

# ANALYSIS OF FACTORS INFLUENCING INTRODUCTION OF E-HEALTH: A CASE STUDY OF ESTONIA

<sup>1</sup>SHIO BO, <sup>2</sup>SO MORIKAWA

The University of Tokyo  
Email: sticksalt@gmail.com, morikawa@civil.t.u-tokyo.ac.jp

---

**Abstract-** Many countries around the world have been trying to introduce e-health to solve health problems. However, countries trying to introduce e-health often face various problems preventing successful introduction. In order to identify bottlenecks and influencing factors that help to overcome them, we studied the implementation process of Electronic Health Record (EHR) in Estonia, which is said to be one of the most advanced countries in terms diffusion of e-health, adapting Technology Acceptance Model (TAM). We identified three bottlenecks in diffusion process; 1) healthcare providers do not start to use EHR in the beginning; 2) healthcare providers stop using EHR when the number of users are small; and 3) the number of citizens using EHR do not increase in the end. Estonia succeeded in overcoming these bottlenecks by increasing a sense of expectation or giving a pressure to healthcare providers (bottlenecks 1,2) and by introducing new services (bottleneck 3).

---

**Index Terms-** information and communication technology (ICT), e-health, diffusion bottlenecks, Technology Acceptance Model (TAM).

---

## I. INTRODUCTION AND RELATED STUDIES

Recently, Internet has been more and more integrated in public services and this trend make our lives much easier. Use of Internet in healthcare sector is called e-health. With e-health, patients can know all of their own health information which they use to manage their health [1]. Also, healthcare providers can streamline their workflow [2], get more information of patients [3], and reduce medical errors [1]. Generally, e-health is said to improve quality of care, increase efficiency, and reduce cost of healthcare [4].

Many countries around the world have been trying to introduce e-health to solve health problems. US decided to make a system which can share medical information among healthcare providers and patients on a budget of 19 billion dollars in 2009 in order to reduce medical errors occurring 44000~98000 and increase cost efficiency of healthcare [5,1]. Countries such as UK, Netherland, South Korea, Sweden, Denmark and Australia also have made the same kinds of nationwide health information exchange system [6]. Not only for developed countries, but for developing countries introduction of e-health is encouraged in the 2030 Agenda for Sustainable Development [7], and countries like Rwanda, Ghana and India have been introducing e-health system [8]. It can be said that the effect of e-health is broadly recognized, and more and more countries are trying to introduce e-health systems.

However, countries trying to introduce e-health often face various problems preventing successful introduction. Understanding development stages of e-health implementation helps us to identify possible obstacles for introducing it. World Health Organization (WHO) divided the national context for

e-health development into three types, which can be considered as three steps for introducing nationwide e-health system [9]. Each step has its specific problems. The first step is called “Experimentation and early adoption”, where projects are rarely sustainable due to the lack of ICT infrastructures and skills. In this phase, strengthening digital infrastructure such as computers and internet is the priority concern. The second step is called “Developing and building up”, where some kinds of e-health systems has emerged although they are remained fragmented. In this phase, consensus among stakeholders to build nationwide e-health system must be reached, and e-health system would be built. Problems would be resistance of stakeholders due to privacy concerns [10], interoperability if local system has already existed in medical institutions [11], standardization of use of words or technical terms [12], and other things needed to build e-health system. The third phase is called “Scale up and mainstreaming”, where healthcare providers and citizens gradually start to use e-health, and e-health becomes widespread in the society. In this phase, the main problem is a lack of acceptance by healthcare providers and citizens [13].

Though these problems in each step are identified in previous research, academic works on solutions for them are surprisingly few [14]. Solutions for the third phase are particularly needed because countries rarely overcome the problem in the third phase and succeeding to diffuse e-health. In Canada, for example, only 37% of practitioners and 65% of hospitals use e-health system in 2013 [6]. In England, patients who access their health data was only 0.01% of the population [15]. Though Europe has many countries in the third phase, the rate of digitalized prescription

remains only 32% [16].

In contrast to these countries, Estonia is said to be one of the most advanced countries in terms of e-health. Estonia introduced nationwide e-health system in 2009, and in just 5 years, 72% of all healthcare providers change medical information, and almost all of the prescriptions is submitted electronically [17]. The high acceptance of e-health in Estonia is particularly unique. Therefore, it is meaningful to analyze the implementation and diffusion process of e-health in Estonia and draw some implications from it.

## II. ANALYTICAL METHOD AND FRAMEWORK

This research focuses on the implementation and user diffusion process of Electronic Health Record (EHR) in Estonia, which is the fundamental service among the whole e-health system. There are two steps to analyze diffusion process of EHR in Estonia. Firstly, general diffusion process of EHR and problems occurring in diffusion process are clarified based on expert opinions and literature review. For this purpose, both merits and risks of EHR for users are clarified. Also, the time when each merits or risks come to be effective would be clarified in order to analyze dynamism of EHR diffusion. From these information, the bottlenecks in diffusion process would be speculated.

Secondly, factors influencing bottlenecks in Estonia are clarified based on an interview survey. Interview surveys were carried out in October 2016 in Tallinn and Tartu, Estonia, and the interviewees are hospital doctors, healthcare publisher, government officers and university professors. To summarize information we gathered we adapted Technology Acceptance Model (TAM) to identify significant influencing factors which led to overcome the bottlenecks in its diffusion process. TAM is an influential model for information system adoption, and also used to explain acceptance of e-health in some researches [18]. TAM explains that perceived usefulness (PU) and perceived ease of use (PEOU) directly influence the intention to use an information system [19]. PU is defined as “the degree to which a person believes that using a particular technology will enhance his/her performance” and PEOU is defined as “the degree to which a person believes that using a particularly system would be free of effort.” We focus on factors affecting PU and PEOU in the bottlenecks of diffusion process.

## III. MERITS, RISKS AND DIFFUSION PROCESS OF EHR

### A. Merits and Risks of EHR

EHR has various merits for healthcare providers and

citizens. For healthcare providers, there are mainly three merits; 1) increase of efficiency; 2) improvement of quality of care; and 3) cost reduction [4]. Firstly, about increase of efficiency, healthcare providers easily search and store information of patients with EHR [2]. Also, if an insurance scheme requires them to send information, this process of sending information can be streamlined. These make work of healthcare providers more efficient. It should be noted that healthcare providers might feel the former merit after a certain period of time because information of patients such as record of medication would be useful and be searched in the next time the patients get sick. Secondly, about improvement of quality of care, healthcare providers can make better decisions in medical process with more information of patients [20]. Also, systems could suggest the opinion for treatment based on information of patients and medical knowledge stored in them, which would be a support of decision making for healthcare providers. These merits need certain amount of information of patients. Therefore, they should use EHR for a while and store information in EHR, and then benefit from it. Lastly, about cost reduction, healthcare providers could save cost of printing papers, unnecessary drugs, and others coming from increased efficiency [21]. This merit would be realized by manager of medical institution rather than clinicians.

On the other hand, Citizens also have three merits; 1) increase of efficiency, 2) leading healthier life, and 3) cost reduction. Firstly, about increase of efficiency, citizens could know their own health information more easily, and also save time of medical treatment by reducing repeated treatment and sharing information online [20]. This merit could be more effective after more healthcare providers enter health information. Secondly, about leading healthier life, citizens could benefit from improvement of quality of care provided by healthcare providers. Also, citizens could more easily manage their health with more health information available [1]. This merit would also be effective after healthcare providers use EHR. Lastly, about cost reduction, less treatment because of improvement of quality of care leads to less spending for cost of healthcare [20]. This merit could be understood as a result of leading healthier life.

EHR also has some risks for its users when introduced. For healthcare providers, there are mainly five risks. The first one is monetary cost. Building a system of EHR costs a lot for medical institution. Also, certain amount of money would be needed for its maintenance [21]. This could be the burden for medical institution for introducing EHR. The second one is a change of workflow. EHR requires healthcare providers to enter information of patients into computers. This could be an extra work for them particularly for the beginning. Those who are not used to using computers like elderly people tend to suffer from this change. The third one is

work evaluation by others. Sharing information could make healthcare providers feel afraid that their decision in treatment could be evaluated by others. This prevent them from using EHR actively. The forth one is leakage of privacy. Building a central database could cause a risk of leakage of a lot of health information. Health information is said to be the most sensitive information and leakage of it could cause severe social damage [10]. Healthcare providers usually give importance to this problem and resist to use EHR. The fifth one is inefficiency due to flaw in system. If the system does not perform as healthcare providers thought, they have to struggle to use it spending much time. Also, in case of downtime of system, information of patients could be unavailable at all [2]. Because there are many urgent situations in health sector, inefficiency could be a big risk for healthcare providers.

On the other hand, for citizens, there is one risk, which is leakage of privacy. Although there is only one risk for citizens, leakage of privacy is such a severe risk that citizens could make strong public opinion of opposition to use EHR.

Table 1 shows merits and risks of EHR for both healthcare providers and citizens. Aiming to analyze dynamism of diffusion process, the difference in timings when each merit/risk appears should be noted.

**Table 1: Merits and Risks of HER**

User	Specific merits/risks	Timing when each appears
<b>Healthcare Providers</b>		
Merits	Increase of efficiency	After a certain period of time
	Improvement of care quality	After information is stored
	Cost reduction	All times
Risks	Monetary cost	Particularly big in the beginning
	Change of workflow	In the beginning
	Evaluation by others	All times
	Leakage of providers' privacy	All times
<b>Citizens</b>		
Merits	Increase of efficiency	After information is stored
	Realizing healthier life	After information is stored
Risks	Cost reduction	After information is stored
	Leakage of citizens' privacy	All times

**B. Diffusion Process**

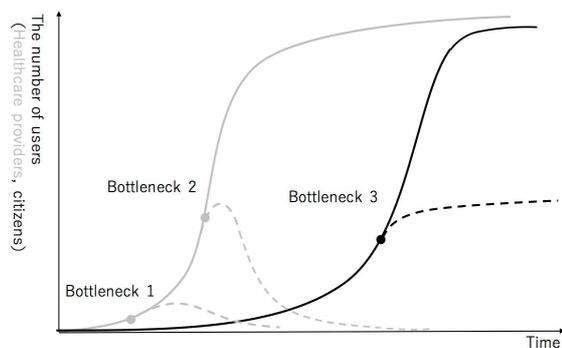
We would analyze diffusion process based on Rogers' innovation adoption curve [22]. Because there are two users of EHR, two curves should be considered. However, these two curves should have an order because diffusion of healthcare providers affect that of citizens. Since all merits for citizens are effective after their health information are stored, citizens would not actively use EHR before healthcare providers use it. Thus, diffusion among citizens would follow that among healthcare providers.

In the diffusion process among healthcare providers, there are mainly two bottlenecks. The first one occurs in the very beginning of diffusion process. In the

beginning, risks like monetary cost and change of workflow are particularly big. In addition, some merits are not effective before using for a certain period of time. Therefore, it is difficult to make healthcare providers start to use it and some incentives for them might be needed. If incentives are correctly given, some healthcare providers who are sensitive to new technology would start to use EHR. The second one occurs when some healthcare providers have used EHR although the number of users are still not large. In this situation, some of the merits are still not effective because EHR lacks much information of patients. Therefore, healthcare providers who have adopted EHR tend to feel more risks than merits, and stop using it. Stop using EHR would cause less information in EHR, which means that the merits of EHR would further decrease and more healthcare providers would stop using it. This negative cycle might cause total failure of diffusion among healthcare providers and also among citizens.

If EHR diffused among healthcare providers, citizens would start to use it. Risk for citizens is leakage of privacy. However, this would be less concerned because some measures might be taken as healthcare provider use EHR in spite of the same risk. Therefore, citizens could be thought to easily adopt EHR if there are enough merits. However, merits such as increase of efficiency and cost reduction could be realized only when citizens get sick. Therefore, citizens who do not have chronic diseases or severe diseases would seldom feel merits of EHR. In addition, if they have less illness and less cost of healthcare because of using EHR, they would hardly notice that because it is difficult to be aware of what is reduced unless they actively manage their own health. Because of these reasons, diffusion among citizens would not proceed successfully. This could be the third bottleneck of diffusion of EHR.

Bottlenecks in diffusion process are shown in Figure 1. Gray line is innovation adoption curve of healthcare providers and black line is that of citizens. Dotted line shows diffusion curve if bottlenecks are not overcome. From the next chapters, how these bottlenecks could be overcome will be clarified by analyzing process of introducing EHR in Estonia.



**Figure 1: Bottlenecks in EHR diffusion process.**

## IV. THE ESTONIAN CASE

### C. History

Estonia is the northernmost of the Baltic countries, located on the east coast of the Baltic Sea. Its area is 45226 square kilometers, and it has a population of around 1.3 million. Estonia belongs to the North Atlantic Treaty Organization (NATO) and the European Union (EU) in 2004. Since its independence from USSR in 1991, Estonia proceeded radical economic reform, which makes it have the highest GDP among Baltic countries [23]. The government of Estonia in collaboration with private sectors had invested a lot to the information technology (IT) industry and digital infrastructures such as computers and Wi-Fi. The government of Estonia had a clear strategy to develop the country by means of IT industry, which inspired private sectors [24]. The way of national development using IT was described in Principals of the Estonian Information Policy adopted in 1998. This document was updated every few years following the context of national development at that time [25]. Today, a lot of e-services are available in Estonia and people benefit from efficiency of these e-services [25].

Estonia had tried to change old health system of USSR since its independence. In 1990s, a critical structural reform was carried out and some fundamental organizations managing health related issues were established [26]. Ministry of Social Affairs, which is an organization managing entire health system and also managing introduction of EHR later, were organized in this period. After this structural reform, in 2000s, several laws related to medicines and health services had passed focusing on transparency and efficiency of health system [26]. After these reforms were completed, Estonia came to focus on further efficiency and sustainability [26]. Introduction of EHR was formulated in such a context. At that time, e-services had already existed in other sectors. For example, internet banking in 1996 was said to be the first successful e-services in Estonia [27]. Also, e-tax was available, which makes declaration of annual tax much efficient. Thus, people experiencing these e-services naturally accepted the idea of EHR [28].

Before introduction of EHR, many medical institutions had already had their own system for sharing information locally inside the institution. However, there were no standard for data type so that they could not share information among institutions. Also, the data was not shared with the government. This caused a problem that the government could not get trustful health statistical data for improving healthcare system. To solve this problem and to improve quality of healthcare, Ministry of Social Affairs initiated the project of introducing nationwide EHR with three other e-health services; e-Prescription, e-registration, and digital images. The

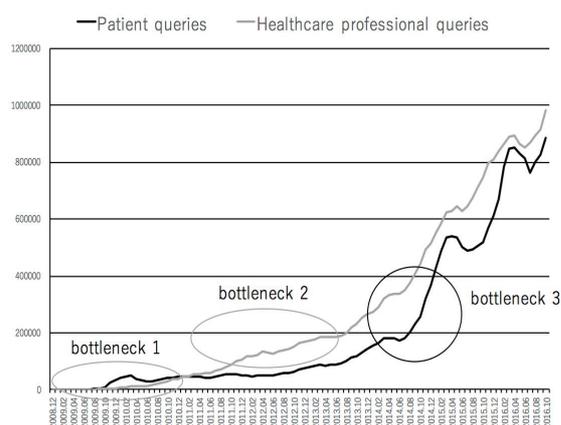
budget allocated to EHR was 1.6 million euro and 75% of that was funded by European Regional Development Fund (ERDF) [29]. Ministry of Social Affairs established Estonian e-health foundation to manage development and operation of whole e-health system and assigned a part of tasks to it. The member of management board of Estonian e-health foundation entitled various stakeholders in order to smoothly get consensus of related actors such as 3 big hospitals, Ministry of Social Affairs, ambulance association, family doctor association, Estonian Health Insurance Fund, and hospital association. Also, while building the system, discussion with many kinds of stakeholders were conducted frequently. The stakeholders include patients, primary care doctors, special care doctors, hospital doctors, software vendor, and so on. Some discussions were broadcasted on TV show drawing public attention. Media also promoted EHR, whose main topic was about its security and merit. In 2009, EHR system was completed and people started to use it.

Ministry made using EHR mandatory by law, and gave subsidy for introducing EHR. All medical institutions needed to connect their system to the central database of EHR. Big hospitals were initially opposed to introduce EHR because most of their patients did not go to other institutions and they have almost all of necessary health information so that they found no merits but only cost for introducing EHR. However, they changed their attitude and started to use EHR after some patients asked them why they did not do. Thus, in a few years, most of the medical institutions connected. However, according to survey conducted in 2012, the rate of medical institutions who have entered the data to the database of EHR remains only 34% [30]. The main reasons for not using EHR were “using it takes too much time”, “there is no information about how to use it” and “as data must be entered in their own databases anyway, they don’t think duplicating it in e-health is necessary” [30]. Also, there was an opinion that they did not know when to submit the data [30]. These opinions show that the system of EHR was not suitable for healthcare providers at this stage. To solve this problem, usability of EHR was improved based on feedback of users around 2013. Time stamp was one of the most effective tools introduced at that time. It enabled primary care doctors to send documents without entering their own signature every time they processed it. In addition to some improvements of the system like time stamp, the government visited some institutions that did not send data to EHR and solved problems of each [30]. Due to these measures, the number of documents in EHR had gradually increased. Also, other e-health services such as e-prescription, e-consultation, and e-ambulance was introduced, and these grew awareness of e-health for

healthcare providers. This might also contribute to the increase of use rate of EHR.

As for citizens, their use rate was very low before 2014 in spite of understanding its usefulness. A survey conducted in the end of 2012 by the government showed that the number of unique users of patient portal, which was the platform of EHR for citizens, was only 48386 out of a population of 1.3 million [31]. Another survey showed that one of the main reasons for not using patient portal was lack of information [32]. The new portal site was released in August of 2013, which was easier to use than previous one, and have some new functions. After releasing, further additional functions had introduced [32]. These made EHR more attractive to citizens. One example is e-certificate. It digitally provided legal health certificate which is used when people wanted to update driver license or buy guns [32]. This made it much easier to get health certificate comparing to previous situation where people had to go to medical institutions several times. Also, in 2016, the service that showed how much healthcare providers were reimbursed for each treatment was introduced. This service increased the use rate of citizens from 5% to 17%. Considering that this number include people without any problems on health, the use rate of citizens was high.

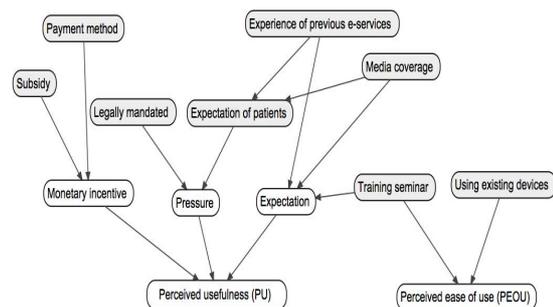
Figure 2 shows the number of queries to EHR by healthcare providers and citizens. Estonia overcame bottleneck 1 around 2010, bottleneck 2 around 2012, and bottleneck 3 around 2015. Below, we investigate factors affecting PU and PEOU described in TAM in each period of time, and analyze which factors was particularly influential.



**Figure 2: The number of users' queries (moving average).**  
(Data adapted from Ministry of Social Affairs)

#### D. Overcoming Bottleneck 1 around 2010

Gray boxes in Figure 3 show factors influencing PU or PEOU around 2010, particularly when healthcare providers started to use EHR. There are mainly three ways affecting PU; 1) monetary incentive; 2) pressure; and 3) expectation.



**Figure 3: Factors led health care providers to start using EHR around 2010 (bottleneck 1).**

1) Monetary incentive: Subsidy given to health institutions when introducing EHR gave them monetary incentive. Also, some reimbursement scheme could be monetary incentive such as capitation, quality bonus scheme (QBS), DRG-based payment. Under these scheme, healthcare providers could get more reimbursement if they improved their quality of care. Since EHR is said to improve quality of care, these scheme worked like monetary incentive to introduce EHR. However, although these monetary incentives existed, these seemed to be less influential because of reasons below. Subsidy was said to be not large enough to pay introduction cost and medical institutions still suffered from cost problem. Also, benefit from reimbursement scheme was based on uncertain increase of quality of care. Therefore, it could be said that the influence of monetary incentives was little for starting to use EHR.

2) Pressure: Using EHR was mandated for healthcare providers according to law. If they did not use it, they might lose their license. This gave a pressure for healthcare providers to use EHR. Also, pressure from patients was so effective that big hospitals started to use EHR. In this time, patients should have no merits for EHR because no data has stored in EHR yet. However, patients saw media like TV or newspapers and thought that EHR should be useful for them.

3) Expectation: Before EHR was introduced, there have been many e-services and people had benefitted from it. From the experience of previous e-services, people generally supported digitalization. This made people expect to the benefit of EHR. Also, massive media coverage around implementation of EHR convinced people the efficiency of EHR. In addition, in training seminars for healthcare providers, efficiency of EHR was frequently explained, which raised expectation to EHR.

Meanwhile, there were two factors affecting PEOU. In training seminars, how to use EHR was explained. Healthcare providers could use EHR more easily after these seminars. Also, the fact that EHR introduction did not cause replacement of existing systems would affect PEOU. Medical institutions were not required to replace their existing systems, but just update their

systems so that they could connect to EHR. This also did not require healthcare providers to learn how to use from the beginning. Thus, healthcare providers might feel easier to use comparing to total replacement of systems. However, these factors affecting PEOU could be influential after starting to use EHR because they might feel ease of use only after using it, and could not be decisive factors of starting to use it.

Therefore, among these factors, monetary incentive was less influential, and factors affecting PEOU could be influential rather after starting to use EHR. Thus, pressure and expectation with factors affecting those are thought to be influential factors to overcome bottleneck 1.

*E. Overcoming Bottleneck 2 around 2012*

Gray boxes in Figure 4 show factors influencing PU or PEOU around 2012, particularly when healthcare providers continued using EHR. Most factors in Figure 4 have already explained in Figure 3, except for improvement of usability. Around 2012, Usability was largely improved with additional functions like time stamp. This improvement made EHR easier to use and increase PEOU of healthcare providers. Among these factors, monetary incentive was again not influential because of its uncertainty. Also, the government did not have a way to know if healthcare providers were using EHR. Thus, legislation seemed to have no effect in this time. In addition, improvement of usability was just improvement of defect in the design. Thus, it could not be the factors for overcoming bottleneck. Actually, this factor rather shows usability was nothing to do with continued use of healthcare providers. For the reason above, expectation and pressure with factors affecting those (except for legally mandated) are thought to be influential factors to overcome bottleneck 2.

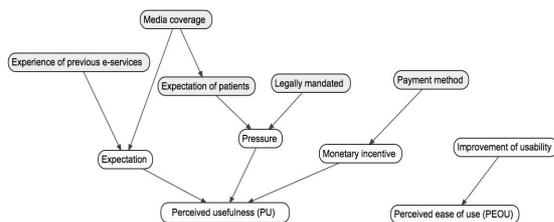


Figure 4: Factors led healthcare providers to continue to use EHR around 2012 (bottleneck 2).

*F. Overcoming Bottleneck 3 around 2014*

Gray boxes in Figure 5 show factors influencing PU or PEOU around 2014, particularly when the use rate of citizens was increased. Citizens also had expectation to EHR for experience of previous e-services and media coverage. However, around 2014, various new services were launched such as e-Certificate, visualization of reimbursement, e-Consultation and e-Ambulance. Citizens would benefit from these new services and use rate was increased. Improvement of

usability was just improvement of defect in the design. Thus, it could not be the factors for overcoming bottleneck. For the reason above, new services might be the influential factors. It should be noted that most of the new services were based on information in EHR. For example, e-Consultation, which was official consultation between primary care doctors and special care doctors, needed sufficient information for them to diagnose patients. Also, there were services that utilize information stored in EHR in social system. E-certificate, which was the official health certificate available online, utilize information stored in EHR when citizens needed to use it in other situations than health such as updating driver license or buying guns. Therefore, it could be said that these kinds of new services could be released only after a certain amount of information was stored. Also, utilization in social system might be useful for citizens.

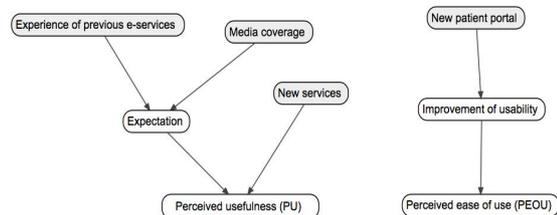


Figure 5: Factors related to increase in citizens' use rate around 2014 (bottleneck 3).

**CONCLUSION**

We analyzed the general diffusion process of EHR based on merits and demerits and the timings when they appear. Based on this, we identified three bottlenecks in diffusion process; 1) healthcare providers do not start to use EHR in the beginning; 2) healthcare providers stop using EHR when the number of users are small; and 3) the number of citizens using EHR do not increase in the end. From the data about the number of queries provided from the government of Estonia, Estonia could be said to have overcome each bottleneck around 2010, 2012, and 2014. In each period of time, factors influencing PU and PEOU, which is related to users' intention to use according to TAM, are clarified. About the bottleneck 1 and 2, factors which increase a sense of expectation or give a pressure to healthcare providers are particularly effective. These factors can be media coverage, experience of previous e-services, and legislation. About the bottleneck 3, new services could have large influence. These new services are often based on information stored in EHR, and related to other social system than health. These implications are reasonably effective considering to problems coming from the characteristics of EHR which prevent the diffusion, because they act as additional facilitators which add a kind of new values for users. The government planning to introduce e-health



- [http://pro-ehealth.eu/fileadmin/pro-ehealth/casestudies/proehealth\\_case\\_report\\_estonia\\_ehr.pdf](http://pro-ehealth.eu/fileadmin/pro-ehealth/casestudies/proehealth_case_report_estonia_ehr.pdf).
- [30] National Audit Office, "Activities of the State in Implementing the e-Health System: Do the State, Doctors and Patients Benefit from e-Health?," Jan. 2014. Accessed Mar. 10, 2017. [http://egov.nik.gov.pl/egov/EE/2014/eHealth/E-health\\_eng.pdf](http://egov.nik.gov.pl/egov/EE/2014/eHealth/E-health_eng.pdf).
- [31] Janek Metsallik, Personal Communication, 2016.
- [32] H. Laarmann. "Document D10.3 Final Pilot Evaluation - Estonia Version 1.0," sustains: Support USers To Access INformation and Services, Feb. 2015. Accessed Mar. 10, 2017. <http://www.sustainsproject.eu/sustainsproject/attachment/d103v11.pdf>.

