eHEALTH IN THE PUBLIC SECTOR: AN EMPIRICAL ANALYSIS OF THE ACCEPTANCE OF GERMANY’S ELECTRONIC HEALTH CARD

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Given the increasing importance of eHealth as an integral part of eGovernment, this contribution concentrates on the issue of acceptance regarding the introduction of the German electronic health card (eHC). A brief introduction highlights the relevance of the subject and the differing acceptance rates of patients and service providers, i.e. physicians. Based on both the technology acceptance model and the relevant literature, important factors influencing the attitude towards and the potential use of the eHC are conceptualized and integrated in a research model. The empirical examination was conducted throughout Germany through an online survey of physicians. Overall, 502 responses were collected and included in the analysis, which was carried out with structural equation modelling using EQS. The empirical results show that the relevant determinants of the acceptance of the eHC in Germany, such as efficiency and usability of the system and the cost–benefit ratio, were properly identified.

INTRODUCTION

The dynamic development of innovative information and communication technologies has transformed the supply chain of the health sector (see Keen 1994). New sector-spanning eHealth applications that are independent from time and space are enabling faster and more efficient communication within the full range of health care services. A crucial component of this development is the introduction of the German electronic health card (eHC).

This technology project can be described as a microchip-based patient identification card intended to improve medical and administrative communication (Fulcher 2003, p. 27; Pagliari et al. 2007, p. 330). The fast and secure availability of patient data for different physicians that is enabled by this kind of smart card establishes a foundation for networked medical treatment. Additionally, the eHC is part of one of the world’s largest telematic projects in the health sector. The wide scope of this public service technology makes it an important example of eGovernment projects, which have become an important research stream within public administration (see Currie et al. 2008; Nasi et al. 2011). Any possible failure in the system’s implementation would have monetary, political, and administrative consequences. Therefore, public acceptance of eHC use is of interest to public administration practitioners and political stakeholders as well as health care professionals.

The adoption of smart cards as a mean of identification and communication in health care systems varies across countries (Booz & Company 2008, p. 56). Whereas countries like Taiwan, Italy, Slovenia, and Germany are planning or currently implementing a strategy based on smart cards with medical functionality, other countries like France and Austria prefer to use smart cards primarily as a secure insurance identifier. A third group of countries, like the UK, the USA, and Canada rely mainly on paper-based or plastic cards, which are used exclusively for citizen identification and do not support smart card...
features. Furthermore, countries exhibit differences concerning their preferred political strategy regarding smart cards in the health care sector. However, it can be expected that more and more countries will follow successful first-movers in this area of eHealth.

The introduction of the eHC can be understood as a foundation for an eHealth infrastructure throughout Germany. Considering the difficult financial situation facing the health system, the implementation of the eHC pursues the super-ordinate goal of modernizing the health care system, in particular regarding public health care insurance. Here, the main focus is on aspects such as networked data management and the realization of cost savings. Other goals to be reached are: improving treatment and quality of medical care in general, minimizing errors, and decreasing the workload of medical staff (Bales 2005, p. 727).

So far, the test phases carried out by the German Federal Ministry for Health have chiefly tested the technical components with regard to their suitability and reliability. Social context factors from the external environment, as well as the social interaction between health care providers (i.e. physicians, hospitals etc.) and care recipients (i.e. patients), have been only marginally examined. In order to successfully advance the eHC project and guarantee the realization of the system’s potential as soon as possible, interaction between all of the people involved as well as their continuous acceptance and satisfaction is indispensable (Krüger-Brand 2004, p. 864; Fleßa 2007, p. 19; Hackenberg and Matthies 2007, p. 60).

In particular, with recent changes in health care it has become apparent that large acceptance issues can arise if a transparent and comprehensive information policy is not provided for in advance (Tscheulin and Helmig 2000, p. 105; Rienhoff et al. 2004, p. 1791; Rienhoff and Verhey 2005, p. 48). For the service receivers – the patients – the information policy for the eHC seems to have worked in the best possible way, as empirical research has found a generally positive attitude towards the eHC within this group (Ernstmann and Pfaff 2006, p. 370; Brüss 2007; Sunyaev et al. 2009, p. 749). Factors leading to a high degree of acceptance among the service receivers include the voluntary nature of the system and patient empowerment (Groß 2007, p. 13).

Contrary to this, acceptance of the eHC within the health care provider community has to be rated as rather low, despite that the basic idea of the eHC is to make their work easier (Ernstmann and Pfaff 2006, p. 371; Hillienhof 2007, p. 20). Surveys have shown that especially physicians have a rather low acceptance rate regarding the use of the eHC (Ernstmann and Pfaff 2006, p. 370; Ärztekammer Berlin 2008). Apart from the considerable changes in work routines induced by the eHC, physicians mainly criticize the substantial organizational and additional investments that come along with the costs of introduction (Krüger-Brand 2004, p. 864; Ernstmann and Pfaff 2006, p. 372). In particular, the costs for hardware, training, and technical support are pointed out, costs which to a considerable extent are to be borne by physicians alone (Hillienhof 2007, p. 20; Montgomery 2007, p. 8). In this context, attention has also been drawn to the inverse distribution of the burden of expenditure between health insurance companies and physicians. On the whole, it has been claimed that the cost–benefit ratio merely shifts, at the expense of the health care providers. Furthermore, from the physicians’ point of view unresolved technical issues, such as the speed of the system, still need to be addressed (Hillienhof 2007, p. 20).

Due to the lack of transparency regarding the introduction of the eHC, and in connection with the other issues described above, a considerable problem regarding physicians’ acceptance has arisen (Ernstmann and Pfaff 2006, p. 370; Hillienhof 2007, p. 20). Yet despite this problem of acceptance by health care providers and the great importance
of the eHC project, there has been little research in this area to date (Rienhoff 2001, p. 642; Ernstmann 2007, p. 35). This may in part be due to the fact that in order to fully capture the complexity of an acceptance issue, extensive analyses are necessary in order to identify specific factors of acceptance which, in turn, lead to higher acceptance and hence to successful implementation. Therefore, prospective, theory-driven research approaches and comprehensive evaluation methods – such as structural equation modelling – are needed in order to improve the international research on technology acceptance in the health sector (Ernstmann 2007, p. 102).

This study pursues the goal of developing a theory-driven, hypotheses-testing contribution to the empirical measurement of the above outlined acceptance issue on the part of physicians. In order to meet this objective, the following chiefly deals with the super-ordinate issue: Which essential factors affect the acceptance of the eHC from the point of view of the physicians? The issue is divided into two relevant fields of study: the identification of factors influencing the acceptance of the eHC, and the analysis of the causal path from influencing factors and acceptance.

This paper is divided into six sections. The second section identifies the limitations of the current state of research. The third section presents the theoretical framework by which the research model can be conceptualized in the fourth section. In the fifth section, the focus is on the empirical study. In this section, therefore, the database, data collection, and data evaluation are presented and the model is empirically examined in its entirety. The sixth section summarizes the results and presents the implications for science and practice.

LITERATURE REVIEW

In the following, an overview of empirical papers regarding the acceptance of electronic card systems in the health sector is provided. In the literature, however, only a limited number of specific analyses on the acceptance of the eHC can be found, the focus of which has so far been mainly on budgeting and organizational structures (Vera and Foit 2005, p. 376).

In general, research regarding the acceptance of the eHC by physicians has been rather limited in value. To date, there are only a few papers – especially ones with an empirical basis – on this subject and they do not provide clear indications of the factors that can inhibit or gradually increase the physicians’ willingness to accept the eHC (Hu and Bentler 1999, p. 1; Rienhoff 2001, p. 642; Ernstmann 2007, p. 35).

In summary, five relevant contributions can be identified that examine the introduction of a new electronic card system in an existing health care system. Table 1 gives an overview of these studies with a focus on the following criteria: issue of the study, theoretical basis, empirical examination, and findings. For the German case of the eHC, the studies by Pfaff and Ernstmann (2005) and Ernstmann (2007) are relevant. These examine the acceptance of the eHC with a strong focus on the health care providers, especially physicians. Pfaff and Ernstmann (2005) found a knowledge gap and a corresponding information demand among physicians and medical staff in hospitals, which in turn influenced the perceived usefulness and acceptance of the system. Ernstmann (2007) showed that the perceived usefulness of the system by physicians is influenced by psychological factors such as the feeling of being integrated in the process of technology development and implementation.

On an international level, the studies by Aubert and Hamel (2001), Liu et al. (2006), and Pizzi et al. (2005) need to be stressed. Aubert and Hamel (2001) conducted a study among
### TABLE 1  Description of the papers on the acceptance of electronic card systems

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Title</th>
<th>Issue</th>
<th>Theoretical basis</th>
<th>Empirical examination</th>
<th>Object of study/result</th>
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<tr>
<td>Aubert and Hamel (2001)</td>
<td>Adoption of smart cards in the medical sector: the Canadian experience</td>
<td>Determination of the factors relevant for the application of smart cards in the medical sector</td>
<td>Sequential, Political, Serendipitous Model</td>
<td>Sample 1: n = 287 health professionals n = 300 health service clients Sample 2: n = 526 health care practitioners n = 123 health care clients</td>
<td>The most important factor with the application of smart cards is the advantage for the health care providers. Of secondary high importance are: compatibility, image, ease-of-use, and quality support.</td>
</tr>
<tr>
<td>Erstmann (2007)</td>
<td>Determinants of the subjective benefit analysis of the electronic health card and of the electronic prescription (translated from the German original title)</td>
<td>Theory-based examination of the determinants of the acceptance of the eHC and the electronic prescription among German physicians</td>
<td>Technology Acceptance Model</td>
<td>n = 188 physicians in private practice</td>
<td>High expected benefit results from being involved in the development of the technology and from expecting to spend little effort on training. In addition, it was found that a higher benefit is expected among women and in small practices.</td>
</tr>
<tr>
<td>Author/Year</td>
<td>Title</td>
<td>Issue</td>
<td>Theoretical basis</td>
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| Liu et al. (2006) | The impacts of smart cards on hospital information systems. An investigation of the first phase of the national health insurance smart card project in Taiwan | Examination of the impacts of the first phase of Taiwan’s Bureau of National Health Insurance smart card project on existing information systems of hospitals |                                                                                  | n = 104 hospitals | Data collection approach: primary statistical Recommendations for introducing similar projects:  
• Create public awareness through special programme or campaigns in order to explain the smart card, how it works and how it is used.  
• Improve the quality of the NHI-IC cards.  
• Conduct extensive tests of the hardware and software connected with the NHI-IC card system before it becomes operational.  
• Promote further examinations in a real test environment and develop an instrument for identifying problems. |
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<th>Empirical examination</th>
<th>Object of study/result</th>
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<tr>
<td>Pfaff and Ernstmann (2005)</td>
<td>Acceptance study on the introduction of the health card (translated from the German original title)</td>
<td>Determination of the existing success factors as well as barriers regarding the introduction of the eHC from the perspective of physicians in private practice</td>
<td>Technology Acceptance Model</td>
<td>n = 243 Attendees of the MEDICA congress and the MEDICA trade fair 2004</td>
<td>Including physicians in future steps of development and introduction of the electronic health card in order to facilitate successful implementation.</td>
</tr>
</tbody>
</table>
| Pizzi et al. (2005) | Factors related to physicians’ adoption of electronic prescribing: results from a national survey | Identification of the factors relevant for physicians to apply electronic prescriptions | Transtheoretical Model of Change | n = 1104 physicians | Reasons why the electronic prescription has not yet gained further currency:  
  • Physicians do not believe that the system brings them an advantage.  
  • Physicians know too little about electronic prescriptions. |
health care providers as well as health care receivers in Canada in order to assess the acceptance of a smart card technology. They found that a direct benefit for both stakeholder groups needs to be inherent in the system if it is to motivate them to adopt the technology. Furthermore, 14 factors influencing the acceptance of the smart card technology were identified. Based on empirical data, Liu et al. (2006) conclude that the following factors are crucial for the successful implementation of smart cards in the health care sector: public awareness of the smart card policy and the proper usage of the cards, quality of the cards, comprehensive software and hardware testing, and tools for the fast identification of potential problems. Pizzi et al. (2005) identified barriers and benefits in the context of the introduction of the electronic prescribing system E-RX in the USA. Using a sample of physicians, they found the following barriers prevent physicians’ acceptance and use of the system: cost of the system, time to install and change office procedures, uncertainty in acceptance of E-RX in pharmacies, time to correct faultily transmitted prescriptions, and patient confidentiality concerns. Benefits included a reduction in medication errors and abuse of prescriptions, reduced treatment costs, and improved health care quality.

Overall, it can be said that the research in German-speaking countries focuses primarily on the impacts of the eHC with regard to budget and technology. International studies also focus on acceptance issues, but methodologically the selected contributions exclusively use univariate analyses. This approach is insufficient due to the considerable complexity of acceptance research. A fully specified multivariate model for this field of research, one which is deduced from theory and rigorously tested with the most appropriate statistical techniques, is not yet available.

THEORETICAL FRAMEWORK

The theoretical basis of this study is the Technology Acceptance Model. Apart from a clearly structured specification of the basic hypotheses within the framework of the technological acceptance research, this provides foundations for conceptualizing and operationalizing external factors of acceptance.

The Technology Acceptance Model is a theory of individual behaviour which explains acceptance from a rational choice perspective. Because of their central role in the health care sector and their direct influence on the attitudes of patients, physicians were chosen as the key informants on this subject. Therefore, this study examines the individual factors of acceptance of physicians, as representatives of health care providers.

Despite several points of criticism that have been raised regarding the use of this theory in the context of health care systems (Zheng et al. 2007, p. 59), the authors found an approach based on the Technology Acceptance Model to be useful for the following reasons: the criticism of the applicability of the theory mainly refers to medical services in the context of diagnosis, treatment, or recovery. The implementation of the eHC-system, however, is more focused on functions of data management, which imply similar characteristics to common IT systems. Acceptance on the side of the health care providers is a key factor for the successful implementation of the eHC because they manage the technical infrastructure and serve as the interface between patients and the supplied services. They are the most relevant group of users, since patients do not directly interact with the system and health insurers use it only for cost management. Therefore, the authors chose physicians as the key informants on the use of the system. In this context the different factors leading to a high or low degree of acceptance are of direct relevance to political and other health care-related stakeholders. Moreover, criticism concerning the
lack of explanatory and practical value of the theory (Chuttur 2009) is not applicable to this specific subject. The Technology Acceptance Model has been found to be a frequently used and reliable theory for generating empirical measures in the context of user acceptance (Venkatesh 2000, p. 343; Legris et al. 2003, p. 202). It is said to be one of the most frequently used and best empirically confirmed models for examining the determinants of ‘usage acceptance’ (Chau and Hu 2002, p. 191; Ma and Liu 2004, p. 59) and, furthermore, to have a particularly high explanatory value compared to alternative models (Mathieson 1991, p. 173; Venkatesh and Davis 2000, p. 186; Gentry and Calantone 2002, p. 945).

Acceptance of the distribution of new technologies is of particular relevance. Due to a low degree of willingness to accept the usage of new technology systems, often a system does not catch on in practice despite high functional suitability. With the help of acceptance research, it can be determined which factors are most influential in determining the frequency of usage and/or the acceptance of a technical innovation.

The Technology Acceptance Model was originally developed by Davis (1986) and is a refinement of the Theory of Reasoned Action (Bales 2005, p. 727). The basic idea of the Technology Acceptance Model is to examine the acceptance of information technologies. The goal is to create causal explanations that are theoretically grounded and which can be realized in practice to influence the acceptance of new technologies.

The model postulates two dimensions that are crucial for acceptance: the perceived usefulness and the perceived ease-of-use of new technologies (Davis 1986). The perceived usefulness indicates to what extent the user of a new technological system is convinced that using the technology will improve their performance in the given area of responsibility. The perceived ease-of-use, by contrast, describes the degree of effort the user expects is required to be able to employ the new technology in the future (Davis 1989, p. 320; Davis et al. 1989, p. 985; Ma and Liu 2004, p. 60). Both the perceived usefulness and the perceived ease-of-use are affected by external factors. These determinants can range from technological system properties to the users’ personal characteristics to environmental factors (Ernstmann 2007, p. 17).

The attitude towards using the system resulting from these factors indicates to what extent the person adopts a positive, negative, or neutral stand towards the usage of the system. This attitude ultimately results in a behaviour towards the system: the intention. Therefore, contrary to the Theory of Reasoned Action, intention in the Technology Acceptance Model is directly determined not only by the attitude towards using the system, but also by its perceived usefulness. Ultimately, the actual usage of the system results from the intention. The interrelatedness of the described dimensions is illustrated in Figure 1.

Davis (1986) intended to analyze the usage of information systems in the work environment and, with the aid of these findings, to improve their acceptance. The object of observation in the Technology Acceptance Model is the employees’ acceptance of the system within a company. However, the focus can also be transferred to the issues concerning the eHC which are the object of this study. Furthermore, this model intended to be a general explanation model for the behaviour of users towards innovative technological systems. Thus the model has a wide range of applications.

Regarding the introduction of the eHC, the Technology Acceptance Model can be used as the ideal theoretical framework for identifying the determinants of acceptance concerning the eHC from the perspective of physicians. Since the potential users of the eHC have little or no experience in using the system, due to the testing phase of the project, a survey based on observations of the action or usage acceptance does not make sense. On the one hand, an empirical measurement in the survey is problematic because
of the limited scope of usage; on the other hand, it has to be assumed that the behaviour of inexperienced users differs from that of experienced users. Instead, this study focuses on measuring the ‘attitude acceptance’, which aims at predicting the actual usage employing the construct of usage intention. Here, attitude acceptance is understood as a permanent adaptation of perception on a cognitive and affective level connected with responsiveness to the systems of the eHC (Müller-Böling and Müller 1986, p. 26).

CONCEPTUALIZATION AND HYPOTHESES GENERATION

Having described the theoretical framework of the study and hence identifying the general model parameters of the Technology Acceptance Model, this article must now identify the concrete determinants or external factors influencing the acceptance of the eHC. To do so, the findings from the literature on electronic card systems and the basic literature on the Technology Acceptance Model are consulted. The first subsection focuses on the factors influencing perceived usefulness, while the second subsection describes the factors affecting perceived ease-of-use. The section concludes with a presentation of the overall model and the corresponding system of hypotheses.

Perceived usefulness of the eHC

In the basic literature on the Technology Acceptance Model, the perceived usefulness is defined as the user’s subjective probability that using a specific technology will improve their future performance within the scope of the organizational context (Davis et al. 1989, p. 985).

Whether a technology is considered useful depends largely on the social framework. The social influence of a person’s environment plays a vital role in whether acceptance is formed and in which way it is formed with regard to the new technology. In the context of the Technology Acceptance Model, Venkatesh et al. (2003) define social influence as the ‘degree to which an individual perceives that important others believe he or she should use the new system’ (Venkatesh et al. 2003, p. 451). In a similar observation, Thompson et al. (1991) coined the term ‘social norm’. Karsh (2004), however, specifies this social influence
or the social norm on the variables of recognition and image. If the adaptation to a new system leads to positive recognition for a user within a social group, this can accelerate the general process of adaptation and acceptance. Within the context of the introduction of the eHC, the social influence of peer groups was particularly important for promoting acceptance of the system (Pfaff and Ernstmann 2005, p. 35). In this connection, it can be assumed that if interest groups or the groups that came into contact with the eHC early on create a positive effect on the social environment regarding the usefulness, then this environment in turn develops a positive perception of the perceived usefulness of the eHC.

Another factor that can affect the willingness to accept the introduction of the eHC on the part of the physicians is the efficiency of the system. The efficiency of a new technology is directly connected with its perceived usefulness (Davis 1989, p. 319). Aubert and Hamel (2001) and Lee (2004) revealed that a particularly efficient system leads the user to expect to gain a relative advantage from using the newly introduced technology. This relative advantage, however, has to be clearly perceptible for the user to develop a general acceptance of the new technology. Regarding the efficiency of the eHC, the aspect of data security plays a vital role. As Pizzi et al. (2005) established in their studies, this variable is of particular importance because it affects the level of trust in the new technology and hence its acceptance.

An aspect that is always vehemently discussed regarding the introduction of the eHC is the physicians’ expectation of productivity or performance improvements through the system. These expectations are defined as the degree to which a person believes that using the new system will help to improve overall job performance (Venkatesh et al. 2003, p. 447). Davis (1989) thinks that this factor is of particular relevance for creating a generally positive attitude of acceptance. Within the context of the eHC, anticipated time-saving deserves special mention, as the eHC is supposed to lighten the administrative burden on physicians and allow them to focus on medical care. Another important aspect in this context is the optimization of operational organization. Here, Pfaff and Ernstmann (2005) identify the factor of potential improved organization of the medical practice as having a significant impact on the acceptance of the eHC.

Regarding the introduction of the eHC to date, most physicians have criticized the very opaque communication and poor instruction on the subject. A factor that takes up this issue, but was only identified in later elaborations on the general Technology Acceptance Model, is the factor of inclusion in implementation. In a study by Aubert and Hamel (2001), this factor is captured under the generic term ‘involvement’ and denotes a mechanism through which a person sees themselves as a part of the development, design, or introduction of an innovation. This personal involvement leads to an increase in the personal willingness of acceptance. The importance of involving the relevant stakeholder in the implementation process has been pointed out in the context of the eHC as well. Here emphasis was placed, in particular, on the communication of relevant knowledge concerning the introduction of the eHC. In order to involve the users, they have to be well informed about alterations or the subject has to have an extensive presence (Pfaff and Ernstmann 2005, p. 26).

In the context of the discussions about the financial aspects of the eHC (investment costs, funding gaps, and savings potentials), the cost–benefit ratio is of particular relevance to physicians. Discussed as a ‘cost–benefit paradigm’ in Davis (1989), the expected benefit and expected costs that have to be paid for it are of particular importance. Boonstra et al. (2004) and Pizzi et al. (2005) also attached high significance to the cost–benefit factor in their studies of the acceptance of a new technology.
Perceived ease-of-use of the eHC

The perceived ease-of-use describes the extent of the expected efforts the user requires to employ the new technology in the future (Ernstmann 2007, p. 17). Different factors can affect the perceived ease-of-use, which in turn has a direct influence on the perceived usefulness of a technology.

An important factor regarding the acceptance of the eHC by physicians is the compatibility of the new system with already existing software and hardware. In this context, compatibility describes the trouble-free integration of a new system into existing systems, one which has no negative influence on the workflow, the environment, or other social systems. The compatibility factor has already been identified in numerous studies on the acceptance of new technologies and its effect on the perceived ease-of-use has been confirmed (Aubert and Hamel 2001, p. 881; Karsh 2004, p. 389; Pizzi et al. 2005, p. 28). In the basic literature on the Technology Acceptance Model, Davis (1989) points out the significance of the compatibility factor of a new system for increasing the perceived ease-of-use through simple usage.

The introduction of the eHC requires a new system be installed along with corresponding software and hardware components. Therefore, another factor concerning the acceptance of the eHC by physicians is the usability of the electronic system that is to be introduced. Davis (1989) points out that the acceptance of a new technology strongly depends on how easily the system can be learned as well as how intuitively it can be used, which leads to the substantial and rapid building of competence. With regard to usability, the factor of clarity and comprehensibility of a system plays a vital role. A system that is to be newly implemented has to be clearly and comprehensively structured for the user if it is to positively affect their attitude towards the system and hence increase their willingness to accept it (Davis 1989, p. 319).

In order to successfully implement the eHC system, basic technical components have to be developed in a way which does not impede workflow. As Karsh (2004) has already described, the reaction time or the speed of the system and the risk of malfunctions due to, for instance, breakdowns within the system, significantly affect the willingness of acceptance. Here, in particular, the manageability of the system comes into effect (Davis 1989, p. 319). The user has to be able to manage the system in such a way that any system failures or lower data bit rates than required do not disturb the work routine. In connection with the manageability of the system, the quality of technical support in order to eliminate any malfunctions has also been highlighted in the literature (Aubert and Hamel 2001, p. 881).

In summary, eight external factors could be identified that affect perceived usefulness and perceived ease-of-use. Figure 2 presents the identified external factors on the left-hand side as well as their effect on the basic system of the Technology Acceptance Model on the right-hand side. In the following, the hypotheses integrated in Figure 2 are specified in more detail.

As is presented in the model (see Figure 2), five external factors could be identified that have an effect on perceived usefulness. This leads to five confirmatory–explicative hypotheses:

\textit{Hypothesis 1}: The greater the social influence of the environment, the greater the perceived usefulness of the eHC.

\textit{Hypothesis 2}: The higher the efficiency of the system, the greater the perceived usefulness of the eHC.
Hypothesis 3: The higher the expectations placed on the system in terms of productivity/performance, the greater the perceived usefulness of the eHC.

Hypothesis 4: The greater the involvement in the implementation of the introduction of the eHC, the greater the perceived usefulness.

Hypothesis 5: The higher the cost–benefit ratio in favour of the physicians, the greater the perceived usefulness of the eHC.

In the context of perceived ease-of-use, which is of central importance for the acceptance of the eHC, three external factors could be derived. This is expressed in three other confirmatory–explicative hypotheses of the study:

Hypothesis 6: The higher the compatibility of the system, the higher the perceived ease-of-use.

Hypothesis 7: The better the usability of the system, the higher the perceived ease-of-use.

Hypothesis 8: The better the manageability of the system, the higher the perceived ease-of-use.

Furthermore, six hypotheses can be developed on the basis of the Technology Acceptance Model. These hypotheses describe the correlation of the perceived usefulness and the perceived ease-of-use as well as the attitude towards using the system, the intention and the final decision to use the system.

Hypothesis 9: The greater the perceived usefulness, the greater the intention to use the new system.
Hypothesis 10: The greater the perceived usefulness, the better the attitude towards using the new system.

Hypothesis 11: The higher the perceived ease-of-use, the greater the perceived usefulness.

Hypothesis 12: The higher the perceived ease-of-use, the better the attitude towards using the new system.

Hypothesis 13: The better the attitude towards using the system, the greater the intention of using the new system.

Hypothesis 14: The greater the intention of using the new system, the greater the usage of the new system.

RESULTS OF THE EMPIRICAL STUDY

This section will proceed as follows. First, the database and the procedure of data collection are described. Subsequently, the causal analysis used in the study is quickly explained and the procedure for examining the construct is addressed. Afterwards the structural model is examined. The operationalization of the individual factors – including the common criteria for examination – is presented in the Appendix.

Database and data collection

The starting point of the study was the lack of willingness amongst health care providers to accept the introduction of the eHC. Not only physicians, but also hospitals, pharmacies, and nursing staff are considered as health care providers. However, studies of the eHC that have been conducted to date have found that physicians in particular have a low level of willingness to accept the eHC, yet they are the ones that play the major role in the successful introduction of the eHC. Therefore, this study focuses solely on physicians.

For this study, an online questionnaire – a digital, standardized survey – was preferred to an oral survey because, above all, it provides the opportunity to create more statistical units. Furthermore, the degree of standardization of the digital survey made it possible to compare the survey data of the individual physicians. To counter any communication problems that might arise from ambiguously phrased indicators, the online questionnaire was developed in two steps. Therefore, both an Anderson/Gerbing Pretest and, in January 2009, a pre-survey with a total of 87 physicians was carried out.

Between February and April 2009, out of a population of 314,912 working medical practitioners (Bundesärztekammer 2007) 2,411 randomly chosen physicians throughout Germany were contacted via e-mail and asked to participate in the online survey, which also offered the possibility to return the survey via fax or e-mail. Altogether, 502 responses were collected. This corresponds to a response rate of 20.8 per cent. Since comparable empirical studies attained response rates ranging from 3.7 per cent (Pizzi et al. 2005) or 9.4 per cent (Bhattacherjee and Hikmet 2008) to 21.7 per cent (Liu et al. 2006), the response rate can be classified as high. The sample can be further analyzed by profession. It consisted of general practitioners (24.3 per cent), medical specialists (40.2 per cent), medical practitioners in hospitals (5.2 per cent), and dentists (30.3 per cent). The low response rate by medical practitioners working in hospitals may be related to higher workloads, less opportunity to access internet surveys during working hours, or a reduced perception of an implementation problem concerning eHC.
A late-response bias was not found in the sample. Late responses did not vary significantly from early ones in a t-test, which can be interpreted as an initial indicator that non-response bias was avoided (Armstrong and Overton 1977). However, non-response bias cannot be rejected completely since reasons for answering late may vary from reasons for not answering a survey at all (Mentzer and Flint 1997). Furthermore, it has to be considered that the sample may be affected by a technology bias, since less technology-savvy medical practitioners may have refused to answer the online survey more often than others. However, it has to be considered that nearly 100 per cent of Germany’s medical practices are connected to the internet since online cost accounting for compulsory health insurance is mandatory (DGN 2011).

Method of examination and test criteria
When observing the research model, it is evident that a procedure has to be chosen which allows for examining complex interrelationships. The procedure must be able to process latent variables, i.e. variables that cannot be directly measured. Moreover, it has to allow the empirical examination of the system of hypotheses by using a multivariate procedure of data analysis that can at the same time shape and examine relations between several latent constructs. In the end, with regard to these requirements, only the empirical procedure employing structural equation models is suitable, because it has become established as a reliable procedure of data analysis for research in the above described context.

As the procedure of analysis, covariance structure analysis was chosen for this study, as it is particularly oriented to the parameters. It is of a strongly hypotheses-testing nature, which is why larger samples (>200) are required if one is to obtain statistically robust results (Chin and Newsted 1999, p. 336). The software program EQS 6.1 was employed for the analysis.

The latent constructs that form the basis of this study cannot be directly measured, and therefore have to be measured using manifest variables (Bagozzi and Philips 1982, p. 465). In this connection, it is necessary to operationalize every latent construct, i.e. to make it measurable. The indicators are conceptualized to be directly measurable and as signifying the existence of the phenomena that are intended but cannot be directly detected (Kline 2011, p. 9). The rules of correspondence between the indicators and the factors are of significance in this context. This study includes only reflective operationalization.

A large number of criteria to assess the quality of operationalizations have been established in the literature. In this context, a distinction can be made between criteria of the first and the second generation. Cronbach’s Alpha, the item-to-total correlation, and the exploratory factor analysis are among the criteria of the first generation. The criteria of the second generation comprise indicator reliability, factor reliability, and average variance extracted as well as chi-squared value, Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Comparative-Fit Index (CFI), Tucker–Lewis Index (TLI), and Root-Mean-Squared-Error-of-Approximation (RMSEA) (Browne and Cudeck 1993, p. 136; Bagozzi and Baumgartner 1994, p. 398; Hu and Bentler 1999, p. 27; Hair et al. 2010, p. 664; Kline 2011, p. 199). The common values for the criteria of good quality measurement are employed in this study and the validity and reliability are examined in a multi-level process (Hair et al. 2010, p. 654).

Analysis of the research model
The analysis of the individual measurement models in the Appendix shows that the indicators used are highly reliable and valid. Therefore, the entire model is examined
in the next step. Figure 3 presents the results of the causal-analytical examination of the acceptance model concerning the eHC in Germany.

On the whole, the model shows a good fit. The values of the CFI and TLI just missed the minimum requirements. At 0.881 and 0.837, respectively, the values of the CFI and TLI are just below the value of 0.9 which these two criteria require for good quality. However, this is acceptable due to the less restrictive assumptions in complex models (Hair et al. 2006, p. 753). The RMSEA – which is important in complex models – shows a particularly good value (0.053) and is well below the maximum limit of 0.08.

The following will elaborate on the dimensions of perceived usefulness and perceived ease-of-use before presenting the results of the basic hypotheses of the Technology Acceptance Model.

The very high $R^2$ value of 0.959 of the perceived usefulness indicates that the external factors make a high explanatory contribution. The results reveal that four out of the five factors have significant positive effects on the perceived usefulness. In this connection, the efficiency of the system, with a value of 0.767, and the factor of the cost–benefit ratio for the physicians, at 0.555, have to be highlighted. With a path coefficient of 0.206, the expectation of the system in terms of productivity/performance has a rather small but significant effect on the perceived usefulness. The same applies for the factor of social influence of the environment, which relatively constitutes the lowest significant path coefficient, with a value of 0.068. All in all, hypotheses 1, 2, 3, and 5 cannot be rejected. However, it was found that the factor of involvement in the implementation does not have a statistically significant influence on perceived usefulness. Therefore, hypothesis 4 has to be rejected.

Perceived ease-of-use has a very high $R^2$ value as well. This value, in turn, confirms that the external factors explain a considerable proportion of the variance of the perceived ease-of-use and hence that the relevant factors were identified. All three factors have significant coefficients. Observed relatively, the factors of the usability and manageability of the system are highly relevant. With a path coefficient of 0.167, the factor of the compatibility of the system has a rather small effect on the perceived ease-of-use. Therefore, this factor can be considered to have little effect. On the whole, hypotheses 6, 7, and 8 cannot be rejected.

Furthermore, the empirical study of the interrelatedness of the basic hypotheses of the Technology Acceptance Model reveals that hypotheses 9, 10, and 11 as well as 13 and 14 cannot be rejected. It is evident from the path coefficients of perceived ease-of-use to perceived usefulness that perceived ease-of-use has a rather small but significant effect on perceived usefulness. The value of the path coefficient here is 0.121. With values of 0.792 and 0.688, respectively, the path coefficients are considerably stronger between perceived usefulness and the attitude or intention to use the system. In relation to the other path coefficients in this context, the direct effect between attitude towards using the system and intention is rather small. Here, the value of the path coefficient is merely 0.328. The strongest correlation is the one between the intention and usage of the system. The value of this path coefficient is 0.988. All in all, the explained variances of each construct can be considered satisfactory as well. While more than 60 per cent of the attitude towards using the system is explained by the preceding factors, the intention and the eventual usage reveal $R^2$ values of $>0.9$.

The data structure, however, did not confirm the connection between the perceived ease-of-use and the attitude towards using the system. The path coefficient between these two dimensions of the model is $-0.041$. Hence, the path coefficient is trivial, insignificant, and does not have the sign expected. As a result, hypothesis 13 has to be rejected. Ma and
Perceived usefulness

- Efficiency of the system: 0.767***
- Productivity and performance expectations: 0.206***
- Involvement in implementation: 0.555***
- Cost-benefit ratio

Perceived ease-of-use

- Compatibility of the system: 0.167***
- Usability of the system: 0.740***
- Manageability of the system: 0.648***

Attitude towards using the system

- Social influence of the environment: 0.068**
- Productivity and performance expectations: 0.047 N.S.

Intention

- Usage of the System

R² = 0.959

R² = 0.621

R² = 0.935

R² = 0.977

Significance level:
* p ≤ 0.10; ** p ≤ 0.05; *** p ≤ 0.01
Liu (2004, p. 66) found this insignificant link to be a common phenomenon in research based on the Technology Acceptance Model. Nevertheless, ease-of-use has an indirect effect on the attitude towards using the system through its significant connection to perceived usefulness. Our findings, therefore, suggest that in the context of the eHC perceived ease-of-use may be fully mediated through perceived usefulness. Further studies are needed to clarify this matter.

**SUMMARY AND IMPLICATIONS**

The starting point of this study was the high discrepancy between the considerable potentials of the introduction of the eHC and the low level of acceptance by physicians. In this connection, a model based on the Technology Acceptance Model was developed that contains the dimensions of perceived usefulness and perceived ease-of-use. These dimensions were expanded by other external factors or determinants in the context of the eHC. Moreover, the model was subjected to an empirical examination based on 502 questionnaires completed by physicians. The results reveal that, on the whole, the relevant determinants of the acceptance of the eHC were identified and the established hypotheses cannot be rejected.

The study contributes to the advancement of science in two ways: on the one hand, acceptance research in general is promoted; on the other hand, the empirical scientific basis of the field of sustainability of public health care is improved.

The study constitutes a theory-driven contribution to the empirical identification and measurement of determinants of the acceptance and usage of the eHC from the perspective of the physicians. The measurement scales employed proved to be valid and reliable and can also be used for future research in the field of acceptance research in the health sector. The theoretical framework used to derive the model can be rated as very useful for examining technology acceptance in the field of eHealth. Moreover, the study can serve as a starting point for other studies of acceptance issues among health care providers.

The advantages of this model are manifold. First, influencing factors of user acceptance for eHC were identified from a physician’s perspective. This can be regarded as a contribution to explaining the discrepancy between the high potential of the eHC and the low acceptance among physicians, which leads to implementation obstructions. Implications for public administration can be derived from the relevant aspects of user acceptance. Furthermore, by modelling the individual intention to use the specific system of eHC, the proven theoretical framework of the Technology Acceptance Model could be applied to other relevant eHealth subjects. The limitations of this model include the exclusive examination of only one, even if central, stakeholder group in the health care sector and the lack of direct findings on a social level due to inappropriate data, which is based on individual statements. Further research could include aspects of innovation theory (Rogers 1962) to broaden the perspective.

With regard to the two hypotheses that had to be rejected, there seems to be a special need for further research. No significant connection could be found between involvement in implementation and the perceived usefulness. On the one hand, this is a surprise considering that studies ascribed a major role to involvement in the implementation process for the perceived usefulness. On the other hand, the causal pathway could be interpreted to signify that, due to the lack of a cooperative introduction process, physicians do not see an increased benefit through involvement. This interpretation is supported by the theoretical observations of the Technology Acceptance Model. Another way to
interpret this finding is that due to the already well-advanced introduction phase of the eHC in Germany, there is no longer an opportunity for involvement in implementation to exert an influence.

Furthermore, it would make sense to examine other stakeholder groups. Other groups of players in health care, such as pharmacists or health insurance companies, should be observed. They have other cost–benefit calculi with regard to the eHC and might present a different willingness of acceptance. In particular, a comparison between the model used here and other specifications could reveal further conflicts of interest and attitudes of acceptance. Besides examining different stakeholder groups, another empirical study would be of great importance. Since this study refers to a particular point in time and hence represents the range of opinion within only a short period of time, it would be of interest to carry out a longitudinal study and to compare those results with the present results.

From the empirical results, practical implications can be derived with regard to increasing the acceptance of physicians to the introduction of the eHC. The results of this study reveal that, within the implementation process of the eHC, chiefly the cost–benefit ratio and the efficiency of the system as well as the usability and manageability of the system are relevant for the physicians and they have a considerable effect on the attitude of acceptance. Therefore, these factors should be of special interest to public administration and other involved parties during the implementation process and subsequent functional expansion of the eHC. The cost–benefit factor plays an important role in the implementation process, because – in the opinion of many physicians – the financial effort for acquiring and maintaining the system does not sufficiently outweigh the resulting benefit. In general, however, costs are considered not only with regard to the acquisition of the technical components, but also regarding the increased work effort expected and the associated longer working hours needed to compensate for the expenses. A first starting point for optimizing the cost–benefit ratio from a public administration point of view would be to improve the communication of information regarding the expected costs to be incurred by physicians accompanied by expense allowances. Purposeful financial support and education by training staff on the work processes would be favourable in order to compensate for the additional costs caused by the increased amount of initial work.

The efficiency of the system is considered as critical by the physicians, particularly in terms of data security and potential misuse of data. The primary concern of the physicians is the unauthorized access of a third party to stored data. So far, the physicians have rated the security system of the eHC as relatively weak and they have criticized potential risks and issues concerning data security. In this connection, approaches should be developed that address the issue of misuse of data and clearly explain the security components of the eHC to the physicians in order to create a bond of trust.

Further components of the efficiency of the system concern the concrete range of services of the system, the improvement of work processes within the field of work of the physicians, and an altogether improved health care system. In order to enhance acceptance, the relative advantage of the new technology and the increased benefit that results from using the new system should be better communicated and practically demonstrated to the physicians.

Another factor in the acceptance process is the usability of the system, though it does have only an indirect effect through the perceived usefulness of the eHC. Therefore, in order to positively encourage the acceptance by physicians during the implementation process, adequate measures for promoting the usability have to be presented to them. For
instance, offering training could support the implementation process and have a positive and long-term effect on the application process.

The usability of the system is accompanied by the factor of its manageability. The manageability of the system chiefly concerns the technical components of the new system. Important factors in this context are, in particular, the bit rates and the dependability of the technology, accompanied by potential technical malfunctions. Support tools help the manageability and should be available to the physicians during the implementation as well as the subsequent processes. This support component could generate increased security for the physicians regarding the handling of the system and hence have a positive effect on its acceptance.

In summary, this study presented a model of acceptance of the eHC in Germany from a health care provider perspective. A multivariate analysis of a quantitative survey of a sample of physicians provided some initial insights into the factors relevant to the acceptance of this system. Despite the limitations of this study, scientific and practical implications for public administration could be derived and suggestions for further research provided.

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**APPENDIX**

<table>
<thead>
<tr>
<th>Social influence of the environment</th>
<th>$\alpha = 0.836$</th>
<th>CFI =</th>
<th>DEV = 0.631</th>
<th>FR = 0.837</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3 Due to the positive image of the eHC, the introduction is considered to be very useful.</td>
<td></td>
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<tr>
<td>1.4 Physicians and health care facilities that use the eHC have a higher social prestige than those sceptical of the eHC.</td>
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<tr>
<td>1.5 The usage (within the regions tested) of the new eHC systems can be regarded as an honour for a health care facility.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Efficiency of the system</th>
<th>$\alpha = 0.922$</th>
<th>CFI =</th>
<th>DEV = 0.698</th>
<th>FR = 0.920</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 The eHC leads to increased data security and can effectively reduce misuse of data.</td>
<td></td>
<td></td>
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<tr>
<td>2.2 The eHC provides valuable support in documenting case histories and health care services.</td>
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<tr>
<td>2.3 In the health sector, the eHC helps to save labour and hence costs in many areas.</td>
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<td></td>
<td></td>
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<tr>
<td>2.6 The eHC will altogether improve the treatment of patients through better service.</td>
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<td></td>
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<tr>
<td>2.7 The introduction of the eHC will improve the efficiency of the health care system.</td>
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</tbody>
</table>

<table>
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<tr>
<th>Expectation in terms of productivity and performance</th>
<th>$\alpha = 0.871$</th>
<th>CFI =</th>
<th>DEV = 0.663</th>
<th>FR = 0.721</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 On the whole, the introduction of the eHC leads to an optimization of the operational organization (treatment, admission, and administration of patients).</td>
<td></td>
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<tr>
<td>3.2 The introduction of the eHC facilitates communication among general physicians, specialists, and the hospital.</td>
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<tr>
<td>3.3 The introduction of the eHC reduces the time spent on the administration of patients.</td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Involvement in the implementation</th>
<th>$\alpha = 0.827$</th>
<th>CFI =</th>
<th>DEV = 0.489</th>
<th>FR = 0.826</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 The physician’s interests were taken into particular consideration in the decision to introduce the eHC.</td>
<td></td>
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<tr>
<td>4.2 The medical self-administration adequately represents the physician’s interests in the planning of the introduction of the eHC.</td>
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<tr>
<td>4.3 The physician’s interests were adequately taken into consideration regarding the relevant functions of the eHC.</td>
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<td></td>
<td></td>
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</tbody>
</table>
4.4 Altogether, the interests of the physicians and health care facilities have been adequately considered in the conception and introduction of the eHC.

4.5 All relevant target groups were involved in the introduction of the eHC.

Cost–benefit ratio
\[ \alpha = 0.900 \quad \text{CFI} = \quad \text{DEV} = 0.756 \quad \text{FR} = 0.903 \]

5.1 The ratio of the costs that practices incur from the introduction of the eHC to the benefits received is well-balanced.

5.2 The introduction of the eHC will considerably reduce general administrative costs.

5.3 The eHC allows reducing costs in the field of care provision in a short time.

Compatibility of the system
\[ \alpha = 0.892 \quad \text{CFI} = \quad \text{DEV} = 0.734 \quad \text{FR} = 0.892 \]

6.2 The practice EDP will be compatible with the new EDP required for the eHC.

6.5 Altogether, the technical system of the eHC will be compatible with already existing systems.

6.6 Altogether, the eHC will be highly compatible with the systems used at the moment.

Usability of the system
\[ \alpha = 0.811 \quad \text{CFI} = \quad \text{DEV} = 0.634 \quad \text{FR} = 0.812 \]

7.1 It will be easy for physicians in practices to use the new technology of the eHC.

7.2 The eHC system will be designed in an easy and intuitive way.

7.3 The eHC system will be easy and simple to use.

Manageability of the system
\[ \alpha = 0.842 \quad \text{CFI} = \quad \text{DEV} = 0.659 \quad \text{FR} = 0.850 \]

8.2 In case of system breakdowns competent support will be provided in order to solve the problem.

8.4 Security restrictions effectively prevent unauthorized access to the eHC system.

8.5 The manageability of the system will altogether be satisfactory and adequate to guarantee the smooth treatment of patients.

Usefulness
\[ \alpha = 0.955 \quad \text{CFI} = \quad \text{DEV} = 0.809 \quad \text{FR} = 0.955 \]

9.1 The eHC is a useful modernization in health care.

9.2 The eHC allows tasks in health care to be carried out more easily.

9.3 Using the eHC leads to a better treatment of patients.

9.4 On the whole, the benefit of the eHC is to be considered positive.

9.5 On the whole, the eHC is one of the most useful systems in health care.

Ease-of-use
\[ \alpha = 0.958 \quad \text{CFI} = \quad \text{DEV} = 0.821 \quad \text{FR} = 0.958 \]

10.1 It will be easy to use the eHC system in everyday life in the practice.

10.2 The eHC system will be compatible with all aspects of our work.

10.3 It will be easy for the patients and safe to use the eHC system.

10.4 Altogether, the ease-of-use of the eHC is to be considered as good.

10.5 Altogether, the usage of the eHC system will be designed to be user-friendly.

Behavioural intention
\[ \alpha = 0.980 \quad \text{CFI} = \quad \text{DEV} = 0.924 \quad \text{FR} = 0.980 \]

11.1 If the possibility arises to use the eHC sooner than planned we will seize it.

11.2 It is very likely that I would use the eHC sooner than planned if I could.

11.3 We are willing to use the eHC as soon as possible.

11.4 If we had the choice we would introduce and use the eHC as soon as possible.

Personal attitude
\[ \alpha = 0.982 \quad \text{CFI} = \quad \text{DEV} = 0.947 \quad \text{FR} = 0.982 \]

12.1 We think that the introduction of the eHC makes sense.

12.2 We think that the introduction of the eHC is necessary.

12.3 We think that the introduction of the eHC is good.

Usage
\[ \alpha = 0.921 \quad \text{CFI} = \quad \text{DEV} = 0.740 \quad \text{FR} = 0.919 \]

13.1 We will use the eHC to its full extent.

13.2 Using the eHC entails many advantages.

13.3 We are convinced to use the eHC in the near future.

13.4 It makes sense to use the eHC.