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HEALTHCARE RESILIENCE: A DYNAMIC CAPABILITIES VIEW FOR EXPLORING THE ROLE OF DIGITAL TECHNOLOGIES AND KNOWLEDGE ABSORPTION IN MANAGING OPERATIONAL FAILURES

IL DOTTORE
ING. IACOPO RUBBIO

IL COORDINATORE
CHIA.MO PROF. ING. SALVATORE GAGLIO

IL TUTOR
CHIA.MO PROF. ING. MANFREDI BRUCCOLERI

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PREFACE

This thesis is submitted for the degree of Doctor of Philosophy at the Università degli Studi di Palermo. The supervisor of this work is Professor Manfredi Bruccoleri of the Università degli Studi di Palermo (Italy).

In this research, the results of two research papers I worked on during the three years of Ph.D. studies are presented:

- Rubbio, I., Bruccoleri, M., Petrosi, A., Ragonese, B. (2018). Digital Health Technology enhances resilient behavior: evidence from the ward; *International Journal of Operations and Production Management*, Vol. 39; No. 4; pp. 594-627.

- Rubbio, I., Bruccoleri, M. (2019). Absorptive Capacity increases Healthcare Resilience: unfolding the relationship between Digital health and Patient Safety; *International Journal of Operations and Production Management* (under review)

The previous versions of these articles have been submitted for participation in various Italian and international conferences:

- Rubbio, I., Bruccoleri, M., Perrone G. (2019); Disclosing the relationship between Digital Technologies and Healthcare Resilience; presented at 26th EurOMA - European Operations Management Association Conference, 17th – 19th June, Helsinki (Finland).

- Rubbio, I., Bruccoleri, M., Perrone G. (2018); The role of Digital Technology in increasing Healthcare Organizations Resilience; presented at 25th EurOMA - European Operations Management Association Conference, 24th – 26th June, Budapest (Hungary).

- Rubbio, I., Bruccoleri, M., Perrone G. (2018). The Role of Digital Technology in Increasing Healthcare Organizations Resilience; presented at XXIX Riunione Scientifica Annuale dell'Associazione Italiana di Ingegneria Gestionale AiIG, 11th October – 12th October, Castellanza (Italia).

- Rubbio, I., Bruccoleri, M., Perrone, G. (2017); Resilience practices and patient safety: a multiple case study; presented at 24th EurOMA - European Operations Management Association Conference, 1st – 5th July, Edinburgh (Scotland).

- Rubbio, I., Bruccoleri, M., Perrone, G. (2017); Digital health technology enhances the resilient behaviour of workers: evidences from the ward; presented at XXVIII Riunione Scientifica Annuale dell'Associazione Italiana di Ingegneria Gestionale AiIG, 19th October – 20th October, Bari (Italia).

- Rubbio, I., Bruccoleri, M., Perrone, G. (2016); Introducing "Healthcare Resilience" in Clinical Risk Management; presented at 23rd EurOMA - European Operations Management Association Conference, 17th – 22th June, Trondheim (Norway).

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Although the work done together is not reported in this thesis, I would like to thank Professor Martinez of the University of Cambridge, with whom I had the honour of working for six months at the Institute for Manufacturing, discovering as well as a great teacher, a wonderful person. I will never end to thank her, for various reasons.

I would also like to thank the Professors of the department with whom I collaborated, and my fantastic colleagues, always available to help me, in particular psychologically. The moments spent together and the laughter were necessary to face the difficult moments that, inevitably, the Ph.D. course puts in front of you.

My thoughts and my thanks also go to my family and, in particular, to my mother. During these three years we have faced apparently insurmountable difficulties, going through times of great discouragement, yet my parents never made me weigh the situation, showing to be incredibly strong. I don't think there are words to thank you enough.

Finally, I cannot find the right words to thank Maria Chiara, the person who was closest to me during these three years. My outbursts, my problems and my stress have been periodically poured on her that, as only she knows how to do, has always been able to find the right words, calm me and be a wise source of advice and suggestions. Thank you for being what you are.

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INTRODUCTION

1.1 Introduction

Medical errors are one of the most significant cause of deaths in the western countries, nevertheless their importance is widely under-recognized (Makary and Daniel, 2016). Their occurrence is often not attributable to the responsibility of a precise person or team, but it is mainly due to the aggregation of a sum of also "small" operational failures which arise through the execution of the processes (Tucker, 2004).

Operational failures are of numerous and different kinds: examples of these failures range from using an inappropriate equipment, to missing necessary staff during the care process, to making mistakes in patient identification (Tucker et al., 2008). An accurate management of these failures could have positive impact in terms of patient safety (Tucker, 2004; Tucker and Edmondson, 2003). Improvements could be achieved by avoiding the occurrence of these operational failures; however, this is not always possible in practice. In fact, since the elimination of every source of negative events is not achievable in reality, a high reliable organization needs to protect itself against their unavoidable occurrence (Hollnagel, 2008). Thus, besides putting major effort in trying to avoid them, line professionals and, more in general, healthcare systems need to develop the capability to manage these negative circumstances when they, unavoidably, occur (Tucker, 2009). This is defined as *resilience*, namely the capability to absorb strain and keep working even when things are hard (Weick and Sutcliffe, 2011). Resilience is a concept more and more used in different areas of knowledge (Linnenluecke, 2017). There are businesses where simply it is not possible to prevent all the failures and disruptions that, potentially, may occur during the executions of activities; consequently, being resilient is the key to survive in a dynamic environment.

The goal of this chapter is to provide a summary of the concepts of operational failures and resilience in health care and an overview of the organization of this thesis. In particular, section two briefly presents the literature concerning the topics, the identified gaps and the related research questions. Section three presents how the research articles constituting the foundation of this doctoral thesis aim to address the gaps. Section four

focuses on the applied methodologies in the two articles. Finally, the last section of the chapter provides the structure of the thesis.

1.2 Literature review, gap and research questions of the thesis

In order to study the phenomena of operational failures and resilience within the healthcare context, I made a literature review focusing on these two concepts.

As regards the operational failures, some research articles focused on their definition, distinguish them into problems and errors based on the consequences on the workflow (Tucker, 2004), or on their causes, for example focusing on those factors that, according to the system approach theory (Reason, 2000), can generate them because of a breakdown that occur between the elements that compose it (Carayon et al., 2006; Tucker et al., 2008). What is missing in research on operational failures is the analysis on how employees manage them when, unavoidably, occur. Curiously, there are two categories of practices, namely workaround and error-handling, that although the authors do not refer them such practices implemented to manage operational failures, it is clear that they are implemented in order to manage respectively problems and errors. In fact, workaround are those practices that are implemented by employees in order to overcome and minimize the effect of an obstacle during the execution of work activities (Alter, 2014), while within the error-handling category fall all those activities that allow to detect, explain and correct the error (Kontogiannis, 2011).

As regards resilience, the safety management paradigm of resilience engineering is a widely used in order to study the positive actions implemented by practitioners during the execution of their daily activities (Patriarca et al., 2017). In particular, this paradigm suggests to focus on those things that goes right while practitioners execute their daily activities, instead of focusing only on adverse events or other negative occurrences (Braithwaite et al., 2015; Hollnagel et al., 2006; Sujan et al., 2017). Nonetheless, within this stream of research, to my knowledge there are no studies that focus on the causes of the situations that call for the implementation of resilience or how employees implement resilient actions.

In other management fields, lots of studies analyses resilience as a capability (Linnenluecke, 2017), in particular in operations management field the supply chain management is often studied through the lenses of dynamic capabilities theory (Spring et al., 2017). This is why I suppose that studying resilience in healthcare domain using the

dynamic capabilities theory could bring important results in the understanding of the phenomenon. Furthermore, taking into account that both workaround and error-handling are practices that do not follow standard, it could be interesting studying how the implementation of technologies can help in being resilient against operational failures. Finally, in case of operational failure occurrences, there is the need for practitioners to make real-time decision in very short time (Dy and Purnell, 2012), acquiring and using the necessary information to make the right choice. The large amount of different kinds of knowledge from which these information is drawn makes interesting to understand the mechanisms implemented in this process.

In sum, the main gaol of this thesis can be operationalized in the following three research questions:

1. How do healthcare providers employ resilient behaviours to solve operational failures and improve patient safety?
2. How do healthcare technologies support such a resilient behavior?
3. Does the implementation of healthcare technologies improve resilience through patient-specific knowledge?

1.3 Purpose and relevance of the thesis

The main goal of this doctoral thesis is the investigation of the concept of resilience in healthcare domain, in order to manage the occurrence of operational failures and reducing the negative impact of adverse events, increasing the level of patient safety. Furthermore, this research aims to explore if and how technologies can help practitioners in being more resilient. In order to explore this general aim, I divided it into three different research questions, above mentioned.

The issues related to the first two research question have been explored in the research article titled “Digital health technology enhances resilient behaviour: evidence from the ward” (Rubbio et al., 2018). This research article aims to explore what are the capabilities that enable physicians and nurses to be resilient in order to manage the occurrence of operational failures that diverts the sequence of activities and tasks from the normal course, with all the consequent risks in terms of patient safety. Within the field of Operations Management (OM) lots of techniques and tools have been developed in order to improve patient safety; most of them can be found in the literature on clinical risk management, quality management and lean management (McFadden et al., 2006;

McFadden, Stock and Gowen, 2015; Stock et al., 2007), and their main goal it the reduction of the risk of harm in terms of the probability of occurrence the event, e.g. through the implementation of guidelines, protocols and statistical or quality process control, which help to find and categorize all the possible errors and failures that can occur during care processes. The professional service nature of the care services (Dobrzykowski et al., 2016a) make arduous to predict all the possible operational failures which may occur during the activities daily executed by physicians, nurses and surgeons within a healthcare organization. Because of this, all these figures have necessarily developed capabilities in order to adjust, respond and resolve these failures when, unavoidably, occur and undermine the work as imagined. These capabilities and their associated techniques can be connected to a high-level capability, namely the resilience: looking at the resilience definition as made by the British Standard Institution (2014), namely "the ability to anticipate, prepare for, respond and adapt to events, both sudden shocks and gradual change; that means being adaptable, competitive, agile and robust.", it is immediate to attribute the possession of this capability to healthcare workers.

Even if it is easy to observe healthcare workers to implement practices attributable to resilience, e.g. when "a lack of support staff (housekeepers, secretaries) caused inefficiencies and interruptions for physicians and nurses who had to perform support staff functions (e.g. answering phones, cleaning rooms) themselves" (Tucker et al., 2008, p. 1815), there is no paper which analysed resilience in healthcare within the OM literature. Similarly to other industries, in health care it is possible to look at an increasing trend in the implementation of different kinds of technologies in order to support operations (Bayo-Moriones et al., 2015; Sharma et al., 2016a). The usage of these technologies may improve operations in health care in different ways, very different both in terms of peculiarity and variability, e.g. the electronic health record (EHR) enables line professionals to cope with patient information more systematically and effectively; whereas telemedicine has the potential to decrease the waiting times for patients. Even if some researches empathized the risk related to the usage of digital technologies in healthcare sector in terms of patient safety (Kim et al., 2017), in this research I found empirical confirmation of the usage by physicians and nurses of these technologies in order to manage operational failures.

The issue concerning the third research question has been investigated in the research article titled "Absorptive Capacity increases Healthcare Resilience: unfolding the relationship between Digital health and Patient Safety" (Rubbio and Bruccoleri, in

review). In this research article, the aim of the study concerns the mechanisms that allow technologies to help practitioners to be resilient, focusing on their capacity to avoid that a particular type of adverse events, namely the cascade events, occur during the provision of care processes. Digital health (DH) supports many different processes executed inside a hospital and the comprehension of the real impact of DH on healthcare performance is a hot topic in the literature (Chaudhry et al., 2006). A number of studies focus on the impact of DH on patient safety, probably the most critical dimension of quality in healthcare (Gardner et al., 2015). However, these studies show contrasting findings, as it arises by the comparison between the Froehle and White (2014) and Sharma et al. (2016). Given the academic but also practitioner interest in comprehending the link between DH and patient safety, and assuming that healthcare resilience improves patient safety, it would be a logical follow-on to explore whether DH influences resilience.

Surprisingly, in the context of healthcare operations management the relationship between DH and resilience has not been investigated under the lens of dynamic capabilities and the potential effects of DH on healthcare resilience has been disregarded so far. To investigate such relationships, in this paper we use the concept of Absorptive Capacity (ACAP), i.e., the ability of the healthcare organizations to access and exploit knowledge (Zahra and George, 2002). We argue that the ability to easily and quickly access and exploit patient-specific knowledge will boost the efficacy and responsiveness of line professionals and managers in their real-time decision-making process, which is suddenly requested as soon as an operational failure occurs, increasing in this way the healthcare system's resilience. We then pose the hypothesis that the DH, which is used to execute and support daily healthcare activities, boosts physicians and nurses' patient-specific knowledge ACAP (Hopp et al., 2018), thus increasing resilience and, in turn, improving patient safety performance. The comprehension of the above described phenomenon will contribute to the open debate about the impact of DH on resilience, and the findings of this research may have relevant practical implications for increasing patient safety in our hospitals. In sum, in this paper we wish to explore if and how the adoption of DH favours healthcare organizations in terms of patient safety through the mechanism of resilience. To this purpose, we develop a conceptual model grounding on the theoretical framework of the dynamic capabilities view (Barreto, 2010; Teece et al., 1997) and the ACAP concept (Zahra and George, 2002). To empirically test our hypotheses, we designed a survey and collected primary data from 159 respondents from 53 Italian healthcare organizations.

By answering the research questions related to the discussed issues, this thesis aims to contribute to the literature concerning operational failure and resilience in health care and to provide useful insights and suggestions to managers to obtain improvements in terms of quality.

1.4 Methodologies

In this thesis I decide to implement both qualitative and quantitative research methodology. The empirical analyses that I carried out are based on primary data collection, which were collected and analyzed through the usage of different methodologies: in the research article on which Chapter 4 is based I collected the data through interviews and analysed them implementing the methodology of case research, while in the research article on which Chapter 5 is based I collected the data through a multi-respondent survey and analysed them implementing the methodology of Structural Equation Modeling.

As regards Chapter 4, I decided to implement the methodology of case research to provide a deep insight into the concept of resilience mechanisms and capabilities in healthcare and, moreover, to understand how DH technologies impact healthcare resilience. In order to increase the knowledge regarding resilience, which is viewed as comprising a number of dynamic capabilities, I focused on an empirical examination of practices implemented by employees in the field. In fact, studying dynamic capabilities, as constituted by various practices, may "help to develop a deeper understanding" (Dabhilkar et al., 2016, p. 2). Consequently, a case research approach was chosen because it is a suitable method for attaining as much information as possible from operational activities and tasks for the purpose of theory building (Voss et al., 2002). Case research calls for dealing directly with nurses and physicians, observing their behavior and talking to them with the aim of gathering as much useful information as possible. Moreover, the strict relations and collaboration with healthcare operators during the development of the study allowed to absorb tacit knowledge about the phenomenon from the perspective of their experience (Sherman and Webb, 1988).

In Chapter 5, to empirically test the hypotheses, I designed a multi-respondent survey and collected primary data from 159 respondents from 53 Italian healthcare organizations. The unit of analysis is represented by the single organization. The survey was divided in three different sections, each of them was addressed to a different figure

within the organization. The main reason behind this choice was to avoid as much as possible the common method bias, which can arise if there is only one respondent who assesses the different dimensions which compose the theoretical model that is going to be tested. In order to evaluate the impact of DH on resilience through ACAP I used the SEM methodology, that is particularly indicated for the study of models with observed and latent variables (Wamba et al., 2017) and in presence of mediator dimensions (Boyer et al., 2012)

1.5 Thesis outline

This work is structured in six chapters as follows.

Chapter 1 provides an outline of the operational failures and resilience concepts in healthcare domain, focusing on the importance of these issues for the patient safety and, consequently, for increasing quality. At the end of the chapter, a short summary of the structure of the thesis is presented.

In Chapter 2 the concepts of operational failures and resilience are analysed, presenting a list of the main definitions used in literature and a literature review. Moreover, as a consequence of this in-depth study, three unexplored issues in literature are presented and discussed.

Chapter 3 focuses on the most important theories used in order to study operational failures and resilience in healthcare domain, examining also the theories widely adopted in operations management field used in this thesis.

Chapter 4 is based on the research article by Rubbio et al. (2018). The aim of this article is to investigate the implementation of resilience in healthcare context, with a focus on the capabilities and the technologies that enable practitioners to be resilient. At the beginning of the chapter the conceptual framework used to explore the phenomenon is explained. Thereafter, the construction of the protocol for the interviews is presented and the collected data are coded and analyzed as provided by case analysis methodology. Finally, findings and consequent propositions are listed

Chapter 5 is based on the research article by Rubbio and Bruccoleri (in review). It focuses on the impact of technologies in healthcare in order to enable and increase resilience behaviors. The chapter begins with the discussion concerning the framework subject of study and the related hypothesis, moving toward the definition of the methodology implemented and the sample surveyed. In the end, results are examined.

Chapter 6 starts with the summary and conclusions of this thesis. Then, the main theoretical contributions and the most interesting managerial implications are listed and discussed. Finally, the limitation of the thesis and the future research directions are presented.

Chapter 2

UNDERSTANDING OPERATIONAL FAILURES AND RESILIENCE IN HEALTH CARE: LITERATURE REVIEW AND RESEARCH OBJECTIVES

2.1 Introduction

The increasing complexity of the systems where people works, force them to cope with the management of the related risks (Heckmann et al., 2015). In healthcare, one of the most impacting risk is associated to the patient safety, both because of the magnitude consequent to their occurrence and the high cost (McFadden, Stock and Gowen, 2015). Over the years healthcare providers started to study the problem, giving rise to the clinical risk management, defined as an approach to increasing quality in healthcare which puts emphasis on recognizing circumstances which put patients at risk of harm, and then acting to prevent or control those risks, with the goal to both improve safety and quality of care for patients and to reduce the costs of such risks for health care providers (Verbano and Turra, 2010; Walshe and Dineen, 1998). In practice, the goal is avoiding that adverse events, namely "an injury resulting from a medical intervention, or in other words, it is not due to the underlying condition of the patient."(Kohn et al., 2000, p. 4) occur.

The high complexity of healthcare delivery (Nembhard et al., 2009) combined with its being a professional service in nature (Dobrzykowski et al., 2016b) suggest to focus on the conditions where failures occur rather than on changing the way in which workers perform their activities (Reason, 2000). It's widely acknowledged that adverse events mostly represent the "tip of the iceberg" (Parnes et al., 2007; Reason, 2000), because while the care process is being provided, lots of operational failures, which can be defined as " breakdowns [that] interfere with work, reducing employee effectiveness by increasing the time required to complete tasks. have the potential to produce an adverse event" (Tucker, 2004) (e.g. a missing insulin syringe could makes it impossible to provide the exact drug dosage), can hinder the normal course of care processes.

Even if avoiding the occurrence of operational failures is the best way, in practice this is not possible or is not convenient for the organization (Tucker, 2004; Tucker and Singer, 2015), so it is necessary to manage them when occur, trying to avoid they cause adverse events. This capability to deal with unexpected situations in healthcare domain,

making adjustments caused by the difference between activities and tasks as imagined and the way they are carried out is defined as *resilience* (Hollnagel et al., 2015; Sujan et al., 2017).

The concept of resilience is increasingly used in diverse areas of knowledge (Linnenluecke, 2017). In fact, there are businesses where it is not achievable the prevention of all the failures which, hypothetically, can occur throughout the accomplishments of activities, therefore being resilient becomes a must. Nevertheless, in healthcare domain, specifically in operations management literature, there are no studies focusing on analyzing the impact of resilience behavior on patient safety. This is why I decided to focus on this area of knowledge, with the purpose of framing the capabilities that enable a healthcare organization to be resilient, the (eventual) positive impact on patient safety and, last but not least, the impact that digital technologies can have on improving resilience.

The remainder of this chapter is organized as follow. The next section presents an overview of the broad operational failure and resilience definitions that are in the literature. Finally, the last section defines the unexplored resilience in healthcare issues that represent the center of this work.

2.2. Definition of operational failures

The importance for the organizations, regardless the specific area of business, to deal with operational failures is well depicted in the work of Lewis (2003). He investigates different types of operational failures, with causes very different each other, from workforce and organization to facilities strategy. This because the author considers as operational failure:

> *"an input or "cause" dimension based around some typology of operations-related events".*

In health care, lots of different adverse events are caused by small process failures that occur during the delivery of care (Halbesleben et al., 2008; Reason, 2000; Stevens and Ferrer, 2016). These small failures are referred to through different names in literature, such day-to-day operational problems (Holden et al., 2013), hassles (Beaudoin and Edgar, 2003),glitches (Uhlig et al., 2002), and process failures (Tucker and Edmondson, 2003) and operational failures (Tucker, 2004). Although in my research I properly considered papers in the field of health care in operations management that analyzed the concepts defined by the above terminology, I decided to focus mainly on operational failures, as

most of the work dealing with impact of these small failures in terms of patient safety define these failures as "operational".

The major expert on operational failures in healthcare is certainly Tucker, who deals with them in various articles (Berry Jaeker and Tucker, 2016; Singer and Tucker, 2014; Tucker, 2004, 2009; Tucker et al., 2007, 2008; Tucker and Edmondson, 2003; Tucker and Singer, 2015; Tucker and Spear, 2006; Zheng et al., 2017). The first definition of operational failure in health care was provided by Tucker (2004):

> *"[Operational failures are] disruptions or errors in the supply of necessary materials or information to employees".*

This definition highlights that operational failures stem from process breakdowns that impact the supply of materials and information in the organization (Angst et al., 2011; Boyer et al., 2012; Fredendall et al., 2009). Furthermore, the author states that there are two types of operational failures, namely disruptions and errors, based on their cause, with the latter resulting from incorrect human actions and behavior.

The role that seems to be most affected by operational failures is that of the nurse, as confirmed by the number of articles that focuses on their occurrence in relation to the activities performed by nurses (Gaffney et al., 2016; Stevens et al., 2017; Stevens and Ferrer, 2016; Tucker, 2004; Tucker and Spear, 2006). Based on this context, Frumenti and Kurtz state the following definition (2014:)

> *"Operational failures on nursing units result from a combination of factors including lack of necessary resources and absence of systematic proactive approaches to deal with task interdependence and the uncertainty characteristic of many nursing and patient care interactions"*

Surprisingly, there is only a limited amount of paper that explicitly focus only on the impact that operational failures have on physician (Hilligoss and Vogus, 2015). Nevertheless, the impact can be hard, because of the role played by physician in the healthcare organizations and the impact that can have on patient safety (Hilligoss and Vogus, 2015)

Rather than focusing on who causes the operational failures, during the years scholars such Tucker started to focus on the work system as a whole as the cause of operational failure, as depicted in the following definition (Tucker and Spear, 2006, p. 646):

> *"[Operational failures are] defined as the inability of the work system to reliably provide information, services, and supplies when, where, and to whom needed"*

The previous definition, as well as materials (supplies) and information, include the services as categories impacted by operational failure occurrence. In fact, to consider the operational failures associated only to materials and information is reductive, because of the complexity of healthcare setting. There are other dimensions which need to be considered when dealing with operational failures, as stated by Debono et al. (2013, p. 7):

> *"Operational failures including resource issues, equipment not stocked properly, documentation not completed, missing information and medications and environmental factors"*

The importance of the operational failures is related to the bad consequences that their occurrence can have on the care processes. In fact , they represent a significant source of interruptions (Rivera-Rodriguez and Karsh, 2010; Tucker and Spear, 2006), with all the bad consequences that, in healthcare setting, can stem from interrupting the nurse or physician workflow, both in terms of patient safety and economic (Rivera-Rodriguez and Karsh, 2010; Tucker, 2004). Furthermore, Rivera-Rodriguez et al. pay attention to the objective associated with an interruption: in this context, operational failures have the characteristic of not being associated with any objective when they occur (Rivera-Rodriguez and Karsh, 2010, p. 310)

> *"Operational failures [are] external interruptions without goal"*

With the term external the authors refer to a situation in which an external agent breaks the normal course of events or workflow.

The first definition which merges both the causes and the consequences was given by Stevens and Ferrer (2016):

> *"[operational failures are] task interruptions due to something or someone not being available when needed"*

At the end, because of the complexity of the issue mainly due to the complexity of healthcare systems and the related care processes, and its multidisciplinary nature, the definition of operational failure that I decided to adopt is the following (Stevens et al., 2017):

> *"operational failures [are] breakdowns in system processes that should reliably provide supplies, equipment, information, or human resources when, where, and to whom these are needed to complete the work. Such failures can be related to problems in information, tools and equipment, materials and supplies, budgetary support, help from others, and work environment factors such as lighting or space. Operational failures occur in work that is complex, like health care, and their solutions often require input from more than one unit within the organization"*

In fact, this definition covers the phenomenon in the widest possible way, with the goal to not exclude any kind of operational failures which, potentially, can cause adverse events. In particular, this definition:

1. Focuses on the work system as a whole, without the distinction based on the presence of the human factor as the cause of the operational failure (operational failures [are] breakdowns in system processes)
2. Does not consider only missing information and materials as sources of operational failures, but it includes whatever resource is necessary in order to deliver a care process (Such failures can be related to problems in information, tools and equipment, materials and supplies, budgetary support, help from others, and work environment factors such as lighting or space.)
3. Highlights the different roles involved in the management of operational failures (more than one unit within the organization)

2.3 Definition of resilience

The concept of resilience is based on the principle that "failures are breakdowns in the normal adaptive processes necessary to cope with the complexity of the real world and that success relates to organizations, groups and individuals who produce resilient systems that recognize and adapt to variations, changes and surprises" (Patterson et al., 2007, p. 155).

In health care domain, the topic of resilience has been studied within the scope of resilience engineering, that represents a paradigm which focuses on helping workers in managing complexity under pressure in order to be successful (Hollnagel et al., 2006). Within this field of study, lots of definition of resilience were given by scholars, for example Hollnagel, a scholar who has been focusing on resilience in healthcare for years, defined it as (2007, p. 16)

> *"the intrinsic ability of an organization (system) to maintain or regain a dynamically stable state, which allows it to continue operations after a major mishap and/or in the presence of a continuous stress".*

And (2011, p. 36):

> *"the intrinsic ability of a system or an organisation to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions".*

There are scholars who state that resilience is an ability that allows people and organization to avoid failures, not to work in their presence (e.g. see the definition provided by Jeffcott et al. (2009, p. 256))

> *"resilience refers to the ability, within complex and high-risk organisations, to understand how failure is avoided and how success is obtained. It describes how people learn and adapt to create safety in settings that are fraught with gaps, hazards, trade-offs, and multiple goals"*

There are also definition of resilience in health care involving the personal component of the worker (Jackson et al., 2007, p. 3)

> *"we refer to resilience as the ability of an individual to adjust to adversity, maintain equilibrium, retain some sense of control over their environment, and continue to move on in a positive manner"*

Although there is no doubt that resilience is a capability that impact on the operations executed by healthcare practitioners, only a small number of articles study the phenomenon of resilience in healthcare in the operations management field without focusing on the supply chain. In fact, it is possible to find a sufficient number of papers dealing with health care supply chain, such as the one written by Mandal, who refers to supply chain resilience as (2017, p. 3):

> *"a dynamic capability that enable firms to prepare for uncertainties through adequate planning with their supply chain partners so as to sustain performance in the event of a disruption"*

The previous definition is interesting because it associates resilience with the concept of dynamic capabilities, namely the "firm's potential to systematically solve problems, formed by its propensity to sense opportunities and threats, to make timely and market-oriented decisions, and to change its resource base" (Barreto, 2010, p. 16). This theory is increasingly used in operations management field, in order to explain how workers and

companies adapt to external and internal pressures, so it seems to be suitable in order to frame resilience in health care, not only with regards to supply chain.

The problem with this definition is that it is narrowed to the supply chain, and does not consider all the possible failures and disruptions which can arise in other areas of the healthcare organization. A more comprehensive definition and, to my knowledge, the only one of resilience in health care within operations management field, was provided by Davis et al., who define resilience as (2019, p. 2):

> *"the ability of a system to resist against and then recover from the impact of a disruption"*

Also the British Standard institution provides a definition of resilience as (2014):

> *"the ability to anticipate, prepare for, respond and adapt to events – both sudden shocks and gradual change. That means being adaptable, competitive, agile and robust"*

In this definition the ability to be resilient can be addresses if three capabilities are owned by the organization, namely to be:

- adaptable to shocks and changes;
- agile when they occur;
- robust against their consequences.

So, even in this definition, it is possible to ascertain the multi-capabilities nature of the resilience ability/capability.

Finally, as regards the concept of resilience in business and management research, the literature review of Linnenluecke (2017) helps us to better frame what it means for scholars. In fact, the author investigates how the resilience concept was developed in these branches of knowledge. In particular, the author does not provide an univocal definition of resilience, but states that there five different lines of enquiry concerning the phenomenon, which look at the resilience phenomenon as:

- organizational responses to external threats;
- organizational reliability;
- employee strength;
- adaptability of business models;
- design principles that reduce supply chain vulnerabilities and disruptions.

The substantial differences among these definitions is represented or by the size of the unit of analysis (the organization or the employee) or by the context, which can be specific (such the supply chain) or, as in the other cases, generic or not defined; but, most important, what these definitions have in common is the cause of the resilience behaviour, namely the need to adapt to or to be resilient towards something, such a disruption or, more in general, an external threat.

For the main goal of my research, namely to study how healthcare organizations are resilient towards operational failures, it was important to take into account two different characteristic of resilience, namely:

- it should not be considered an ability owned exclusively by employees or the organization as a whole, in fact in healthcare context, there are operational failures for which there is the need that the organization is resilient and other for which the single physician or nurse needs to be resilient;
- it should be considered as a dynamic capability, because to be resilient means to adapt to a changing environment, which force the normal course of events to change, causing the reaction of the system.

These two characteristics guided me in the investigation of resilience behaviours in healthcare context, as will be demonstrated in the chapter 4 and 5 of this work.

Table 1 contains definitions of operational failures and resilience above mentioned and discus

Table 1: Operational Failures and Resilience Definitions

OPERATIONAL FAILURES		**RESILIENCE**	
DEFINITION	AUTHOR(S)	DEFINITION	AUTHORS
"an input or "cause" dimension based around some typology of operations-related events".	Lewis (2003)	"the intrinsic ability of an organization (system) to maintain or regain a dynamically stable state, which allows it to continue operations after a major mishap and/or in the presence of a continuous stress".	Hollnagel (2007)
"[Operational failures are] disruptions or errors in the supply of necessary materials or information to employees".	Tucker (2004)	"the intrinsic ability of a system or an organisation to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions".	Hollnagell (2011)
"Operational failures on nursing units result from a combination of factors including lack of necessary resources and absence of systematic proactive approaches to deal with task interdependence and the uncertainty characteristic of many nursing and patient care interactions"	Frumenti and Kurtz (2014)	"resilience refers to the ability, within complex and high-risk organisations, to understand how failure is avoided and how success is obtained. It describes how people learn and adapt to create safety in settings that are fraught with gaps, hazards, trade-offs, and multiple goals"	Jeffcott et al. (2009)
"[Operational failures are] defined as the inability of the work system to reliably provide information, services, and supplies when, where, and to whom needed"	Tucker and Spear (2006)	"we refer to resilience as the ability of an individual to adjust to adversity, maintain equilibrium, retain some sense of control over their environment, and continue to move on in a positive manner"	Jackson et al. (2007)
"Operational failures including resource issues, equipment not stocked properly, documentation not completed, missing information and medications and environmental factors"	Debono et al. (2013)	"a dynamic capability that enable firms to prepare for uncertainties through adequate planning with their supply chain partners so as to sustain performance in the event of a disruption"	Mandal (2017)
"Operational failures [are] external interruptions without goal"	River-Rodriguez and Karsh (2010)	"the ability of a system to resist against and then recover from the impact of a disruption"	Davis (2019)

"[operational failures are] task interruptions due to something or someone not being available when needed"	Stevens and Ferrer (2016)	"the ability to anticipate, prepare for, respond and adapt to events – both sudden shocks and gradual change. That means being adaptable, competitive, agile and robust"	BSI (2014)
"operational failures [are] breakdowns in system processes that should reliably provide supplies, equipment, information, or human resources when, where, and to whom these are needed to complete the work. Such failures can be related to problems in information, tools and equipment, materials and supplies, budgetary support, help from others, and work environment factors such as lighting or space. Operational failures occur in work that is complex, like health care, and their solutions often require input from more than one unit within the organization"	Stevens et al. (2017)		

2.4 Literature review on operational failures and resilience in health care

2.4.1 Operational failures

In the last years, since the publication of To Err is human (Kohn et al., 2000), many efforts have been made in order to get improvements on patient safety. One of the most critical challenges in healthcare is dealing with patient safety (Li and Benton, 2006; McFadden et al., 2009), which can be defined as "freedom from accidental injury" (Kohn et al., 2000). Accidental injuries are caused by adverse events, namely, "an undesired patient outcome that may or may not be the result of an error" (Thomas and Brennan, 2001, p. 32). Adverse events have an extremely strong effect in terms of the harm caused to patients and, in extreme (but not rare) cases, human life (James, 2013; Kohn et al., 2000). Additionally, their economic impact is not negligible, as evidenced by the amount of money spent to resolve correlated harm and damage claims (Van Den Bos et al., 2011).

Despite the sense suggests to focus mostly on physicians and/or nurses making medication errors, it's commonly accepted that adverse events mainly represent the "tip of the iceberg" (Parnes et al., 2007; Reason, 2000). In fact, during the care process, a number of operational failures may cause an adverse event (Tucker, 2004), which makes it impossible to provide the correct drug dose, may cause an adverse event; or the absence of a nurse, which may force the head nurse to take her/his role leaving her/his job temporarily, may potentially have bad consequences for the ward. Thus, improving the patient safety by dealing with operational failure is without any doubt related to the management of operations.

According to the system approach theory (Reason, 2000), failures that cause adverse events during the workflow progress are due, above all, to "upstream systemic factors." These factors, which potentially affect patient safety, are well represented in the Systems Engineering Initiative for Patient Safety model developed by Carayon et al. (2006). Grounded in systems engineering, the model focuses on the interactions between people and their surroundings. At the centre of the model, there is a person (a hospital worker or a patient) who performs various tasks using different tools or technologies and respects the organizational conditions within a physical environment. All these factors interact with each other and influence processes and outcomes.

An operational failure can be defined as a breakdown in healthcare work system (Tucker et al., 2008), including any type of undesirable occurrence impacting on a component or an interaction between components of the work system. A comprehensive definition of operational failure can be found in Tucker (2004), where the author distinguishes between problems, i.e. anything that disrupts the normal workflow and hinders employees from executing expected tasks (such as a missing syringe) and system errors, defined as the execution of a task that is subsequently determined to be unnecessary or wrong. In a further study, the same author classified operational failures according to different categories, the six most recurrent of which are equipment/supply, facility, communication/documentation, staffing/staff development, medication and process/policy (Tucker et al., 2008). Work system represents a "basis" for the care processes to be run; as a consequence, an operational failure impacts on the care process too.

2.4.2 Resilience

Resilience is a concept more and more used in different areas of knowledge (Linnenluecke, 2017). There are businesses where simply it is not possible to prevent all the failures and disruptions that, potentially, may occur during the executions of activities, consequently being resilient becomes a need. This is the case of supply chain management, where all the possible risks are not preventable, so the research is trying for years to provide model, insights and suggestions in order to manage failures and disruptions (Kim et al., 2015; Spring et al., 2017). In particular, the main goal is "maintaining continuity of operations at the desired level of connectedness and control over structure and function" (Ponomarov and Holcomb 2009, p. 131).

The need to study resilient practices in healthcare systems is also stated in the resilience engineering literature (Patriarca et al., 2017). Resilience engineering is considered to be a safety management paradigm for different domains and healthcare is one of those domains that mostly use resilience engineering (Righi et al., 2015). Although resilience engineering is defined as "the deliberate design and construction of systems that have the capacity of resilience" (Fairbanks et al., 2014, p. 381), scholars typically use this acronym to refer only to resilience (Bergström et al., 2015). Resilience engineering acknowledges that performance in healthcare settings, both high and low, is mainly due to the capacity of operators to make adjustments in their everyday clinical work

(Braithwaite et al., 2015). These adjustments, caused by the difference between the work as it should be carried out – work-as-imagined – and how it is really executed – work-as-done, lead scholars to assess the opportunity to learn from everyday clinical work (Sujan et al., 2017) without stigmatizing every behavior or task that differs from how it was designed.

Over the years, researchers have tried to further specify the scope of resilience engineering. In their literature review, Patriarca et al. (2017) categorized resilience engineering research according to four different subcategories, one that was more theory-oriented (the theory of resilience engineering in healthcare) and three that were more practice-oriented (resilience engineering for designing technological devices, modelling resilience engineering in healthcare and resilience engineering in practice). However, I found no studies in the resilience engineering literature that anchor the observed resilient practice to the operational failure that requires it. This is a significant gap because recognizing what kind of event triggers a given resilience practice or, the other way around, what resilience practice can counteract a specific operational failure, would enable the creation of a framework that helps to promote resilience in practice. On the other hand, the literature on OM widely recognizes the importance of error management in healthcare (Kanse et al., 2006; Kessels-Habraken, De Jonge, et al., 2010; Kessels-Habraken, Van der Schaaf, et al., 2010; Parnes et al., 2007) "100% safety cannot be achieved because errors will surely arise"(Kessels-Habraken, Van der Schaaf, et al., 2010, p. 1301).

Two types of practices related to the management of operational failures have been largely analyzed for this purpose, namely, workaround and error-handling practices. A comprehensive definition of workaround is: "a goal-driven adaptation, improvisation, or other change to one or more aspects of an existing work system in order to overcome, bypass, or minimize the impact of obstacles […] that are perceived as preventing that work system or its participants from achieving a desired level of efficiency, effectiveness, or other organizational or personal goals" (Alter, 2014, p. 1044). This kind of practice has been largely subjected to criticism in the healthcare domain because of the risk entailed in the negative effects that may originate from its implementation (Halbesleben et al., 2008; Tucker, 2004). Error-handling refers to errors that occur, e.g. when a task is executed incorrectly. According to Kontogiannis' (2011) conceptualization, the phases of error-handling are: error detection, i.e. the operator realizes that an error is about to occur or suspects that an error has occurred, explaining the error, i.e. the operator identifies the

nature of the error and explains why it occurred, and correcting/recovering from the error, i.e. the operator modifies an existing plan or develops a new one to compensate.

Even if working-around and error-handling have in common the management of an unexpected event, their main difference lies in when the operational failure is detected. In fact, problems directly affect the standard activities that healthcare operators have to execute, causing a "block" such that nurses and physicians are unable to execute their standard activities, forcing them to stop and work around the block. In this case, the detection is immediate (Tucker, 2004). Errors are different because they may not be evident until the resulting adverse event occurs, e.g. during the drug delivery process, an error could occur that is the result of a nurse taking the wrong drug from the shelf but the detection may not occur until after the wrong drug has been delivered to the patient and she/he begins to disgorge. This difference becomes more evident when analyzing problems and errors in terms of their effect on the workflow. A problem interrupts the workflow and, as a result, workers have to deviate and generate a solution in order to solve it. An error does not necessarily cause an interruption and a deviation from the normal workflow; this depends on the ability to detect the error and to take counter-measures. Even if these two kinds of practices have been analyzed separately in the literature, it is clear to us that both workaround and error-handling practices can be considered two important mechanisms of being resilient.

2.5 Defining unexplored resilience and operational failures in health care issues

2.5.1 The capabilities which enable resilient behaviours

Previously, I have written how the literature on resilience in healthcare domain falls within the resilience engineering paradigm and mechanisms and practices such workaround and error-handling closely related to the workflow. In particular, in the resilience engineering domain, only few researches study resilience as a kind of ability owned by workers, team or the firm itself. For example, Hollnagel et al. (2007) distinguish four abilities, namely knowing what to do, learning from the experience, monitoring the work environment for changes and anticipating demand in the future, and Cuvier and Falzon (2011) added the coordination to this group of abilities.

Looking at the amount of paper that, in different management fields, studied the concept of resilience as a capability (Linnenluecke, 2017), it is reasonable to consider this

concept in this manner. Furthermore, the supply chain management is one of the areas where resilience has been studied more in deep (Spring et al., 2017). In the recent past, the researchers that focus on operations supply chain management have undertaken to identify the components of the resilience capability of a supply chain; in particular, in the work of Chowdhury and Quaddus (2017), a detailed representation of these components is reported.

To conclude, the preferred approach to analyze resilience by OM community considers resilience as constituted by a number of dynamic capabilities and, because of this, papers dealing with resilience should look at this concept through the lenses of the dynamic capability theory/view (Teece et al., 1997; Zollo and Winter, 2002). Because of this, I decided to study resilience in healthcare by adopting the dynamic capabilities theory: in particular, I studied the daily practices executed by nurses and physicians which are reasonably related to dynamic capabilities. This approach was already adopted by scholars which focused on the type of the association between dynamic capabilities and operational practices (Winter, 2003): e.g. Dabhilkar et al. (2016) operationalized supply chain resilience identifying four groups of practices by analyzing the resilience components with which they are connected, finally Birkie (2014) identifies five operational resilience "core functions", each of them associated with dynamic capabilities and operational routines.

2.5.2 The role of technologies in enabling resilient behaviours

The new technologies, which gave origin to the Industry 4.0, are offering to a number of different businesses the possibility to innovate the processes executed by the workers, increasing the quality, the effectiveness and the efficiency of the services delivered. With the term DH are embraced lots of different information technologies, which in particular in healthcare domain include mHealth, eHealth, health IT, and plenty of other technologies (U.S. Food and Drug Administration, 2019).

The topic of the impact evaluation of DH on the healthcare organizations performance is studied by a number of recent researches (Chaudhry et al., 2006), but the outcomes of these research does not help to disentangle the question. At the same time, a number of researchers highlighted the possibility of the occurrence of negative events associated with the usage of DH in hospital, consequently the discussion about the effects of DH in healthcare context is complex. (Froehle and White, 2014; Gardner et al., 2015;

Holden and Karsh, 2009; Kim et al., 2017). In this research I assert that studying how DH is utilized during the provision of care services, e.g. the use of the technologies during surgery, can provide meaningful results concerning patient safety management.

Considering that workaround, error-handling and resilience work practices are non-standardizable in nature, I am interested in comprehending the support that the DH technologies can provide to the implementation of resilience capability within a healthcare organization. This rationale can be framed within the wider idea that "operations management, information systems and healthcare management have the potential for synergistic results that improve efficiency and quality" (Devaraj et al., 2013, p. 182).

In sum, resilience capabilities are essential to improve patient safety, and the new digital technologies can meaningfully impact how line professionals and managers improve this kind of capabilities.

2.5.3 The role played by the knowledge in being resilient

To execute their daily activities and tasks, line professionals and managers working in healthcare context rely on both their technical expertise and acquired knowledge (von Nordenflycht, 2010). The essential uncertainty of the healthcare setting, combined with the fact that the inherent characteristics of patients mean that care services need to be highly customized (Dobrzykowski et al., 2016a), request that line professionals have to start lots of real-time decision-making activities during the provision of most healthcare services (Dy and Purnell, 2012).

The usage of different types of knowledge (Chakravarty, 2014a), from general clinical knowledge to specific patient-related knowledge, represents an important "means" in order to make right decisions in each step of the care process. In particular, the evidence-based medicine, which is the representation of knowledge based on real facts, was the fundamental source of knowledge for physicians and nurses (Ferlie et al., 2012; Lambert, 2006). Among the different kinds of knowledge which can be used by physicians and nurses, clinical knowledge and evidence-based medicine provide useful information that are widely applicable to choices when dealing with a class of patients, or with public health policies. Conversely, the kind of knowledge specifically related to patient data, focused on patient's clinical history, can bring important benefits in the

decision concerning how to behave in order to counteract the occurrence of an operational failure.

2.6 Conclusion

A number of definitions were provided by the authors both of operational failure and resilience. In this thesis I decided to adopt two definitions of operational failures and resilience that have some characteristics. First, the definition of operational failure comprehends the system as a whole and does not make distinction based on the presence of human factors, is not limited in considering as causes of occurrence only missing information and materials, finally put in evidence the importance of the different roles within the organization. Second, the definition of resilience depicts it as an ability that can be owned both by employees and the organization as a whole, and define resilience as a dynamic capability, because of the dynamic environment for which it is needed.

Finally, this chapter lists what are the main gaps individuated in literature, namely if there are particular capabilities that enable employees and organizations to be resilient and, in case, what are them, what is the role of new technologies in enabling this capability, and what is the role played by the different types of knowledge that can be used by physicians and nurses in implementing resilient behaviours.

Chapter 3

THEORIES USED FOR STUDYING RESILIENCE IN HEALTH CARE

3.1 Introduction

Because of the newness of the topic, namely the study of resilience in healthcare in order to manage operational failures, there are no theories that were used in order to analyze the phenomenon. Nevertheless, the studies which have focused on resilience or operational failures, have used different theories, which are listed in Table 2:

Table 2: Main Theories on Operational Failures and Resilience in Health Care

THEORY	EXPLANATION	TOPIC
Organizational Learning	"[…] *a process of improving organizational actions through better knowledge and understanding*" (Tucker et al., 2002)	Operational failures
Human Condition	"[…] *employees choose to engage in costly behaviors only when they believe that potential benefits outweight cost* (Tucker, 2007)	Operational Failures
Job Design	" […] employees' behaviors at work can be shaped by how their work tasks are structured and are not just an outcome of employee personality or work culture" (Tucker, 2016)	Operational Failures
Human Reliability	"[…]in order to identify the causes of a damaging or harmful event, it is important to observe not only the direct responsibility of individuals, but above all the conditions in which the personnel work and the organizational context in which the accident occurred (the strategic decisions adopted, the training of operators, communication processes, safety culture, etc.)" (Verbano and Turra, 2010)	Resilience
Resilience Engineering	"The theory of resilience engineering aims at widening the traditional 'find and fix' approach on adverse events, paying instead more attention to things that go right in normal work, i.e., inherent resilience" (Patriarca et al., 2017)	Resilience
High Reliability Organizational	"High reliability organizational theory advocates the existence of high reliability organizations that consistently perform well regarding safety even if they are complex and tightly coupled. According to this theory, this performance is due to specific systems and processes within these organizations."(De Koster et al., 2011)	Resilience

These theories are suitable for studying operational failures and resilience from different points of view. Nevertheless, there are some reasons why I decided not to use some of these theories, but to focus on dynamic capabilities theory and absorptive capacity theory. In fact, the focus of this thesis is on if and how healthcare organizations implement resilient behavior, because of this the theories related to operational failures have not been taken into consideration; in fact, these theories seem not no to be suitable in order to explain or frame resilient behaviors in healthcare context. In addition, the theories used to study resilience in health care does not explain what healthcare workers should do or how they should be in order to be resilient. In fact, the human reliability theory states (correctly) that the conditions where people work are the responsible of the occurrence of negative events, while high reliability organizational theory assumes the presence of specific system and processes that enable organizations to be resilient. Finally, the resilience engineering theory is the most suitable for the purpose of this thesis, but it focuses mainly on the healthcare system, not on the people that execute the healthcare operations.

Because of the aim of this research, in order to study the phenomenon of resilience in healthcare context, I decided to use two theories widely used in operations management context, namely the dynamic capabilities theory (Teece et al., 1997) and the absorptive capacity theory (Cohen and Levinthal, 1990).

3.2 Dynamic capabilities theory in operations management

The concept of "dynamic capabilities" was introduced for the first time by Teece et al. (1997) to describe those capabilities that enable a firm to address rapidly changing environments. In few words, dynamic capabilities view considers the firm subject to external influence (Aragón-Correa and Sharma, 2003; Teece, 2007), with the potential to generate changes in the routines (Gilbert, 2005; Lavie, 2006), which can be addresses by means of changing/reconfiguring available resources (Eisenhardt and Martin, 2000; Helfat et al., 2007; Zahra et al., 2006).

Dynamic capabilities have been studied in different areas of knowledge and from different points of view. Formerly, the concept was introduced to study industries characterized by highly changing markets and rapid technological transformations (Teece et al., 1997). Today, the number of business contexts that operate under turbulent environments is quite big; thus, it is not surprising that the studies that use dynamic

capabilities view embrace several management fields, ranging from supply chain (e.g., Brusset and Teller, 2017; Dabhilkar et al., 2016), to productions systems (e.g., Secchi and Camuffo, 2016), to information technology (e.g., Raymond et al., 2017), to healthcare operations management (e.g., Dobrzykowski et al., 2016; McFadden et al., 2015). One fact remains certain; the quite ambiguous nature of the concept "dynamic capabilities" has caused that in some (few) cases it has been used as construct/dimension of a theoretical framework, e.g., in Wamba et al. (2017); in other cases (the majority) it has been used as a theoretical framework (the dynamic capabilities view) where the hypotheses are grounded, e.g., in Chowdhury and Quaddus (2017). In this paper I follow the latter approach.

In order to better frame dynamic capabilities view, Barreto (2010) defines a dynamic capability as the firm's potential to systematically solve problems. In particular, he distinguishes four primary firm's propensities that form a dynamic capability: (i) to sense opportunities and threats, (ii) to make timely decisions, (iii) to make market-oriented decisions, (iv) to change firm's resource base. In this paper, I decided to ground our theoretical model on the above-mentioned conceptualization provided by Barreto (2010), because I think it operationalizes the multidimensional construct "dynamic capability" in four clear and unambiguous facets.

3.3 Absorptive Capacity theory in operations management

The new businesses are focusing more and more on knowledge management, because of its strong impact in terms of organizational performance (Cohen and Levinthal, 1990). Previous papers highlights how the capacity to manage operations management knowledge can enable organizational outcomes, in particular focusing on the acquisition of knowledge (Setia and Patel, 2013). It is widely recognized the complexity of knowledge management, which requires the creation of organizational capabilities (Zahra and George, 2002). In this context, the Absorptive Capacity (ACAP) may be defined as the capability of an organization to acquire and exploit knowledge in order to obtain a competitive advantage (Cohen and Levinthal, 1990; Zahra and George, 2002).

Since the beginning of its statement, ACAP was intended as an organizational capability in order to effectively manage knowledge (Cohen and Levinthal, 1990). The concept of ACAP was originally used in R&D context, in order to clarify how knowledge is acquired and used. In particular, in order to operationalize the concept researchers

started to consider ACAP as an organization's knowledge base, operationalizing it such organization's R&D activities (Setia and Patel, 2013). Nevertheless, this way to look at absorptive capacity is not considered as comprehensive by some author, which prefer to consider ACAP such a capability (Lane et al., 2006; Todorova and Durisin, 2007; Zahra and George, 2002). When looking at ACAP as a capability, it can be decomposed in two different components: the Potential ACAP (PACAP) and the Realized ACAP (RACAP) (Lane et al., 2006; Setia and Patel, 2013; Zahra and George, 2002): the PACAP is the capability owned by an organization to "value and acquire external knowledge" (Zahra and George, 2002, p. 190), while the RACAP may be defined as "the firm's capacity to leverage the knowledge that has been absorbed" (Zahra and George, 2002, p. 190).

Recently, this concept has already been adopted in healthcare context: Ding (2014) and Harvey et al. (2015) used ACAP to analyze the linkage between two main dimension, namely experience and hospital performance. In particular, Ding states that each healthcare organization has its set of routines, namely to acquire, assimilate, transform and exploit knowledge, but, consequently they have different PACAP and RACAP based mainly on their experience (Ding, 2014). Furthermore, in their work, Harvey et al. analyze how also in healthcare context it is important that organizations start to invest to improve their stock of ACAP, because of its path-dependent and cumulative nature, so they can facilitate additional development because they know what further knowledge is needed and know how to access and exploit it (Harvey et al., 2015)

In the literature focusing on resilience, ACAP can help in the understanding of two phenomena. First, in case of operational failure occurrence, the importance to get access quickly and easily to patient-related information: in fact, during the provision of care processes, to get access to this kind of information very easily and quickly can increase the probability that the line professional decisions are more effective in terms of patient-safety, also because of the increasing amount of time available to make the solution effective. Second, the transformation and the exploitation of knowledge, in fact, this capacity can be fundamental for the line professional in order to make the right decision in a short time, delivering the right treatments and, more thoroughly, to solve problems or errors.

In sum, I suppose that ACAP, considered as a combined learning (acquisition) and acting (exploitation) mechanisms, can positively impact on healthcare organizational resilience.

3.4 Conclusion

In this chapter I depicted the most important theories used in order to study resilience and operational failures in healthcare domain. In particular for resilience, the newness of the subject forced me to look at other context, not specifically related to health care, in order to understand through which lenses to observe the phenomenon.

The amount of theories used to study operational failures and resilience allowed to understand what are the main components of resilience and operational failures concepts; nevertheless, in order to frame these two phenomena within the frame of operations management literature, they are not suitable because of different reasons. In particular, the research focusing on operational failures mainly focus on their causes (such system approach theory) or negative impact, but do not focus on the tasks that workers and organization carry out in order to manage it. At the same time, research on resilience in healthcare setting, represented by resilience engineering literature, suggest to focus on what are the good actions and tasks executed that do not allow negative events to occur (not on the actions that cause their occurrence), but the way in which workers implement resilient behavior is not analyzed

Because of this, I decided to focus on two theories already studied in other contexts for the study of resilience, such dynamic capabilities and absorptive capacity, in order to better understand what are the capabilities that enable employees to be resilient and how they can manage the available knowledge to be more resilient.

Chapter 4

THE IMPACT OF DIGITAL HEALTH TECHNOLOGY IN ENHANCING RESILIENT BEHAVIOUR

4.1 Introduction

This chapter is based on the research article titled "Digital health technology enhances resilient behaviour: evidence from the ward" which aims to investigate if and how healthcare professionals implement resilience practices in their daily routine (Rubbio et al., 2018). In particular, the goal is to comprehend the mechanisms and capabilities that enable healthcare resilience and the role that the implementation of digital technologies has in improving these mechanisms and capabilities. The relevance of the topic is attributable both to its newness and to the new way to look at the outcomes of the implementation of digital technologies in healthcare domain. First, to our knowledge this is the first paper which aims to deepen how healthcare professionals implement resilience behaviours and practices in order to improve patient safety; second, it points out the possibility that new digital technologies, more and more used in healthcare context, other than improving the effectiveness and the efficacy of the practitioners' daily work, can assist them in the implementation of resilient practices.

Because of the newness of the topic, I used the case research methodology, that is particularly recommended in case of phenomena for which there is the need to define new theoretical frameworks and conceptual models (Karlsson, 2016; Voss et al., 2002). Specifically, I made interviews to physicians and nurses working in the surgery wards of two different healthcare organizations. In order to capture the role played by digital technologies in enhancing resilient behaviours, I chose healthcare organizations with a very different level of confidence with and implementation of digital technologies.

The chapter is organized in this way: first, it begins with the description of the studied dimensions considered as prominent for the goal of the study; second, it describes the research context, the case studies and how the data were collected and analyzed; finally, the chapter discusses the findings and the results.

4.2 Defining the dimensions to investigate to study resilience in healthcare domain

A thought-provoking study from Makary and Daniel (2016) estimates that medical errors are the third leading cause of death in the USA. The same authors predict that medical errors that threaten patient safety are under-recognized in many other western countries. Despite the fact that common sense would suggest focusing mostly on physicians and/or nurses as the causes of adverse events, it is commonly recognized that adverse events are largely "the tip of the iceberg" (Reason, 2000) and are caused by a number of operational failures that occur during the care process (Tucker, 2004). Thus, improving patient safety must also be related to the management of such operational failures. Operational failures in healthcare can be classified into: problems that disrupt the normal patient-care workflow because, for instance, employees need something they do not have at the right time (Tucker and Edmondson, 2003) and, consequently, they cannot continue to follow standard tasks; and errors that result from the execution of unnecessary or incorrect tasks (Tucker, 2004).

Healthcare operations have the typical characteristics of professional service operations: high customer contact and customization, high service process variation and substantial external influence on service providers (Dobrzykowski et al., 2016). These characteristics make it difficult to forecast all the possible operational failures that can occur and even when it is possible to anticipate their occurrence, it is not always possible to prevent them. For these reasons, on a day-to-day basis, healthcare operators and the entire healthcare system need to adapt, improvise, react and solve the failures that occur: being resilient is the only key for guaranteeing patient safety in these cases. The British Standard Institution (2014) defines organizational resilience as "the ability to anticipate, prepare for, respond and adapt to events – both sudden shocks and gradual change; that means being adaptable, competitive, agile and robust." The concept of resilience has been widely explored in other management fields, such as supply chain management (Linnenluecke, 2017). However, it has not been considered in healthcare OM research, even though in practice, we observe physicians and nurses regularly implementing actions that can be classified as resilience practices, e.g. when "a lack of support staff (housekeepers, secretaries) caused inefficiencies and interruptions for physicians and nurses who had to perform support staff functions (e.g. answering phones, cleaning rooms) themselves" (Tucker et al., 2008, p. 1815). The need to study resilient practices in healthcare systems is also stated in the resilience engineering (RE) literature (Patriarca

et al., 2017). RE is considered to be a safety management paradigm for different domains and healthcare is one of those domains that mostly use RE (Righi et al., 2015). Although RE is defined as "the deliberate design and construction of systems that have the capacity of resilience" (Fairbanks et al., 2014, p. 381), scholars typically use this acronym to refer only to resilience (Bergström et al., 2015). RE acknowledges that performance in healthcare settings, both high and low, is mainly due to the capacity of operators to make adjustments in their everyday clinical work (Hollnagel et al., 2015). These adjustments, caused by the difference between the work as it should be carried out – work-as-imagined – and how it is really executed – work-as-done, lead scholars to assess the opportunity to learn from everyday clinical work (Sujan et al., 2017) without stigmatizing every behavior or task that differs from how it was designed. Given the crucial role that being resilient against operational failures has on patient safety, we wonder if and how healthcare systems develop and promote their resilience capabilities. Furthermore, in this paper, we also focus on the role of digital health (DH) technologies in enabling such capabilities. As in other industrial sectors, in healthcare, we observe a general trend in implementing technology that supports operations (Bayo-Moriones et al., 2015; Sharma et al., 2016). The improvements that are achievable by implementing DH are highly distinct because of their peculiarity and variability. For example, the electronic health record (EHR) allows physicians and nurses to manage patient information in a more orderly and effective way, while telemedicine can reduce waiting times for patients. Although recent studies have provided evidence of the risk that digital technologies in healthcare may threaten patient safety (Kim et al., 2017), we found anecdotal evidence that physicians and nurses also use these technologies when managing operational failures but no study has explored how they use these technologies for this purpose and if they are effective. In other words, if and how digital technology enables and supports the resilience capabilities in a healthcare setting is not precisely known.

Because of the lack of papers studying resilience in healthcare within the OM, there is a lack of a substantial theoretical framework or conceptual model to use in order to study the phenomenon in a rigorous way. Because of this, I decided to study the presence of resilience in healthcare domain starting from the conceptual framework defined by Chowdhury and Quaddus (2017) (Figure 1), whose dimensions are defined in **Table 3**.

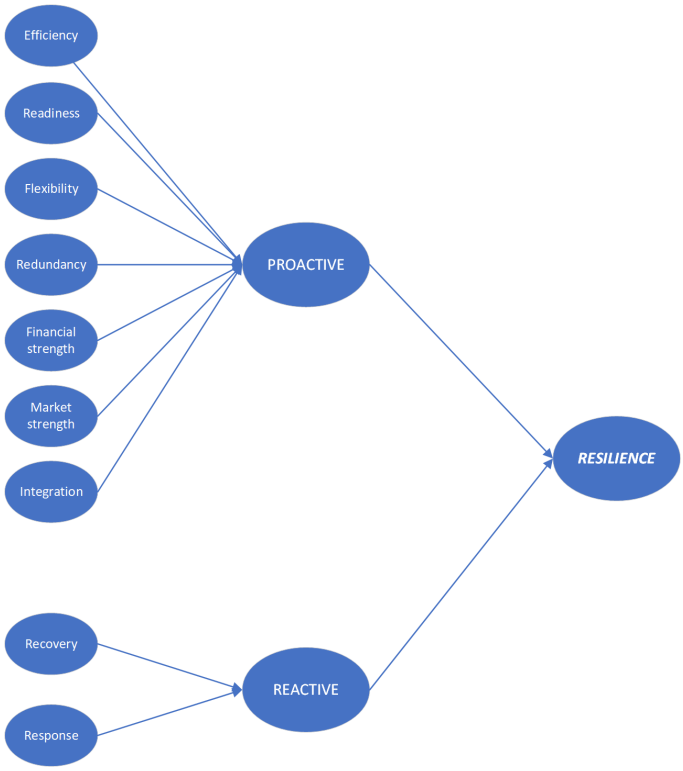


Figure 1: Operational Dimensions of Resilience (adapted from Chowdhury and Quaddus, 2017)

Table 3: Definitions of Framework Dimensions

DIMENSION	DEFINITION
Efficiency	Capability to produce outputs with minimum resource requirements (Pettit et al., 2010)
Readiness	Ability to discern potential future events or situations (Pettit et al., 2010)
Flexibility	Rapid decision-making, rapid and effective internal communications, capacity for fast learning and the ability to quickly adapt routines and strategies (Pal et al., 2014)
Redundancy	Duplications of capacity so that operations can continue following failure (Juttner and Maklan, 2011)
Financial Strength	Capacity to absorb fluctuations in cash flow (Pettit et al., 2013)
Market Strength	Status of a company or its products in specific markets (Pettit et al., 2013)
Integration	Information flow with different departments of organization (Pettit et al., 2013)
Recovery	Capability to quickly recover from interruptions (Chowdhury and Quaddus, 2017)
Response	The ability to mitigate disruptions in the shortest possible time and with the smallest impact (Pettit et al., 2013)

This framework incorporates lots of the dimensions proposed by other authors (Linnenluecke, 2017; Pettit et al., 2010; Wieland and Wallenburg, 2013), who analysed resilience in OM field, without involving the healthcare domain. In particular, the authors studied the resilience through the lens of dynamic capabilities view identifying dimensions, sub-dimensions and related variables which compose the resilience of a supply chain actor. Nevertheless, the increasing amount of paper in OM, dealing with health care, that use dynamic capabilities view in order to explain different phenomena, (Anand et al., 2009), especially when dealing with clinical risk management (Dobrzykowski et al., 2016a), justify the choice.

4.3 Empirical investigation of resilience in health care through primary data analysis

4.3.1 Research context: the ward of two different healthcare structures

The unit of analysis is represented by the ward of a healthcare organization. The choice to focus on a ward and not on the whole healthcare organization depends on a number of motivations. The first is related to the complexity of a hospital, demonstrated by the number of wards whose specialties can be very different each other, which doesn't allow the researcher to gain sufficient knowledge about processes and tasks executed by physicians and nurses during daily activities. Because of this, in order to better comprehend the research context and the dynamics among the healthcare workers, I focused only on a single ward in each hospital. The second is related to the role that patients plays during the provision of care, in fact, in the surgery ward, the patient interacts with healthcare professionals and have an active role, for example taking prescribed drug by her/himself, furthermore there is a high level of process variation because of the different inherent characteristics of the patients, which strongly influence the workflow. The third is the strong impact of surgeon's knowledge on their day-to-day activities, which gives the capability to minimize management's intervention in governing the workflow. The sum of this characteristics made the surgical ward appropriate to be the unit of analysis of this study.

In this (exploratory) phase of the research on the topic I am interested in, there is no reason to think that the geographical location can represent a meaningful variable that

influences healthcare providers resilient behaviours, so in order to simplify the data collection activities I chose the units of analysis coming from a region in the south of Italy, namely Sicily. Another goal was to conduct the study as comprehensively as possible, so I focused only on two healthcare organizations. These two structures are very different concerning the strength of DH adoption, and how I evaluated it is explained in the following section. Conversely, while choosing the sample, I was not able to differentiate in terms of hospital's resilient behavior. Even if the nature of the two hospitals is public and they depend, as other hospitals in the same region, on the same regional healthcare agency which strategically control all of them, from an operational point of view these structures have a high level of autonomy; because of this, their choice does not influence the results of the research.

The building of the Hospital A was concluded in the early 1990s, but during the following years it was equipped with modern medical devices and equipment, which make it a state-of-the-art hospital. The assisted population is of nearly 31,000 units, while the covered area is about 206 km^2.

The Hospital B, a public/private joint venture, was founded in 1997. The involvement of one of the most important academic medical center of America, which during the years has brought its knowledge and experience to the hospital, makes it a center of excellence for transplantation in Italy. Furthermore, this hospital was the first in the south of Italy to receive the Joint Commission International accreditation. Other data are in Table 4:

Table 4: Hospitals A and B Healthcare Data (2016)

Hospital	*Beds*	*Ordinary Admissions*	*Average Ordinary Hospitalization (days)*	*Bed Occupancy Rate*	*Case-mix Index (Italy CMI = 1)*	*DH adoption**
A	*136*	*6943*	*5.94*	*83.52%*	*1.04*	*Medium (in line with Italian hospitals)*
B	*78*	*2778*	*9.6*	*93.7%*	*2.7*	*High*
Italy Average	*116,18*	*4883,5*	*6.86*	*79.2%*	*1*	*-*

* Based on opinions of head managers of the information systems

4.3.2 Primary data collection

For the collection of data from through semi-structured interviews, I defined two slightly different protocols (Figure 2):

PATIENT SAFETY

1. What do you do to ensure "patient safety" during your work? [What do you do to ensure "patient safety" in light of your role?]
2. Do you think that the ability to handle an "operational failure" when it happens is important in a hospital? Why? Have you ever found yourself in a situation like this? Give me an example [Do you think that the ability of your subordinates to manage a "failure" when it happens is important in a hospital? Why?]
3. Have you ever been able to handle an "operational failure" when it happened? What enabled you to manage it? Did you use an IT system when you were handling the failure? [NOT ASKED TO HEADS]
4. Have you ever been unable to manage a "failure", even if you were capable of doing it? What stopped you? [NOT ASKED TO HEADS]
5. In terms of patient safety improvement, do you feel that you are using all your knowledge, experience and skills to achieve positive results? If not, why not? [NOT ASKED TO HEADS]

RESILIENCE (Problems and Errors)

The researcher shows the slide containing the categories of operational failures

For each category, the researcher asks the following questions:

6. When a problem that can have an impact on patient safety occurs, how do you behave? Give me an example [When one of your subordinates has a problem (and as a consequence the workflow is blocked) that can have an impact on patient safety, how would you like the subordinate to act? Why? Give me an example.]
7. What are the factors (responsibility, fear, fear of being seen, times to be respected, etc.) that influence your behaviour? [What are the factors that affect your wishes?]
8. If, in order to solve the problem you need to break guidelines, protocols, etc. ... would you do it? Why? Would you give me an example of when you had to do it? [If, in order to solve the problem (in order to overcome the block to the workflow) the subordinate breaks guidelines, protocols, etc., ... how would you react? Give me an example.]
9. When trying to solve the problem, did you use any digital technology? Give me an example? Do you think that, in general, digital technology may help physicians and nurses to solve problems in healthcare? Why? [Do you think the digital technologies used in your ward will inhibit or will help physicians and nurses to solve problems? Why? Give me an example.]
10. When you realize that you made an error that could have an impact on the patient safety, how do behave? Give me an example. [When a subordinate realizes that he/she has made an error that could have an impact on patient safety, how would you like the subordinate to act? Why? Give me an example.]
11. What are the factors (responsibility, fear, fear of being seen, times to be respected, etc.) that influence your choice? [What are the factors that affect your wishes?]
12. If, in order to correct the error you need to break guidelines, protocols, etc., ... would you do it? If so, why? If not why not? [If, in order to solve the error the subordinate breaks guidelines, protocols, etc., ... how would you react? Give me an example.]
13. Would you give me an example of when you had to do this? [NOT ASKED TO HEADS]
14. When trying to correct the error, did you use any digital technology? Give me an example. Do you think that, in general, digital technology may help physicians and nurses to correct errors in healthcare? Why? [Do you think the digital technologies used in your ward will inhibit or will help physicians and nurses to solve problems? Why? Give me an example.]

Figure 2: Physicians, Nurses, Head Physicians, Head Nurse [Questions for Head Physicians and Head Nurses in square brackets]

This approach enables to explore the components of the conceptual framework by asking questions concerning the topic but, in the meanwhile, it allows to understand facets that, because of the novelty of the concepts, were not previously analyzed.

The different operational failures that line professionals and managers can experience are the main causes of this protocol differentiation. In fact, generally a

physician or a nurse executes a resilient practice in case of her/his mistake or because she/he is missing an equipment fundamental to accomplish the task, while a head physician or a head nurse has to solve operational failures which are caused by physicians or nurses or are related to the organization of the work practices in the hospital or in the ward. The consequence is that line professionals are resilient toward operational failures which directly impact their job, while managers have to solve problems caused also by other figures. As a result, to properly evaluate the capability to manage the operational failures which are the liability of these different professional groups, I implemented two diverse views. The questions asked to management professionals aimed to comprehend how they manage circumstances where the line professionals under their supervision cope with operational failures, while the questions asked to line professionals were directly linked to how they manage operational failures. In order to elude influencing predeterminations concerning resilience capability and its linkage with DH, the central focus of the questions is represented by the operational failures. In fact, I showed real instances of operational failures and, then, I asked how they react to their occurrence. The ratio is that every action in contrast to an operational failure is related to a resilience behavior, consequently, in order to obtain as much information as possible, I explored how management and line professionals "in practice" manage operational failures, even embracing the use of any DH. The work of Tucker et al. (2008) represented the starting point for the definition of the two protocols; in fact, in their work they categorized operational failures in different groups, which constituted the topics of the interviews questions.

Before starting the data collection (November 2017), I prearranged a meeting with the clinical risk manager and the head information systems manager of the hospitals, to explain the goal of the research and why I wanted to interview line professionals from the surgical ward. In the first part of the meeting I showed the head information systems manager a list of technologies (Table 5):

Table 5: List of (Clinical and Augmented Clinical) Digital Health Technologies (adapted from Sharma et al., 2016)

Operating Room (Surgery) Peri-operative	An OR application that provides clinical documentation/management of relevant Real time surgery procedure, both from a OR nurses and Anesthesiologists perspective
Operating Room (Surgery) Post-operative	An OR application that provides clinical documentation/management of relevant follow-up procedures, transfers to step down units, ICUs, etc. both from a OR nurses and Anesthesiologists perspective
Operating Room (Surgery) Pre-operative	An OR application that provides clinical documentation/management of relevant pre-surgery information and patient preparation for surgery. It also provides for the management of relevant pre-surgery availability/scheduling/reservation/preparation of room, OR supplies/meds, and staff
Clinical Data Repository	A centralized database that allows organizations to collect, store, access and report on clinical, administrative, and financial information collected from various applications within or across the healthcare organization that provides healthcare organizations an open environment for accessing/viewing, managing, and reporting enterprise information
Order Entry (Includes Order Communications)	A legacy HIS application that allows for entry of orders from multiple sites including nursing stations, selected ancillary departments, and other service areas; allows viewing of single and composite results for each patient order. This function creates billing records as a by-product of the order entry function
Blood Bank	An application specifically designed to support the management and operations of a hospital blood bank. These systems require FDA certification.
Anatomical	An application that is used to manage the operations of histology and cytology departments within the pathology laboratory
In-house Transcription	Transcription functions are performed within the healthcare organization using internal resources and applications
Clinical Decision Support	An application that uses pre-established rules and guidelines, that can be created and edited by the healthcare organization, and integrates clinical data from several sources to generate alerts and treatment suggestions
Nursing Documentation	This software documents nursing notes that describe the care or service to that client. Health records may be paper documents or electronic documents, such as electronic medical records, faxes, emails, audio or video tapes and images. Through

	documentation, nurses communicate their observations, decisions, actions and outcomes of these actions for clients. Documentation software tracks what occurred and when it occurred
Computerized Practitioner Order Entry (CPOE)	An order entry application specifically designed to assist practitioners in creating and managing medical orders for patient services or medications. This application has special electronic signature, workflow, and rules engine functions that reduce or eliminate medical errors associated with physician ordering processes
Physician Documentation	The use of structured template documentation by physicians to capture any of their patient findings that are part of the electronic medical record (e.g. history and physicals, diagnostic findings, discharge notes, etc). The structured template documentation captures discreet data that is used for interaction with the clinical decision support system relative to evidence-based medicine guidelines and/or protocols. Dictation and transcription applications do not qualify as a physician documentation application for the purpose of this study
Nurse Staffing/Scheduling	An application that automates decisions about staffing, nursing stations, and scheduling nurses' time. May include functions that enable a hospital to quickly review and generate its nurse scheduling; adjust staffing and scheduling based on patient volume, acuity, and staff ability; keep records for budgeting; produce management reports on productivity and census; and maintain records on personnel qualifications
Electronic Medication Administration Record (EMAR)	An electronic record keeping system that documents when medications are given to a patient during a hospital stay. This application supports the five rights of medication administration (right patient, right medication, right dose, right time, and the right route of administration)

Indeed, to evaluate the DH adoption levels of the two healthcare organizations related to the average level of use in Italy (Table 4), I straightforwardly asked the head information systems manager of each organization, considering that both have a great experience concerning IT in hospitals because they worked in IT departments of different hospitals in Italy. After showing them the list of technologies, I asked to give us an estimation of the level of DH adoption of the hospital in comparison with the Italian context. These statements, with the first impression that I had after the visit of the hospitals and the hospital documentation such the annual report on performance and quality, absolutely revealed that Hospital B presents a higher level of information technology adoption compared to the Italian average. In particular, Hospital B was one of the pioneers in the patient case process digitalization, and as result the Healthcare Information and Management System Society assigned a level 6 out of 7 in terms of digitalization. To better understand the importance of this acknowledgement, consider that only 6 percent of hospitals in North America have a level 7 (source: www.himssanalytics.org). Furthermore, in 2012 Hospital B received the "Italian innovation prize for ICT in healthcare" in the category "business intelligence systems" from the Healthcare ICT Observatory of the School of Management of the Politecnico di Milano. Later, I organized a focus group with the head physician and the head nurse from the two wards to elucidate our need to interview both of them, the physicians and the nurses from the ward. I asked them to show us the ward, to better comprehend the context where professionals execute their activities and to take inspirations for the questions. Overall, I planned and conducted 18 interviews, 9 from both the hospitals. They encompassed 4 interviews with management professionals (head physicians and head nurses from each hospital), 6 with physicians 3 from Hospital A and 3 from Hospital B, finally 8 with nurses, four from Hospital A and 4 from Hospital B. Lastly, I made direct observation and collected and examined documentation to gain verification and supplementary information which could be matched that generated from the interviews (Yin, 2013). These interviews were audio-recorder, transcripted and studied using ATLAS.ti® software, and lasted from 30 to 70 minutes. At the end, I made within and cross-case analyses.

4.3.3 Case analysis

Open, axial and fixed coding (Strauss and Corbin, 1998) with within-case analyses allowed to bring out five distinct capabilities, having an important role in the operational

failure management. Related to these, the medical, organizational and patient-related knowledge of the worker implicated in the problem-solving have an essential role as enabler. The coding process involves different steps. In the first, I synthesized the parts of text concerning countermeasures towards operational failures, e.g. “head physician tells a nurse to execute a task he shouldn’t” or “asking the head physician for help if you have doubt”. In the second (axial coding) I created codes which represent comparable concepts, e.g. the two codes above mentioned were grouped into the collaboration between head physician and nurse code. Finally, through the third step (selective coding) it was possible to find high-level concepts which may be comprehended as capabilities, e.g. collaboration between head physician and nurse and collaboration between head physician and physician are grouped within the vertical collaboration capability.

Below, Table 6 shows the frequency of each resilience dimension and sub-dimension that surfaced during the interviews, subdivided according to interviewee’s role and the hospital, in order to demonstrate the chain of evidence which guided us in the coding activity.

Table 6: Frequencies of Evidence of Resilience Dimensions

	NURSE	HEAD NURSE	PHYSICIAN	HEAD PHYSICIAN	Tot	HOSPITAL A	HOSPITAL B	Tot
HEALTHCARE KNOWLEDGE	5	4	18	2	29	17	12	29
Experience	4	3	8	1	16	11	5	16
Clinical knowledge	0	0	4	0	4	4	0	4
Organizational dynamics	1	1	6	1	9	2	7	9
READINESS	3	0	6	0	9	6	3	9
Operational failure detection	0	0	5	0	5	3	2	5
Readiness training	2	0	0	0	2	1	1	2
Readiness resource	1	0	0	0	1	1	0	1
Forecasting	0	0	1	0	1	1	0	1
COLLABORATION	3	3	11	5	22	8	14	22
Vertical collaboration	2	2	3	2	9	6	3	9
Horizontal collaboration	1	1	8	3	13	2	11	13
FLEXIBILITY	4	3	11	3	21	11	10	21
Multi-skilled workforce	1	1	6	1	9	7	2	9
Service delivery flexibility	3	2	5	2	12	4	8	12
PATIENT-RELATED KNOWLEDGE ACAP	0	0	7	2	9	0	9	9
RESPONSE	3	0	6	2	11	7	4	11
Quick response	2	0	4	1	7	5	2	7
Response team	1	0	2	1	4	2	2	4
TOTAL	18	10	59	14	101	49	52	101

There are some evident differences between Hospital A and Hospital B. For instance, the codes clinical knowledge and multi-skilled workforce, are more recurrent in Hospital A,

whereas patient-related knowledge absorptive capacity (ACAP) and horizontal collaboration are more recurrent in Hospital B. The outcomes of this analysis will be utilized later in the research.

Concerning DH, most of the data I collected was related to three technologies, the HER, telepathology and the optical head-mounted display (OHMD) (in beta-testing phase). A meaningful difference among these systems is that the first two are regularly implemented and used by the users, while the OHMD is not used as a regular technology yet. Nevertheless, one of the reasons why I chose Hospital B is because of its status in terms of digital technologies adoption, so I decided to consider this technology in this work to expand findings which are the results of looking at the first two technologies, that are widespread in a number of hospitals. One of the most interesting findings is the linkage between these technologies and some of the resilience capabilities.

4.4 Findings

4.4.1 Healthcare knowledge

During the interviews, the medical and organizational knowledge of physicians and nurses arose as central to manage operational failures effectively, in fact line professionals execute actions as a result of and sustained by different kinds of healthcare knowledge. This knowledge can come from their working experience or from their clinical and medical studies, or even from their educational background. Consequently, even if the knowledge cannot be considered as capabilities, because of their importance I decided to consider them in the resulting framework. Moreover, I noticed that not only clinical knowledge influences the adoption of resilient capabilities, but also the knowledge concerning the dynamic and organizational aspects of the hospital and, in particular, of the ward. More specifically, three types of knowledge emerged.

I named the first as experience, namely the form of knowledge about the clinical and care processes and medicine which had been gained throughout years of works. The positive impact of professional experience in healthcare context has already been studied by different scholars (Ding, 2014). Lots of interviewees referred to professional experience as a fundamental “means” in order to overcome operational failures. One physician from Hospital A told us that, once, he/she had to perform an urgent computed tomography scan on a critical patient and that, suddenly, the machine stopped working:

“So I did another exam, an explorative laparoscopy […]. I can do it because I have done that exam in the past: while a CT is relatively harmless, exploratory laparoscopy is an invasive procedure that can endanger the patient, can lead to death. But I can do it because I have enough experience to do it safely”.

In contrast to the concept of experience, for which I found many evidences about its effectiveness in managing operational failures, I found a small number of evidences about the importance of clinical knowledge learned during university studies, master studies or higher courses. The findings prove that this type of knowledge can be coded either as know-what as know-how (Edmondson et al., 2003). One physician from Hospital A told us the in case of breakage of the suture stapler, he solves the problem by “Doing everything manually, as I used to do in the past. It’s acceptable, but it’s clear that it’s better with the stapler”. The physician knew the technique to use to suture the patient manually because: “Maybe I belong to a transitional generation, which has learned both old and new techniques; whoever learned surgery before, only knows how to employ manual techniques, while those who learned surgery later, only know modern techniques. I am among the minority who knows how to do both.” A second, interesting case concerning a very urgent surgical operation where, because of some radiology tests were missing, one physician from Hospital A operated on “a broken spleen with only one hand in the stomach, which they used to do a long time ago. This was a technique I studied”. Moreover, Furthermore, I found a third type of knowledge that seems to have an important role to be able to react to operational failures within the ward, i.e. the knowledge of organizational dynamics. This includes being aware of tacit knowledge, which includes all those non-written practices and peculiarities typical of hospitals, particular characteristics of colleagues and interpersonal relationships.

The importance of the tacit component of knowledge is already recognized by Tucker et al. (2007) and Berta and Baker (2004). For example, a physician from Hospital A told: “If I realize that I have carried out a strenuous exam and I think it is appropriate to keep the patient under observation […] I know that we have a room in the ward where we have three beds, which are not counted in the fourteen official beds of our ward. We use them for special situations, for example when a patient under observation may cause you problems after six, eight hours.” Another evidence I found is that, in order to solve operational failures, the knowledge of organizational aspects and practices linked to non-written agreements between wards. For instance, there is the possibility that a ward borrow materials and equipments from another one (“I asked for [missing suture] from

other wards," said a physician from Hospital B) or may consent a modification in the resource planning ("I verified by calling the radiology ward and asked whether the CT exam could be postponed for one hour. In this way, instead of processing our patient, radiology can process a patient from another ward and solve our departmental problem," said a physician from Hospital B).

4.4.2 Collaboration

Chowdhury and Quaddus model of resilience capabilities (2017) already includes the concept of collaboration, although it is a variable of the dimension "integration". Nevertheless, I upgraded this concept considering it as a capability, composed of different dimensions, which is a common way in the operations and supply chain management literature (e.g. Senot et al., 2016; Stank et al., 2001; Vachon and Klassen, 2008). The interviews allowed me to observe many different ways of implementing collaboration when resilience practices were executed, unfolding the complexity of this dimension.

When different employees belonging to different organizational levels, such head nurse and nurse or head physician and physician, collaborate to manage an operational failure, they are establishing a vertical collaboration. This kind of collaboration can follow two directions: top-down and bottom-up: the first when an employee belonging to a specific organizational level need help from employees from a lower level (e.g. when the head physician from Hospital A "must call a nurse as a 'third hand' during a surgical operation"); the second when an employee asks an employee belonging to a higher organizational level for help to counteract an operational failure, e.g. a nurse from the Hospital B "immediately called the anaesthetist in order to manage the allergy as soon as possible". Interestingly, an unexpected case of vertical collaboration between a nurse a patient's relative arose thanks to an interview: I found a circumstance where a particular typology of bed, which enables the nurse to move obese patients without the help of other workers, was missing, so a nurse from Hospital A was obliged to "look for help from the patient's relatives to move the patient from the bed to the wheelchair because it is absolutely impossible to do it alone".

Another type of collaboration I found is the horizontal collaboration, which is realized between employees or organizational entities belonging to the same organizational level start to cooperate in order to solve an operational failure. This kind of collaboration occurs inside the ward, for instance, between two nurses in Hospital B:

"A few days ago I had to draw some blood from an obese patient. I tried once but the blood was not coming out; I tried the second time and even in this case I wasn't able to access the blood vessel, so I decided not to try anymore […] it was painful for the patient […] and I asked my colleague for help". This collaboration can also take place between wards, for instance in the Hospital A: "If an antibiotic goes out of stock during the weekend, my colleagues borrow it from another ward, such as orthopaedics or intensive care. On Monday morning, as soon as I'm told that his occurred, I activate the procedure to restore the drug to the other ward. Anyway, it's something that happens inside the hospital, among all wards" (head physician).

I found evidences of direct linkages between DH technologies and both types of collaboration I found, vertical and horizontal, due to the augmented capacity that they provide to workers in sharing information. I found that telepathology was able to significantly support the horizontal collaboration between the researchers and the consultants of different hospitals in case of need for help due to care process complications. As said by a physician from Hospital B: "We use this technology a lot in collaboration with an American university in the case of resolving particular complications". Therefore, the technology was implemented to solve a complication, namely an operational failure, by enhancing the knowledge of the situation by means of collaboration with another structure outside of the hospital. Furthermore, I found that EHR allows an effective collaboration between nurses and/or physician in Hospital B during patient treatment, in fact by means of this technology they are able to exchange information about patients even if they are not "physically" together: "If I've got to do an urgent transplant and I'm at home, I can start seeing and studying the patient's radiological images".

4.4.3 Readiness

Lots of practices seem to be commonly implemented by healthcare workers in order to quickly noticing the operational failure occurrences. In the literature on supply chain resilience, the variable named "disruption detection", that appear in Chowdhury and Quaddus (2017), can be reasonably associated with this concept. The interesting thing is that there are circumstances in which the readiness capability is obtained by means of personal mechanisms. For instance, a physician from Hospital B said: "[…] I always like to follow my own routine of work activities; this is so standardized in my mind that, with

the activities always being the same, even if I'm distracted by something else, I will always get back to the previous point and check the results to ensure everything is alright". A dimension that seems to have a positive influence is the collaboration, in fact a physician from Hospital A said: "[…] there is a problem that is decontextualized by your routine, maybe the patient has a bronchitis that causes the fever, but you think it's because he has a perforated colon. I see a colleague who didn't start my own 'mental path' who tells me 'did you check his chest?' By being redundant we try to optimize."

The two instances I have above mentioned are unequivocal evidences of the readiness component of the resilience; at the same time, the latter could be coded as an instance of horizontal collaboration capability. In particular, by studying this evidence in more detail, I could see that collaborating with a colleague allowed the physician to be able to implement his own readiness. The consequence is that it is possible to conclude that the horizontal collaboration capability can enable the operational failure detection capability.

I have also found further instances of other readiness capability dimensions, already present in the model of Chowdhury and Quaddus (2017): they are readiness resource, forecasting and readiness training. The readiness training has the particularity that is not voluntarily implemented, but it is something that workers are forced to develop because of their critical working conditions, or the fact that they are under pressure: "[…] We're working continuously because we have enormous problems regarding the logistics, the infrastructure, the turnaround, the relationship with colleagues […] managing the exception and dealing with the urgency is our real work; thanks to this we have now created alternative guidelines in our minds," said a nurse from Hospital A.

In sum, I found that through operational failure detection, readiness resource, readiness training and forecasting, workers are able to implement the readiness capability, which is an enabler, both directly and indirectly, of healthcare resilience. In general, operational failure detection is not linked to other variable or, otherwise, it is only initiated by variables which are related to the collaboration concept, while readiness resource and forecasting enable the accomplishment of other variables to improve healthcare resilience.

4.4.4 Flexibility

Flexibility represents an important mechanism to enable the resilience of an organization; in support of this statement, the above-mentioned model of Chowdhury and Quaddus (2017) includes flexibility among its dimensions. Even in healthcare context the relationship between flexibility and resilience seems to be "strong", as demonstrated by the number of occurrences in which workers, both directly and indirectly, have highlighted the importance of its utilization. In fact, interviewees showed lots of different situations where they had faced different kinds of failure and, for each of them, they explained me the importance for the employee to be multi-skilled or for the service delivery to be flexible. In particular, throughout a multi-skilled workforce, there is the possibility to implement a quick response, that is fundamental in opposing the operational failure when it happens. Anyway, there are cases in which a multi-skilled workforce needs to be juxtaposed with a readiness resource in order to execute a quick response, for instance when "[…] the patient had to be monitored immediately, but there is only one crash cart, […] so (the nurse) had to use something different, such as a sphygmomanometer or an oximeter that we found at the time" (said a physician from Hospital A) or from collaboration, e.g. when the head nurse of Hospital A knows that "To make it work (the pulse oximeter) I need a quantity of sensors. If the sensors are missing, I am supposed to ask the head physician 'can I order the sensors?' In fact, the head physician trusts me, and there is a tacit agreement among us that I can order the sensors autonomously […] it's not reasonable that, every time, I have to ask."

Another important capability which enables resilient behavior was coded by me as service delivery flexibility. I found a particular situation, specifically insulin administration via an alternative syringe, where a nurse from Hospital B told me: "Today, however, you cannot use one syringe instead of another because you can cause even more severe failures". The use of a syringe type rather than another is a clear demonstration of the concept of flexibility that, if in case of emergency can be effective, from another side can generate dangerous situations. Indeed, there is the possibility of administering a wrong dose of the drug, precisely because of the different graduation marks of the two syringes. Consequently, although the capability to be flexible can bring benefits in terms of operational failures management, it is crucial to keep in mind the possible negative consequences and compare them with the positive ones.

The use of technology can be a valid tool to support workers' flexibility, in fact I observed how the use of OHMD allows surgeons to be “multi-tasking”. In healthcare literature, multi-tasking is considered as a skill developed by emergency department workers, as well as in other healthcare workplaces (Laxmisan et al., 2007). Multi-tasking seems to be a crucial skill for the implementation of day-to-day actions in a dynamic setting such as the healthcare one, but can lead to the occurrence of problems and errors because of the interruption of work which occur during the switch between two tasks, compromising patient safety. In sum, multitasking is, by necessity, pervasive in healthcare context, but can negatively influence patient safety (Douglas et al., 2017). At any rate, there is a specific kind of multi-tasking activity, namely interleaved multi-tasking, defined as “the management of multiple tasks in which there is switching between tasks that are progressing in parallel” (Douglas et al., 2017, p. 46), in which the simplification arising from the process of multi-tasking may decrease or limit the number of errors that happen. In fact, when I ask a physician from Hospital B to say what were the improvements gained by using OHMD, he said: “They help me because, for example, when something regarding the operation goes wrong and I need to know something about the patient, I can access it immediately just by asking my OHMD”. In sum, the surgeon was obliged by the situation to stop the activity to obtain important information, then he returned to the operation. This kind of technological glasses enabled the switch by speeding up and simplifying it, making needed information easily accessible, in fact the surgeon did not need to move from his position near the patient, or even took off gloves, just because there was no substantial interruption in the operation.

In conclusion, I found that service delivery flexibility and multi-skilled workforce are two variables of flexibility dimension, but they are differently linked to resilience: if the service delivery flexibility is directly linked to healthcare resilience, a multi-skilled workforce is often connected to other variables such vertical collaboration or readiness resource, and enables a quick response to operational failures. Moreover, it was found that service delivery flexibility can also negatively influence patient safety, leading to an operational failure.

4.4.5 Patient-related knowledge ACAP

In various circumstances it was possible to observe how important the ability to acquire patient-related knowledge was in order to achieve a quick response. For instance, a

physician from Hospital B told me that "Thanks to the OHMD, I can immediately retrieve it [patient information] and choose the best strategy", while at the same time one of the colleagues of the same hospital said "The transplant is an activity we mainly execute with urgency, it means the hospital calls us when we're at home, so on my personal computer I can see whatever I need to be ready by accessing the EHR. If I've got to do an urgent transplant, and I'm at home, I can start seeing and studying the patient's radiological images". I also observed cases in which the capability to exploit the knowledge which had just been assimilated concerning the patient was crucial to effectively avoid to cause harm to the patient, for example, a physician from hospital B said, "[telepathology] allows us to have a new opinion on histological samples which often are in line with our initial belief. This, for sure, makes us more confident and fast in making the final decision", consequently easing and improving the needed critical decision-making process in case of failure occurrence.

4.4.6 Response

In the Chowdhury and Quaddus' (2017) appears the response capability, which is associated with three variables, namely response team, quick response and effective/adequate response, all of which emerged from the interviews conducted in this research. All of these have a positive influence on the implementation of resilient practices; the quick response is performed as a consequence of other variables, for example the multi-skilled workforce. For instance, once one of the surgeons from Hospital A had a breakdown with a suture stapler and was obliged to "do everything manually, as they used to do in the past. It's acceptable, but it's clear that it's better with the stapler."

There are many ways in which DH technologies support the response capability. For instance, in case of rare and difficult clinical cases for which additional diagnostic advice are crucial, the usage of telepathology enables physicians to get a quick respond from other colleagues which are in remote places. In detail, the greatest benefit obtainable from the implementation of this technology is given by the reduction of the amount of time necessary to exchange the massive quantity of patient data: "[we use] a system through which we're able to make a medical report with images remotely, in fact, we have a place in Italy where we do particular kinds of tests and, rather than exchanging information through a CD, we use the Internet. We implement a very sophisticated system

in order to be sure that no frame will be lost during the data transmission," said a physician of the Hospital B.

Additionally, the EHR data enables the physician from hospital B regardless of where he/she is, to receive important information about patient that allow him/her to quickly decide what to do when it is time to operate: "The transplant is an activity we mainly execute in urgency, it means the hospital calls us when we're at home, so thanks to my personal computer I can see whatever I need to be ready by accessing the EHR."

Lastly, the responsiveness is positively impacted by the usage of OHMD technology because there is no need for the surgeon to interrupt the workflow, even in case of an unexpected problem-solving activity in relation to the patient: "[with these glasses] I don't need to stop the workflow because I don't need my hand to obtain the information, I only have to ask".

4.5 Discussion

Operational failures in the healthcare context are usual and healthcare organizations and wards are used to counteracting them by implementing resilient behavior, that enables them to keep working and to preserve patient safety (Fairbanks et al., 2014). In this chapter, I have tried to comprehend this behavior in depth by examining the findings of our case research through the lens of dynamic capabilities, such in Chowdhury and Quaddus (2017). In particular, by extending the findings of Tucker (2004), who identified two categories of practices, workarounds and error-handling, for solving operational failures, problems and errors, by including the conceptualization of Alter (2014), who defined workaround practices in detail, and by incorporating the work of Kontogiannis (2011), that defined a conceptual model for studying error-handling processes, I have classified the different possible capabilities that are required in case of resilient behavior deployment. These capabilities are comparable to those classified by Chowdhury and Quaddus (2017), even if a few differences can be put in evidence because of the inherent differences between supply chain and healthcare fields.

Within-case analysis has enabled me to detect the dynamic capabilities in the healthcare setting and also to find different cases where resilience practices and the behavior of the organization are promoted by a mixture of two or more capabilities. In both of the cases, I identified capabilities that impact each other, and the combination of

which enables resilience behavior. Table 7 presents the emerged linkages with some examples of interviewees' quotations from which the linkages have been coded.

The identified capabilities and the network of relationships I found are schematically depicted in Figure 3, that includes all the dimensions and linkages that emerged in Hospital A, Hospital B or in both.

Table 7: Summary of Linkages between Resilience Dimensions

Quotation	*Dimension 1*	*Dimension 2*	*Coded Linkages*
**"While the head physician was struggling to get the equipment, my co-worker started making room [within the injury] and with my hand I took the gauze and put it on, but no one told us how to react, we just relied on our familiarity with similar situations."*	*Healthcare Knowledge (experience)*	*Collaboration (vertical)*	*Healthcare Knowledge → Collaboration*
"So, I did another exam, an explorative laparoscopy […]. I can do it because I have done that exam in the past: while a CT is relatively harmless, exploratory laparoscopy is an invasive procedure that can endanger the patient, can lead to death. But I can do it because I have enough experience to do it safely."	*Healthcare Knowledge (experience)*	*Flexibility (multi-skilled workforce)*	*Healthcare Knowledge → Flexibility*
"If I realize that I have carried out a strenuous exam and I think it is appropriate to keep the patient under observation […] I know that we have a room in the ward where we have three beds, which are not counted in the 14 official beds of our ward. We use them for special situations, for example when a patient under observation may cause you problems after six, eight hours."	*Healthcare Knowledge (organizational dynamics)*	*Readiness (forecasting)*	*Healthcare Knowledge → Readiness*
"I immediately called the anaesthetist in order to manage the allergy as soon as possible."	*Collaboration (vertical)*	*Response (quick response)*	*Collaboration → Response*
"If an antibiotic goes out of stock during the weekend, my colleagues borrow it from another ward, such orthopaedics or intensive care; on Monday morning, as soon as I'm told that this occurred, I activate the procedure to restore the drug to the other ward. Anyway, it's something that happens inside the hospital, among all wards."	*Collaboration (horizontal)*	*Flexibility (service delivery flexibility)*	*Collaboration → Flexibility*
"There is a problem that is decontextualized by your routine, maybe the patient has a bronchitis that causes the fever, but you think it's because he has a perforated colon. I see a colleague who didn't start my own 'mental path' who tells me 'did you check his chest?' By being redundant we try to optimize."	*Collaboration (horizontal)*	*Readiness (operational failure detection)*	*Collaboration → Readiness*
"We use this technology in collaboration with an American university in case we have to solve particular complications."	*Collaboration (horizontal)*	*Patient-related Knowledge ACAP*	*Collaboration → Patient-related Knowledge ACAP*
"The patient had to be monitored immediately, but there is only one crash cart, […] so, [the nurse] had to use something different, such as a sphygmomanometer or an oximeter that we found at the time."	*Readiness (readiness resource)*	*Flexibility (multi-skilled workforce)*	*Readiness → Flexibility*
"Thanks to the OHMD I can immediately retrieve it [patient information] and choose the best strategy. [with these glasses] I don't need to stop the workflow because I don't need my hand to obtain the information, I only have to ask."	*Flexibility (multi-skilled workforce)*	*Patient-related Knowledge ACAP*	*Flexibility → Patient-related Knowledge ACAP*
"Do everything manually, as they used to do in the past. It's acceptable, but it's clear that it's better with the stapler."	*Flexibility (multi-skilled workforce)*	*Response (quick response)*	*Flexibility → Response*
"The transplant is an activity we mainly execute in urgency, it means the hospital calls us when we're at home, so thanks to my personal computer I can see whatever I need to be ready by accessing the EHR. If I've got to do an urgent transplant, and I'm at home, I can start seeing and studying the patient's radiological images."	*Patient-related Knowledge ACAP*	*Response (quick response)*	*Patient-related Knowledge ACAP → Response*

*It was possible to obtain more than one linkage from the same quotation/evidence.

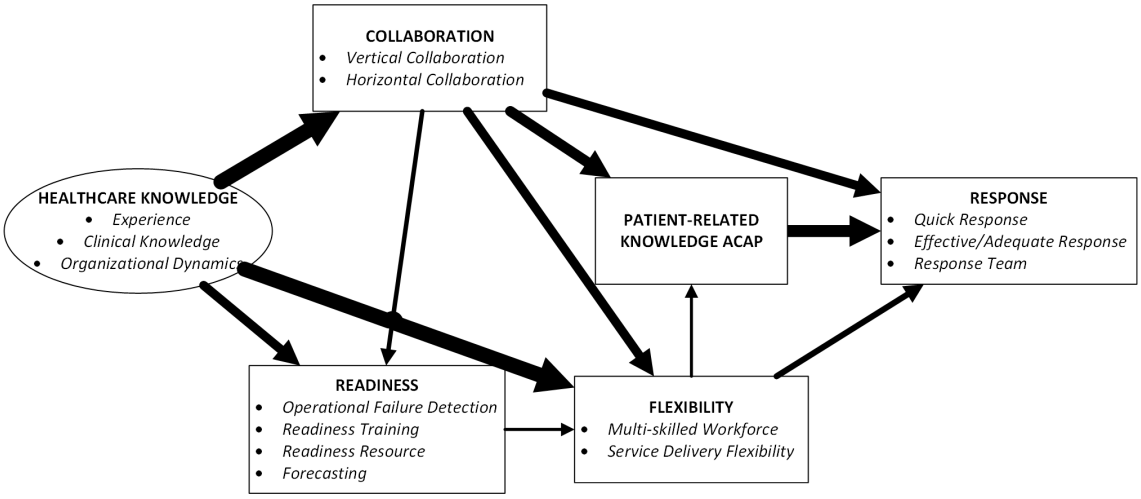


Figure 3: Dynamic Capabilities Network for Resilient Behavior in the Healthcare Domain

The thickness of the arrows specifies the how many times I found evidence of the relationship, indicating its strength. Moreover, the direction of the arrows indicates that I was told that one capability leads to another capability. Figure 3 also shows the fundamental role that nurses and physicians' medical and organizational knowledge had in enhancing resilience capabilities. This is in line with the indication of Cepeda and Vera (2007) that capabilities can be studied as "processes" based on knowledge.

The following discussion is separated into two parts. The first includes our arguments related to the findings from the within-case analysis, without distinguishing between the two cases (P1–P3), and the second presents our discussion of the findings from the cross-case analysis (P4–P5).

4.5.1 Clinical knowledge and knowledge of organizational dynamics sustains the implementation of dynamic capabilities for resilient behavior in healthcare settings

In the within-case analysis of the two hospitals, the rationale for elucidating the role of knowledge in healthcare resilience is linked to the typical roles of different kinds of knowledge content (medical or organizational) and the different kinds of knowledge sources (university/education/studies or practice/experience). I found that workers' knowledge of their hospital and ward operations and colleagues, involving the facilities, dynamics, habits and routines, personal traits and interpersonal ties, has the prospective to enable the exploitation of dynamic capabilities, allowing the organization itself to be

resilient. Often, this form of knowledge is not written down, consequently there are no official guidelines which outline and elucidate the dynamics and the practices executed in the hospital or, in particular, inside a single ward. Among the findings, one of the most robust is that the physicians and nurses' knowledge about the level to which the employees from different wards can interact with each other by making diverse requests, from borrowing material and stuff to delaying an exam, increasing the flexibility and, consequently, the organizational resilience in a substantial way. The connection between knowledge and collaboration in the healthcare context has already been investigated by Senot et al. (2016), who exposed that a collaboration between physicians and nurses is allowed by formal and informal mechanisms such as informal meetings or conversations, that enhance the extent of knowledge of the employees. Furthermore, the linkage between the level of knowledge and flexibility was studied by Laxmisan et al. (2007), that found that tacit knowledge allows physicians and nurses to execute the process of multi-tasking. I define the first proposition, graphically represented in Figure 4, using an extract from Figure 1:

P1: Individuals' knowledge of the hospital organization, operations and colleagues fosters horizontal collaboration between wards, which may increase the resilience through flexibility.

Figure 4: Dynamic Capabilities Network for Resilient Behavior, P1

Knowledge of the ward and of the hospital dynamics, in general, is not the only possible kind of knowledge that can support resilience. The medical and clinical knowledge gained from the individual's past studies and work experience is a fundamental antecedent to resilient behavior. Sometimes, as an outcome of what they had learned from university courses, some physicians could find different and alternative ways to manage a failure, for instance by retrieving some dated or out-of-practice techniques from their memory when, for some motivation, the most advanced ones could not be used because of a failure. In some cases, the university studies may enable the physician or the nurse to be multi-skilled and, therefore, can help her/him to respond quickly to the failure. This is in line

with the results of Nair et al. (2013), who uncovered that clinical flexibility enables healthcare organizations to deliver faster services. Our second proposition (shown in Figure 5) is:

P2: Individuals' clinical knowledge, acquired during university studies, increases an organization's resilience by enhancing flexibility through a multi-skilled workforce, which, in turn, increases the quick response capability.

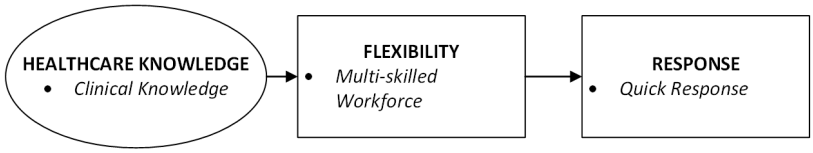


Figure 5: Dynamic Capabilities Network for Resilient Behavior, P2

Zollo and Winter (2002) specify that the experience growth process is a fundamental basis for developing dynamic capabilities and Eisenhardt and Martin (2000) state that dynamic capabilities in high-velocity markets are experiential processes. To corroborate the meaning of previous work experience for resilience, I found lots of cases in which this had assisted physicians and nurses to find solutions or had helped them to be confident about doing something that was differed from the norm. I perceived the scale and the scope of its positive influences in almost all the dynamic capabilities that determine the resilience behavior of the healthcare organization. The third proposition (Figure 6) is:

P3: Workers' (nurses and physicians) past work experience is a critical antecedent to most healthcare capabilities, which foster resilient behaviour even in the absence of collaboration.

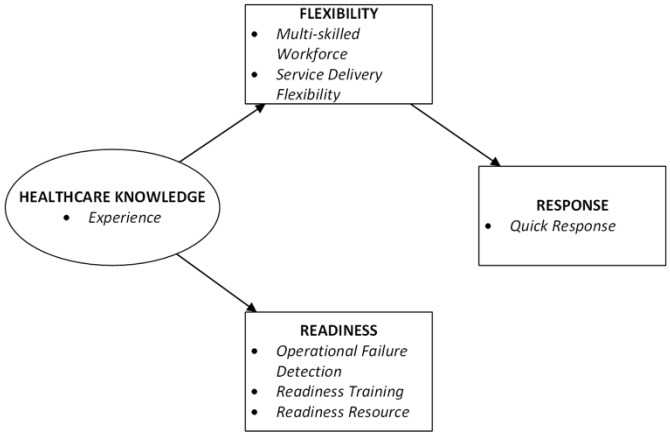


Figure 6: Dynamic Capabilities Network for Resilient Behavior, P3

4.5.2 DH technologies support resilience capabilities through stimulating patient-related knowledge ACAP

The comparison of the two cases (cross-case analysis) to describe the role of knowledge in healthcare resilience, led me to follow a rationale that is different to that resulted from the within-case analysis. Indeed, while the within-case analysis was more dedicated to the roles of different kinds of knowledge content, medical or organizational, and different kinds of knowledge sources, university/education/studies or practice/experience, the cross-case analysis enables us to examine the temporary acquisition of knowledge, assimilation and exploitation in respect of the patient's conditions and her/his clinical history, that, throughout DH technologies, were shown to have fundamental roles in the execution of resilience capabilities. In fact, I found lots of instances in which the DH technologies helped physicians and nurses to execute resilient practices. In other words, when relating the two cases, I first observe that all the quotations/observations concerning the dimension of patient-related knowledge ACAP come from professionals in Hospital B (see Table 8).

Table 8: Frequencies of Evidence of Linkages between Resilience Dimensions

Linkage	*Nurse*	*Head Nurse*	*Physician*	*Head Physician*	*Tot*	*Hospital A*	*Hospital B*	*Tot*
Healthcare Knowledge → Collaboration	*0*	*2*	*6*	*2*	*10*	*4*	*6*	*10*
Healthcare Knowledge → Flexibility	*1*	*2*	*7*	*0*	*10*	*7*	*3*	*10*
Healthcare Knowledge → Readiness	*3*	*0*	*3*	*0*	*6*	*4*	*2*	*6*
Collaboration → Response	*2*	*0*	*2*	*1*	*5*	*2*	*3*	*5*
Collaboration → Flexibility	*0*	*2*	*2*	*2*	*6*	*3*	*3*	*6*
Collaboration → Readiness	*0*	*0*	*3*	*0*	*3*	*2*	*1*	*3*
Collaboration → Patient-related Knowledge ACAP	*0*	*0*	*5*	*2*	*7*	*0*	*7*	*7*
Readiness → Flexibility	*2*	*0*	*0*	*0*	*2*	*1*	*1*	*2*
Flexibility → Patient-related Knowledge ACAP	*0*	*0*	*2*	*0*	*2*	*0*	*2*	*2*
Flexibility → Response	*1*	*0*	*3*	*0*	*4*	*4*	*0*	*4*
Patient-related Knowledge ACAP → Response	*0*	*0*	*6*	*2*	*8*	*0*	*8*	*8*
TOTAL	*9*	*6*	*39*	*9*	*63*	*27*	*36*	*63*

More specifically, in line with the arguments of Raymond et al. (2017), in approximately all of the analyzed workaround and error-handling practices where DH was used, this seemed to improve the role of nurses and physicians' knowledge in handling the failure. In particular, I observed that the knowledge that was improved by DH technologies was not knowledge of the hospital or the ward routines and dynamics, nor the medical and

clinical know-how acquired throughout studies or work experience, it was knowledge of the patient's medical conditions and history. Figure 5 depicts the connections among the nascent dimensions, where the gray-colored dimensions come from Hospital B only.

As indicated in Figure 5, there is a central difference between the employees use of the two sorts of knowledge. While clinical and organizational knowledge are the points of departures that let physicians and nurses to acquire dynamic capabilities, namely collaboration or flexibility, on the other hand, knowledge of the patient's medical conditions is attainable as an outcome of collaboration and flexibility. These, at the same time, are enabled by DH, in fact technology enables the collaboration, between the physician and another physician in another hospital, that enables the acquisition and exploitation of the knowledge about the patient. In sum, I define the following proposition:

P4: In order to implement a resilient practice, the clinical and organizational knowledge act as starting points for the acquisition of different dynamic capabilities; conversely, by increasing physicians and nurses' ACAP, dynamic capabilities are crucial for acquiring and exploiting knowledge of patients' conditions.

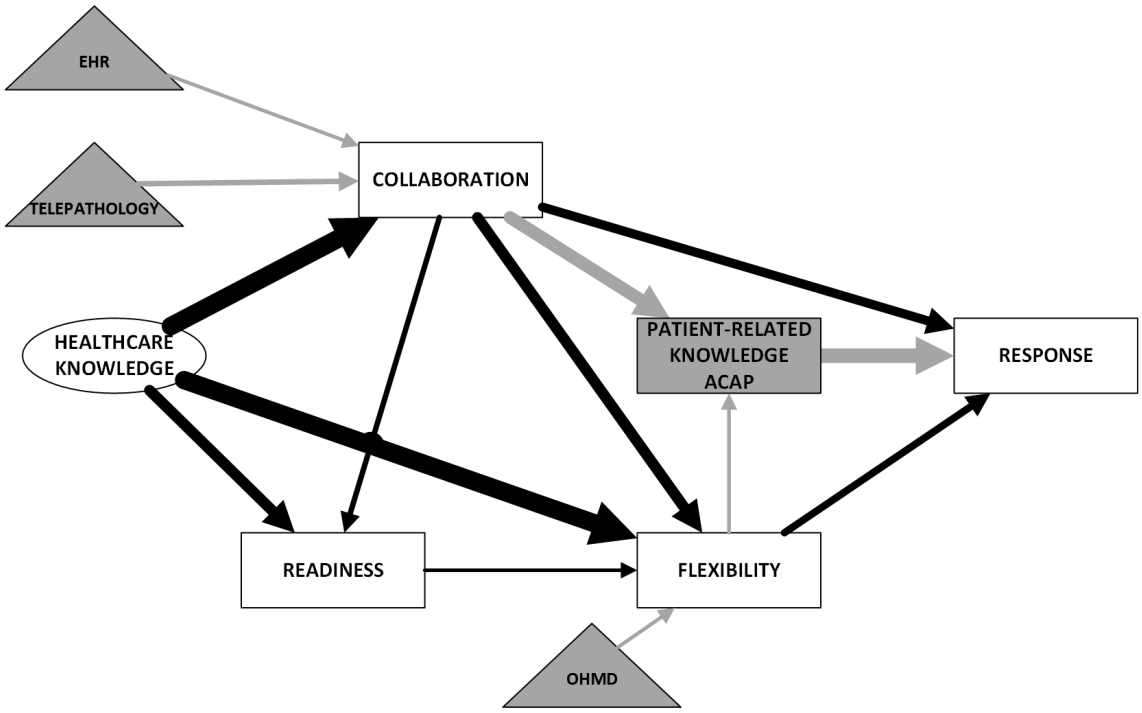


Figure 7: Dynamic Capabilities and DH Network for Resilience Behavior in the Healthcare Domain

More in detail, I observed that this kind of ACAP raises the response capability and is raised by other dynamic capabilities, specifically, flexibility and collaboration. The first link is between EHR and telepathology technologies with the collaboration capability (Figure 7). Indeed, whenever these two technologies were used to manage an operational failure, they enabled physicians and nurses to acquire knowledge through the collaboration with other colleagues, as a result of which they could implement a quick response. The next proposition (Figure 8) is:

P4a: The EHR and telepathology technologies enable the collaboration among physicians and nurses. This increases their patient-related knowledge ACAP, which, in turn, supports the quick response capability when an operational failure occurs.

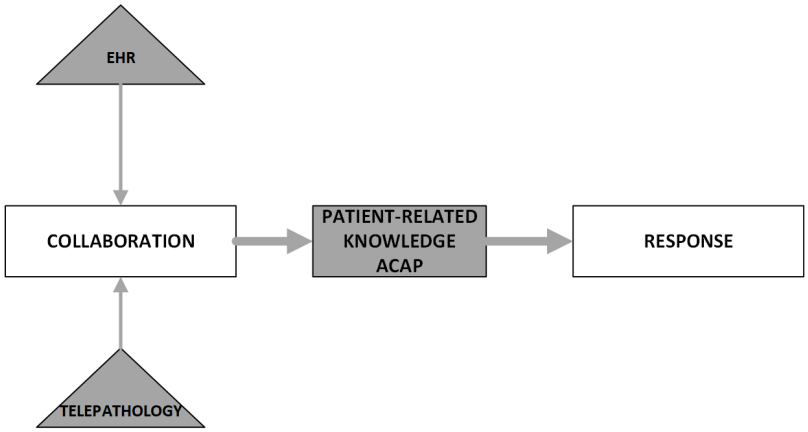


Figure 8: Dynamic Capabilities and DH network for Resilience Behavior in the Healthcare Domain, P4a

Last but not least, I found that the OHMD sustains the flexibility of the physician, who, for example, can execute different activities at the same time. Even if in some circumstances multi-tasking should be prevented, there are situations where this is not feasible, for instance, when it concerns "those activities that cannot be eliminated nor delegated but have to be handled by people" (Laxmisan et al., 2007, p. 809). I found evidence of the implementation of OHMD in situations where there was no possibility of removing or assigning activities: for instance, during surgery, the surgeon's liability often compels him to acquire first-hand patient-related information to continue the operation. In these circumstances, the OHMD may be considered as a cognitive artifact. "Cognitive artifacts, defined as physical objects made by humans for the purpose of aiding, enhancing, or improving cognition, can play an important role in helping the clinicians"

(Laxmisan et al., 2007, p. 809). In conclusion, by easing multi-tasking, DH encourages resilience behavior and this is not only because of its positive impact on collaboration. Hence, the next proposition (Figure 9) is:

P4b: The OHMD technology supports the flexibility of physicians. This increases their patient-related knowledge ACAP, which, in turn, supports the quick response capability when an operational failure occurs.

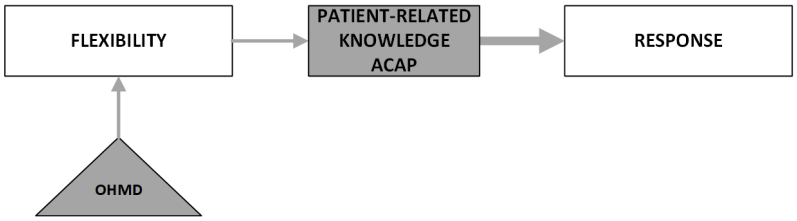


Figure 9: Dynamic Capabilities and DH Network for Resilience Behavior in the Healthcare Domain, P4b

The function that DH has in enhancing resilience by means of knowledge of the patient's medical conditions can, in fact, be inferred through the lens of the ACAP theory, which states the capacity of an organization to acquire and exploit knowledge in order to obtain a competitive advantage (Cohen and Levinthal, 1990; Zahra and George, 2002). In particular, I found cases where DH technologies enable employees to acquire knowledge, others where they sustain its assimilation and others where it is convenient for exploitation. This is in accordance with the findings of Raymond et al. (2017). who, in the healthcare management context, contextualize ACAP in IT-based clinical knowledge management and find that in primary healthcare, e-learning and EHR capabilities enable clinicians to acquire and exploit clinical knowledge. I found, for instance, that by enabling fast access to the patient's file, EHR permits the fast acquisition of knowledge related to her/his medical state and history, that (as already noted) – is remarkably important in case of operational failure occurrence. In addition, the OHMD sustains the acquisition of knowledge and its exploitation: I was told by physicians that they may use in real time what they are learning about the patient from the OHMD, with no need to interrupt the workflow. I, therefore, state:

P5: DH technologies promote the implementation of resilient practices by enabling, supporting and speeding up the acquisition, assimilation and exploitation of patient-related knowledge during the management of an operational failure.

The findings above analyzed have the possibility to give valuable contributions to previous literature and meaningful consequences to healthcare managers that aim to improve patient safety management (that are discussed in the final chapter of this thesis). These results represented the starting point for the building of the conceptual framework at the base of the research depicted in the following chapter. In fact, the following research uses a quantitative methodology, with the collection of data based on survey, in order to confirm the results qualitatively obtained in this chapter.

Chapter 5

ABSORPTIVE CAPACITY INCREASES HEALTHCARE RESILIENCE: UNFOLDING THE RELATIONSHIP BETWEEN DIGITAL HEALTH AND PATIENT SAFETY

5.1 Introduction

This chapter is based on the research article titled “Absorptive Capacity increases Healthcare Resilience: unfolding the relationship between Digital health and Patient Safety” and it purposes to reveal if Digital health improve Patient safety (Rubbio and Bruccoleri, in review). This article can be considered as the "continuation" of the one mentioned in the previous chapter: in fact, I aimed to translate the already identified relationships quantitively. Specifically, this chapter explores how healthcare organizations can improve patient safety by through resilience by increasing their absorptive capacity thanks to the implementation of various digital technologies.

The relevance of the study is attributable to the more and more extended usage of DH in healthcare organizations, that leads to analyse its influence on healthcare processes. Scholars that have already studied the phenomenon found very different results (Froehle and White, 2014; Gardner et al., 2015; Sharma et al., 2016b); furthermore, there are no studies which relate DH and resilience concept.

In this chapter I present an analysis which examines the way in which different mechanisms concerning the relationships between healthcare workers and DH; to do this, I conducted a multi-respondent survey addressed to healthcare organizations operating in the Italian context. The multi-respondent nature of the research allowed me to investigate the relationships between very different dimensions, each of them is related to a different group of healthcare workers, but continuing to considerate the healthcare organization/hospital as the unit of analysis of the study. In fact, while for some dimensions and variables linked to DH I was forced to consider as respondent the Health Information Technology (HIT) specialist of the hospital, for other dimensions I had to consider the point of view of the physicians and/or nurses or that of the managers of the organizations. After data collection, I used the SEM in order to validate hypotheses.

The chapter presents four sections. Initially, I introduce the conceptual framework and the definition of the hypothesis. Next, I explain how I conducted the empirical study presenting how I designed the questionnaire, the sample data, their collection and the adopted measures, the SEM analysis and the results. Finally, in the last section the obtained results are discussed.

5.2 Definition of a conceptual framework to investigate the role of digital health in improving patient safety

The hypotheses proposed in this chapter aim to disentangle the multifaceted and indirect link between digital health adoption in a healthcare organization and its resilience, mediated by the patient-specific knowledge absorptive capacity of its line professionals and managers. In the following sections I am going to explain the ratio of the two set of hypotheses that I aim to ascertain.

5.2.1 Hypothesis 1: The relationship between Absorptive Capacity and Resilience

Healthcare services, which are *professional* in nature, have features (such as high customization and process variation) which make them subject to changing situations and their evolution very hard to predict (Dobrzykowski et al., 2016a). Hence, dynamic capabilities are fundamental to survive in this setting. Specifically, the *operational failures* are an significant source of variability within care processes (Tucker, 2004). The type and nature of operational failures can be very different: from the impossibility to get in touch with the doctor because the phone of the ward temporarily crashed, to the occurrence of patient's condition never seen before. An operational failure, for definition, is a *problem* (e.g., a missing syringe) or an *error* (e.g., wrong medication) that arise during the delivery of the healthcare service. Dynamic capabilities, by increasing the healthcare organization's potential to timely solve problems and face unexpected and new situations, are strongly required to counteract operational failures.

Resilience is described as "the ability to anticipate, prepare for, respond and adapt to events – both sudden shocks and gradual change; that means being adaptable, competitive, agile and robust" (British Standard Institution, 2014); therefore, a resilient worker/organization is supposed to have the ability to cope with a sudden shock (e.g., an operational failure) being malleable and robust. Resilience, because of its intrinsic

characteristics, in the recent past has been framed by scholars such as a dynamic capabilities. (Chowdhury and Quaddus, 2017; Dabhilkar et al., 2016; Kamalahmadi and Parast, 2016; Sutcliffe and Vogus, 2003); the common characteristics between the two concepts is visible in Chowdhury and Quaddus (2017) where the dynamic capabilities to sense, reconfigure and transform resources "*can be viewed as the resilience capabilities of the organizations* […] *to overcome these* [environmental] *turbulent changes*".

Because of the highly dynamic and uncertain context, care processes involve frequent quasi-real-time decision making activities which are based on the combination of line professionals' expertise and the volume and worth of their knowledge base (von Nordenflycht, 2010). Acknowledging the importance of a knowledge grounded on real facts, for years evidence-based medicine (with its systematic methods) was the key source of knowledge for practitioners (Ferlie et al., 2012; Lambert, 2006). Evidence-based medicine and clinical knowledge refer to the body of knowledge which is broadly applicable to decisions about how to deal with multiple patients and public health policies (encompassing evidence-base knowledge). Contrarily, patient-specific knowledge (PSK) regards patient-specific data and refers to personal patient case history. In fact, the integration of clinical knowledge and patient-specific knowledge is important to make healthcare services effective (Chakravarty, 2014b).

I already said that being resilient against an operational failure in healthcare asks for fast and reactive reaction of line professionals and managers who need to make real-time decisions about what to do and how to solve the problem or handle the error. The body of clinical know-how and experience of the decision maker is indisputably crucial in this situation. However, no matter how much is wide and deep her/his clinical know-how, without precise data on the patient conditions, history, and characteristics it will be very difficult for the line professional to make quick decisions or take effective counter-actions in case of operational failures. In other terms, when an operational failure occurs, knowing as much as possible about the patient, whose safety is threated by possible consequences of the failure itself, is very essential.

Studying the line professionals and managers' capacity to access, acquire, assimilate and exploit PSK is thus very important to comprehend the whole healthcare systems resilience capability. To this purpose I use the concept of absorptive capacity (ACAP) of an organization. ACAP is defined as the dynamic capability of an organization to acquire and exploit the knowledge in order to obtain a competitive advantage (Zahra and George, 2002). ACAP has been largely considered a dynamic capability; as such, it

helps the organization to use/reconfigure available resources and supports problem-solving by helping make timely and customized choices (Barreto, 2010). Considering the above-mentioned argumentations, I state that PSK ACAP of physicians, nurses and managers of a healthcare organization, defined as the capability to rapidly acquire and exploit knowledge about a specific patient (e.g., her/his clinical conditions), has the potential to support the organization in implementing resilient practices to solve operational failures, because it allows practitioners to make timely, appropriate, effective and patient-specific choices that are necessary to stop the chain of unwanted events and the risk of harm.

H1: Patient Specific Knowledge Absorptive Capacity of a Healthcare Organization is positively associated with its Resilience Capability

5.2.2 Hypothesis 2 set: The impact of Digital health on Absorptive Capacity

With the term DH I include all the technologies used in healthcare domain included in categories such as mobile health, health information technology, wearable devices, telehealth and telemedicine, and personalized medicine (U.S. Food and Drug Administration, 2019). As a matter of fact, the studies that evaluate the advantages of DH adoption in healthcare in terms of operations performance offer contradictory results (Chaudhry et al., 2006; Sharma et al., 2016a). Furthermore, I found that those studies that analyse the impact of DH on patient safety often focus on information systems that are used by clinical risk managers or quality managers (e.g., incident reporting systems) or concentrate on the hospital use of error data for detecting and reducing hospital errors (e.g., in Gardner et al., 2015). Contrarily, I believe it is worth wondering: what is the effect of those digital technologies that are used during, and in support of, a surgery operation on the risk of harm for the patient? Can a nurse or a physician take advantage from the electronic health record of a patient in order to rapidly retrieve data on her/his very recent health conditions and biometric parameters with the aim to make a more "informed" decision to solve some just happened failure?

In fact, there are plenty of DH solutions that, although not properly designed to support clinical risk management practices, may potentially improve patient safety by supporting line professionals in their day-to-day tasks by enhancing their PSK ACAP. DH has already been considered a means to improve knowledge management and organizational learning, and to enhance dynamic capabilities (Sher and Lee, 2004). In

healthcare setting, the adoption of DH has the potential to facilitate the absorption of patient-specific information in a more effective and rapid way (Hopp et al., 2018), thanks to two mechanisms.

First, a widespread *usage* of DH within a healthcare organization (in term of "who" use it and "for what") may enable the capability of the organization to learn and accumulate knowledge (Queenan et al., 2011), but also to exploit it; in fact, the use of "ancillary health information technology applications" such as radiology and laboratory systems may support line professionals decision-making processes by means of a more effective patient-specific information flow (Bardhan and Thouin, 2013). The importance of distinguishing DH usage vs. proxy of its simple adoption, has been stated by a number of scholars. Devaraj and Kohli (2003) stated the level of investment in DH is not sufficient in order to assess the performance obtainable thanks to DH, but it is fundamental to consider also how DH is used; Yaraghi et al. (2015) investigated how a number of drivers affect DH adoption and usage separately, highlighting the difference between these constructs formulating, case by case, different hypotheses.

Second, the level of DH *accessibility* (in term of how it is ubiquitous, then how quickly and easily the worker can access the DH) allow the organization to use new knowledge more effectively and provide better services (Roberts et al., 2012). The high intensity of communication and collaboration among line professionals during operations is a peculiar characteristic of healthcare domain (Lenz et al., 2002; Mihailidis and Bardram, 2006) and some DH are designed to facilitate practitioners in the timely sharing of worth information. Furthermore, today, healthcare information system allows physicians and nurses to have fast and easy access to patient information (Berg, 2002); in particular, *e-health* technologies allow information to be delivered or enhanced through internet and related technologies (Ruiz Morilla et al., 2017): for example, the use of mobile technologies may enable physicians to access patient-specific information in very different places, with significative improvements in terms of knowledge acquisition (Mickan et al., 2013; Ventola, 2014). Furthermore, an improved access to DH may impact on the realized ACAP based on the capacity to transform and exploit knowledge (Raymond et al., 2017). In fact, these capabilities are closely related to the operations executed by line professionals, because they involve the routines that coordinate the medical tasks required to perform clinical activity (Grimaldi et al., 2013). Consequently, the possibility to have an immediate and easy access to information through the DH may impact on the operational activities executed by line professionals, by changing their

routines and procedures used to combine existing and new knowledge and to transform it into operations (Zahra and George, 2002).

Therefore, I state that DH usage and accessibility may allow practitioners to acquire and exploit patient-specific knowledge faster, thus increasing healthcare organization's PSK ACAP:

H2a: Digital health Adoption is associated to Patient-Specific Knowledge Absorptive Capacity through the mechanism of Digital health Usage

H2b: Digital health Adoption is associated to Patient-Specific Knowledge Absorptive Capacity through the mechanism of Digital health Accessibility

Figure 10 summarizes the hypothesized conceptual model grounded on the theoretical lens of the dynamic capabilities view. The operationalization of each construct is discussed in the next section.

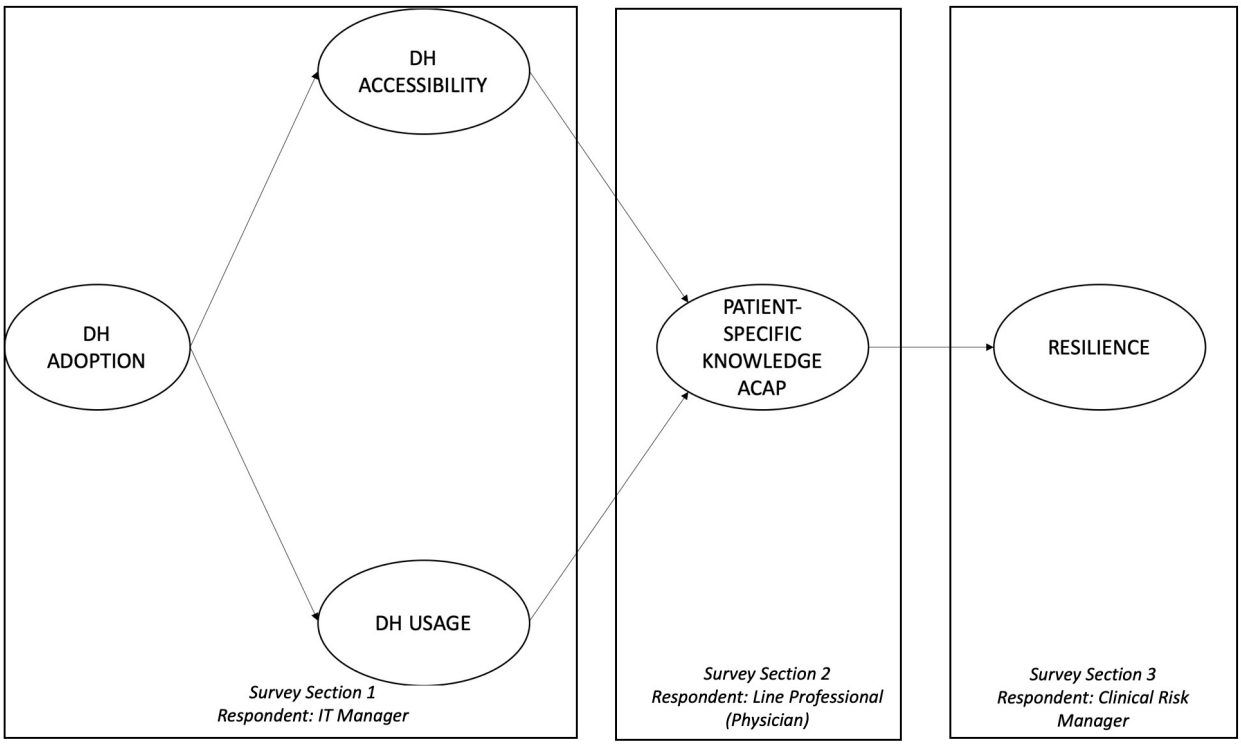


Figure 10: Theoretical Model

5.3 Empirical investigation of the role of Digital health in increasing Resilience through secondary data analysis

5.3.1 Questionnaire Design and Pilot Test

To test the hypotheses, I collected primary data through an *ad-hoc* designed multi-respondent survey, where the healthcare organization is the unit of analysis (questionnaire items in Table 9).

The questionnaire consists of three different sections, each of them designed for a type of respondent (Figure 10). The questions listed in the Section 1 aim to measure the level of DH adoption, usage, and accessibility within the healthcare organization; the respondent is the Information Technology (IT) manager. The questions listed in the Section 2 aim to assess the PSK ACAP within the organization; the respondent is a line professional (either a physician or a nurse). Finally, the questions listed in the Section 3 aim to assess the level of resilience within the healthcare organization; the respondent is the clinical risk manager. Using a multi-respondent survey reduces as much as possible the common method bias; furthermore, asking the questions to specialists increases the reliability and the worth of the answers.

I showed the first draft of our questionnaire's sections to two experts/consultants of digital health, then to a head physician, and to a clinical risk manager. Thanks to their comments and suggestions, I added, deleted and revised some items and some terminology (in particular the parts of the survey directed to the IT manager and the clinical risk manager). I was also suggested to include, at the beginning of each questionnaire section, a glossary for ambiguous words such "adverse events" or "operational failure". Later, I sent the mails containing the survey to four healthcare organizations for a pilot test, to assess if they had problems or troubles in answering the questions. I did not need to modify the survey after reading both the answers and the feedback from the respondents.

5.3.2 Sample, data collection and measures

The population of the study is represented by 575 Italian hybrid public-private hospitals (the whole Italian population) listed into a dataset freely downloadable from the Italian Ministry of Health's website. I decided to focus only on hybrid public-private healthcare

Table 9: Questionnaire Items

CONSTRUCT	MEASUREMENT ITEMS	SCALE	SOURCES	RESPONDENT
DH ADOPTION	(List of questions regarding the functionalities present in the computerized medical record) • Intake form • Patient's clinical history • Allergy/Intolerance • Patient's pharmacological therapy history • Problem list • Physical examination • Pain profile • TEV risk evaluation • Physician's daily records • Pharmacological therapy management • Antineoplastic therapy prescription • Nursing folder • Vital parameters • Nursing daily records • Rehabilitation folder • Reports/consultancy • Blood components management • Histological management • Room allocation • Discharge report • Surgical report management • Health records • Specialist examination management • Ward "take in charge" • Transfer • Surgical operations and diagnosis • Hospital discharge form closing • Hospital discharge form joint review • DRG computation • Hospital discharge form flow • Interface with lab • Interface with radiodiagnostic	YES/NO	HIMSS	IT Manager
DH USAGE	• dhusa_1: Few departments use a DH • dhusa_2: Many of the functionalities and modules available in the SI in the departments are used	5-point Likert scale	Queenan et al., 2012	IT Manager
DH ACCESSIBILITY	• dhacc_1: You can access the SI via smartphone / tablet • dhacc_2: It is possible to access the SI from a few locations • dhacc_3: There are terminals inside the inpatient rooms that allow access to the Computerized Medical Record or to the SI	5-point Likert scale	Ruiz-Morilla et al., 2017 Experienced IT Managers	Physician/Nurse

PATIENT-SPECIFIC KNOWLEDGE ACAP	• pska_1: Patient information can be accessed very quickly • pska_2: Patient information is very clear • pska_3: Information about the patient to whom I have access rarely is useful • pska_4: Through the available information on the patient, it is often possible to find the most appropriate way to act • pska_5: Through the available information on the patient, if the most appropriate way to act is found (see previous question), it is often possible to act in this way • pska_6: New patient information is rarely compared to previous ones	5-point Likert scale	Lichtenthaler 2009; Zahra and George, 2002; Pavlou and El Sawy, 2006; Jansen et al. 2005	Physician/Nurse
RESILIENCE	• res_1: A DELAYED INTERVENTION / TREATMENT has often led to an ADVERSE EVENT • res_1: A RETARDED INTERVENTION / TREATMENT often led to a SENTINEL EVENT • res_2: A DIAGNOSIS / TREATMENT NOT MADE has often led to an ADVERSE EVENT • res_2: A DIAGNOSIS / TREATMENT NOT MADE has often led to a SENTINEL EVENT • res_3: ADMINISTRATION OR INTERRUPTION OF PHARMACIES (administration of analgesic or anticoagulant, interruption of a diuretic, etc.) ASSOCIATED WITH PROBLEMATIC CONDITIONS OF THE PATIENT (presence of a hematoma, low platelet count, congestive heart failure, etc. ..) often led to an ADVERSE EVENT • res_3: ADMINISTRATION OR INTERRUPTION OF DRUGS (administration of analgesic or anticoagulant, interruption of a diuretic, etc ...) ASSOCIATED WITH PROBLEMATIC CONDITIONS OF THE PATIENT (presence of a hematoma, low platelet count, congestive heart failure, etc. ..) often led to a SENTINEL EVENT • res_4: A SURGICAL INTERVENTION / SURGICAL PROCEDURE / INVASIVE EXAM (colorectal surgery, thoracic tube removal, cystoscopy, colectomy, etc ...) WITH CONSEQUENT COMPLICATIONS often led to an ADVERSE EVENT • res_4: A SURGICAL INTERVENTION / SURGICAL PROCEDURE / INVASIVE EXAM (colorectal surgery, thoracic tube removal, cystoscopy, colectomy, etc ...) WITH CONSEQUENT COMPLICATIONS often led to a SENTINEL EVENT • res_5: THE USE OF AN INVASIVE MEDICAL / SURGICAL PRESIDIUM (venous catheter, etc ...) often led to an ADVERSE EVENT • res_5: THE USE OF AN INVASIVE MEDICAL / SURGICAL PRESIDIUM (venous catheter, etc ...) often led to a SENTINEL EVENT • res_6: An ERROR (haemorrhage of the femoral artery at the injection site, intravenous volume overload, excessive saline administration, inhalation of external material, etc ...) often led to an EVENT EVENT • res_6: An ERROR (haemorrhage of the femoral artery at the injection site, intravenous volume overload, excessive saline administration, inhalation of external material, etc ...) often led to a SENTINEL EVENT	5-point Likert scale	Coding of cascade events in Levinson (2010)	CR Manager

organizations and not on the pure public Italian healthcare organizations because of the nature of our research and because of the way the Italian public healthcare system is structured.

On the one hand, our research focuses on operational aspects of patient safety, on the reaction of nurses and physicians to operational failures, on how digital health is used by line professional to solve problems and access patient-specific knowledge. Our survey is, in fact, designed to ask questions to nurses and physicians, but also to clinical risk managers and IT managers who has daily contact with operations and with the care process; our survey is designed to measure dimensions that strictly relate to day-by-day tasks executed during the delivery of care processes. Consequently, the respondents have to be experienced and constantly "in touch" with operations.

On the other hand, in Italy, pure public healthcare organizations are very large and often, if not always, each single organization includes many hospitals, clinical structures, and other medical units grouped by region or province. Each organization has one clinical risk manager and one IT manager, who sit in the headquarter offices and not frequently spend time within operative units. Also, DH adoption and usage may be very different within different medical centres of the same healthcare organization. Conversely, hybrid public-private healthcare organizations are smaller and most of the time include only one healthcare facility. The average number of beds of Italian private-public organizations is 110.83; of Italian pure public organizations is 297.07. In this type of organization, although both IT manager and clinical risk manager occupy managerial positions within the organization, they are more likely aware of operations executed by line professionals of the hospital, they are in direct contact with line professionals, knowing clinical procedures, activities and tasks in more depth.

Starting from the official list of Italian hybrid public-private hospitals, I first built up a dataset containing basic registry data of each healthcare organization, such as geographical location, number of beds, and other hospital data. I then looked for and collected data about their e-mail address and phone number on their official website. I contacted by phone and by email every organization of the dataset, introducing ourselves, the aim of the research and asking for clinical risk manager's telephone number or e-mail address. I decided to have a direct contact with the clinical risk manager because of her/his professional interest in the theme of patient safety, but also because I believe he/she could better understand the aim of the research and stimulate the interest of her/his colleagues in participating at the survey. After I got her/his contact, I phoned or mailed her/him,

introducing ourselves and the purpose of the study, explaining the structure of the survey and specifying who had to be the respondents. To incentivize the participation, I promised I would have shared with them the results of the research. Once the hospital accepted to participate in the research, I sent the mail containing the link to the web-based survey. The clinical risk manager was given the duty to answer the questionnaire for Section 3 and to send the questionnaire to the its colleagues (IT manager and line professional) for answering respectively Section 1 and Section 2. Four weeks after sending the mail, I sent a reminder mail in case of missing answer by at least one of the three respondents. At the end of the process, I collected 159 responses, constituting complete responses of 53 different healthcare organization, approximately the 9.2 % of the entire population. Table 10 reports some descriptive statistics of the sample and the whole population.

Table 10: General Sample and Population Statistics

		Sample	Population
n. of organizations		53	575
geographical distribution	South	43%	37%
	Center	21%	21%
	North	36%	42%
Age (years)	<20	21%	21%
	21-50	44%	54%
	>50	35%	25%
n. of beds (avg.)		118.6	110.13

The key constructs in our conceptual framework are DH adoption, DH usage, DH accessibility, Resilience, PSK ACAP. In this section, I report more detailed information about these constructs, their operationalization and the measurement scales.

5.3.2.1 Resilience

Resilience is the dependent variable of this study. To measure it, I look at the occurrence of a specific kind of events, namely the "cascade events" (Levinson, 2010). A cascade event is a set of events, each causing another; it involves a start event (an operational failure), which usually is not an adverse event (for instance an anticholinergic class drug administration), which unfortunately causes a series of other events till the adverse event; this set of events can be considered as collapsed into a single (cascade) event. A resilient organization should be able to manage a cascade event in such a way

that the chain of events does not transform into an adverse event, thus avoiding that the initial operational failure turns into a patient harm. Cascade events have been observed on-site and described in detail by Levinson (2010); basing on Levinson's analysis, I developed 6 categories of cascade events, distinguished by the type of start event that triggers the flow of events. I measured resilience by asking the clinical risk manager how much frequently (in a Likert scale) in her/his hospital each type of start event leads to the occurrence of an adverse or sentinel event; consequently, the higher the frequency, the lower will be the level of resilience.

5.3.2.2 DH adoption, DH usage and DH accessibility

To measure the level of DH adoption, a list of healthcare information systems was shown to the respondent (IT manager), who had to flag which of these are implemented in the hospital. Previous researchers measured the level of adoption of information and communication technology in a healthcare organization by assessing how many of types of information systems are installed and used within the organization (Bardhan and Thouin, 2013; Menachemi et al., 2008; Sharma et al., 2016). To this purpose, authors usually refer to a list of different types of systems (e.g., electronic health record, CAT). I followed a similar approach and referred initially to all the technologies listed in the Health Information Management System Society (HIMSS) dataset (https://www.himss.org). The HIMSS dataset, available from the HIMSS foundation upon request, provide meaningful and wide information on the adoption of very different kind of technologies/applications within the healthcare context in the US (Menachemi et al., 2008). This dataset has already constituted a meaningful source of data for a number of OM studies (e.g. Gardner et al., 2015 and Sharma et al., 2016). The 106 listed technologies/applications of the HIMSS are clustered in 23 very different categories, ranging, for example, from "Ambulatory" to "General Financials". For the purpose of this study I focused only on a subset of technological applications within the database. A first skimming occurred by dropping those technologies which, obviously, cannot help line professionals to increase their resilience, such as "Spam/Spyware Filter" applications. Then, with the help of two consultants/experts on digital health in healthcare, I delineated the technologies that were suitable with the purpose of the study and that were likely implemented by the Italian hospital. Consequently, at the end of the process, I selected 32 different systems/applications potentially impacting in terms of resilience. I used 32

binary items, one for every system/application, and asked the IT manager whether each of them is adopted by the healthcare organization. In other words, I measured DH adoption by counting how many systems/applications were selected by the respondent.

Apart from DH adoption, in our model I also considered other two variables related to DH: (i) the usage of the DH (2-items), (ii) the accessibility of the DH (3-items). The items of (i) aim to assess the extent of usage of DH in terms of number of functionalities and wards/units that use DH. In order to create the questions related to the two previous items, I took insights from the questions defined by Queenan (2011) in order to evaluate the extend of use the CPOE technology, but considering that in this work I aim to assess the extent of use of a number of technologies within the hospital, I adapted them. The items of (ii) refer to the presence of different devices enabling an easier and faster access to information. In order to define the questions, I started from the definition of e-health functionality provided by Ruiz Morilla et al. (2017, p. 1) "[…] the access to health resources and healthcare by electronic means". Furthermore, with the support of two consultants/experts on digital health in healthcare, I operationalized this concept by defining three different questions (see Table 9).

5.3.2.3 PSK ACAP

To measure the level of PSK ACAP within the healthcare organization, I developed the questionnaire items grounding on the works on ACAP of Zahra and George (2002), Lichtenthaler (2009), Pavlou and El Sawy (2006), and Jansen et al. (2005). I measure both the dimensions *potential* (PACAP) and *realized* (RACAP) absorptive capacity (Zahra and George, 2002); the former points to the ability to acquire and assimilate knowledge, the latter pertains to the potential to transform and exploit knowledge.

PACAP is a three-items measure: it aims to assess the acquisition and the assimilation of patient-specific knowledge. In particular, these items aim to quantify how easy is to access patient information and what is its value and usefulness. Even RACAP is a three-items scale: the objective is to measure the transformation and the exploitation of patient-specific knowledge. Items for the transformation of patient-specific knowledge focus on the capability to understand what to do by means of the available patient-specific information, while items for the exploitation of knowledge focus on the effective possibility to make use of patient-specific knowledge in practice.

5.3.2.4 Controls

I used four control variables which may be correlated to the level of hospital resilience and, more in general, to patient safety performance. First, I controlled for the level of usage of software systems supporting infrastructural activities (e.g., administration, accountability, reporting), i.e. software that are not directly used by line professional during the care processes. I controlled for this variable because these software systems may influence the clinical risk management capabilities and, consequently, patient safety. I made two five-points Likert scale questions, asking how many functionalities provided by the software for the administration and management of statistics are used and how many functionalities provided by the software for clinical risk management are used. Second, I included the number of beds as a proxy of hospital size. This because a bigger healthcare organization has the possibility to use more resources in order to reduce the number of errors (Mcfadden and Gowen III, 2015) and, consequently, the number of cascade events. Third, I controlled for the case-mix index (CMI) of the organization; this is a synthetic measure of the average severity of illness of the patients within the healthcare organization. I controlled for CMI because higher CMI values may lead to higher probability of cascade events occurrence. Fourth, I controlled for the number of adverse and sentinel events, because, similar to CMI, higher number of adverse events or sentinel events could mean high number of cascade events.

5.3.3 SEM analysis

5.3.3.1 Scale Assessment and Measurement Model

All the dimensions were treated as first-order factors. Except for items used to assess the adoption of DH, which are binary (yes/no), the other were assessed using a 5-level Likert scale. The high number of items used to assess the adoption of DH forced us to partially disaggregate the related dimension (Garver and Mentzer, 1999). I randomly assigned 32 items to 4 parcels, each parcel containing 8 items, whose value is provided by the sum of the value of its items (Bagozzi and Heatherton, 1994). Considering each item may assume values 0/1, the value of each parcel ranges from 0 to 8.

In regards to the measurement of the dimension *resilience*, by adopting suggestions by one of the clinical risk management specialists who was involved in this research during the questionnaire design, for each category of cascade event I made two

questions, one related to the occurrence of an adverse event and one to a sentinel event. This because the vocabulary related to patient safety concepts could lead respondents to misunderstanding. In order to reduce as much as possible subsequent biases and to make responses more robust, I averaged the value of the two responses for each category of cascade event.

I used the CFA to assess the construct validity of the model. During the process, I crossed 4 items in order to improve model fitting: I dropped variables "pska3", "pska5", "res4" and "res5" respectively from the constructs *PSKACAP* and *resilience* because of their factor loadings were lower than 0.6 (Behregarai, 2014).

The unidimensionality of the constructs was assessed investigating factor loadings. Each one has a value above 0.6 and $p < 0{,}001$, confirming the hypothesis of unidimensionality of the scales (Table 11).

Table 11: Measurement Model Statistics

Indicator	Standard Loadings	Construct	Cronbach's alpha	CR	AVE
dhado_1	.932	DH Adoption	.918	.920	.745
dhado_2	.913				
dhado_3	.692				
dhado_4	.893				
dhusa_1	.793	DH Usage	.757	.760	.612
dhusa_2	.772				
dhacc_1	.909	DH Accessibility	.834	.845	.651
dhacc_2	.860				
dhacc_3	.621				
pska_2	.641	PSKACAP	.808	.814	.526
pska_4	.791				
pska_5	.827				
pska_6	.620				
res_1	.784	Resilience	.809	.812	.520
res_2	.748				
res_3	.684				
res_6	.661				

Model fit: $\chi^2_{(109)} = 127.15$, $\chi^2/df = 1.17$; GFI = .96; TLI = .949; CFI = .959; RMSEA = .056, SRMR = .07)

In order to assess the reliability and convergent validity of the constructs, I computed Cronbach's alpha, composite reliability (CR) and average variance extracted (AVE) (Table 11). All the values of alpha and composite reliability for all the constructs are above the minimum of 0.7 (Hair et al., 2010), and all the values of average variance

extracted for all the constructs are above the minimum value of 0.5 (Chin, 1998), suggesting a good level of construct reliability

Descriptive statistics are reported in Table 12. I evaluated the discriminant validity confronting the AVE of each dimension with its correlation with the other dimensions (Table 13).

Table 12: Measurement Model Descriptive Statistics

	Mean	Standard Deviation
DH Adoption	5.142	2.052
DH Usage	4.368	.728
DH Accessibility	2.824	1.248
PSKACAP	4.359	.542
Resilience	2.802	.910

Table 13: Measurement Model Correlation Matrix

	DH Adoption	DH Usage	DH Accessibility	PSKACAP	Resilience
DH Adoption	.745				
DH Usage	.310*	.612			
DH Accessibility	.358**	.140	.651		
PSKACAP	.208	.588**	.187	.526	
Resilience	-.216	-.349*	-.376**	-.342*	.520

*p<.05; ** p<.01

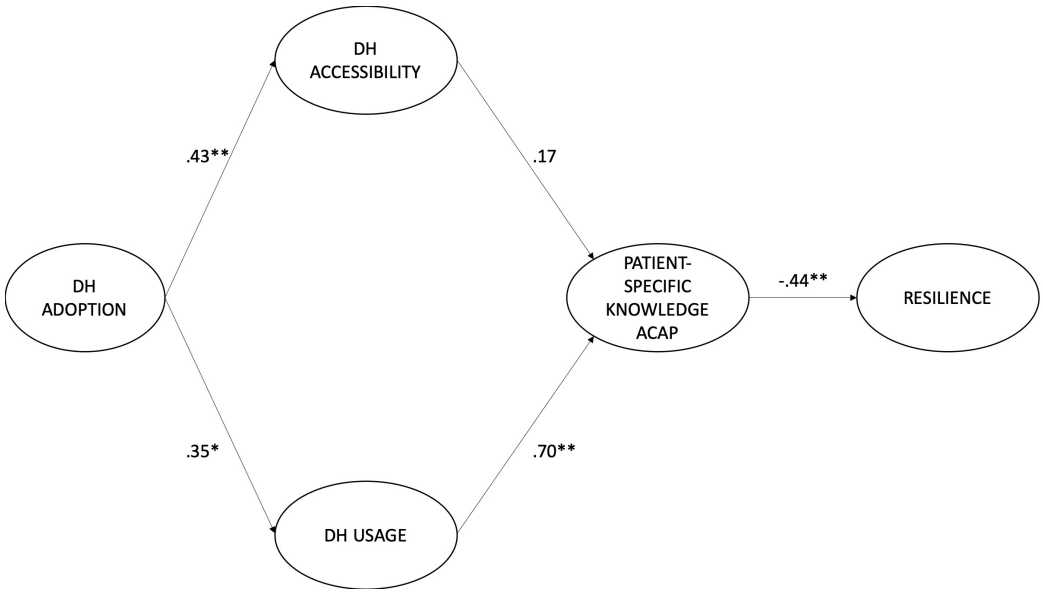
The AVE is greater than correlations for all the dimensions, except for the couple and *PSKACAP-DH usage,* but the very small difference between the two values did not force us to make model adjustments. The CFA indices are overall acceptable ($\chi^2_{(109)} = 127.15$, $\chi^2/df = 1.17$; GFI = .96; TLI = .949; CFI = .959; RMSEA = .056, SRMR = .07).

5.3.3.2 Structural Model

Figure 11 illustrates the structural model with the values of the standardized path coefficients and their statistical significance. In a preliminary version of the model, I also included the four control variables. Considering the coefficients of these linkages were not significant, I decided to not include them (Cao and Zhang, 2011).

By observing statistics related to model fitting ($\chi^2_{(114)} = 133.73$, $\chi^2/df = 1.173$; GFI = .96; TLI = .947; CFI = .956; RMSEA = .057, SRMR = .092), the only indices that is

above the thresholds is the SRMR. Nonetheless, the other indices tell us the model may be considered as acceptable.



* indicates loadings significant at p<.10; ** indicates loadings significant at p<.01
($\chi^2_{(114)}$ = 133.73, χ^2/df = 1.173; GFI = .96; TLI = .947; CFI = .956; RMSEA = .057, SRMR = .092)

Figure 11: First Structural Model

The values of the path coefficients lead us to make some considerations. According to the hypotheses, there are coefficients whose value and significance are satisfying; in particular, the link between *PSKACAP* and *resilience* is negative (as expected) and significative (p-value = .002) and all the paths linking *DH adoption* to the other DH related dimension are positive and significative (see Table 14). On the other hand, the path linking *DH accessibility* to *PSKACAP* is not significant. The consequence is that, in this model configuration, the only significant path that starting from *DH adoption* allows to get to *resilience* is composed of *DH adoption-DH usage-PSKACAP-resilience* (Figure 11)

Table 14: First Structural Model Path Coefficients

Paths	Std. Estimate	Standard Error	p
DH Adoption → DH Usage	.341	.145	.019
DH Adoption → DH Accessibility	.433	.126	<.001
DH Usage → PSKACAP	.699	.112	<.001
DH Accessibility → PSKACAP	.167	.133	.21
PSKACAP → Resilience	-.442	.144	.002

Table 15: First Structural Model Bootstrapping Analysis Results

Paths	Estimate (mean)	95% Credibility Interval	Two-tailed significance
DH Adoption → PSKACAP	.311	[.096, .525]	.008
DH Usage → Resilience	-.309	[-.613, -.044]	.022
DH Accessibility → Resilience	-.073	[-.294, .018]	.115
DH Adoption → Resilience	-.137	[-.348, -.017]	.019

In order to test the mediating role of both *DH usage, DH accessibility* and *PSKACAP*, I performed the bootstrapping method (Rungtusanatham et al., 2014). This modern method allows to have an immediate statistical test on the mediating roles of the variable in the model, providing a confidence interval for each indirect effect path (Pemartín et al., 2018). In particular, I followed the procedure suggested by Cheung and Lau (2008). The outcome (Table 15) suggests us that the only one variable which does not play a mediating role is *DH accessibility*, because the confidence interval contains the value 0 (Rungtusanatham et al., 2014). Furthermore, I may observe that *DH adoption* has an indirect positive and significative effect on *PSKACAP*, through the mediation variable *DH usage*. On the other side, *DH usage* has an indirect negative and significative effect on *resilience*. The former indirect effect leads us to state that adopting a number of different DH enables practitioners to get and exploit patient-related information only if it is accompanied by a widespread usage of them; the latter indirect effect tells us that *DH usage* increases the *resilience* of a healthcare organization through the mechanism of *PSKACAP*.

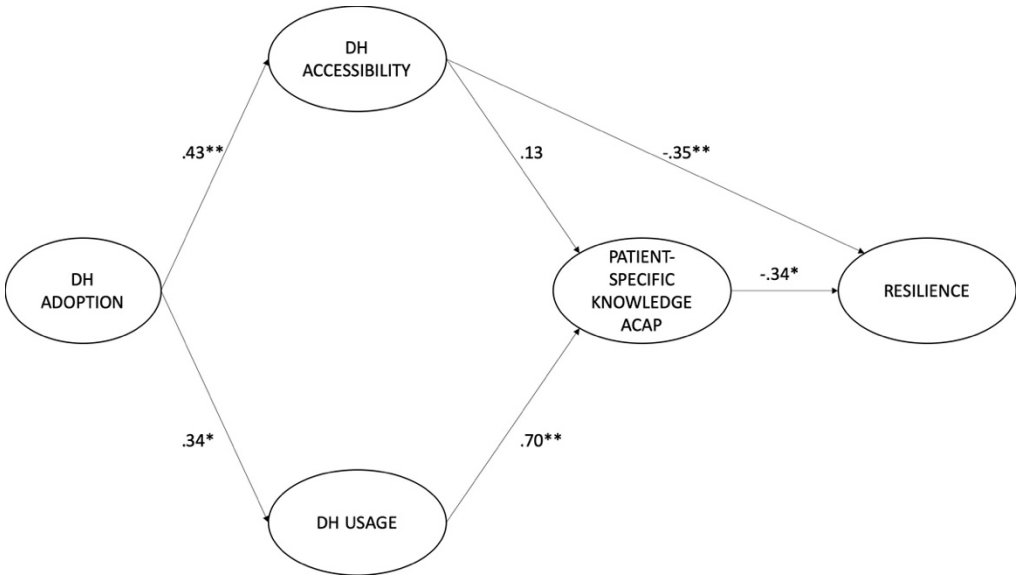
5.3.4 Further theory building and Post-hoc analysis

The comparison between the structural model's and the measurement model's fitting indices leads us to suppose there is room to improve the model (Hair et al., 2010). In fact, the values of the structural model modification indices suggest us that by adding a path

coupling *DH accessibility* and *resilience* it is possible to obtain improvements in terms of fitting. But, as specified by Hair et al. (2010), the addition of paths within a structural model needs to be adequately theoretically justified. In the previous sections I discussed why DH would be related to ACAP and why ACAP would be related to resilience. Our theoretical foundation relies on the dynamic capability nature of the ACAP: briefly, a healthcare provider with a high level of ACAP has a better aptitude to cope with adversity, by means of an easier and faster acquisition and exploitation of patient-specific knowledge; consequently, having access to DH, by facilitating and accelerating this process, is a meaningful means for increasing an organization's ACAP. Nonetheless, the link between DH accessibility and resilience it is improbable to be totally mediated by ACAP. Likely, there are other mechanisms and/or capabilities that, enabled by DH accessibility, can provide significative improvements in terms of resilience.

In particular, the linkage between *DH accessibility* and *resilience* may be explained by means of other mechanisms already studied under the lenses of dynamic capabilities, such as *process improvement initiatives* (Dobrzykowski et al., 2016a; Gowen et al., 2012) and *collaboration* (Lee and Rha, 2016; Scholten and Schilder, 2015). Among different process improvement initiatives, lean orientation has characteristics that enable an organization to be resilient, because of its focus on the adaptation on customer needs (Laganga, 2011). In order to implement a comprehensive lean orientation, a key role is played by the internal integration of a healthcare organization, namely "the extent to which communication, coordination, and teamwork exists across functions within an organization" (Dobrzykowski et al., 2016a, p. 5). In this context, improving the level of accessibility to DH, not only allow to get patient-specific information, but also to better adapt on patient needs through the collaboration with other practitioners within the organization, for instance by asking quick information about the care process. For these reasons, I am confident that adding the path from *DH accessibility* to *resilience* is a suitable choice. I run again the SEM and the results are reported in Figure 12.

The fit indices of the revised model ($\chi^2_{(113)} = 128.65$, $\chi^2/df = 1.14$; GFI = .97, TLI = .96; CFI = .97; RMSEA = .051, SRMR = .073) suggest that it is meaningful. Furthermore, the values of the standardised coefficients are very similar to the previous ones, confirming hypothesis 1 and 2a, while hypothesis 2b is only partially confirmed (Table 16). Furthermore, the relationship between *DH accessibility* and *resilience* is negative and significant, as I expected by analysing the modification indices and reviewing the literature as above reported



* indicates loadings significant at p<.01; ** indicates loadings significant at p<.05

($\chi^2_{(113)}$ = 128.65, χ^2/df = 1.14; GFI = .97, TLI = .96; CFI = .97; RMSEA = .051, SRMR = .073)

Figure 12: Second Structural Model

The fit indices of the revised model ($\chi^2_{(113)}$ = 128.65, χ^2/df = 1.14; GFI = .97, TLI = .96; CFI = .97; RMSEA = .051, SRMR = .073) suggest that it is meaningful. Furthermore, the values of the standardised coefficients are very similar to the previous ones, confirming hypothesis 1 and 2a, while hypothesis 2b is only partially confirmed (Table 16). Furthermore, the relationship between *DH accessibility* and *resilience* is negative and significant, as I expected by analysing the modification indices and reviewing the literature as above reported.

Concerning the mediating variables in the model, the bootstrapping analysis results continue to suggest us that all the supposed mediation effects are verified, except for the *DH accessibility* (Table 17). Nevertheless, it is interesting to analyse the total effects of *DH adoption* and *DH accessibility* on *resilience*. First, in this new model the impact of *DH adoption* on *resilience* is negative and significative (p = 0.005), while in the previous configuration it was less robust with a p-value greater than 0.05; consequently, I may conclude that thanks to both *DH accessibility* and *DH usage*, a healthcare organization is more resilient against operational failures. Second, the comparison between the indirect and the total effect of *DH accessibility* on *resilience* leads us to confirm what the assessment of the direct effect already suggested: the "mechanism/s" by which an easier accessibility to DH improve resilient behaviours does not involve the *PSKACAP*, but could comprehend the implementation of lean practices or a better and more meaningful collaboration among line professionals.

Table 16: Second Structural Model Path Coefficients

Paths	Std. Estimate	Standard Error	p
DH Adoption → DH Usage	.342	.145	.019
DH Adoption → DH Accessibility	.433	.126	.001
DH Usage → PSKACAP	.699	.113	<.001
DH Accessibility → PSKACAP	.134	.135	.320
DH Accessibility → Resilience	**-.346**	**.143**	**.016**
PSKACAP → Resilience	-.340	.150	.024

Table 17: Second Structural Model Bootstrapping Analysis Results

	Indirect Effects			Total Effects		
Paths	Estimate (mean)	95% Credibility Interval	Two-tailed significance	Estimate (mean)	95% Credibility Interval	Two-tailed significance
DH Adoption → PSKACAP	.297	[.088, .518]	.010	.297	[.088, .518]	.010
DH Usage → Resilience	-.238	[-.532, -.019]	.052	-.238	[-.532, -.019]	,052
DH Accessibility → Resilience	**-.046**	**[-.238, .024]**	**.139**	**-.392**	**[-.688, -.097]**	**.010**
DH Adoption → Resilience	-.251	[-.508, -.102]	.005	-.251	[-.508, -.102]	.005

5.4 Discussion

Our results explain how the adoption of DH within the healthcare context enables line professionals to be more resilient, in some cases through the enhancement of their PSKACAP. I believe this represents a valuable contribution, both from the research and practitioner perspectives. As already discussed in the introduction, the impact of DH on patient safety has not been clearly assessed in the literature; some studies found its impact as positive (Kohli and Tan, 2016), some other studies look at it as a threat for patient safety (Kim et al., 2017). The first contribution of our research is, indeed, to this open debate and controversial topic. I make this contribution by offering a different point of view.

More in detail, I observed that the DH adoption in a healthcare organization, mediated by its usage and accessibility, enables line professionals to be more resilient by impeding that, operational failures turn into adverse events, with obvious negative consequences for patients. This result answers the call for further investigations launched

by Ayer et al. (2018), who already discovered the positive impact in terms of operational performance of digital patient records transferring. Moreover, the impact of DH usage on resilience follows the results obtained by Queenan et al. (2011) who, beyond highlighting the importance to discriminate between adoption and usage of technologies in healthcare domain, found that, in the particular case of the Computer Physician Order Entry (CPOE), the actual usage of the technology brings benefits, not just its adoption. Finally, concerning the DH accessibility, it is worth mention that the literature on digital health has largely disregarded this concept. Leslie et al. (2017) studied the effects of a similar dimension, namely HIT "availability", related to the number of computers and mobile work stations "to support HIT work during rounds" (Leslie et al., 2017, p. 1334) and found this may foster the creations of spatial and data silos, with problems in terms of information exchange. The same authors, however, state that further research should investigate the impact of HIT availability on patient outcomes (Leslie et al., 2017). On the one hand, part of our results confirms some of the findings of Leslie et al. (2017) because DH accessibility, by enabling the creation of physical and data silos, counterintuitively does not support the exchange of information and the patient specific knowledge absorptive capacity; on the other hand, our research integrates the findings of Leslie et al. (2017) because I found evidence of the positive impact of DH accessibility on resilience.

Another interesting contribution of this study concerns the operationalization of resilience in healthcare domain. In fact, by focusing on the occurrence of cascade events and clustering them through a coding process, I was able to define a set of items to measure how much a healthcare organization reacts and absorbs operational failure, i.e. how much it is resilient. There is a number of papers which, in other management fields, define different ways to assess resilience; for example Chowdhury and Quaddus (2017) define resilience as composed of a number of different capabilities and define items to measure each of them. In this paper, I use a different way to assess this complex construct: for the first time, at least in the healthcare domain, I propose a measure for the actual resilience performance of the organization.

From a more theoretical perspective, the most relevant contribution of this work regards the ACAP theory and, more specifically: 1) the introduction of the concept Patient-Specific Knowledge ACAP; 2) the insights concerning the relationship between digital technologies and absorptive capacity, a relationship not enough analysed (Roberts et al., 2012).

Concerning point 1), I defined PSKACAP which could bring benefits to healthcare organizations providing more and more customized care processes in need of patient-specific data (Hopp et al., 2018). In fact, today the amount of patient-specific information potentially attainable by means of DH is more and more remarkable; because of this it is necessary to focus also on the capabilities that allow to manage this information in the best way (Kohli and Tan, 2016). Because of this, investigating the PSKACAP of a healthcare organization may represent an important instrument in order to assess how the huge amount of patient-specific information can be acquired and used meaningfully. In particular, in this paper I focus on the importance of the speed (a relevant ACAP dimension) in acquiring and exploiting patient-specific information and knowledge, but in other researches there is room to explore the impact of other ACAP dimensions on this kind of knowledge.

Concerning point 2), I found that the adoption of DH increases ACAP only through a real and wide usage of DH. Contrarily, I observed that even if the DH adoption in healthcare organization is positively related its accessibility, it is not via this dimension that DH increases the PSKACAP. These results allow us to contribute to the theory concerning the relationship between ACAP and technologies, deeply investigated by Roberts et al. (2012). In particular, the first result can be explained by considering that an appropriate usage of DH allows to manage more complete patient information, because they provide the possibility to link different sources of data (Kohli and Tan, 2016). This result answers the request from Roberts et al. (2012) to do empirical investigation concerning the role of IT in the relationship between ACAP and knowledge transfer, confirming the positive relationship they had already assumed. Instead, according to Leslie et al. (2017) the second, counterintuitive result can be explained by considering that dissemination of DH for the whole hospital can enhance the creation of data silos, which in turn does not increase the PSKACAP, but on the contrary can decrease the acquisition of knowledge. This result extends the theoretical framework defined by Roberts et al. (2012); in fact, they state that the interaction among IT capabilities (technology platforms, IT tools for storing, archiving, retrieving, and sharing historical information, integrated IS capability) and coordination and socialization capabilities increases the ACAP of an organization. But they do not focus on the direct effect that one can have on the other, in particular the negative effect the easy access provided by DH can have on the capability of the organizations' worker to coordinate each other.

From a practitioner point of view, being more resilient means improving patient safety, the management of which represent a problematic argument for hospitals (Makary and Daniel, 2016). To improve patient safety, healthcare organizations invest large amount of money in clinical risk management systems, incident reporting system, statistical tools, decision support systems. In this paper I showed how even digital technology systems used by physicians and nurses within the ward during the care process indirectly contribute to improve patient safety through the mechanism of resilience. For this reason, I suggest managers should consider the potential of DH in increasing resilience when they have to decide whether to adopt or not them, how to use them and how much access to them offer to line professionals. The cost of patient safety is higher and higher, and the impact of being resilient on patient safety cannot be anymore disregarded. In particular, manager should pay attention on how the digital technologies can increase PSKACAP of line professionals, focusing on the exchange rate and the usability of patient-specific information. Nonetheless, managers should pay attention not only on the simple acquisition and adoption of DH, but on the actual use of it, on its width of its usage and on how it is ubiquitous and accessible to the workers. In fact, the simple adoption of a technology does not mean it is properly and/or widely used, consequently there is the need to stress the importance of a correct and extended usage of the available technologies (Devaraj and Kohli, 2003): I found both level of usage and accessibility increase resilience. As a natural consequence, healthcare organizations should make sure that physicians, nurses, and other line professionals are enough skilled to use digital health during the care process in a meaningful way, and should encourage them to use exploit digital technologies features to access and use patient-specific knowledge. Finally, managers should guarantee that technologies are easy to access, ensuring that they are available at the points of care; because of this, mobile devices such smartphone or table should be, where possible, preferred to work station not readily available when needed.

Chapter 6

CONCLUSION

6.1 Introduction

The aim of this final chapter is to discuss the contributions that stem from the works that I carried on concerning the research questions. Furthermore, limitations and further research directions are highlighted.

The chapter is organized as follows. At the beginning, summary and conclusion of this work are showed. The following section focuses on the theoretical contributions on the literature concerning resilience in healthcare context, while section four puts in evidence what are the interesting implications for managers. At the end of the chapter, limitations and future research directions are indicated.

6.2 Summary and conclusion

This thesis investigates the concept of resilience in healthcare context through the study of related capabilities, the role of knowledge possessed by employees and the technologies implemented. I found a dearth of research that aims to explore resilience in the healthcare OM domain, although there are lots of practical examples related to it, which are visible by just spending a couple of days in a hospital ward. To reach the goal, this thesis investigated three unknown issues concerning resilience in healthcare. The first investigation concerns what are the capabilities that allow a healthcare organization to implement resilient behaviors, defining a framework which puts them in relation each other. The second is related to the relationship between technologies and resilience, in particular it was discovered that different types of technologies have an impact on different capabilities and that the only adoption is not enough to reach the goal to be resilient. Finally, the third issue is about the role of knowledge in being resilience, finding that to be able to acquire and exploit knowledge about patient conditions are core tasks for the implementation of resilient behaviours.

In order to address the goals of this work, I tried to answer the following research questions:

1. How do healthcare providers employ resilient behaviours to solve operational failures and improve patient safety?
2. How do healthcare technologies support such a resilient behavior?
3. Does the implementation of healthcare technologies improve resilience through patient-specific knowledge?

In order to answer the questions, I developed my research grounded on theories depicted in Chapter 3. Furthermore, in this chapter I have analized the main theories used to study the phenomena of operational failures and resilience in healthcare context, justifying the choice to focus on dynamic capabilities and absorptive capacity theories.

Chapter 4, based on the research article titled "Digital health technology enhances resilient behaviour: evidence from the ward", aims understand the capabilities that enable healthcare resilience and how digital technologies can support these capabilities. The research methodology of within- and cross-case research applied on two Italian hospitals was used to analyse resilience capabilities and to comprehend how healthcare technologies influence healthcare resilience. The analysis of the interviews though coding activity put in evidence the presence of five different dynamic capabilities that enable employees to be resilient in operational failures management. Moreover, three different kind of knowledge emerged as enablers of capabilities and, consequently, resilience, and also the role of healthcare technologies in enabling the different capabilities revealed its importance.

In Chapter 5, based on the research article titled "Absorptive Capacity increases Healthcare Resilience: unfolding the relationship between Digital health and Patient Safety", I studied if outcomes related to the implementation of technologies in healthcare context are positive in terms of patient safety by studying the impact of this class of technologies on patient safety through resilience. Surprisingly, in the context of healthcare operations literature the relationship between DH and resilience has been disregarded so far, although its comprehension would definitively contribute to the open debate on the impact of DH on patient safety. In order to understand this linkage, I defined a theoretical model and tested it by using data collected through a multi-respondent survey and analysing them through Structural Equation Modelling technique.

The findings showed in Chapter 4 and 5 may extend and enrich the amount of literature and the theories used in order to study the topic of this research. In addition, these conclusions can support healthcare management in making the best choices to allow the organization to be more resilient and, consequently, to improve patient safety and the

quality of the services provided. discussed in following. The above is discussed in the following sections.

6.3 Theoretical contributions to resilience in healthcare literature

The theoretical contributions of this thesis mainly concern the literature on resilience in health care and the theories of dynamic capabilities and absorptive capacity. In particular, these contributions are related to the role of capabilities that enable resilience, the role of technologies in enabling resilience and, finally, the relationship among different kinds of knowledge and resilience.

6.3.1 Contributions on the role of capabilities that enable resilience

From a theoretical point of view, this thesis provides contributions and insights into the dynamic capabilities theory in different ways. First, it was discovered that, in order to avoid operational failures, employees implement resilient practices alone or in collaboration with other employees: in both cases, the resilient practice is not executed by following organizational routines or managerial processes. This observation is important because the focus of the dynamic capabilities theory is on these kinds of routines or processes (Eisenhardt and Martin, 2000; Peteraf et al., 2013; Teece et al., 1997); thus, this research suggests that practices implemented by single (or small groups of workers) may be the direct expression of a dynamic capability, without being a representation of an organizational routine or a managerial process.

Second, in the vast majority of the observed cases, there is more than one dynamic capability behind a resilient work practice; hence, these different capabilities turn out to be highly interrelated. Salvato and Vassolo (2017), who studied dynamic capabilities as a multilevel concept, recently examined the relationship between different kinds of capabilities in which the different levels are connected to each other following a vertical pattern – from the level of the individual to that of the organization. In contrast, the relationships that emerged in this study have to be considered horizontal, where, because of their different nature, the differences among capabilities are not quantitative but qualitative. These kinds of relationships have not been studied in the dynamic capabilities theory.

6.3.2 Contributions on the relationship between knowledge and resilience

The important role of knowledge in improving resilience can be identified through the lenses of absorptive capacity and dynamic capabilities theories. In fact, ACAP, seen as a dynamic capability, can surely help to explain the role of knowledge in implementing resilient practices. I used the theory of ACAP in an original way, i.e. by applying its underlying concepts of knowledge acquisition, assimilation and exploitation in the very short term. In this work operational failures are considered as activation triggers (Zahra and George, 2002) that require the acquisition, assimilation, transformation and exploitation of useful knowledge in order to manage them within a few seconds or minutes (in any event, before they become adverse events). Thus, when carrying out some resilient practices, the requested ACAP has to be fast and needs to be related to knowledge about the patient's medical state and history. This is quite different from the classical interpretation of ACAP found in the strategy literature where it is usually used to explain a company's innovation and adaptation processes that result from its capacity to acquire and exploit knowledge from the external environment. While, in fact, R&D processes gain advantage from external knowledge acquisition and exploitation, in operational contexts, it is not just external knowledge that matters. In process improvements, in error handling, in problem solving and in operational failures management, the internal transfer of knowledge is very important in leveraging (Johnston and Leenders, 1990). In fact, many of the reported behaviors from our case studies that reflect ACAP's impact on resilience relates to the ability to acquire patient specific data from internal sources (both information systems and colleagues) and to the line professionals' sharing of details and ideas about their practice in real time to solve operational failures.

Furthermore, in Chapter 5 I defined a particular kind of ACAP, namely Patient-Specific Knowledge Absorptive Capacity (PSKACAP), which could bring benefits to healthcare organizations providing more and more customized care processes in need of patient-specific data (Hopp et al., 2018). In fact, today the amount of patient-specific information potentially attainable by means of DH is more and more remarkable; because of this it is necessary to focus also on the capabilities that allow to manage this information in the best way (Kohli and Tan, 2016). Because of this, investigating the PSKACAP of a healthcare organization may represent an important instrument in order to assess how the huge amount of patient-specific information can be acquired and used meaningfully. In particular, in this paper I focus on the importance of the speed (a relevant

ACAP dimension) in acquiring and exploiting patient-specific information and knowledge, but in other researches there is room to explore the impact of other ACAP dimensions on this kind of knowledge.

6.3.3 Contributions on the role of technologies that enable resilience

The DH technologies have the potential to increase employees' resilience because they can enable employees' ACAP. The knowledge acquired, assimilated or exploited through DH is mostly patient-centered and related to the patient's clinical condition, diagnosis and cure issues, which, in turn, will boost resilient behavior.

Other studies have focused on the role of ACAP in supporting digital technology implementation, as in Raymond et al. (2017); I focused on the opposite effect. I think that this different perspective is due to the time factor: the short period of time that is available for the employees to manage operational failure pushes them to use DH technologies in order to quickly deal with their occurrence. This different perspective allows us to contribute to the much-discussed topic of the consequences of DH for patient safety. As already mentioned, there is nothing in the literature that provides a unique answer to this question. Although it is fair to argue that IT in healthcare will reduce medical error (the third leading cause of patient death in the USA), evidence of IT-related patient harm is mounting (Kim et al., 2017). The reasons for this may be highly diverse and may originate in system designs, implementation or use. Furthermore, some communication technologies may increase the risk of physicians and nurses becoming distracted (Froehle and White, 2014) and IT incidents can lead to large-scale adverse events (Chen et al., 2017).

Even in relation to the operator's capability to be resilient, I found new kind of results with respect to the existing literature. For instance, Smith et al. (2014) found that electronic health record (EHR) may, in some way, reduce resilient behavior because physicians are conscious that their actions will be fully monitored and evaluated and, thus, they tend to avoid working around a problem or handling an error if the necessary procedure has not previously been prescribed or approved.

In addition, the obtained results explain how the adoption of DH within the healthcare context enables line professionals to be more resilient, in some cases through the enhancement of their PSKACAP. I believe this represents a valuable contribution, both from the research and practitioner perspectives. As already discussed, the impact of

DH on patient safety has not been clearly assessed in the literature; some studies found its impact as positive (Kohli and Tan, 2016), some other studies look at it as a threat for patient safety (Kim et al., 2017). Consequently, a contribution of the research is, indeed, to this open debate and controversial topic. I make this contribution by offering a different point of view.

More in detail, I observed that the DH adoption in a healthcare organization, mediated by its usage and accessibility, enables line professionals to be more resilient by impeding that, operational failures turn into adverse events, with obvious negative consequences for patients. This result answers the call for further investigations launched by Ayer et al. (2018), who already discovered the positive impact in terms of operational performance of digital patient records transferring. Moreover, the impact of DH usage on resilience follows the results obtained by Queenan et al. (2011) who, beyond highlighting the importance to discriminate between adoption and usage of technologies in healthcare domain, found that, in the particular case of the Computer Physician Order Entry (CPOE), the actual usage of the technology brings benefits, not just its adoption. Finally, concerning the DH accessibility, it is worth mention that the literature on digital health has largely disregarded this concept. Leslie et al. (2017) studied the effects of a similar dimension, namely HIT "availability", related to the number of computers and mobile work stations "to support HIT work during rounds" (Leslie et al., 2017, p. 1334) and found this may foster the creations of spatial and data silos, with problems in terms of information exchange. The same authors, however, state that further research should investigate the impact of HIT availability on patient outcomes (Leslie et al., 2017). On the one hand, part of our results confirms some of the findings of Leslie et al. (2017) because DH accessibility, by enabling the creation of physical and data silos, counterintuitively does not support the exchange of information and the patient specific knowledge absorptive capacity; on the other hand, our research integrates the findings of Leslie et al. (2017) because I found evidence of the positive impact of DH accessibility on resilience.

Another interesting finding concerns the adoption of DH, which I observed increases ACAP only through a real and wide usage of DH. Contrarily, I observed that even if the DH adoption in healthcare organization is positively related its accessibility, it is not via this dimension that DH increases the PSKACAP. These results allow us to contribute to the theory concerning the relationship between ACAP and technologies, deeply investigated by Roberts et al. (2012). In particular, the first result can be explained

by considering that an appropriate usage of DH allows to manage more complete patient information, because it provides the possibility to link different sources of data (Kohli and Tan, 2016). This result answers the request from Roberts et al. (2012) to do empirical investigation concerning the role of IT in the relationship between ACAP and knowledge transfer, confirming the positive relationship they had already assumed. Instead, according to Leslie et al. (2017) the second, counterintuitive result can be explained by considering that dissemination of DH for the whole hospital can enhance the creation of data silos, which in turn does not increase the PSKACAP, but on the contrary can decrease the acquisition of knowledge. This result extends the theoretical framework defined by Roberts et al. (2012); in fact, they state that the interaction among IT capabilities (technology platforms, IT tools for storing, archiving, retrieving, and sharing historical information, integrated IS capability) and coordination and socialization capabilities increases the ACAP of an organization. But they do not focus on the direct effect that one can have on the other, in particular the negative effect the easy access provided by DH can have on the capability of the organizations' workers to coordinate each other.

6.4 Managerial implications

Aside from offering a few contributions to the theory of dynamic capabilities and absorptive capacity, and the literature on patient safety, operational failures and DH, the presented thesis, which explains resilience capabilities in healthcare and their relations with DH technologies, may also have implications for healthcare managers who continually look for improvements in terms of patient safety, the latter now considered to be a national priority (McFadden et al., 2009).

Other than engaging in building complex clinical risk management techniques, when trying to promote a culture of patient safety, I suggest that healthcare managers should focus on promoting and enhancing the dynamic capabilities that I have shown are the basic elements for implementing resilient practices. Other researchers in the field of healthcare OM have already provided suggestions on how to obtain improvements in dynamic capabilities. For example, Senot et al. (2016) found that in order to improve collaboration among physicians and nurses, it is necessary to encourage both formal (weekly safety rounds) and informal (hallway talks between nursing staff and physicians) mechanisms that complement each other.

From a practitioner point of view, being more resilient means improving patient safety, the management of which represent a problematic argument for hospitals (Makary and Daniel, 2016). To improve patient safety, healthcare organizations invest large amount of money in clinical risk management systems, incident reporting system, statistical tools, decision support systems. In this paper I showed how even digital technology systems used by physicians and nurses within the ward during the care process indirectly contribute to improve patient safety through the mechanism of resilience. For this reason, I suggest managers should consider the potential of DH in increasing resilience when they have to decide whether to adopt or not them, how to use them and how much access to them offer to line professionals.

I found that DH technologies play an important role in supporting or even enabling dynamic capabilities. In a healthcare organization, promoting the use of technologies that are enablers of dynamic capabilities, such as the ones I have considered in this study, may be the key to increase resilience to operational failures. When selecting DH technologies, healthcare managers should take this aspect into account. Furthermore, in Chapter 4 our cross-case analysis clearly shows that in the absence of a high level of digital technology adoption (Hospital A), hospital's resilience may be more dependent on human resource polices and structures and a collaborative culture and climate. For example, the evidence shown in Table 8 suggests that Hospital A gets resiliency from the link healthcare knowledge→flexibility→response, while Hospital B gets resilience mainly from collaboration→patient-related knowledge ACAP→esponse. Also, looking over to Table 6, I see that flexibility is attributed in Hospital A to the multi-skilled workforce vs the service delivery system in Hospital B.

The cost of patient safety is higher and higher, and the impact of being resilient on patient safety cannot be anymore disregarded. In particular, manager should pay attention on how the digital technologies can increase PSKACAP of line professionals, focusing on the exchange rate and the usability of patient-specific information. Nonetheless, managers should pay attention not only on the simple acquisition and adoption of DH, but on the actual use of it, on its width of its usage and on how it is ubiquitous and accessible to the workers. In fact, the simple adoption of a technology does not mean it is properly and/or widely used, consequently there is the need to stress the importance of a correct and extended usage of the available technologies (Devaraj and Kohli, 2003): I found both level of usage and accessibility increase resilience. As a natural consequence, healthcare organizations should make sure that physicians, nurses, and

other line professionals are enough skilled to use digital health during the care process in a meaningful way, and should encourage them to use exploit digital technologies features to access and use patient-specific knowledge.

Finally, managers should guarantee that technologies are easy to access, ensuring that they are available at the points of care; because of this, mobile devices such smartphone or table should be, where possible, preferred to work station not readily available when needed.

6.5 Limitations on the study and directions for future research

This study has a number of limitations. I would like to cite a few of them here.

The first limitation is related to the sampling and the number of cases studied in Chapters 4 and 5. As already explained, I decided to choose only two cases in order to deeply analyze the healthcare context. It is, therefore, necessary to extend the study into other healthcare contexts in order to verify whether the dynamic capabilities (particularly those appearing in the final propositions) are again present or whether there are others that I did not notice, i.e. for the purpose of generalizability. Moreover, I used a hybrid theoretical-convenience sampling approach. It is theoretical in that the choice of sample was driven by the degree of adoption of digital technologies. On the other hand, it cannot be considered theoretical in terms of resilience. The newness of the subject in the OM field (resilience in healthcare) and concerns about the impossibility of a preliminary assessment of the "level of resilience" of a healthcare organization did not allow us to critically choose the cases with regard to this dimension. Because I recognize that pure theoretical or pure random sampling has the potential to provide more robust outcomes, I suggest that further studies consider using larger samples and different sampling approaches. As regards the study in Chapter 5, because of the type of healthcare organization I decided to study, hybrid public-private hospital in Italy, I cannot conclude the findings would apply to other types of healthcare organizations such as, for instance, large public multi-facility healthcare organizations. However, it is worth to mention that, often, research demonstrated how, even if public and private healthcare organizations can be very different in organizational terms, there are no significant differences in terms of quality performance (Andersen and Jakobsen, 2011; Tynkkynen and Vrangbæk, 2018). Nevertheless, it would be interesting to confirm the applicability of this model directly to pure public healthcare organizations; I am conscious that it is not easy to find the right

figures to survey for the questions related to DH and PSKACAP, at least in the way they have been designed in this research.

The second limitation is attributable to the number of responses. In fact, I obtained a response rate of about 9%, which, even if comparable to other studies based on survey administration (Inman et al., 2011; Secchi et al., 2018), should be increased. I did put a lot of effort for maximising the number of responses to the survey, for example by directly phone calling the clinical risk manager of each of the healthcare organization, even more than once, for reminding to invite her/his colleagues (from the ward and from the IT department) to answer the survey in order to have a "complete" answer. In fact, the multi-respondent nature of the survey requires much more engagement of the respondents because they have to participate by answering the survey, but also have to promote the participation of other colleagues (not any type of colleague, but specific roles). Due to this design, unfortunately, when I closed the survey I had to reject 20 responses because they were not "complete".

The third limitation is due to the optimistic approach I had toward resilient practices, when, in fact, Tucker (2004) and Halbesleben et al. (2008) stressed the potential negative impact that practices such as workarounds may have in a healthcare setting, both in terms of economics and patient safety. Consequently, I suggest further studies with the goal of testing if and how dynamic capabilities that foster the implementation of resilient practices may also have a negative impact or if there is the possibility of applying some kind of effective "constraints/controls" to these capabilities in order to obtain only positive effects.

Fourth, our model explains resilient behavior via dynamic capabilities and considers DH as a way to increase resilience. I do not consider other "non-digital" methods that can be used to promote, foster and enable resilience. Further studies should incorporate and assess the combined effect of DH and proper managerial techniques for increasing resilient behavior and patient safety. For example, the model should include well-structured practices for managing care process interruptions (such as in Froehle and White, 2014) and lean methods, such as marking "the points in the medication preparation they have reached" or by using visible artifacts (such as in Patterson and Wears, 2015, p. 46). Moreover, this study applies the dynamic capabilities theory to employees' practices and further studies should analyze whether the practices of hospital managers or organizational routines have the potential to increase the resilience of a hospital or a ward in a complementary manner.

Fifth, in this study, the unit of analysis consists of a hospital ward and I subsequently managed data and information from the employees without distinguishing between the roles they played. Nevertheless, if I consider the types and number of pieces of evidence related to different professional roles I can observe some dissimilarity. To cite the most manifest, I only found evidence related to patient-related knowledge ACAP in interviews with physicians and head physicians, while evidence related to the readiness capability was only found in interviews with line professionals. In sum, our preliminary findings suggest there may be differences in the interviewees' responses dependent on their role in the workplace. As mentioned in this research, I deliberately did not analyze our results from this perspective, but I strongly believe future research should explore this issue further. Investigating if and how management vs line professional and nurse vs doctor may contribute to the ward resilience capabilities would be extremely interesting and surely deserves to be deepened in further studies.

Sixth, in this study, I intentionally focused on resilience capabilities with respect to operational failures and on the role of digital technology in supporting resilience. I did not focus on if and how specific resilience capabilities and specific digital technologies might be more useful and effective for specific types of operational failures. I strongly support further research to investigate this issue.

In order to extend the results of this research, future research should focus on personal factors which potentially may increase the PSKACAP. In fact, in this research I focus only on DH as enabler of PSKACAP, nevertheless more general research focusing on ACAP have already studied factors influencing ACAP not closely related to technologies, such the experience (Zahra and George, 2002) or other social integration mechanisms (Todorova and Durisin, 2007). The impact of personal factors on the meaningful usage of technologies is worthy of attention, as evidenced by other researches focusing on how these factors, interacting with environmental factors, has effect on information technology usage behaviour (Holden and Karsh, 2009).

Furthermore, further researches should focus in a more holistic way on the concept of resilience. In fact, the measure I adopted to assess resilience focuses only on the capability of a healthcare organization to interrupt the cascade events occurring during daily work. Nonetheless, resilience is a broad concept that embraces not only the capacity to keep working when thing get hard, namely the capability to react, but also bouncing back or learning from them (Weick and Sutcliffe, 2011). In fact, it would be interesting to deepen if and how a healthcare organization, after a failure, is able to return to the

previous state or if there are permanent modifications in its assets, and to understand if these new assets are designed in order to better counteract new possible failures.

Finally, future researches should focus on DH accessibility concept. In fact, considering the results of this research, it is fundamental to better understand what are the capabilities and/or mechanisms that mediate the relationship between DH accessibility and resilience. Among the improvements obtainable through easy access technologies, it is possible to find a faster use of evidence-based decision support and a more efficient execution of work practices (Mickan et al., 2013); subsequently it is interesting to study if potential capabilities/mechanisms related, for example, to the improvements above mentioned, are positively impacted by a greater level of DH accessibility.

Finally, I think it would be interesting to explore resilience behavior through the lens of dynamic capabilities in professional service settings other than healthcare. As already discussed, professional services share particular features that do not easily allow them to prevent all the possible "failures" that may occur while carrying out the operations. Consequently, resilient capabilities are much needed when managing operational failures in these sectors and, thus, for improving their quality performance.

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