The Role of Digital Technology in Increasing Healthcare Organizations Resilience

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Abstract

Digital technology in healthcare is more and more used by nurses and physicians during the daily work. However, nowadays research is not able to state if outcomes related to its implementation are unequivocally positive or negative in terms of service quality. Furthermore, one of the most significant quality dimensions in healthcare domain is represented by *patient safety*: because of this, lots of papers were written aiming to assess the impact of digital technology implementation on this dimension, but even in this case conclusions are ambiguous. Assuming that digital technologies enable employees' *resilience behaviours* and *absorptive capacity*, grounding on *dynamic capability* theory, we conducted a survey research involving Italian private clinics, in order to understand if digital technology increases *patient safety* by decreasing the number of *cascade events*, namely "some of the most serious adverse events".

Keywords: Health Information Technology, Resilience, Patient Safety

Introduction

Digital technology (DT) in healthcare supports many different processes executed inside a hospital, from patient record registration to nurse staffing system, from picture archiving/communication to automated pharmacy storage. The impact of DT adoption on operations performance is a hot topic in healthcare literature (Chaudhry et al., 2006), as showed by the number of studies analyzing the relationship between DT and patient safety (seen as a dimension of quality performance in healthcare operations). Findings of these studies are quite contrasting, e.g., Froehle and White (2014) found that the use of technology in healthcare represents a cause of distraction and interruption of work,

while Sharma et al. (2016) suggest to implement "bundle" of technologies in order to obtain quality improvements.

Even if trying to avoid negative events occurrence for patient safety improvement is theoretically correct, it is not sufficient in practice. Being *resilient*, namely having the capability to absorb strain and keep working even when things are hard (Weick and Sutcliffe, 2011), is crucial to allow healthcare organizations taking negative events on when they, unavoidably, occur. Although the relationship between the adoption of digital technology and patient safety has been somehow analyzed, surprisingly, in the context of healthcare operations the relationships between DT and resilience has been disregarded so far. This is why in this paper we wish to explore if and how the adoption of DT favors healthcare organizations in terms of patient safety, by allowing physicians and nurses to be resilient towards negative, unavoidable events.

In sum, by answering the research question *"Does, and how, DT enable healthcare organizations to be resilient in order to increase patient safety?"* we aim at contributing to the debate concerning the impact of DT on healthcare operations performance, and specifically to cover a gap in the literature where the relationship between DT and resilience has not been considered so far.

Theoretical Background

Resilience in OM

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).

Healthcare has inherent features such high customization and service process variation (Dobrzykowski et al., 2016), that makes arduous to prevent all the possible failures happening, according to not very satisfactory results obtained, in the last years, applying the traditional Clinical Risk Management techniques. Failures in healthcare domain have already been named (*operational* failures), analyzed (*problems* and *errors*) and clustered (Tucker and Edmondson, 2003) (Tucker, 2009).

An operational failure is a *trigger event* which, through a number of *cascade events*, may lead to an *adverse event.* A healthcare organization is resilient when it is able to manage a failure and to avoid it transforms to an adverse event.

Knowledge and Absorptive Capacity

Activities in healthcare call for complex technical expertise and knowledge intensity (von Nordenflycht, 2010). Furthermore, the well-structured physicians knowledge networks represents the basis for the development of medical expertise (Lin et al., 2008).

Adopting a process-oriented point of view, the high level of service customization, due to the inherent characteristics of the customers (patients), causes the care process

development difficult to be predicted (Dobrzykowski et al., 2016). Furthermore, a number of decision-making processes by physicians and nursed are required (Dy and Purnell, 2012). In these cases, the integration of clinical knowledge and patient-specific knowledge is important to make healthcare services effective (Chakravarty, 2014). Clinical knowledge refers to the body of information which is broadly applicable to decisions about multiple patients and public health policies, in contrast to patient-specific data, which represent the patient-specific knowledge foundation.

To better understand the role of knowledge in being resilient, we use the Absorptive Capacity (ACAP) concept. ACAP is defined as the capability of an organization to acquire and exploit the knowledge in order to obtain a competitive advantage (Cohen and Levinthal, 1990) (Zahra and George, 2002). This concept was originally created for R&D environments, particularly to better understand the mechanisms underlying its meaningful implementation. But, over the last years, it has been also used in healthcare context (Harvey et al., 2015) (Ding, 2014). In this paper we use the concept of ACAP because the capability of being resilient strongly depends on the easy and fast access to clinical and patient-specific knowledge, but also on the aptitude in using and exploiting the knowledge to solve problems and/or handle errors. For this reason we use Potential ACAP (PACAP) and Realized ACAP (RACAP) concepts (Zahra and George, 2002): PACAP refers to the capacity to acquire and assimilate knowledge, while RACAP refers to the capacity to transform and exploit knowledge.

Digital Technology

Nowadays, Information Technology (IT) represents an important resource available for the companies in order to reach their goals and objectives, no matter the peculiar business in which they operate (Gardner et al., 2015). In this context, healthcare may be considered as the "bad egg": the amount of money spent in IT investments is tinier than the one of the other industries (Devaraj et al., 2013); furthermore, important sources state that the usage of DT may cause error, harm or death (Gardner et al., 2015).

In order to remove any doubt, lot of research focused on evaluating the IT impact on quality (Chaudhry et al., 2006), with conflicting results. This may be explained considering different factors: first, researchers focus on a limited number of technologies, consequently, it is not easy to grasp the positive effects obtainable thanks to their integration (Sharma et al., 2016); second, studies focused on the relation between IT and the focal dimension of quality in healthcare, namely *patient safety*, analyze only ITs strictly and directly linked to it, e.g. Gardner et al. (2015) studied how DT improve the capability to manage a large amount of *data related to errors* during a patient care process in order to diminish the likelihood of future re-occurrences, or Holden and Karsh (2009) studied the advantage of DT on patient safety by focusing on the relationship between the *level of usage of medical error/incident reporting systems* and patient safety.

Based on the above arguments, in our research we study a number of ITs (not only a small number), without considering if they are strictly and directly linked to patient safety. To identify them, we used the DB provided by HIMSS foundation, that includes a wide range of DTs, evaluating only those which allow physicians and nurses to be *resilient* or to improve their *absorptive capacity* (ACAP).

Theory and Hypotheses Development

Theory of dynamic capabilities is used to justify the links among the dimensions constituting our model (Figure 1). Dynamic capabilities are defined such "a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness" (Zollo and Winter, 2002, p. 340). This continue modification of activities and routines is the focus of a resilient behavior, as above mentioned, consequently resilience may be considered as a dynamic capability. Furthermore, also ACAP may be reasonably considered as a dynamic capability (Roberts et al., 2012).

Our conceptual model is grounded on the idea that DT may foster dynamic resilience capabilities through ACAP. In particular, the DT increases PACAP by helping the organization to acquire and assimilate patient-specific knowledge. This increase is due mainly to the sharing of information within the organizations, enabling a growing number of employees to acknowledge patient-specific knowledge, consequently increasing the PACAP of the organization itself. At the same time, the implementation of DT enabling the sharing of information with other organizations outside the clinic, supports this last in the decision-making process: e.g. sharing lab results with high-specialized organization facilitates physicians to diagnose a strange disease, namely to exploit the knowledge increasing the RACAP.

The relation between ACAP and these resilience dimension is explained by the role of knowledge in relation to dynamic capabilities (Zollo and Winter, 2002). In fact, the learning mechanisms have the potential to influence the development of dynamic capabilities, consequently the ACAP may influence the presence of the resilience within the organization.

Finally, dynamic capabilities are meant to provide firms with the ability to reconfigure their operational capabilities in environments characterized by rapid or discontinuous change (Helfat and Winter, 2011). During the care processes, patient conditions are a source of uncertainty that make the environment unstable. Consequently, we suppose that resilience, through PACAP and RACAP, enables the reconfiguration of skills and processes in order to obtain improvements in terms of patient safety.

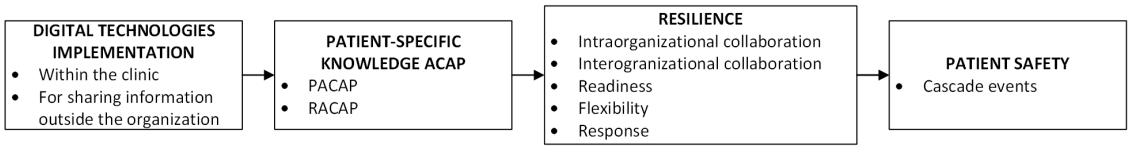

Figure 1 – Theoretical Model

Research Method

We are developing a dataset by collecting data from a multi-respondent survey of Italian clinics. Survey items are in Table 1.

Cascade Events

The dependent variable of the study is represented by the patient safety. During the years, lots of methods and tools have been developed in order to assess this quality

dimension in healthcare domain, such the adverse events or the Patient Safety Indicators (PSI) (Greenberg et al., 2009); however, for the aim of this study, these measures are not suitable. This is due to the fact that, in this research, to assess the level of patient safety within a healthcare organization is used in order to measure how much this organization is resilient. A scarce number of adverse events, or a low PSI value, do not guarantee that the organization is resilient; in fact, the ability to exclusively prevent that operational failures occur could be the only cause of these values. Consequently, we decided to focus on the occurrence of a narrowed kind of event, namely the *cascade events* (Levinson, 2010). The ratio is that a cascade event involves a starting and not adverse event, e.g. anticholinergic class drug administration, which may cause a series of adverse event which collapse into a single (cascade) event. In these cases, resilient organizations have the capability to manage as good as possible exactly the circumstance, avoiding they become an adverse event causing a patient harm. To our knowledge, there is no classification of cascade event in literature, there is only a list of them (Levinson, 2010), observed on-site. Consequently, they are excessively detailed in order to directly ask their occurrence to the respondents: there is a high probability their occurrence is close to zero. Thus, starting from their definition, implementing the coding methodology, we developed 6 categories of cascade events, distinguished by the kind of start event that triggers the flow of events. Finally, we asked the Clinical Risk Manager (CRM) how many times each start event leads to the occurrence of an adverse or sentinel event through the use of a Likert scale. We suppose that, if the occurrence is low, the organization is resilient, because it is able to react and stop the cascade.

DT implementation

DT implementation consists of three sub-constructs that focus on (i) the management patient information inside the clinic (7-items), (ii) outside the clinic (5-items), (iii) and the accessibility of the DT (3-items). Furthermore, a list of DT tools was shown to the respondent (Information Systems Manager), who was requested to flag which of these are implemented in the clinic. For the definition of the items and the list of tools, we looked at the functionalities of the technologies within the HIMSS dataset. More specifically, with the help of two experts on Information Technology in healthcare, we outlined the technologies and the functionalities that were suitable with the purpose of the study and that were likely implemented by the Italian clinics.

Resilience

The measure of *resilience* is based on Chowdhury and Quaddus (2017) model of resilience in supply chain management grounded on dynamic capability. The model identifies a number of dynamic capabilities that enable resilience behaviors by organizations within a supply chain. Adapting the model to the healthcare domain, we focused on the employment of four capabilities, namely (i) intraorganizational collaboration (4-items), interorganizational collaboration (ii) readiness (4-items), (iii) flexibility (2-items), (iv) response (3-items).

ACAP

Measures both for PACAP and RACAP are grounded on Zahra and George (2002), Lichtenthaler (2009), Pavlou and El Sawy (2006), finally Jansen et al. (2005).

PACAP is a five-items measure: the first three assess (i) the acquisition of patient-specific knowledge, the other two (ii) the assimilation of patient-specific knowledge. In particular, the first three items aim to quantify how easy is to access patient information, while the last two questions focus on its value and usefulness.

RACAP is a four-items scale: the first two assess (i) the transformation of patient-specific knowledge, the other two (ii) 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 patient-knowledge focus on the effective possibility to realize patient-specific knowledge in practice.

Controls

We used six control variables in order to make results more valuable. We measure the use of software that are not closely related to the care processes (such those used for statistics or CRM) because they have the potential to bring benefits in terms of patient safety, but without enabling resilient practices by practitioners.

We included the number of beds as a proxy of clinic size. This because a bigger healthcare organization has the possibility to use more resources in order to reduce the number of errors (Mcfadden et al., 2015) and, consequently, the number of cascade events.

The Case-Mix Index (CMI) measures the severity of illness of the patients within the healthcare organization. Consequently, we decided to use this measure to control for the higher probability of cascade events occurrence for those clinics with a higher CMI.
Finally, we included the number of adverse and sentinel events to control for underlying causes of bad patient safety outcomes.

Pilot test

In order to assess format of the survey, we showed it to two experts of healthcare IT, to a Head Physician and to a Clinical Risk Manager. Through their suggestions, we revised some items as a whole and terminology of others (in particular the parts of the survey directed to the IT Manager and the CRM). We decided to include, at the beginning of each part, a glossary for ambiguous words such adverse events or operational failure.

Later, we sent the mails containing the survey to four clinics. We did not need to modify the survey after reading both the answers and the feedback from the respondents.

Sample

We used three different respondents for the survey, (i) the IT Manager, (ii) a Physician, (iii) the Clinical Risk Manager. The population is represented by Italian clinics, which are listed into a dataset we downloaded from the Italian Ministry of Health's website. The dataset contains 594 clinics, covering the whole Italian population. The choice to implement a multi-respondent survey is necessary in order to reduce as much as possible the common method bias; furthermore, asking the questions to specialists increases the reliability and the worth of the answers.

Findings

This research is still on-going. At the moment when this paper was submitted (May, 8) we already obtained contact information from clinic websites. We sent a mail or phone-called the clinics, introducing ourselves and asking for the contact of the clinic CRM. After we got the CRM contact, we phoned or mailed her/him, introducing ourselves and the purpose of the study, explaining the structure of the survey specifying who had to be the respondents. To incentivize the participation, we promised to the clinics we will share with them the results of the research. Finally, we sent the mail containing the link to the survey. Four weeks after sending the mail, we sent a reminder mail in case of missing answer by at least one respondent. We are still collecting data.

Conclusion

This is a working paper, consequently it is not possible to draw conclusions yet, in fact the available data are not sufficient in order to get a meaningful statistical analysis. Anyway, through this study we aim to provide useful insights concerning the potential that technology has to improve healthcare operations and, consequently, patient safety, moreover we aim to contribute to the debate concerning the impact of technology in healthcare domain.

From a theoretical point of view, this work aims to provide insights concerning the role of technologies within ACAP theory, a role today not enough analysed (Roberts et al., 2012), and the role of resilience in healthcare within the OM field, still not studied as it has already been done in other OM fields such supply chain.

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Table 1 – Survey Items

CONSTRUCT	***MEASUREMENT ITEMS***
IT for MANAGING PATIENT INFORMATION INSIDE THE CLINIC	(List of questions regarding the functionalities present in the computerized medical record Inside the clinic: 1. Few departments use a SI 2. Many of the functionalities and modules available in the SI in the departments are used 8. The SI allows to send laboratory tests to many other departments 9. The SI allows to send images of the radiology department to many other departments 10. The SI allows to send cardiological images to many other departments 11. The SI allows to send dermatological images to many other departments 12. I SI allow you to send messages / contact a large number of doctors / specialists from other departments
IT for MANAGING PATIENT INFORMATION OUTSIDE THE CLINIC	Inside the clinic: 3. The SI allows to send laboratory tests to many other hospitals / clinics 4. The SI allows to send in digital format images of the radiology department to a few other hospitals / clinics 5. The SI allows to send images of the cardiology department to many other hospitals / clinics 6. The SI allows to send images of the dermatology department to many other hospital / clinical facilities 7. The SI allows to send messages / contact a large number of doctors / specialists from other hospitals / clinics
IT ACCESSIBILITY	Inside the clinic: 13. You can access the SI via smartphone / tablet 14. It is possible to access the SI from a few locations 15. There are terminals inside the inpatient rooms that allow access to the Computerized Medical Record or to the SI
CONTROLS	16. Many of the functions provided by the software used for the administration and management of statistics are used 17. Many of the functionalities provided by the software used for clinical risk management are used
INTERORGANIZATIONAL COLLABORATION	Inside the clinic: 1. It rarely happens to seek support (advice, help, advice) from doctors / nurses who do not work in the clinic 2. There are numerous official collaboration agreements with other hospitals / clinics 3. It is always convenient to work with colleagues from other hospitals / clinics 4. Colleagues from other hospitals / clinics with which they work are fully deserving of trust
PACAP of PATIEN-SPECIFIC KNOWLEDGE	Inside the clinic: 8. Patient information can be accessed very quickly 9. Patient information is very clear 10. It is easy to access patient information that I need 11. Information about the patient to whom I have access rarely is useful 12. Before taking action on the patient, all the information available on him is carefully analyzed
RACAP OF PATIENT-SPECIFIC KNOWLEDGE	Inside the clinic: 13. Throught the available information on the patient, it is often possible to find the most appropriate way to act 14. Throught of 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 15. New patient information is rarely compared to previous ones 16. It is well known who is the best among colleagues in interpreting, on a case-by-case basis, the individual categories of tests that can be done to the patient (for example the best to analyze a brain CT scan, the best to analyze a specific test of laboratory, etc. ...)
RESILIENCE	Inside the clinic: 5. It rarely happens to ask for support (advice, help, advice) to doctors / nurses working in the clinic 6. It is always convenient to work with colleagues who work in the clinic 7. Colleagues who work in the clinic with whom to collaborate are fully deserving of trust Inside the clinic, when an operational failure occurs *:* 17. Often we ask for help from your primary / head nurse; 18. A colleague is often asked for help; 19. The resources available are perfectly adequate to be able to deal with it; 20. The resources to be able to deal with it are easily accessible; 21. Doctors and nurses are able to carry out several activities at the same time to be able to deal with it; 22. To solve the problem, the activities that were taking place are often postponed; 23. We work as a team, subdividing the tasks; 24. We can respond quickly; 25. It is counteracted in a very rough manner Inside the clinic, regarding the operational failures: 26. Official procedures or simple practices are applied in order to be aware as soon as possible of their occurrence; 27. Tutorials and / or lessons are held to prepare to face them

PATIENT SAFETY	1. Do you have a database where you register ADVERSE EVENTS? 2. If so, how many ADVERSE EVENTS are recorded on average in a year? (if you do not have certain data, make an estimate) 3. Do you have a database in which you record the SENTINEL EVENTS? (if you do not have certain data, make an estimate) 4. If so, how many SENTINEL EVENTS are recorded on average in a year? In clinic: 5. A DELAYED INTERVENTION / TREATMENT has often led to an ADVERSE EVENT 6. A RETARDED INTERVENTION / TREATMENT often led to a SENTINEL EVENT 7. A DIAGNOSIS / TREATMENT NOT MADE has often led to an ADVERSE EVENT 8. A DIAGNOSIS / TREATMENT NOT MADE has often led to a SENTINEL EVENT 9. 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 10. 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 11. A SURGICAL INTERVENTION / SURGICAL PROCEDURE / INVASIVE EXAM (colorectal surgery, thoracic tube removal, cystoscopy, colectomy, etc ...) WITH CONSEQUENT COMPLICATIONS often led to an ADVERSE EVENT 12. A SURGICAL INTERVENTION / SURGICAL PROCEDURE / INVASIVE EXAM (colorectal surgery, thoracic tube removal, cystoscopy, colectomy, etc ...) WITH CONSEQUENT COMPLICATIONS often led to a SENTINEL EVENT 13. THE USE OF AN INVASIVE MEDICAL / SURGICAL PRESIDIUM (venous catheter, etc ...) often led to an ADVERSE EVENT 14. THE USE OF AN INVASIVE MEDICAL / SURGICAL PRESIDIUM (venous catheter, etc ...) often led to a SENTINEL EVENT 15. 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 16. 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