The Impact of Digitalization on the Medical Value Network

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Abstract. Digitalization equalizes information asymmetries which increases economic efficiency and transforms many lines of business. It can be argued that digitalization can do the same in the medical and health care market. This article conceptualizes the medical and health care value network and its digitalization utilizing concepts of information asymmetry and value networks. Inefficiencies within the network relating to incomplete information and information asymmetry are identified. Some digital solutions to these issues are suggested including ePrescription and the automatic medicine dispenser.

Keywords: Digitalization · Medicine · ePrescription · Information asymmetry · Value network

1 Introduction

Digitalization has been a buzzword in the 2010s. It has been defined in many ways. In its simplest form it has referred solely to replacing a manual process with an electronic process. An example of digitization is when an organization replaces a paper document with an electronic one. Digitalization on the other hand has been defined as a more far-reaching phenomenon where an organization changes its structures and ways of working [1]. Terms such as re-engineering have been associated with digitalization as well as with an ever growing amount of data and information.

The key components of digitalization are the global digital network and cheap, commoditized computing resources [2]. Information is created at an increasing pace and wide information resources have become available to the masses. This has changed many lines of business. In this article we will examine the potential of digitalization in health care and the medication market. The main research questions we intend to answer are specifically:

- How incomplete information and information asymmetries in the medical value network can be managed?
- How digital tools can support this?

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2 Theoretical Background

2.1 Value Networks

Digitalization can be viewed through the concept of the value network. The value network refers to the network in which an organization operates with other organizations with the aim of producing value for the end-customer in the form of products and services. The value network concept focuses on the information flows between the actors in the network and regards information as a key factor for gaining competitive advantage [3].

The nodes, actors, in the network include customers, outsourcing partners, sales partners and all other relevant parties who collaborate in one way or another with the organization. The key actor in the network is the customer for whom the network creates value in the form of products and services.

The value network is a broader concept than that of the supply chain. Where the supply chain relates mainly to the operative level of an organization and its linear physical processes the value network is a strategic concept. The value network is an emerging structure changing its shape frequently [4].

Each of the actors in the value network possess different assets. These can be tangible or intagible [5]. One intangible asset is information which is utilized within the network as it operates. For example there is information about customers, products, manufactured quantities, prices and so forth.

Information can be scarce and hence highly priced. Actors possessing valuable information have constituted powerful forces in their value networks. Digitalization is changing this however. Information has increasingly become freely accessible and obtaining information has become cheap [6]. This equalizes the power balance within the value network and changes the dynamics in many lines of business, arguably also in those relating to health care and medication [7].

2.2 Asymmetric Information

Akerlof [8] famously discusses the concept of information asymmetry in his seminal work. This refers to a transaction event in which one party has more information than the other. The exploitation of this unequal situation for the benefit of the one party leads to a market failure. Akerlof studied the market of used cars and showed that fraudulent car sellers selling bad cars, called lemons, caused good used cars to disappear from the market. This is called adverse selection.

Information asymmetry does not only occur when the seller has more information. Related concepts include moral hazard which refers to a situation where party A has to bear the risk for party B's actions but does not have adequate information on party B's intentions nor ways to ensure that party B will perform in an efficient manner. Examples of this include when an insured person takes unnecessary risks or when a taxpayer hides information on his or her income from the tax authorities and neglects to pay taxes.

The health care market is subject to information asymmetry on a wide scale as Arrow [9] discusses in his well known article. This is manifested in many ways: for instance, the patient has significantly less information on medical treatments than the physician. The physician on the other hand cannot be certain that patients will follow the prescriptions suggested to them. The information on the past performance of a physician is also scarce which complicates the purchase of medical treatment. Furthermore, the efficacy of a treatment is uncertain at most times.

It can be argued that digitalization can help overcome issues with information asymmetry [6, 7]. As discussed above digitalization adds information which was previously scarce or non-accessible and makes this available to new actors. This can be seen as reducing information asymmetry. The amount of available information is increasing at a fast pace in many fields. What is the situation in the healthcare and medical market? It can be argued that information asymmetry is still a significant problem which could be alleviated by digitalization.

3 Methodology

This is an exploratory study based on existing literature. This is supported by one interview that was used to set the scene in the first place. The focus is on forming an overview of the context and propose future research to gain more profound insight into the area. The context is further explored through illustrative examples.

Topics that we are discussing in this article, such as ePrescription and other ICT-based innovations in the area of medicine, are forming the research area for the writer, which inevitably affected their inclusion into the analysis. The perspective how they are analyzed however is new and we explore the literature in order to find answers for the research questions set in the end of Sect. 1.

As this is an exploratory study we do not intend to answer conclusively to a clearly bounded research questions. Instead, we intend to outline a new way to conceptualize a phenomenon, namely digitalization within the medical area. We acknowledge that further study is certainly needed to inspect and fully understand the phenomenon.

The research followed an iterative process, which is typical with qualitative studies [10]. At the beginning of the study a representative of the Finnish pharmaceutical industry was interviewed [11] in order to identify and outline the problem area. An open interview technique was utilized which was necessary at that stage as the exact research questions were yet to be defined.

The obvious shortcoming of this approach is that it presents only a single perspective to a complex environment. This however should be acceptable as the purpose of the interview was merely to explore the problem area, and not to draw any conclusions to the research questions. Based on the interview, writer's previously gained knowledge in the field, and literature, a model for the health care and medical market was conceptualized utilizing the value network concept.

In the next phase of the study targeted queries were ran to find relevant and recent articles on the management of incomplete information and information asymmetry in identified parts of the medical supply chain. We did not follow a full systematic literature research method, as it was not practically feasible. The reason for this is that

the puporse was to explore the problem area through multiple illustrative examples (ePrescription and other ICT-based innovations). Databases such as PubMed, ScienceDirect, ACM and ProQuest and public search services such as scholar.google.com were utilized.

It also became clear that articles combining the discussed technologies and information asymmetry are scarce. We therefore had to study materials in iterative manner and refine the queries in the course of the study after identifying new potential key words. We however acknowledge that the different topics deserve own dedicated studies and these should be supported by systematic literature research.

4 The Medical Value Network and Information Asymmetries

One of the key problems with health care systems is fragmentation [12]. Dispersed organizational structures with poor information flows can lead to higher costs and poorer quality of care [13]. This makes a network and customer centric approach such as the value network concept particularly attractive as an analysis tool. In the case of the medical market it leads to the creation of understanding on how organizations such as service providers, physicians and pharmacies are linked together and how they co-operate in order to produce value for the patient. Furthermore, it enables the identification of bottlenecks and information gaps which impact a network's performance.

The key segments and actors in the health care value chain can be specified as follows [14]:

- Payers: e.g. government, employers and individuals (patients).
- Fiscal intermediaries: e.g. insurers.
- Providers: e.g. hospitals (service providers), physicians and pharmacies.
- Purchasers: e.g. wholesalers.
- Producers: e.g. medicine and medical device manufacturers (pharmaceutical companies).

Figure 1 illustrates the medical value network populated with these actors. The diagram is intended merely for illustrative purposes and it is not an exhaustive model of the market. Associated regulatory and professional institutions have been omitted for the sake of simplicity for instance. It is a top-level view and does not drill into the details of the diverse ecosystems surrounding the pharmaceutical industry or service production. The purpose of the diagram is to bring forward the conceptual framework for digitalization within the medical care environment.

The dots in the diagram denote actors. The arches illustrate relationships between actors. A physician is employed by a service provider for instance and prescribes treatment for a patient who complies or does not comply with the prescription.

If we consider the information assets which different actors possess we can intuitively draw some findings:

- A physician has information about treatments.
- A patient has information concerning his or her personal health and medication history.

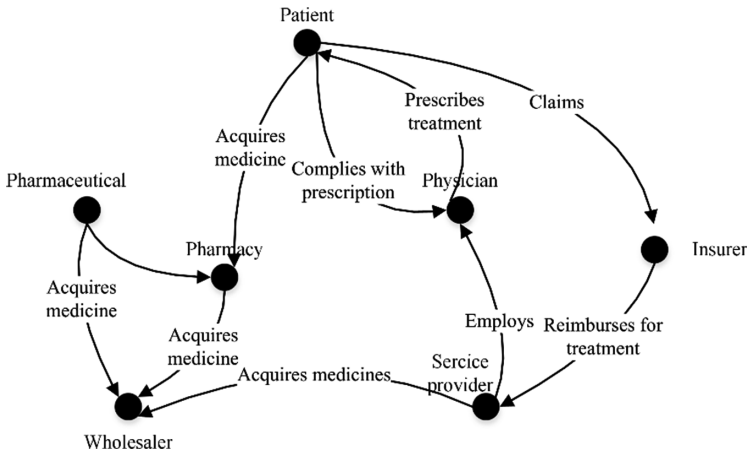

Fig. 1. Medical value network

- A patient has information on his or her compliance as regards a prescribed treatment.
- A pharmacy has information on medicines, alternatives and their market prices.

Considering these information assets and examining the network we can identify a number of information asymmetries between actors. For example:

- Physician – patient: a patient does not have information on the past performance of a physician nor can the patient be certain the care prescribed is effective.
- Patient – physician: a physician cannot be certain the patient complies with the prescription suggested for them.
- Patient – insurance firm: an insurer does not have full information on the actions a patient takes nor the means to monitor them.
- Patient – pharmacy: a pharmacy does not have full information on all past prescriptions ordered for a patient.
- Pharmacy – patient: a patient rarely has extensive information on medicines or on their prices in order to be able to accurately assess or compare the pricing of particular courses of treatment.
- Service provider – medicine wholesalers: medicine spoilage is typically a significant source of costs [15]. It can be caused by the lack of demand management related information.

5 Decreasing Information Asymmetry Through Digital Solutions

5.1 Electronic Prescription

Electronic prescription, or ePrescription, can be defined as "the use of computing devices to enter, modify, review, and output or communicate drug prescriptions" [16].

Regarding information assymetry between patients, physicians and pharmacies the power of electronic prescription lies specifically in improved communication.

The impact of ePrescription on prescription errors and increased communication within the healthcare service chain has been studied in different accounts [17–20]. Various studies suggest that ePrescription decreases medication errors caused by unclear handwriting or otherwise unclear or incomplete prescriptions. Another major benefit is that a more complete view of a patient's medication history is generated.

This increased information can be utilized in the delivery of healthcare services. The prescriber should have adequate information on current and past prescriptions to avoid prescribing overlapping or otherwise non-suitable medication for instance and ePrescription shows the potential to make this possible. ePrescription also undermines a patient's potential to manipulate the information asymmetry associated with prescribed drug misuse cases. This is since all previous prescriptions are visible to the physician. The physician can determine whether there are existing valid prescriptions before prescribing medication such as opioids or stimulants for example.

Lizano-Díez et al. suggests that polymedicated patients specifically have benefited in terms of decreased prescriptions and hence medication costs after the launch of the ePrescription system [21]. The key factor is the increased communication between pharmacies and prescribers which prevents medication errors as well as overlapping prescriptions for medication.

The Finnish Patient Data Repository (KanTa) is a database containing personal healthcare records, including prescriptions, collected from healthcare service providers' patient information systems [22]. It allows a physician to examine thoroughly the healthcare history of a visiting patient when specifying a course of treatment. This was not always possible previously since information was not always shared between different service providers and hence the physician might have lacked information on past prescriptions ordered by another service provider.

The wider debate on the ownership of patient information is relevant with reference to ePrescription. Broadly speaking the question is whether patients should own their own data records. According to the current practice and legislation service providers own healthcare records which they maintain [23]. This field however is emerging and will have many applications; a patient can allow access to his or her personal data in exchange for economic benefits for example [24].

5.2 The Generic Substitution System

The generic substitution system of medicine refers to a system which enforces the use of generic medication over brand name medication. The implementation of this system is possible at many stages of medicine delivery. Physicians can look for the most inexpensive medication when issuing prescriptions for example. Pharmacies can also suggest a generic medicine if one is available. In Finland the latter has been enforced by law; pharmacies are obliged, with some exceptions, to suggest a low cost alternative if one is available [25].

Generic substitution can be regulated by legislation, as is the case in Finland, where the generic substitution system is accompanied by the medicine reference price

system [26]. Pharmacies have to follow reference pricing and it is easy to conclude that the market is highly regulated.

There is evidence that both the generic substitution and reference price systems have had an impact on medicine prices in Finland [27]. The growth of gross pharmaceutical sales has slowed in the 2000s suggesting that these have had an effect [28]. In the US it is estimated that wider adoption of generic substitution would save insurers and patients $9 billion annually in outpatient care [29]. Generic products cost $45 less on average so the impact would be significant for patients and other payers [29].

Regulations and related institutions are typically seen as a way to decrease information asymmetry in a market. It is for instance unlikely that a consumer can assess medicine prices as well as a professional nor do they have the capability to assess a particular substitute for a prescription so the high level of regulation can be considered justified in the medicine delivery market.

There are also disadvantages to regulation. Regulation is expensive to implement and maintain and the institutions involved generate costs. Regulation typically does not keep pace with technological innovations [23]. Often regulations can form barriers to the adoption of new innovations and remain as a subject of continuing lobby by parties who have an interest in keeping the market in its current state.

Digitalization has introduced new trust mechanisms which has undermined the need for regulations [6]. These are typically implemented in platforms which host equal information about suppliers, buyers and services for all platform users. Digitalization has also improved the management of information asymmetry relating to generic substitution: various digital services have emerged which support the search for generic substitute medicines (e.g. [30]). They can integrate open data sources such as pharmaceutical databases and can be used by both physicians and patients.

A key barrier to generic substitution which cannot be overcome by public policies other than increased education is the lack of knowledge amongst both physicians and patients [29]. Physicians often remain cautious in their approach to generic medicines as do patients who often associate higher price with higher value.

Stenner et al. [29] suggest that ePrescribing decision support tools can provide the means to close this knowledge gap. According to their study enhancing the ePrescription system with these mechanisms increased the uptake of generic prescriptions.

5.3 The Automatic Medicine Dispenser

Patient adherence is a key factor in the successful delivery of medication [31]. This refers to a patient's compliance with a prescribed treatment such as medication. Non-compliance with prescriptions costs the US healthcare system $300 billion annually [32]. Non-adherence can be intentional or unintentional [33] and it is problematic from the physician's point of view: the physician can only trust the patient complies with the prescription and follows the treatment.

When assessing a returning patient or monitoring a patient's recovery information on adherence has traditionally been incomplete. Information asymmetry follows when a patient hides information from a physician, intentionally or unintentionally. This can be managed with automatic medicine dispensers.

Modern automatic medicine dispensers are connected online and raise alerts when a patient discards a prescribed course of medication [34]. This information can be provided to the physician in real time and consequently the patient has less opportunity to disguise or deny non-compliance. Although the benefits have been accepted automatic medicine dispensers have yet to be widely adopted, particularly in home use settings.

The reasons for non-adoption have been studied in Finland and they include costs and regulations [35]. Dispensers are typically expensive and they are not fully covered as part of standard health plans. They also need to incorporate failsafes and assurance mechanisms which makes them expensive to build. Regulations also hinder adoption since the fulfilment and validation process requires pharmacy visits.

5.4 Outcomes Based Medicine and Continuous Health Monitoring

The power relationship between the healthcare expert and the patient has traditionally been highly unequal. This is because the expert holds significantly more information on treatments. This information asymmetry can be manipulated for the furtherance of the expert's own interest [36]. For instance if a service provider's revenues are based solely on patient volumes and the efficacy of prescribed treatments is not monitored the quality of care can be compromised to accommodate increased patient flow and the resulting revenues.

We have discussed means for managing asymmetric information in previous sections, namely ePrescription, generic substitution and the automatic medicine dispenser. However these all have shortcomings. Intentional non-adherence can be difficult to control should a patient deliberately wish to disregard a particular medication. On the other hand there is no guarantee that a prescribed medication specified by a physician is the best available treatment for a particular condition.

Outcomes and quality based approaches have emerged to tackle this. They are based on incentivising healthcare providers on the outcomes of treatment. There is evidence that this approach has positive effects on the quality of care [37] and it is actually not an unusual goal for healthcare systems worldwide [12]. These approaches are based on a long-term relationship between physician and patient and on continuous monitoring of medical treatment.

Value-based methods can be utilized to manage information asymmetries in care and medication delivery. Firstly these methods produce information about the efficacy of a prescribed treatment. When recovery is monitored on continuous basis it is possible to assess how well a treatment works for a given patient. This can be linked to incentives and reimbursements associated with the treatment. As a result it equalizes the power relationship between the physician and patient.

Secondly this approach can also help with another instance of imbalance of information between these actors. If the incentive the physician receives depends on the efficacy of the treatment they prescribe then compliance with particular prescriptions should be assured. As recovery is monitored continuously the physician obtains more information regarding the patient's health. This information should allow the physician to determine the extent to which the patient is complying. This can be used to manage

the associated moral hazard problem; hiding information from the other party requires greater effort than before.

It is difficult to implement continuous monitoring and communication without digital means. There are numerous related digital solutions: mobile applications for communication, wearables to collect vital signs and automatic medicine dispensers to support adherence. Sensors have become smaller and cheaper and can be used to analyse sweat for example and monitor health indicators in this way [38]. A recent study also suggests that physicians increasingly utilize mobile applications to communicate with patients and that they also encourage the use of health applications [39].

Another related area is evidence-based medicine. It refers to making medication-related decisions systematically based on scientific evidence instead of relying on intuition [40]. Considering all available information and making decisions based on this reduces uncertainty and bias. The evidence-based approach can be practiced when specifying health policies as well as when treating individual patients. Digital tools are crucial since the approach requires searching and analysing large data sets (e.g. [41]).

5.5 The Availability of Information on Medical Care on the Internet

As described above the healthcare delivery market is pervaded by uncertainty and information asymmetry between health care experts and patients. The issue is particularly severe in emerging countries with undeveloped healthcare systems and associated regulatory frameworks. People have also become reluctant to unconditionally trust experts and seek to be empowered as patients [36]. This has led to the expansion of informal health markets and related new channels.

These new channels typically rely upon digital communication and can be both mobile applications and social media related. There are more than 100,000 health and medication related mobile applications available [42]. Broadly speaking healthcare information has become widely available and it is increasingly used by people looking for medical advice. A recent study suggests that 61 % of the American adult population using the internet goes online for health related information [43]. According to this study health related information is in fact one of the most searched for topics on the Internet.

One specific strand of healthcare information is that related to medication. In addition to online medical information such as pharmaceutical databases, services have emerged for acquiring medication online as well as increasing cost transparency and providing details on generic and alternative medicines (e.g. [30]). This kind of service has the potential to decrease information asymmetry in the medical market especially as this relates to pharmacies and their customers.

5.6 Medicine Demand Management

One topic that was raised in the interview conducted with a pharmaceutical industry representative [11] is that related to the medicine spoilage in hospital surroundings. This has severe economic consequences; according to the WHO's report the losses

from inventory, including spoilage, can exceed 4 % of total medicine acquisition costs for instance [15].

The problem can derive from inefficient management practices [44]. Spoilage can result when medicines are ordered in excessive quantities or in non-optimal package sizes. Medicine shortages, on the other hand, can result in the use of expensive alternatives or in patients remaining hospitalized if medical treatment is not available.

Medicine demand management in hospitals has not been studied widely from an information systems perspective. Although the problem is not directly related to information asymmetry it is a consequence of a lack of information and results in transaction costs and economic inefficiency. It can be argued that spoilage can be reduced with better information management.

This requires combining relevant data from internal sources such as historical data on medicine consumption in hospitals along with data from external sources to help predict future consumption. The external sources could be those shared with other health care providers and the pharmaceutical industry. The information could be used to more accurately specify the quantities of medicines to be acquired. This process will be supported by appropriate digital tools.

One related area is the forecast of vaccine demand. For example, Finland faced a shortage of influenza vaccines in 2015, whereas the previous year the spoilage was 200,000 influenza shots [45]. The prediction models are typically based on age and similar coarse demographic variables [46]. These however do not take into account the public attitude towards vaccination.

Whereas the public sentiment can be an important factor when predicting the demand, it cannot be derived from a typical internal history database. Instead, this information could be extracted from external sources such as social and other media. This in fact has already been tested in United Nations Global Pulse project, in which the public immunization and anti-immunization sentiments were successfully tracked on the basis of social media debates [47].

6 Conclusion

In this article we have examined the digitalization of medical market through the concept of value network. We have also introduced some digital innovations that can be utilized to manage information asymmetries in the value network. It can be argued that equalizing information supply between actors in a value network is one of the benefits achieved through digitalization. It is described below how the discussed innovations map to different information asymmetries introduced in Sect. 4.

- Physician – patient: more information available in Internet, outcomes-based approach.
- Patient – physician: ePrescription, automatic medicine dispenser.
- Patient – insurance firm: outcomes-based approach.
- Patient – pharmacy: ePrescription.
- Pharmacy – patient: generic substitution.
- Service provider – medicine wholesalers: medicine demand mangement.

We can consequently argue that these solutions, which are digital or supported by digital means, can indeed be utilized to manage incomplete information and information asymmetries in the medical and health value network, and hence answer the research questions introduced in Sect. 1.

Electronic prescription has the potential to provide more complete information on patient medication history and hence provide more information to help identify increasingly efficient treatments. Generic substitution supported by digital technologies on the other hand will equalize information asymmetry relating to medicine costs. Value-based methods and increased health and medication information will help to equalize the highly unequal power relationship between health care experts and patients.

Digitalization will also reduce information asymmetry conversely; monitoring patients' compliance with prescriptions using digital tools will undermine patients' ability to disguise or withhold important information from health care experts. Lastly digitalization can enhance medicine demand management and hence reduce medicine spoilage and related inefficiencies.

The real economic impact of digitalization should however be more thoroughly studied in these cases. This is an exploratory study and obviously deeper research to investigate the area is required. Another obvious shortcoming of the article is to omit regulatory institutions, such as governmental and professional bodies, from this model. They have earlier been key actors in the management of asymmetric information. How they support the digitalized market is however not clear and requires research.

The healthcare market has not utilized digitalization as widely as many other lines of business. This can be concluded by comparing ICT investments in different sectors; ICT spend is much lower in relative terms in the health care sector than in sectors such as finance or manufacturing [2]. Undoubtedly EHR systems and such have been widely adopted but these only form the foundation for digitalization. In finance sector money has become virtual for more than a decade and customers are interfaced through digital channels. Similar far-reaching changes are yet to be seen in the medical market.

Costs continue to rise however and therefore there is a growing interest in finding solutions that increase efficiency. We have shown that digitalization could play a role in this and hence it should be one of the key areas of future research.

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