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ORIGINAL PAPER

Adaptations of electronic health records to activate physicians' knowledge: how can patient centered care be improved through technology?

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Abstract The United States of America is known for the rising costs of its healthcare and declining quality of care. While the push towards the integration of the healthcare information infrastructure is seen to be an important step towards addressing problem of the rising costs of healthcare and falling quality of care, the integration of EHR (Electronic Health Records), the central component of this infrastructure, remains a challenge. It appears that physicians are at the center of this bottleneck. The literature suggests that the reasons for the limited use relate to policy, financial and usability considerations, but it does not provide an understanding of reasons for physicians' limited interaction and adaptation of EHR. In this paper, we argue that in order to be able to use the technology to provide better healthcare, physicians need to be able to activate their knowledge through it. We investigate process of adaptations that physicians go through when trying to use electronic health records. Our findings indicate that physician's knowledge identities need to align with the functionalities made available through the technology. We draw upon the framework of knowledge activation in order to understand how physicians use their knowledge to provide better healthcare. Following an analysis of qualitative data, collected in a case study at a hospital using interviews, this research shows how physician's adaptations of EHR activate their knowledge for the purpose of improving healthcare provision. The key contribution of this research is in discovering the ways in which physicians' adaptation of technology can enable knowledge activation.

Keywords Knowledge activation · Electronic health record · Adaptation · Physician · Knowledge identities · Meaningful use

1 Introduction

Healthcare provision in the United States is currently undergoing a transformation that promises to address the high cost and decreasing quality of care. At the center of this transformation is the Electronic Health Records (EHR) technology which is mandated by the Health Information Technology for Economic and Clinical Health Act (HITECH) which authorized incentive payments through Medicare and Medicaid to clinicians and hospitals when they use EHRs privately and securely to achieve specified improvements in care delivery [11]. The road to patient-centered care is paved through HITEC when hospitals use EHRs privately and securely to achieve specified improvements in care delivery. In addition, The American Recovery and Reinvestment Act, passed in February 2009, included a very large stimulus payment for eligible providers, hospitals and physicians for the adoption of EHRs. If providers do not become meaningful users of EHRs by 2015, penalties will be triggered through reduced Medicare payments. The transformation of health care through the use of Health Information Technology continued with the passing of the Patient Protection and Affordable Care Act of 2010, which mandated the integration of physician quality reporting and Electronic Health Record reporting. This Act required the creation of measures and reporting of the "meaningful use of the electronic health record" and "quality of care furnished to an individual." In doing so, the law directly links the adoption of the electronic health record with quality of care to the

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patient. This entails coordination which the Act requires by the use of electronic health records and tele-health technology to better coordinate manage and improve access to care.

This illustrates increasing pressure to operate efficiently in healthcare. Costs are spiraling out of control, due in part to huge amounts of redundancy and waste [24,25,35]. Research has shown that the healthcare industry is plagued by rapidly increasing costs, poor quality of service, lack of integration of patient care, and lack of information accessible via EHR [20,25,26]. Medical errors arise because of process failures, ineffective communication and lack of information. While capturing the benefit from EHRs can enable collaboration among medical practitioners ensuring that hospital care is improved, in practice this is a challenge. According to Clifton [16], healthcare in America costs 2.5 trillion a year and is expected to grow to 4.5 trillion in 6 years. The Institute of Medicine (IOM [25]) reported that the US healthcare system is "fundamentally broken" and called on the Federal Government to make a major investment in information technology in order to achieve the changes, such as the "commitment to technology to manage the knowledge bases and process of care" [[15], p. 178] in order to repair the broken healthcare system.

According to the Agency for Healthcare Quality and Research, automation is able to improve the quality and safety of care delivered by healthcare facilities by enabling collaboration. Within the various specialties, several studies have revealed the benefits of using EHR: EHR reduces errors associated with drug interactions [7], it automatically provides physicians with information about prescriptions, and it improves the quality of patient care [22,24]. Research [3,4,22,24,26] that examined EHR use in hospitals, clinics, and other healthcare settings revealed a consistent theme: Physicians found that EHR improved quality, access, and communications, but it had a net negative effect on workload [34]. Blumenthal and Tavenner [11,12] suggest that once patients experience the benefits of this technology, they will demand nothing less from their providers (p.501).

Understanding the healthcare context in the United States is key to understanding the integration of IS (Information Systems) into the fabric of the health care organizations. According to Fichman et al., at the most general level, 'a striking feature of healthcare industry is the level of diversity that characterizes patients (e.g. physical traits, and medical history), professional disciplines (e.g. doctors, nurses, administrators and insurers), treatment options, healthcare delivery processes and interests of various stakeholder groups [p. 419]. While the technology has the potential to increase the quality of healthcare and reduce its costs, it appears a key challenge relating to the content of the electronic health record is the exchange of data, its analysis, and sharing diagnosis and treatment information from the physicians to the people who need it. In other words, the physicians are at the center of healthcare delivery and hence need to effectively use EHR. The multi-disciplinary nature of the healthcare providers and the information they require contributes to the challenge. Following from this challenge, the research question investigated in this study is *how can meaningful adaptation of Electronic Health Records to activate physician's knowledge enable patient centered healthcare provision?*

We investigate this question by examining the ways in which adaptation of technology by physicians could enable their knowledge to be activated more effectively and efficiently. This question is investigated through a qualitative study that examines how physicians interact with EHR. The key contribution of this research is in discovering the ways in which physicians' adaptation of technology can enable knowledge activation through the use of collaborative tools and processes. Following an analysis of how physicians go through processes of adaptation to activate their knowledge using the Qureshi Keen framework [36], this research illustrates how a collaborative technology architecture can enable the physicians to better interact with their partners using the EHR technology for the purpose of improving healthcare provision. It does this by drawing upon Paul et al. [32] ontology illustrating how EHR has the potential to provide continuity of service and could be a tool supporting collaboration as physicians increasingly work with each other and other service providers.

2 Motivation for electronic health record adaptation

The technology infrastructure that supports decision making by physicians and has now become central to the healthcare provision is known as the Electronic Health Record (EHR) refers to the digital storage of healthcare information about an individual and includes observations, laboratory, tests, diagnostic imaging reports, treatments, therapies, drugs administered, patient identifying information, legal permissions, and allergies stored in various formats [18]. The challenge remains one of integration and targeted access to the data needed to treat patients [17,28]. The government, through HITECH's goal is not adoption alone, but "meaningful use" of EHRs — that is, "their use by providers to achieve significant improvements in care. This legislation ties payments specifically to the achievement of advances in health care processes and outcomes." [[11], p.1]. The key challenge relating to the "meaningful use" of the electronic health records is the exchange of data, their analysis, and sharing diagnosis and treatment information from the physicians to the people who need it. The shared, reciprocal patterns of interaction between physicians and other workers supported by the technology usage, that develop into new processes of meaningful use over time, is what we consider to be *adaptation.*

Preliminary results of the adoption of EHR have demonstrated small increases in the quality of care in diabetes, medication discrepancies and small quality gains in US hospitals, [11,13,17,28]. There is agreement in the current literature that EHR alone will not lead to improvements in the quality of care, as the adoption of such technologies will have to be accompanied by processes and policies that support improved patient care [17,28]. Accompanied by such "meaningful use" policies and procedures that match the use of the technology with improved patient outcomes, EHR has the potential to provide continuity of service and could be a tool supporting collaboration as physicians increasingly work with each other and other service providers. It appears that if physicians are able to use the technology to work with other healthcare workers, the quality of care they provide will improve.

The healthcare system is a complex organization characterized by knowledge workers working as independent professionals. This suggests that mere adoption the technology is not going address costs and quality problems of the healthcare system. Sustained and concerted adaptation of the technology over time needs to be studied in the context of the organization, work practices and the design of the technology itself. While the ability for these knowledge workers to access data effectively and efficiently would improve the quality of work processes and patient care. It appears then that if EHR can serve as a means of enabling collaboration between and among health care providers, then the transformations in IT enabled healthcare can be achieved.

However, EHR, which can enable people to work more effectively and efficiently through access to data, have been underused by U.S healthcare professionals such as physicians. Given the multi-disciplinary nature of the healthcare providers, it appears that the physicians are at the center of care provision and also the bottleneck according to Clifton [16]. In order to improve the use of IT in the U.S. healthcare system, it is necessary to understand what healthcare professionals, especially physicians, think about the use of EHR.

Patient-Centered care is seen to be a natural progression towards greater efficiency and effectiveness in healthcare provision. This form of care is one in which the patient actively participates in his or her care, delivery of care takes place from a patient's point of view, there is greater communication with the patient and therapy is tailored to the needs of the patient [25,26,30]. The implementation of Health Information Technology (HIT) appears to have enabled greater patient centered care through better access to patient data, shorter recovery through targeted care, lower cost through fewer tests and increased meaningful use practices [8,9,10,25].

Patient centered care relies on physicians' capturing the benefit from EHRs to collaborate with other medical practitioners ensuring that hospital care is improved. In practice, this is a challenge when physicians resist technology, rely on other medical personnel to communicate with the patient, and are accustomed to offering standardized therapies instead of those targeted to the patient's needs. The literature indicates that physicians resist the technology due to productivity issues, workflow challenges, lack of support and other issues [2,3,14,16,18,27]. The following section describes the theoretical background used to investigate how physician's knowledge can be activated to provide better patient centered care.

3 Theoretical background: knowledge activation for improved patient centered care

In this section we consider what are the desired adaptations for the activation of knowledge? Technology adaptation is a process understood from a Structuration Theory perspective to be one that evolves over time, sometimes gradually changing the way people work together using the technology while at the same time changing the technology's role in the organization first and then eventually its design [29,39]. The adaptation process involves a dual cycle through which the technology changes the ways in which people work and interact with each other while changing the ways in which they use the technology and the very essence of that technology. Through processes of adaptation, the technology itself changes in response to the work and social processes using it. According to Qureshi and Vogel [39] model of eCollaboration Effects, when people use technology to work with each other, they go through technological adaptation, work adaptation, and social adaptation processes in order to adapt to the structure imposed by the technology, modify their work environments, and social interrelationships [39]. The adaptation of new technology in collaborative relationships occurs when members of a group learn how new technology affects their work relationships and the work environment [37–39].

Successful collaboration requires social adaptation by team members, who must learn to conform to new knowledge, rules, and patterns of interaction that enable them to communicate with each other using the technology. Successful adaptation can bring about benefits to the organization. From an organizational learning perspective, Attewell defined technology assimilation as "a process of organizational learning in which individuals and an organization as a whole acquire the knowledge and skills necessary to effectively apply the technology" [[5], p. 1345]. The burden of learning creates a knowledge barrier that inhibits the diffusion of IT. In these cases, the use of IT can be inhibited as much by the ability to adopt IT systems as the desire to adopt these systems. Both these challenges can be overcome through processes of adaptation that enable collaborative to be brought to bear in activating knowledge.

Knowledge Activation is the conversion of knowledge into action. Activating knowledge, according to Qureshi and Keen [36] is about finding people with relevant knowledge and using it effectively through their willingness to provide, access, and share it as and when needed. This is central to understanding why and how physicians may or may not use technology to support the provision of healthcare. Technologies to support improved healthcare provision will have to enable physicians' knowledge to be activated more effectively. The concept of activation is drawn from social network analysis which suggests that activating knowledge can reduce an organization's dependence on a single set of experts or extend the organization's access to expertise from other organizations or communities. In order to activate knowledge, there has to be a *demand* for it. In the case of physicians, every time there is demand for their knowledge, they are called to use their expertise to provide care to a patient. In order to carry out the demand for the physicians' action, collaboration is needed between the physicians and the other healthcare providers, administrators and insurers involved in the demand for action. In this sense, collaboration is purposeful joint action through the construction of relevant meanings that are shared by members. Collaboration is needed to: 1) determine what action is required and relevant; 2) identify what knowledge is required to carry out required action; 3) demand for action. In order to support collaboration it is useful to have a technology with which to communicate and a social network or "community of minds" [36].

The theoretical framework of knowledge activation [36], suggests that knowledge use is shaped by three individual knowledge identities: 1) accountable which is part of individuals' professional lives; 2) discretionary which is theirs to share voluntarily; 3) autonomous which forms from their private experience. These identities determine the willingness of people to communicate and share. There are many incentives to share accountable knowledge, which is part of responsibility and position. There is less incentive to share discretionary and autonomous knowledge, which is personal and in many instances can be tacit information the owner is unaware of possessing or the owner may carefully guard as a component of his or her identity. The three types of knowledge can be activated through collaboration. This is illustrated in the diagram below:

A key challenge relating to the content of the electronic health record is the exchange of data, its analysis, and sharing diagnosis and treatment information from the physicians to the people who need it. According to Qureshi & Keen [36], occupational communities can have difficulty sharing information between different domains of knowledge that is dispersed across different individuals. The healthcare implementation of EHR has similar issues. Information technology solutions, such as the EHR, tend to focus on stimulating knowledge collection by codifying or explicating knowledge. Typically infrastructures are used for storing, managing and distributing explicit knowledge. Whereas, the knowledge that physicians bring into action when providing care is mostly accountable and discretionary – much of which cannot be codified in any explicit way. This dichotomy explains why physicians are reluctant to use EHR to provide patient care, despite the many benefits of having access to this information.

In order for the different types of adaptations to lead to the activation of the different types of knowledge to obtain the desired outcomes, we need to consider that challenges to technological adaptation lie in that the physician perspective is often overlooked. This is reflected in a seminal Simon quote, "This is an old weakness in engineering design, not peculiar to computers: we are fascinated with our technical capabilities and design sophisticated hammers which go around looking for nails that are shaped so as to be hammerable by them (p. 135)." Challenges to work adaptation can be seen in the reviews of (EHR) literature that show the existing challenges with the alignment of organizational design and the engineered artifact. Niazkhani et al. [[31], p. 546] concluded "When put in practice, the formal, predefined, stepwise, and role-based models of workflow underlying CPOE systems may show a fragile compatibility with the contingent, pragmatic, and co-constructive nature of workflow." Two of the findings of Greenhalgh et al. [[24], p. 767] were "while secondary work (audit, research, billing) may be made more efficient by the EPR, primary clinical work is often made less efficient" and "the EPR may support, but will not drive, changes in the social order of the workplace".

In order to understand how the activation of the different types of knowledge to obtain the desired outcomes, we need to consider that Physicians using technology go through technological, work and social processes to adapt to new work environments. IT affects work relationships and environments. Work adaptation occurs when people adapt the technology to their own ways of working. The work-adaptation process takes place when groups are involved in changing organizational norms and values while using collaborative technology. Information Technology affects the work process itself and the way in which work is carried out [37,39]. Technology adaptation occurs when people learn how to use technological tools to achieve their goals. The more flexible the technology, the easier it is for people to use the technology to meet their needs. In the context of the ontological framework provided by Paul et al. [32], this Model contributes to an understanding of how the technology can enable physicians to use the electronic health records, which is technological adaptation, to work adaptation together with their partners, social adaptation, using the content available to them using the collaboration media to provide better healthcare.

The need for work adaptation to enable collaboration can be seen in Fontaine et al's [21] review of primary care that "The potential for HIE to reduce costs and improve the quality

of health care in ambulatory primary care practices is well recognized but needs further empiric substantiation." IOM [25] claimed that the healthcare system needs to join the IT revolution, and improved information systems may be a critical factor for improving the healthcare system because of the pervasive need to access, record, and share information in order to provide high-quality medical care [25]. Knowledge and learning play important roles in the use of IT, and researchers have developed the diffusion, adoption, and acceptance theories to explain how people adopt, accept, and use complex organizational technologies. Attewell [5] defined complex organizational technologies as "technologies that, when first introduced, impose a substantial burden on would-be users in terms of the knowledge needed to use these technologies effectively" [5]. This is the case with the adaptation of EHRs at the moment.

In order to investigate how the adaptation of Electronic Health Records by physicians to collaborate can enable better healthcare provision, we will have to investigate how physicians bring their knowledge into action. In other words, how do the desired adaptations for the activation of knowledge actually become realized? Knowledge activation is key to understanding how technology adaptation by physicians can lead to improvements in healthcare provision. The following section describes the methodology used to answer this question by investigating how the adaptation of Electronic Health Records by physicians can enable better healthcare provision.

4 Research methodology

This study uses a qualitative inductive research method to examine physician interaction with EHR. This means that the data collected is interpreted using the theoretical background that informs the selection of participants, interview questions and analysis of the data. It uses Eisenhardt's case study approach, in which interviews are the primary data collection method and open coding for data analysis. The Eisenhardt method was chosen as it: 1) Generates relationships or theory with constant comparison literature; 2) Emergent theory is likely to be testable with constructs that can be readily measured; 3) High likelihood of valid relationships, models or theory because the theory building process is tied to data and other evidence.

The data for this research was collected in a large hospital in the mid-west. This hospital was chosen because of its central location and importance in providing healthcare for the city. Seven physicians were chosen because of their centrality in the hospital's ability provide quality healthcare. The seven interviews and represented 66 pages of interview transcripts. This data was collected over a period of 6 months in 2010. This data analysis produced technological, work and social adaptation categories.

Open coding is used to analyze the data and develop concepts as they relate to physician interaction with EHR. The qualitative method and open coding analysis enables discovery of the relationships in the real world situation. Theoretical sensitivity allows the researcher to have insight into and to give meaning to the events and happenings in data. "Insights do not just occur haphazardly; rather, they happen to prepared minds during interplay with the data [[41], p. 47]". Eisenhardt's enfolding the literature step complements the development of sensitivity. "An essential feature of theory building is the comparison of the emergent concepts, theory, or hypotheses with the extant literature [[19], p. 544]". This research utilizes theoretical sensitivity and enfolding the literature to develop the lens for the effort and to strengthen the results. That is, it is discovered, developed and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon [[40], p.23]. This approach is consistent with generally accepted approaches to develop relationships or theory from cases [6,19,42,44].

The following sections describe the open coding process, the results of the open coding and illustrate these using excerpts from interview transcripts to show how the realized adaptations for knowledge activation take place. In these sections we answer the research question: *how can meaningful adaptation of Electronic Health Records to activate physician's knowledge enable patient centered healthcare provision?* We answer this research question by investigating: 1) What are the realized adaptations for the activation of knowledge?, 2) Why or how do these adaptations activate physician's knowledge? And 3) What adaptations can improve the activation of knowledge and hence patient centered care? The analysis below is distilled into a model that enables us to explain how and what adaptations can improve the activation of knowledge and hence patient centered care.

5 Results & analysis

The data for this analysis was comprised of seven physician interviews from varying specialties and represented 66 pages of electronic transcripts. This data was collected over a period of 6 months from October 2009 to March 2010. While analyzing the transcripts of the interviews, "labels of meaning" were identified and placed next to the relevant occurrence. Occurrences were events, happenings, actions, feelings, perspectives, actions and interactions. Categorization of the coding was done in two phases. First, the data obtained from the interviews was coded into broad categories. The interview data was analyzed using Strauss & Corbin's [41] open coding method. Open coding was used to conceptualize raw data by naming and categorizing the phenomena through close examination of the data. During open coding, data was broken down into discrete parts, closely examined and compared for similarities and differences. The coding

process yielded 833 coded quotes. The data representing events, happenings, actions and interactions that were found to be conceptually similar in nature or related in meaning were grouped under abstract concepts that best represent the phenomenon. According to Strauss and Corbin [41], although events or happenings might be discrete elements, the fact that they share common characteristics or related meanings enables them to be grouped. Based on their ability to explain what is going on, certain concepts were grouped under more abstract higher order concepts which Strauss and Corbin [41] term category. Categories have analytic power because they can have the potential to explain why physicians may or may not use the technology and potentially predict the effects of certain implementations on physicians' use. The 833 labels were categorized to compare codes across the interviews. The categories were derived by tabulating the number of occurrences of related concepts.

Reliability of these groupings was achieved through theoretical sensitivity, iterative coding and theoretical sampling. Strauss and Corbin [41] suggest that theoretical sensitivity is required to enable the researcher to interpret and define data and thus develop relationships, models or theories that are grounded, conceptually dense and well integrated. Sources of theoretical sensitivity are the literature, professional and personal experiences. Additional reliability was achieved through the iterative use of open and axial coding to bring out the concepts and discover any causal relationships or patterns in the data. Strauss and Corbin [[39], p.98] state that "though open and axial coding are distinct procedures, when the researcher is actually engaged in the analysis he or she alternates between the two modes". Along with the groupings of abstract concepts (open coding) and identification of causal conditions (axial coding), that lead to the occurrence or development of a phenomenon, additional coding was carried out iteratively using theoretical sampling.

Further reliability was achieved through theoretical sampling, which is the sampling of data on the basis of concepts that have proven theoretical relevance to evolving relationships, models or theories. The form of open sampling used was open sampling which is associated with open coding. Open sampling was used to select additional interview data. The 'slices of data' of all kinds are selected by a process of theoretical sampling, where the researcher decides on analytical grounds where to sample from next. Glaser and Straus ([23], p. 3) state that the researcher does not approach reality as a tabula rasa but must have a perspective that will help him or her abstract significant categories from the data based on the constructs identified in the literature. This data analysis produced technological, work and social adaptation categories. A further analysis of adaptation at each of the three levels revealed the level the physicians are able to use EHR to support their work practices, level of technological comfort and social interactions/connections. The categories, descriptions and number of occurrences are shown in Table 1: Physicians' Adaptation of EHR.

These mappings comprise the first segment of the conceptual framework defined in Figs. 1 and 2. The work, technology and social categories depicted below in Table 1 are the first level results of the mappings.

These results suggest that the majority of realized adaptations for the activation of physician's knowledge relate to work adaptation, which comprise of 68 % of all the occurrences. Work adaptation enables physicians to work within the environment of the EHR while technology and social adaptation have fewer occurrences. This research has shown this far, that EHR have changed the work practices of physicians by forcing them to complete data entry type tasks, change the method of their assessment, and modify the flow of thought recording. It appears EHR success may hinge upon its ability to integrate data, process and thought. The following sections consider in more detail the differences between the desired and realized adaptations for the activation of knowledge; and why and how do these adaptations activate the knowledge? Finally our model will illustrate what adaptations can improve the activation of knowledge and hence patient centered care.

5.1 Physicians adaptation of electronic health records: desired and realized adaptations for the activation of knowledge

EHR has potential to be a tool supporting collaboration as physicians work with each other and other service providers. An analysis of adaptation at each of the three levels revealed the level the physicians are able to use EHR to support their

Table 1 Physician's adaptation of EHR

Category	Description	Occurrences	Ratio
Work	The physician perspective of EHR usage on physician work. Subcategories: Positive Work Impact, Negative Work Impact, Productivity.	197	68 %
Technology	The Physician perspective on implications of IT Context on EHR usage. Sub-categories: System Development, Hardware & Configuration, Training, Documentation, Desire Integrated Systems, Downtime Concern.	75	26 %
Social	The Physician perspective on implications of Social Context on EHR usage.	18	6 %
Total		290	

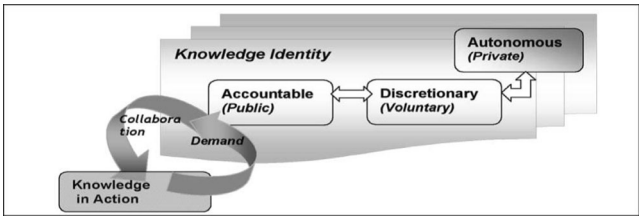

Fig. 1 Theoretical framework of knowledge activation. Source: Qureshi and Keen [36]

work practices, level of technological comfort and social interactions/connections. Delving further into the adaptation, of EHR by physicians, this section reveals the positive and negative occurrences within each category. The numbers of negative adaptation in each category exceed the positive adaptation. These results are depicted in Table 2.

While, the results of the coding analysis revealed that an overwhelming majority of occurrences relate to work adaptation, the majority of the work adaptations were negative. This is an important finding in that physician adaptation of the EHR being investigated was very low. This means that the realized adaptations were lower than expected. This may be because physicians have experienced highly demanding educational and specialized training and are experts in their own profession. Findings from prior research suggest physicians are reluctant to give a positive response to implementation of an IS that interferes with their traditional routines [15]. A key element in understanding physician use of EHR is the critical role played by expertise and values in their work processes. Some authours suggest [2,3] that professional expertise and values can be powerful inhibitors of innovation. This may also explain the low adaptation of the technology by physicians.

Technological adaptation amongst physicians appears to be influenced by their level of comfort and experience with technology. While older physicians are opinion leaders with respect to clinical decisions, younger physicians are frequently leaders in using information technology [2]. In addition, the various processes and infrastructure identified in this research case study do not encourage adaptation. Hence, the frustration amongst physicians and their loss in productivity through the use of EHR exists. This is illustrated in their comments below:

> "What is currently happening is the clinicians are being asked to pay for it, especially the ones that are on productivity, are being asked to pay for it out of their productivity dollars and they are not going to make a return from it."

> "I think that one concern is that you actually spend less face to face time with people whether it's personal family/friend time or patient care, too."

> "One of the things we hear with the Computerized Physician Order Entry system we have here, CPOE, is that most providers will tell us that it costs them time."

> "rather than sitting down and thinking "could this be something else, what am I missing, what else could it be?" We don't have time to do that anymore, and you don't have time to use your clinical skills to take care of our patient.

> "I appreciate the standardization and ease of getting access to a patient's record from anywhere. Overall, I wouldn't trade an EMR for ANY paper charting."

As illustrated by the above quotes, EHR appears to be a new technology that is considered additional work resulting in reduced productivity by the physicians required to use it. At the same time, the benefits of using these technologies have been touted by administrators and politicians. If the physician has a need to address a problem, the physician will turn to technology or other care providers. The physicians in this research all identified a need for additional interfaces and analysis tools to interface with the data. In fact, they have expressed dissatisfaction with the lack of delivery of these types of tools.

A desired adaptation for the activation of knowledge is that an EHR solution must contain more than 'automating' functionality, it must enable 'informating' functionality. A key element in understanding physician use of EHRs is the critical role played by expertise and values in their work process. This research highlights the benefit of inputting the standardized information into the EHR and providing the access from anywhere component. In addition, the downside of the standardization is the lack of support for the physicians' individual high level clinical thinking. Often, the standard interface of required fields distracts the physician from activating higher level identities and support for clinical expertise and thinking. The ability to activate discretionary and autonomous knowledge would increase with adaptations enabling social interaction to improve information sharing and collaboration amongst physicians and other service providers. The following section identifies the adaptations needed to activate the accountable, discretionary and autonomous knowledge identities of physicians as they care for their patients.

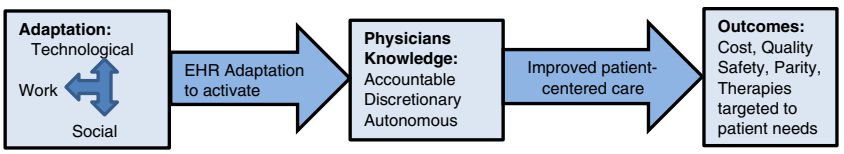

Fig. 2 Adaptations to activate physicians knowledge for improved patient centered care outcomes

Table 2 Physician's positive & negative adaptation of EHR

Category	Description	Positive	Negative	Total occurrences
Work	The physician perspective of EHR usage on physician work. Subcategories: Positive Work Impact, Negative Work Impact, Productivity.	85	112	197
Technological	The Physician perspective on implications of IT Context on EHR usage. Sub-categories: System Development, Hardware & Configuration, Training, Documentation, Desire Integrated Systems, Downtime Concern.	35	40	75
Social	The Physician perspective on implications of Social Context on EHR usage.	0	18	18
Total		125	165	290

5.2 Physicians knowledge activation: why and how do these adaptations activate the knowledge?

It appears that in order for adaptation to take place, the knowledge identities of the physicians need to be addressed. In particular, the physicians' ability to care for patients not only depends on their explicit knowledge, professional identity and accountable knowledge, but their intuition and experience. It is their ability to utilize 'sensemaking' [43] that must be emphasized and supported to enable physician work processes. The adaptation of the technology appears to be a barrier to activation of clinical skills and is supported by this research as indicated by the data, such as:

> "…rather than sitting down and thinking "could this be something else, what am I missing, what else could it be?"
> "We don't have time to that anymore, you don't have time to use our clinical skills to take care of our patient."
> "We have a whole generation of physicians coming up that are not as good at their clinical skills. I am not as good at my clinical skills as my elder colleagues. They can walk into a room and diagnose something because they were good clinicians. Now we look at a patient and say what do they have and then we look at the data and make the data fit what we want it to. Does the data fit what it could possibly be rather than I think it's this, what do I need data-wise to confer? And so I think with EHR we are doing a lot of it, we are spending more time trying to find out what it could be with data rather than talking to a patient."

The above quotes illustrate that physicians routinely activate their accountable knowledge through examination of a patient and then correlating it with additional test data. Adaptation to the electronic health record technology makes the activation of accountable knowledge more cumbersome as they are unable to put into practice and develop upon their clinical skills. In addition, when the implementation of an information system interferes with physicians' traditional practice routines, they are not likely to be accepted by physicians [3]. According to Anderson [2], physicians will oppose any systems that impose major limitation on how clinical data is recorded and how the medical record is organized. Physicians feel it interferes with the way they organize their thought processes in caring for patients. Understanding how physicians work with knowledge in the healthcare domain and the knowledge identities they utilize is an important step in understanding the physicians' perspective on EHR usage.

Adaptation of the technology that may enable better activation of a physician's knowledge, need to include a combination of accountable and discretionary knowledge. While their status and role need to be acknowledged, a physician can be highly valued for other abilities that may not be related to accountable knowledge. The demand for a particular physician is based on much more than ability to demonstrate accountable knowledge. Often the physician has gained vast amount of discretionary and autonomous knowledge that differentiates them from others. For example, experience with similar conditions with other patients, research projects that they may have been involved with or having information on a condition that may not be documented are all aspects of discretionary knowledge that can be activated through adaptations to the technology. Examples of autonomous knowledge that may be activated through adaptations of the electronic health record may require the addition of a blog or community in which the physicians can interact with groups of patients with similar conditions.

Such adaptations of the technology can enable all three knowledge identities to be activated. Physicains are able to complete their work processes without specifically realizing every step of their thought processes or every discrete data element under consideration. It is their ability to combine and utilize their knowledge identities and 'sensemaking' processes that enable them to arrive at superior performance and better patience centered care. The following sections analyse the three types of knowledge, in order to arrive at why and how these adaptations activate the knowledge.

5.2.1 Activation of accountable knowledge

The accountable knowledge is part of the codified knowledge expected in the public identity and responsibility of a physician. It is seen in the interaction with EHR. Physicians have very distinct professional identities. "To be a professional

includes three ideals; 1) that one has skill acquired through specialized training; 2) that one can have a rational account of one's own activities, explaining the 'whys'; 3) that one is dedicated to using one's skills for the well-being of others [[9], p. 51]". Often the physicians' expertise is based on specialized cognitive knowledge and specialized skills. Historically, physicians have a dominant role in the medical model of healthcare [2,3]. Many of the work adaptations required the physician to adjust the work flow of documenting the patient condition. The greater benefit was the ability of physicians' to activate their accountable knowledge as they reviewed prior records and gained insight to the full history of the patient. Successful adaptations have centered around the ability to review the codified, collected details of patient condition and diagnose and direct care with standardized order sets. The ability of the physician to review integrated records from laboratory, radiology, pharmacy and other patient care areas enable the physician to see the integrated view of the patient and successfully activate their accountable knowledge for diagnosis and patient care. These adaptation have enabled physicians to increase their ability to utilize the EHR for exchange of data, its analysis and sharing diagnosis and treatment information.

The recording of accountable knowledge with EHR, as indicated below, is relatively easy. However, the physician perspective tends to indicate the entry of accountable knowledge tends to distract them from other thought processes.

> "think that a lot of consultants, myself included, because there are so many dot points and so much data that we have to put in extra time that we forget to read what's in there. We are so busy trying to document that we are actually not paying attention to what is in the documentation."
>
> "I think you could do a combo where you had point and click history of present illness, review of systems, past medical history, because all of that stuff is easy. I mean for me to document past medical history, review of systems and family history, that can be point and click, that's not the issue, but when you get down to what your thought process is and what you have done for the patient and when you are saying why it's not a heart attack and you think it's chest wall pain and stuff like that, there is no good way to represent that in a point and click type of thing."

This suggests that the tool to support physicians' accountable knowledge is considered inadequate by them. The findings of Qureshi and Keen [36] on the knowledge as an identity have implications for physician use of EHR. The EHR appear to have introduced a paradox where the system supports some work processes and not others. The physicians' knowledge paradox is their inability to bring to bear their combined expertise on a particular problem because the processes and infrastructures of EHR force them to codify accountable knowledge. This paradox is illustrated in the quote below by Qureshi and Keen [36]:

> "…our perspective on knowledge as identity has the following implications for overcoming the knowledge paradox: first and perhaps most importantly, it defines knowledge as part of the person and thus as highly situational. Second, the knowledge management challenge is to activate knowledge via networks. Third, knowledge management will move toward achieving its goals by recognizing the needs for multiple activation networks based on the link between knowledge identities and signing up as a member. All of us have accountable, discretionary and autonomous knowledge. The very same knowledge may have entirely different activation features depending on one's identity. Finally, people determine knowledge in action [[36], p.13]".

This is the minimum requirement for work practice support and a small or insignificant part of their role as a physician. Physicians appear to need much more than codified, accountable knowledge. The systems they interact with need to facilitate the knowledge conversion from tacit to explicit knowledge and support the activation of accountable, discretionary and autonomous knowledge. It appears from the analysis that there are some knowledge processes that need to be addressed. It appears knowledge processes take place as physicians interact with the EHR. In this case, there is a mismatch between the physician work practices and the processes the EHR support. As a result, there is low adaptation.

When accountable knowledge is not sufficient to satisfy a demand for action, discretionary knowledge is activated [36]. The discretionary knowledge is based on experience and is not represented in any particular document or system. It lies in the interaction with humans. Often the answer to such problems lies in experiential and personalized knowledge held by various members of the organization, but not necessarily related to their job description [36]. Collaboration and relationship are necessary at this level.

5.2.2 Activation of discretionary knowledge

Physicians have found EHR a difficult tool to utilize to activate discretionary knowledge. The successful adaptations to date relate to the decision support functions of the EHR and physician collaboration. The physicians do successfully navigate the data and the physicians do appreciate the readily available history and results. However, the 18 negative occurrences of social adaptation indicate the successful support for interaction is not optimal. The focus of the physician interaction with the machine appears to have overshadowed the ability to interact with individuals, specifically, the patient

and other healthcare workers. As physicians have continued to work with the EHR, the technology infrastructure to support physicians has become a central to healthcare provision. The physicians have successfully adapted their EHR use to leverage the digital storage of healthcare information and adapted their use of EHR to include analysis of the aggregate data to activate their discretionary knowledge.

However, there is an indication in the data that the support for discretionary knowledge in the EHR is not sufficient to support this knowledge identity. The physician perspective seems to indicate a loss of interaction opportunity. The focus of entering and representing data tends to overshadow the opportunity for discretionary identity activation. This is illustrated in the quote below:

> "And so I think with EHR we are doing a lot of it, we are spending more time trying to find out what it could be with data rather than talking to a patient."
> "I think physicians are spending less time thinking about things and instead of thinking what could be causing chest pain we are trying to think about what are the 16 dots I need to check to meet the standard to get paid and make sure that I look good that any patient can see rather than sitting down and thinking "could this be something else, what am I missing, what else could it be?"

The frustration with some of the physicians is identified by their inability to place information into the system to reflect their higher level discretionary or autonomous thoughts and assessments. The focus of 'what is going on with my patient and providing that level of assessment and detail' is interfered with the thought of 'how do I use this system and click the required fields'. In many cases, information the physician wants to see or wants to record is not intuitively obvious or supported task in the system.

5.2.3 Activation of autonomous knowledge

The autonomous knowledge is an individual's private identity. The knowledge is highly personal, tacit and experiential. It is mobilized in personal relationships, friendships, mentoring and types of communities. EHR cannot support his type of knowledge identity. It cannot be codified into databases. Yet, it is a key component of physician identity. This is not an area to incorporate into EHR, but is an area we need to consider when considering physicians adaptation to EHR. EHR requirements and interaction cannot distract physicians from accessing the autonomous knowledge identity. This knowledge identity is often the distinguishing factor between physicians. The quote below illustrates this:

> "it's going to be very hard because we all have different brains and we all see things differently, I am a visual person, so when I see it on one sheet and I see all the information I need it is very easy for me to go through that. But to go through page after page after page after page and it's really only a few hours of time doesn't work for my brain. So either I can retool my brain, which I have to do because we are not going to have to have a different system for each provider or I just don't do it."

The above quote suggests that the real challenge with EHR is addressing the needs of physicians to use the EHR to record autonomous knowledge when the interface primarily enables collection of codified information that is contained in the patient records. The EHR strongpoint is the collection of codified knowledge while physicains will also need to connect with patients through collaborative tools such as blogs, community chat functions and support groups of patients facing similar conditions. The EHR tools need to continue to be adapted to the way physicians work and activate their autonomous knowledge.

In working with other physicians and care providers, physicians bring their knowledge into action while drawing upon the skills and knowledge of their colleagues. This means that in order for a technology to effectively support physicians' work, it would have to have functionalities that enable physicians to identify, contact each other and share their knowledge relevant to their cases. This has implications for how we support the physician in utilizing the system and how we support the physician in enabling them to effectively record their discretionary knowledge. Current systems do not appear to support the level of thought processes and knowledge requirements going on in their 'brains'. The following quotes illustrate this:

> "I am not there every day. I have trouble navigating that particular system. Plus it is not as user friendly; it doesn't think for you, there is too much information, too many boxes of checkmark data that is not appropriate for patient care."
> "I like technology when it enhances what I do. I think that technology is the hammer, it is not the person. So, I like technology when it does what I ask it to do, when it doesn't argue with me and when it doesn't make my job harder."
> These comments suggest that EHR emphasis appears to be on the codification of the knowledge physicians possess. The systems impinge on the physicians' ability to access or activate discretionary and autonomous knowledge by forcing attention on the codification of knowledge. This is illustrated in the following quotes:
> "…I used it for a while and did a couple hundred charts and it was arduous and I felt like it wasn't good narrative, it didn't communicate well to other physicians."

> "We are spending less time taking care of the patient and using our mind and more time putting stuff in so that I and the hospital can get reimbursed. So, we are doing a lot of documentation of things for money that doesn't really improve patient care."
> "… it (EHR) doesn't think for you, there is too much information, too many check boxes of check mark data that is not appropriate for patient care."

As illustrated above, this focus on the codification of knowledge is detrimental to the provision of healthcare because the physicians use a combination of their knowledge identities to arrive at conclusions and decisions. The following section illustrates how adaptations to improve the activation of knowledge identities can lead to improved patient centered care.

6 Adaptations for the activation of knowledge for improved patient centered care

Adaptations that can improve the activation of physicians knowledge would have to address all three knowledge identities analysed above. It appears that the EHR could provide shared spaces to enable activation of accountable, discretionary and autnomous knowledge. The components of the EHR can serve a greater functionality than 'storing' information, but should create 'shared spaces' where the various members of the healthcare team can communicate and create shared understanding. While physicians are utilizing the EHR and focusing on 'accountable knowledge', their skill set, value and differentiation are derived from their discretionary and autonomous knowledge identities. The challenge for developing EHR becomes 'how can EHR activate the necessary physician knowledge?' And if the tool does not meet the physician needs, will the physician choose to adapt to the tool? Or are there other work or social adaptations that can enable their knowledge to be successfully activated?

Physicians differ from other users of technology in that they are users relying on knowledge, experience and intuition rather than 'database driven facts'. This may be a reason the computer based EHR have met with limited acceptance among physicians [2]. When the implementation of EHR interferes with traditional practice routines, they are not likely to be accepted by physicians. This is illustrated in the following quotes:

> "I think physicians are spending less time thinking about things and instead of thinking what could be causing chest pain we are trying to think about what are the 16 dots I need to check to meet the standard to get paid and make sure that I look good ."

These findings support the conclusion made by Zuboff (p. 9), which states that organization innovations are necessary to support technological innovations if a firm is to fully benefit from the informating process. It is a process that has implications for the kinds of skills that organization members must develop the articulation of roles and functions and the design of systems and structures that support and reward participation in an informated organization. This suggests that the adaptations of technology will have to support the activation of knowledge identities as well as the work processes that physicians are accustomed to following. These adaptations will have to take place through the technological, work and social processes in order to for the electronic health record adaptation to activate the physicians knowledge. This connection between adaptation and knowledge activation is illustrated in the following diagram:

In order to provide improvements in patient centered care, physicians need technology to enable them to bring their knowledge identities into action when caring for their patients. Patient centered care relies increasingly on the creation of therapies that are targeted to the patient's needs instead of the standard care given for the conditions they may have. Adaptations for such care require greater collaboration with other healthcare providers as they activate their knowledge when there is demand for it. Demand for knowledge takes place when there is a condition requiring their specialist skills or a patient presents. Physicians are needed for their specialist skills and knowledge of medical conditions relating to conditions. Technology can be applied to automate certain parts of this process, but cannot always support the process of bringing knowledge into action. Herein lies a role for collaborative technologies in enabling knowledge to be brought into action. In order to be able to carry out knowledge activation to make sense of the data retrieved through the EHR physicians' process of adaptation will require the technology to be more flexible with greater functionality for collaborative processes between physicians, healthcare providers and patients. The following section explains the process of knowledge activation and attempts to illustrate how physicians' adaptation of EHR can take place.

The data retrieval and analysis functionality serves as a technology mediator for the EHR. In the context of Paul et al's [32] ontology, this means that the technology enables the exchange of content to the extent that physicians are able to use the media. This research has shown that the adaptation processes allow the physicians to use shared spaces and support provided to analyze and interact with the data allowing creation of communication and knowledge from the data. The result is additional capacity for assessment and verification of their accountable knowledge. This means that physicians' diagnosis and treatment options will be of better quality as the system provides more transparency into the use of the content to provide healthcare. This ability to collaborate on diagnosis and treatment options can potentially increased the quality of care.

The discretionary knowledge requires reciprocity and relationship to enable knowledge activation. When there is reciprocity between the diagnosis and treatment options that physicians exchange with the other care providers, the quality of care increases. This research has identified many challenges related to processes and infrastructure that limit the success of this EHR technology mediator. There is an opportunity to improve these processes and infrastructure issues and gain opportunity to provide additional reciprocity and relationship opportunities to evolve.

Activation of Autonomous Knowledge involves trust and personalization. The data indicates dissatisfaction with the lack of personalization available with the EHR and the delays incurred for customization. There is the potential this causes the technology mediator of the EHR provide less support for autonomous knowledge activation. These enhancements to support physician's knowledge activation are illustrated in Table 3.

Physician's accountable knowledge can become more transparent through the shared spaces that support the exchange of data and analysis among physicians and other care providers. Their discretionary knowledge can be supported through the functionalities that enable diagnosis and treatment options to be exchanged with those who need it. The physicians' had significant number of work adaptations to attempt to fit their work processes to the functionality of EHR. Thus, they were able to utilize the EHR as a technology mediator for accountable knowledge activation.

The limited amount of technology adaptation for the activation of discretionary knowledge meant that there was insufficient reciprocity. This would have meant that in return for the physician's knowledge, the other care providers could provide feedback to the physicians as to the accuracy of the diagnosis and effectiveness of the treatments. The social adaptation was also limited. The EHR, in this case, provided limited opportunity for social context and the data indicated system use reduced face to face social opportunities. Adding social networking support to the technology supporting the exchange of medical records would enable the activation of autonomous knowledge. Such collaboration technology features could enable and increase in the effectiveness of treatments by allowing multiple perspectives to be brought to bear on the treatment options. Such social networking and collaboration tools are needed to enable innovations in healthcare provision to be developed and replicated across the board.

This research indicates successful adaptation of the EHR by physicians requires the capacity to enable physicians to activate all three levels of knowledge for use in their work processes. The physician's adaptation of the technology can enable better knowledge activation as they assess and verify the data, solve problems and find innovative solutions to the conditions for which there are few treatments. It is the ability to enable physicians to do more than just record data, but to enable them to share knowledge that is an integral part of themselves' and knowledge they are unaware of incorporating into their awareness. It appears EHR primary strength is to address the explicit accountable knowledge. The majority of physicians' work practices involve their tacit, experiential knowledge which is part of their discretionary knowledge that they bring to bear on their professional responsibilities. The availability and use collaboration tools in the electronic health record system could enable discretionary knowledge to be brought to bear on diagnosis and treatment options thereby increasing the quality of care. Such shared spaces could enable multiple perspectives to be brought to bear on diagnosis and treatment thereby increasing the quality and reducing costs of healthcare provision.

7 Improving EHR to enhance patient centered care

This research has found that the data retrieval and analysis functionality serves as a technology mediator for the EHR. While the work adaptation of EHRs by physicians is largely positive and can lead to meaningful use, their technology and social adaptations remain largely negative. In particular, clinical collaboration and patient interactions remain minimal. While there may be functionalities to support the collaboration and interactions, these have not been realized through the EHR functionality in the hospital studied. In the context of Paul et al's [33] ontology, this means that the technology enables the use of content to the extent that physicians are able to use the media. It also appears that the technology was out of sync with the responsibilities and organizational processes surrounding the work practices of the physicians. The following Table 4 illustrates the constraints surrounding

Table 3 Knowledge is activation with EHR

Knowledge identities	Use of technology (EHR)	Technology mediators	Knowledge in action (physician use– outcome)
Accountable knowledge public	Shared spaces	Data retrieval and analysis	Assess and verify
Discretionary knowledge voluntary	Reciprocity relationship	Diagnosis and treatment	Problem solving
Autonomous knowledge private	Trust, personalization	Social networking	Innovation

Adapted from Qureshi & Keen [36]

Table 4 Physicians' adaptation for patient centered care

Organization	Constraints	Opportunities
Structure	The use of EHR may bring additional complexity into the work environment.	Support physicians with varying degrees of permanence. The frequency with which physicians interact with patients.
Specialization	Different specialties and physician responsibilities.	Integration of data sources from within the organization and integration with clinic and other environments.
Coordination	The flow of information does not appear to support the physician work. The requirement to enter fields in a disruptive order causes loss of thought flow.	The role of the physician and the structure of physician work supported by the EHR. Coordination of patient care.
Task	Information accessibility may vary. Ability to use the technology and to adapt to it may be difficult.	Process gains in terms of productivity, physician practice support and system enhancement.
Learning	The learning opportunities do not appeal to physicians. The ability to work without error is a requirement for EHR usage.	Greater flexibility in opportunities provided for learning and knowledge transfer. Support for patient information access and learning.

Adapted from Qureshi and Vogel[39])

Physicians adaptation of the technology and the opportunities available for patient centered health care.

The table above uses the work of Qureshi & Vogel [39], who found that successful adaptation of technology to work-environments should have the following components: structure, specialization, coordination, task and learning. The authors definition of these components are as follows: 1) the structure is organizational structure within which the EHR is used; 2) the specialization is the specialization of parts which are seen to require integrating mechanisms; 3) the coordination is the connection between different parts or components and content; 4) the task is the specific tasks or processes carried out through the use of specific knowledge and expertise; 5) the learning is as an adaptability to change and an ability to build up a collective reservoir of knowledge and skill.

The analysis depicted in the above Table 4 shows how patient centered care is more likely using the EHRs, even if the technology may not support collaboration in the clinical process. It appears that the EHRs are the catalyst that enables physicians to learn about what the technology can do for them while experiencing the information and knowledge their patients are able to glean from the internet. The following section distills the analysis and offers insights into how physician collaboration may be supported for improved patient centered care.

With the increasing impetus to measure the quality of care, the electronic health records are bringing the patient's perspective into the provision of health care. However, the results of this research have shown that, despite their functionality to support collaboration, the EHRs have not been able to support collaborative care for the most part. It has become more common for patients to search the web and come up with diagnosis and treatments that physicians may not agree with. Given the transformation of health care with Health Information Technology (HIT), Agarwal et al. [1] suggest that the future is not so much in aligning technologies to work practices but is in the use of web services with predefined interfaces and functionality which might not be compatible with existing practice. They foresee the existence of this type of incongruence between the HIT artifacts and work practices to continue as the existing work practices are ripe with inefficiencies. They also identify another prominent function that is lacking in most current systems is support for "rapid learning," where physicians are able to access and swiftly apply findings related to the efficacy of treatments and drugs from biomedical studies to the delivery of care. They also envisage greater use of off the shelf packages as opposed to in-house development. These processes of clinical collaboration that are supported by web services are illustrated in Fig. 3 below:

The model in Fig. 1 illustrates the collaboration process needed to provide patient centered care. This model develops upon what we know about the challenges facing the adoption of EHRs and use the adaptation processes to arrive at ways in which the technologies can be used more effectively by both physicians and patients to improve quality of care. While it is accepted that the patient-physician relationship is at the center of healthcare-provision, access to needed information, techniques and tests is a vital part of this process. The model illustrates how integrating patient medical records with the clinical processes through EHRs with web services can enable physicians, healthcare providers and patients to access knowledge and information needed for "meaningful use" and improved care.

At the very first level is the need to tap into physician's knowledge activation so that they can bring their knowledge identities to action. The access to and use of patient medical records has the potential to bring the work of physicians closer to the needs of the patients through new patterns of interaction supported by the technology. Work adaptation is supported through processes for collaboration, consultation and the coordination of clinical processes. At the moment most of these

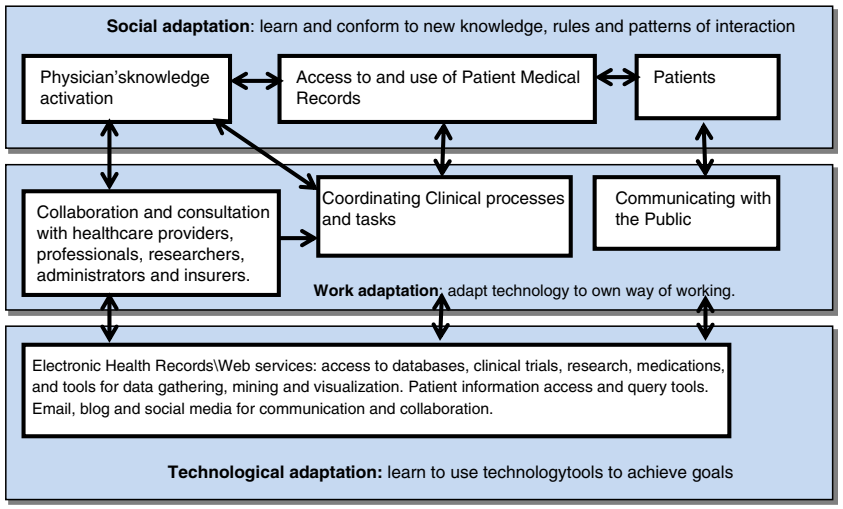

Fig. 3 Model of physician interaction for patient centered care

processes are not supported through EHR but could potentially be and increase the quality of care provided.

At the third and very basic level, EHRs supported by web services that enable Physicians to access information on the latest clinical trials, query databases to find out what would be the most appropriate treatments for their patients are the way forward. Patients also need access to information about their care providers, known treatments, medications and reactions to them. With improved use of information physicians are able to provide care targeted to their patient's needs while patients are able to ask the right questions and know when to go for other medical opinions.

8 Contributions, conclusions and future research

The research has investigated how EHR adaptation by physicians can enable their different knowledge identities to be activated for better healthcare provision through the provision of patient-centered care. Through an analysis of data collected through in depth interviews with seven physicians of varying specialties, this research has shown that current implementations of EHR only support accountable knowledge by providing data to the physicians. There is limited support for the activation of discretionary and autonomous knowledge. Adaptations to activate discretionary and autonomous knowledge of the physicians would entail the provision of shared spaces in which physicains, healthcare providers and patients can interact with each other. This would entail more meaningful use of the technology to be achieved. In order to achieve better quality of care, the electronic health records can provide the transparency needed as they use the technology to exchange content. The physician's adaptation of the technology can enable better knowledge activation as they assess and verify the data, solve problems and find innovative solutions to the conditions for which there are few treatments and seek to develop therapies customized to the needs of the patients.

How to activate physician's knowledge by enhancing the technology supporting the electronic medical record is the key contribution of our research. We have demonstrated the importance of EHR in enabling physicians' knowledge activation and what functionalities can be provided to enhance it. The work processes of the physician, must be considered and their use of accountable, discretionary and autonomous knowledge must be acknowledged and supported. While current technologies for the exchange of medical records support accountable knowledge for the exchange of data and analysis, they do not support the activation of discretionary knowledge which enables diagnosis and treatment. In the context of Paul et al's [32] ontology, this means that the provision of better healthcare requires adaptation of the technology in order to enable the activation.

While, this research identified the processes for supporting the three knowledge identities for professional users to support adaptation, further research is needed to assess the impact of activating each of these knowledge identities on patient care. As the findings of this research connected adaptation and knowledge activation, a natural direction for future research is to expand the research to various types of healthcare organizations and variations of healthcare professionals. This is an increasingly important area for research as we implement IT systems into professional areas.

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