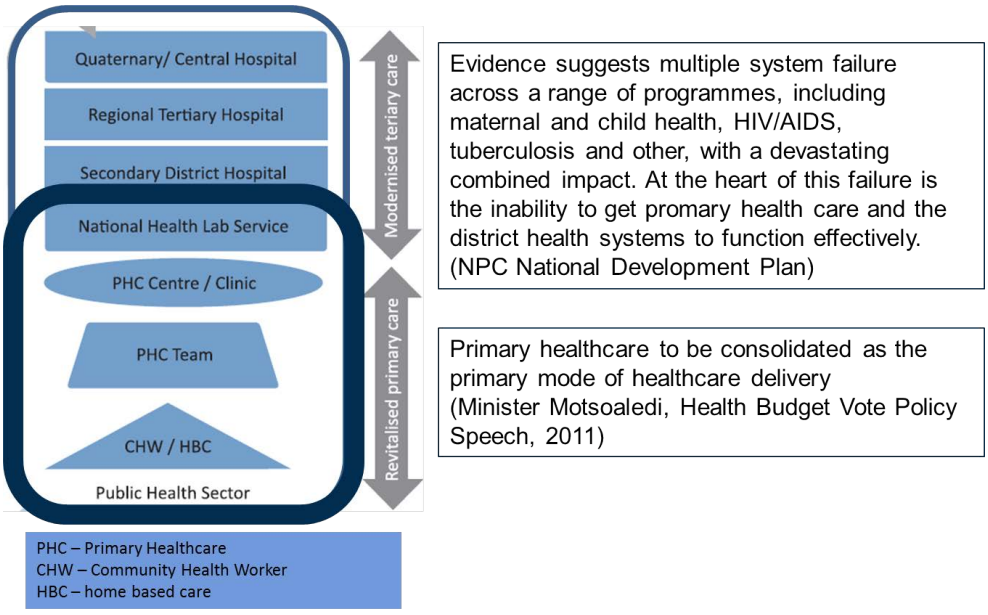


**Figure 4-2: National Development Plan – health landscape and challenges**

The inequity in the health system is seen as a major inhibitor that slows progress towards universal healthcare coverage in South Africa (Marten, McIntyre, Travassos, Shishkin, Longde, Reddy, & Vega, 2014). In addition, despite high national expenditure on health (8.5% of GDP in 2011 against a World Health Organization recommendation of 5%), health outcomes in South Africa remain poor in comparison to other middle-income countries (NDoH, 2012; Alberts, Botha, & Fogwill, 2015). Obstacles in primary healthcare as well as in the use of ICT in healthcare in South Africa include the following (Ouma, 2013; Maillacheruvu & McDuff, 2014):

- Shortage of healthcare workers and inequality of resource distribution
- Wrong drug suppliers
- Use of faulty equipment
- Lack of leadership in the public health sector
- HIV and AIDS pandemic
- Reliable network connectivity
- Cost of acquisition and maintenance of ICT infrastructure and hiring of ICT technical staff
- Concerns about the confidentiality of healthcare records
- Automation or integration of systems requiring technical expertise
- Interoperability and standards of healthcare systems
- Provision of a budget for eHealth solutions (financial and economic sustainability)
- Inadequate stakeholder engagement and establishment of provincial health information system committees
- The type of evaluations done on eHealth
- Lack of policies with implementation guidelines

Two key challenges have been noticed in implementing the **district** health information systems (English, Masilela, Barron, & Schönfeldt, 2011):

- Getting the right human resources skills to troubleshoot and maintain the health information systems – experts who can act as developers, and managers who can create, link and extract integrated data from various sources of the information systems
- Lack of control over the versions of health information systems used in the provinces.

Adding to the challenges above, the adoption of eHealth has been very slow due to the development of integrated Hospital Information Systems (HISs); high costs of acquisition; lack of ICT skills, especially in developing countries; and concerns for the security and confidentiality of electronic healthcare information (Anderson, 2007; Karisa et al., 2014; Meingast et al., 2006).

Even though ICTs in the healthcare domain have evolved from supporting patient administration and billing processes in the mid-1960s to proper Hospital Information Systems (HISs) that can support collection, storage and transmission of clinical records

(including discharge summaries, referral notes, laboratory test results and radiology images as illustrated by Wager et al., 2009), investment into the public health sectors' ICT and HISs has not materialised with the expected high investment returns. So far, ICT and HIS in the public healthcare system have not adequately supported business processes, which resulted in the inability to effectively monitor and evaluate the performance of the South African national health system (Geldenhuys & Botha, 2015). One of the problems identified is the lack of technology policy frameworks and regulations to support ICT procurement and management processes (Kirigia, Sambo, Nganda, Mwabu, Chatora, & Mwase, 2005; South African National Department of Health, 2010).

However, the National Department of Health (2012) embarked on several initiatives to address the above challenges. An example is the Integrated Health Programme for the Primary Healthcare (PHC) facility, which comprises the installation of hardware; connectivity; deployment of the Health Patient Registration System (HPRS) and the District Hospital Information System (DHIS); rationalisation of registers in PHCs; and the integration of identified eHealth applications with the Health Information Exchange (HIE). The CSIR has been tasked by the NDoH to implement these initiatives.

The South African health system is currently reformed to have a greater focus on primary healthcare and preventive care by means of community outreach programmes and supported by a national health insurance (NDoH, 2012). The strategy is to bring healthcare closer to patients' homes through dedicated teams, including the following (Alberts et al., 2015):

- An integrated, district-based team of clinical specialists, initially including an obstetrician and gynaecologist, a paediatrician, a family physician, an anaesthetist, a midwife and a professional nurse
- School-based primary healthcare and health promotion services (e.g. immunisation, physical and mental health and well-being, family planning, etc.), delivered by teams led by professional nurses
- Municipal ward-based primary healthcare workers who work with allocated households to identify health problems and promote active involvement in good health practice by communities.

To make this a reality, it is important to identify the key stakeholders involved in the South African national health system of innovation, as these people will play an important role in re-engineering the healthcare in this country.

### *4.2.2 Stakeholders involved in the National System of Innovation for healthcare*

The following table contains a summary of all the current stakeholders involved in the National System of Innovation (NSI) for healthcare in South Africa:

**Table 4-1: Stakeholders in the National System of Innovation for healthcare in South Africa**

| Stakeholder | Role |
|---|---|
| National Department of Health (NDoH) | In terms of the National Health Act:<br>"74. (1) The national department must facilitate and co-ordinate the establishment, implementation and maintenance by provincial departments, district health councils, municipalities and the private health sector of health information systems at national, provincial and local levels in order to create a comprehensive national health information system." |
| Provincial and District Departments of Health | Responsible for procurement, implementation and support of health information systems |
| National Health Information Systems of South Africa Committee | Committee of health IT staff across all levels of the DoH |
| Local Government | Implementation (working with district health office) |
| Health Information Systems Programme | Responsible for development and deployment of the District Health Information System (DHIS) |
| Health Systems Trust | Performs health research and responsible for rationalisation of health registers (data collection guidelines) |
| Medical Research Council | Currently focused on research to address burden of disease; may fund some eHealth-related work |
| Health Professionals Council of South Africa | Regulates health professionals |
| SITA | Hosts public sector infrastructure and data; public sector ICT procurement.<br>Renders an efficient and value-added ICT service to the public sector in a secure, cost-effective and integrated manner.<br>Contributes to service delivery and citizen convenience as its mission. |
| Strategic Health Innovation Programme | DST vehicle for funding strategic health innovation |
| Higher Education Institutions | Various aspects of research into eHealth; also source of staff |

| | |
|---|---|
| Jembi Health Systems | Health information systems integration and standards |
| mHealth solution providers | Mobile data collection and health services (cell phones, digital pens, portable diagnostic devices) |
| Commercial Integration vendors | Provide IT integration services and tools |
| CSIR | Research, implementation and development body tasked by the Department of Health to address its key priorities; develop and evaluate the interoperability standards, develop reference models and architectures for eHealth interoperability at a national scale, evaluate health information systems at primary and secondary levels of care, develop and maintain the national patient registration system and master patient index, and participate in the design of a future clinic.<br>The CSIR collaborates with all the above stakeholders to achieve these goals. |

All of the stakeholders above have a specific role and mandate to support the NDoH in providing improved services and delivering quality healthcare to the citizens of South Africa. In an effort to support the NDoH to re-engineer the healthcare system in South Africa, the CSIR's Meraka Institute soon realised that most public hospitals do not have HISs that can share and exchange healthcare information of patients. Fragmentation and the inability of HISs to share and exchange the relevant patient healthcare information seriously hamper the coordination of healthcare services. (The issue of fragmentation and interoperability standards were highlighted earlier in Chapter 1, Section A)

The problem of fragmentation has been aggravated by the uncoordinated implementation of HISs, especially at a national level. In many instances, the implementation of HISs is driven by donor-funded vertical programmes that focus on specific eHealth initiatives, such as the monitoring and evaluation of HIV/AIDS programmes. These may not necessarily fit well with a country's overall national eHealth initiatives. A comparative analysis on ICT use to support healthcare in African countries revealed that many of the implementations were pilot projects, which have made scale-ups difficult (Pankomera & Van Greunen, 2014; Spies & Muwanguzi, 2014). Many of the projects required healthcare workers to use mobile phones to retrieve basic healthcare information for patients and to disseminate educational health information to patients by means of text messages (Spies & Muwanguzi, 2014).

Thus, the fragmentation of health information systems and the lack of interoperability constitute a major ICT problem in the healthcare system in South Africa. This was confirmed in the South African eHealth Strategy, 2012-2106 announced by Dr Aaron Motsoaledi, Minister of Health. The South African NDoH has consequently approved the implementation of its national Health Normative Standards Framework (HNSF) for Interoperability in eHealth in a Government Notice signed by the Minister of Health in April 2014 (Motsoaledi, 2014). The HNSF mandates a set of baseline standards to support the interoperability of HISs across the country's public healthcare facilities so as to ensure a seamless, secure and trustworthy

integration and exchange of health information/data across devices, systems, components and business processes.

The HNSF defined a set of IHE (integrating the healthcare enterprise) profiles applicable to selected interoperability problems and associated base standards to be applied and adhered to by healthcare systems in the South African health environment to achieve eHealth interoperability. The HNSF also included a proposed structure for a centralised and shared electronic health record system. This structure defined a number of technical components required to enable interoperability between eHealth systems and compliance with the defined eHealth standards. These components cover health information exchange, shared registers, shared clinical repositories, health analytics, security and auditing services, and third-party healthcare applications. (This infostructure was provided in Chapter 1, Section A)

Although the national Health Normative Standards Framework for Interoperability in eHealth in South Africa did not focus on the architecture of a solution, it recommended a shared national infrastructure, particularly for the national shared registries (such as for patients, facilities and providers). Even though some of the clinical repositories may be centralised, a distributed or federated model is more likely and practical. For more information consult the HNSF (CSIR & NDoH, 2014).

To address the strategic eHealth priority number 8 (see Chapter 1) and specifically the *registration of patients* as identified in the eHealth foundations strategic priority area of the NDoH (2012), the CSIR embarked on developing an electronic Health Patient Registration System (HPRS) in pursuit of a national HPRS and a national master Patient Index for South Africa.

Implementing an electronic system for the registration of patients at healthcare facilities across South Africa will be a feat that is not without its challenges and obstacles. Most South African healthcare facilities do not have adequate infrastructure and Internet connectivity (Geldenhuys & Botha, 2015), both of which are considered essential in delivering on the eHealth strategy. These elements lie within the mandate of the Infrastructure and Connectivity key initiatives of the eHealth foundations strategic area. This mandate is extended to include the procurement and installation of adequate infrastructure at health facilities (e.g. computers, printers, uninterrupted power supplies, as well as network infrastructure equipment) and general internet access (NDoH, 2012).

In many cases, health facilities are located in rural areas, far from cities, and when the expertise of technicians is required to fix internet-related problems onsite, these could take days to resolve. In addition, depending on the contract agreement with the service provider, data bundle limitations (e.g. 1GB per facility per month) could also cause problems for any electronic system dependent on and requiring access to a central server via the internet (Geldenhuys & Botha, 2015).

Within the South African context, the design and implementation of any patient registration system also ought to consider the following policies and regulations affecting eHealth as outlined in the eHealth Strategy (2012) as well as relevant industry standards. The relevant policies, regulations and industry standards, implications and detail discussions are beyond the scope of this chapter, but are listed here for further reference (NDoH, 2012):

- State Information Technology Agency Act, Act 88 of 1998
- The Minimum Information Interoperability Standards
- Promotion of Access to Information Act, Act 2 of 2000
- The Minimum Information Security Standard
- The National Archives and Record Service of South Africa Act, Act 43 of 1996
- The Policy of Free and Open Source Software Use for South African Government
- The National Health Normative Standards Framework for Interoperability in eHealth in South Africa

The requirements and conceptualising of a proposed electronic HPRS (towards a national HPRS for South Africa) were initiated during joint application design sessions where the project team was formed to include members of the CSIR, NDoH, Statistics South Africa, and the National Department of Home Affairs. Daily operations and business processes at clinics were discussed and included in the requirements for a proposed health patient registration system. The resulting requirements were confirmed and refined through a site visit to two purposefully chosen clinics in Gauteng and the Eastern Cape. The refinement was extended to include administrative processes as well as the information required from patients upon visiting facilities (Geldenhuys & Botha, 2015).

### *4.2.3 Patient registration system*

The design of the patient registration system architecture considered six main technological and business areas that would result in an effective solution (Geldenhuys & Botha, 2015):

- Possible intermittent and/or slow internet response at clinics
- Promptly available aggregated patient information to provincial and national management
- Minimal cost to maintain system version at clinics
- Implementation of open source technologies as far as possible to minimise licensing cost
- Ability of the patient registration system to respond instantaneously to requests from approximately 10 000 users from over 4 000 clinics across South Africa
- Security and privacy requirements

The patient registration system architecture consists of multi-tiered client-server architecture – (i) client tier, (ii) presentation tier, (iii) business tier, and (iv) data tier (Van Zyl, 2015). Figure 4-3 outlines the physical implementation model for the patient registration system solution (Geldenhuys & Botha, 2015).

Geldenhuys and Botha (2015) indicate that the patient registration system consists of the following main implementation environments:

- Central server
- Health facility implementation
- National, district and sub-district management offices of the Department of Health
- Home Affairs National Identification System (HANIS)
- Third-party application

Each of these will be discussed in more detail next.

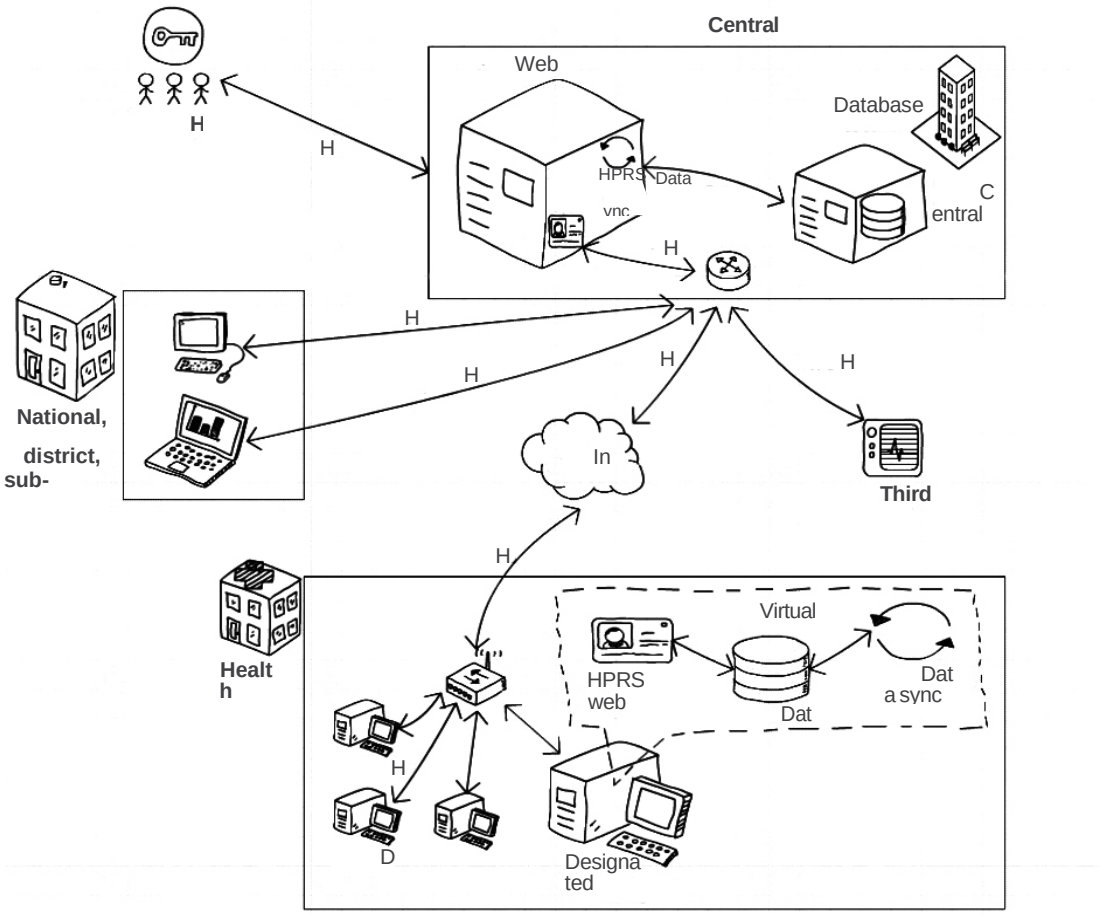


**Figure 4-3: Patient registration system**

## The central server

The central server environment is the core component of the patient registration system and consists of the web application server and the database server. The web application server contains the web application and the data synchronisation server, and it is responsible for responding to HTTPS requests from external sources (e.g. a request from a clerk at a clinic to search for a patient's demographic information). The synchronisation server listens for

incoming requests from synchronisation clients residing at health facilities. Synchronisation requests are requests from health facilities to synchronise data with the central server. These requests are communicated to the central database server. The database server consists of a relational database using open source PostgreSQL version 9.3 and it is responsible for centrally storing patient demographic information for health facilities across South Africa. It is also responsible for handling requests from the web application server via secure protocols.

**Health facility implementation**

The environment in which the health facility is implemented includes (i) desktop computers, (ii) a facility LAN router, and (iii) a facility-designated server machine. *Desktop computers* are any Windows-compatible computer at the health facility that is connected to the local network via the facility router. The patient registration system is mainly accessed from desktop computers located in the reception areas of health facilities. In addition, desktop computers in the reception areas of pilot health facilities have a barcode or driver's licence scanner as well as a fingerprint reader connected.

The barcode scanners are used by clerks to scan the barcode on a patient's identification documentation. Alternatively, if patients provide their South African driver's licence card, the clerk uses the driver's licence scanner to scan the PDF417 code containing the patient's identification number. The fingerprint reader is used to scan the patient's fingerprint, which is displayed on the patient registration system upon a successful scan. The patient's fingerprint image and South African identification number are subsequently sent to the Home Affairs National Identification System (HANIS) for identity verification. (The HANIS environment is discussed in more detail in one of the following sections.)

The *facility LAN router* is the gateway for health facility computers to designated server machines and the internet. Thus, if the facility router is unavailable or faulty, computers in the facility would be unable to access the patient registration system on the designated server machine. The *facility-designated server machine* acts as the *local server* hosting a virtual machine that comprises the patient registration system web application, database, and a data sync client. Desktop computers in health facilities are set up to access the patient registration system on the virtual machine residing on the designated server machine. The main advantage of accessing the patient registration system locally via the virtual machine is that this architecture approach limits the dependency on slow and intermittent internet access. Thus, patients would spend less time waiting for clerks to retrieve their patient information from the patient registration system. The data sync client is responsible for checking if a good internet connection is available and initiating a data synchronisation request with the central server. Alternatively, data synchronisation requests are also automatically initiated by the central server at predefined periods during the day.

**Department of Health offices**

Authorised users at national, district and sub-district health offices are permitted to access the patient registration system reports, as well as to view in real time the number of patients visiting clinics across South Africa. Users only have access to facilities to which they have been assigned. Thus, districts are not permitted to view reports for another district or view real-time patient visiting totals.

Using supported browsers (e.g. Chrome and Internet Explorer), users at Department of Health offices may access the patient registration system on the central server after a successful authentication. Access for users at national, district and sub-district health offices is permitted directly via the internet without the use of a router, as is required by health facilities.

**HANIS**

The patient registration system requests the South African Home Affairs National Identification System (HANIS) to verify the identity of patients visiting health facilities. The verification process uses the patient's identification number and an image of the patient's fingerprint as minimum criteria. Therefore, if a patient does not provide proof of identification (e.g. RSA identity document or driver's licence card), his/her identity may not be verified via HANIS. Visits by patients whose identity could not be verified, are marked as *unverified* patient visits; alternatively, in the case of successful identity verification, the patient registration system marks visits as *verified* patient visits.

**Third-party application**

The third-party application environment refers to any external system that requires access to the national patient register. For example, health facilities with existing healthcare information systems for managing patients' demographic information and recording their visits would access the national patient register directly via an application programming interface (API) hosted on the central server. Future work will include iterations of implementation, evaluation, design and development in pursuit of a long and healthy life for all South Africans (NDoH, 2012).

**Evaluating success and failure in digital health**

Failure in digital health planning, strategies and implementation has been a reality that is difficult to admit – at all levels of engagement, from government, industry, IT-professionals and health professionals to academics, donors, and so forth. Indeed, a clear success bias (Heeks 2006) exists in academic literature that assesses and reports on digital health projects, as well as in discussions within the broader stakeholder community (comprising governments, healthcare administration, IT professionals, health professionals, and, especially in developing countries, donors).

A broad review of failure and success of health IT projects has revealed that at least 40% of generic IT projects are either abandoned or fail to meet business requirements; less than

40% of large systems acquired from vendors deliver as expected, and up to 70% of health IT implementation projects can be assessed as failures. An industry-wide estimate is that about half of all health IT projects fail to meet designated goals and objectives, and a similar number exceed their planned cost or the timeframe for implementation (Kaplan & Harris-Salamone, 2009).

In his review of failure in health IT systems projects, Heeks (2006, p.127) notes that "[t]he best estimate […] is that most HIS fail in some way". Nevertheless, failures offer a great opportunity for learning and improvement, and *failure literature* offers important insights into improving the likelihood of successful adoption and acceptance of digital health systems.

The so-called *design-reality gap* model (Heeks, 2006) captures the central issues and dimensions of failure in digital health projects. Its central claim is that the planning of digital health information systems (HIS) fails to consider the practical realities that frame and constrain the adoption and acceptance of new digital health systems. In short, what looks straightforward and great on an engineer's drawing board as a plan gets stuck in all kinds of challenges when confronted with real people, real organisations and real circumstances. The *messiness* or complexity of reality simply exceeds the imagination of most planners.

It is important to understand that the design-reality gap does not emerge because of the refusal or opposition at implementing level and organisations. This gap, and the risk of failure, emerge typically because the planning stage has failed to investigate and analyse deeply enough the social, cultural, organisational, economic and technological preconditions for adoption and acceptance of new digital health solutions. A proper and in-depth understanding of users goes beyond a mere analysis of the user needs to be satisfied by proposed digital health solutions, and should extend towards change management where careful attention is paid to the preconditions on which users can adopt and accept new solutions. Heeks (2006) consequently proposes that the successful implementation of new digital health solutions requires *adaptive implementation*. As the roll-out of an ambitious digital health projects begins, its management should be prepared to adapt, revise and improvise the original plans as the implementation proceeds. Or, as Heeks remarks, "…the amount of change between 'where we are now' and 'where the Health Information Systems want to get us' is central to health information system success and failure" (Heeks, 2006, p.128).

In the local context, a number of issues may expound the challenges, lending extra weight to the importance of adaptive and improvised change management. It is important to appreciate the distinct features of South African society, as well as those of its social and healthcare services. The social and healthcare services remain fragmented in different layers and sectors, and the initial technological level of different regions and organisations vary significantly. All this is likely to contribute to the emergence of a *design-reality gap*,

underscoring the importance of the style and philosophy of change management for the successful development, adoption and acceptance of new digital health solutions.

Furthermore, in the broader African and developing country context, another set of causes of failure arises. Many digital health projects are created as donor-initiated pilots with a relatively small lifespan or poor sustainability.

In the following section and sub-sections, we briefly sketch some key issues for consideration in managing change and providing an evaluation framework for DHIEs in a South African context. We also develop perspectives on management solutions for managing the roll-out of digital health solutions in South Africa.

### 4.3 Success and failure in Digital Health Innovation Ecosystems

What is the proper framework to assess success and failure in digital health? What specific metrics and which dimensions of the impact and outcomes of the implementation of digital health should be accounted for to evaluate success and failure in digital health? Since digital health is designed as ubiquitous, penetrating through all layers of activity in health and social care, so the range of its impacts – and failure – is extremely broad. When we add to this the notion of DHIEs, the complexity increases, but so too do the impact and outcomes of digital health.

There are numerous possibilities for failure or incomplete success of digital health. It is important to note that the extent of failure varies between complete and zero failure, with most projects demonstrating varying degrees of partial failure. Thus, failure and success are not binary concepts, but should be assessed as multi-dimensional features of a digital health project, especially if we are to contribute towards a constructive evaluation framework in support of improved DHIE planning and implementation.

The healthcare context expounds the meaning of *failure* to go beyond additional cost and delays, and to also involve possible adverse effects on patient healthcare and public health. While financial, technical and contractual failures are relatively easy to detect, issues become more complex once we turn our attention to failure to deliver impact and outcomes. Yet, in the context of health, it is essentially the last category of impacts that matter for success and failure.

The same holds true if digital health initiatives are supposed to contribute to the enhanced innovation capacity of firms, research and development organisations, universities, hospitals, health clinics, and so forth. The impact and outcomes of digital health initiatives to innovation capability are usually affected by indirect channels and a time lag. Thus, we propose a three-tier conceptual framework to monitor and act upon management challenges in the context of digital health, and use it to consider the possible impact and outcome metrics for DHIEs.

Tier one – project failures – focuses on project implementation or operational issues such as cost or scheduling issues, or technical problems associated with the end project. As such, it is confined to focus only on operational issues related to the implementation of a health IT initiative.

Tier two – impact failures – focuses on the expected impacts of a health IT initiative. Such projects affect the management of health systems, the execution of physician or nurse work at clinics, the direct impact on patient safety (e.g. problems caused by faulty software when failing to notify patients of appointments), and so forth.

Tier three – outcome failures – addresses the expected benefits of digital health as broader community-wide or society-wide outcomes. Broadly, this can be translated into improved availability and delivery of health services, or better health. In practice, it should be broken down into more impact-level phenomena that consist of practical outcomes from the vantage point of a health system as an improved cost/benefit ration of healthcare, improved access to healthcare, or even as delivering targeted metrics, such as improved infant care or vaccination rates.

Tier-related discussion points include the following:

- **Project failures:**
  - Budget exceeded
  - Delayed implementation
  - Partial or incomplete implementation
  - Underperformance of hardware and software to the extent that the IT system cannot be adopted for intended use or it fails in terms of interoperability with other relevant IT systems
- **Impact failures:** These are IT failures that adversely affect
  - the management of health systems
  - the administration of care
  - patient safety
  - the collection and analysis of public health information
- **Outcome failures:**
  - Access to healthcare services
  - Expanded service area/clientele
  - Vaccination rates
  - Health monitoring of targeted diseases or population
  - Availability of healthcare services
  - Improved cost-benefit ration of health services

These points for consideration are not exhaustive. The point is that digital health, like all complex projects, should have proper metrics to assess and evaluate. Furthermore, it is essential to develop perspectives to conceptualise the metrics to assess impact on the innovative capacity.

## 4.4 Conclusion

This chapter provided an overview of the challenges and landscape of the South African healthcare system and what is currently being developed in support of the NDoH to address its priorities and the implementation of a national eHealth strategy. Considerations for success and failure in digital health are essential if one is to understand the potential sustainability of such an ecosystem. The next chapter will address Phase 1b where foresighting as well as roadmapping were applied to assist in developing the DHIE.

## 4.5 References


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