Requirements for and Barriers towards Interoperable eHealth Technology in Primary Care

Despite eHealth technology's rapid growth, eHealth applications are rarely embedded within primary care, mostly because systems lack interoperability. This article identifies requirements for, and barriers towards, interoperable eHealth technology from healthcare professionals' perspective — the people who decide when (and which) patients use the technology. After distributing surveys and performing interviews, the authors coded the data and applied thematic analyses. They subdivided results according an interoperability framework to levels of interoperability, as workflow process, information, applications, and IT infrastructure. They found that implementing interoperable eHealth technology in primary care succeeds only when all identified levels of interoperability are taken into account.

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EHealth refers to the use of computer-based technology within a healthcare environment, and includes many applications, varying from electronic health records (EHRs) to specific telemedicine applications, mobile health, and websites that support patients in self-management.[1,2] Despite the rapid growth and promises of eHealth, its applications are rarely embedded within primary care. In the literature, one frequently mentioned barrier towards successful implementation of eHealth in healthcare is the lack of interoperability.[3] This barrier also applies to the domain of primary healthcare.[4]

With this in mind, we implemented a study to identify the issues involved, while also outlining the requirements for successful interoperability in primary healthcare. We focused on the healthcare providers' perspective, because they're the key stakeholders who decide when (and which) patients use eHealth, and they're the primary drivers to decide about the purchase of eHealth applications. Knowledge on requirements and barriers, elicited from these key stakeholders, can be used to create properly

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interoperable technologies and implementation strategies for a durable interoperable eHealth infrastructure. Before we delve into the findings of our study, though, first let's consider some background information.

The Background Elements of Interoperability

Interoperability is defined as the ability for two or more systems or components to exchange information and use the information that has been exchanged.[5] In recent years, interoperability has become a manifest presence, due to omnipresent connections of databases to the Internet and an increasing need among professionals to share data.[6] In this need for easy and swift data exchange among professionals, the healthcare sector is no exception.

Healthcare interoperability applies at different levels. Philip Scott[7] distinguishes two: syntactic (grammatical) and semantic (logical). Syntactic interoperability lets systems process correctly structured information at a technical level, while semantic interoperability lets software systems interpret and validate the exchanged information by a safe reproduction of the contextual meaning of this information. Recently, the European Antilope[8] project for advancing eHealth interoperability presented a model with six interoperability levels (see Figure 1), called the eHealth European Interoperability Framework (eEIF)-refined interoperability model. This model includes the semantic and syntactic levels, classified under their levels of information, applications, and IT infrastructure. Each level in the model shows the need for close cooperation and agreement by different stakeholders to achieve well-organized information exchange.

Together with this framework, the European Antilope project offers a set of use cases, a glossary of interoperability terms and definitions, and a template for the description of use cases. With these tools, stakeholders can achieve a shared definition of interoperability levels. These use cases are the practical starting points in the realization of interoperability within an eHealth project. Based on these use cases, some corresponding realization scenarios have been established. Where possible, these scenarios have been based on existing interoperability profiles and underlying standards.

The EHR is the specific feature that has boosted the importance of interoperability in

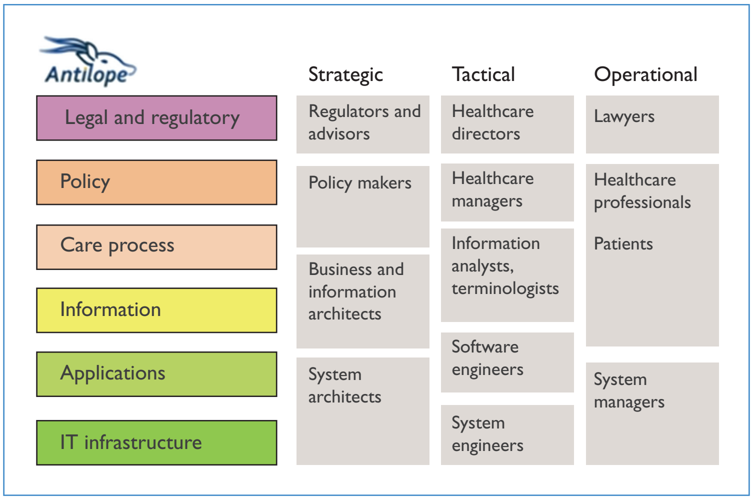

Figure 1. The eHealth European Interoperability Framework (eEIF)-refined interoperability model.[8] Each level shows the need for close cooperation and agreement by different stakeholders to achieve a well-organized information exchange.

healthcare. This digital patient dossier should be linked to all different health information systems (HISs) to inform healthcare professionals at the right time and place, and to ensure correct, up-to-date patient information.[9] Jan Walker and her colleagues[10] calculated that complete interoperability among US HISs could result in saving $77.8 billion a year due to, for example, preventing unnecessary lab tests. Besides cost savings, interoperability can also improve patient safety, as physicians are less likely to make errors when they have a complete and up-to-date dataset during their working processes.[11]

Despite these potential benefits, the actual degree to which we can consider the implementation of an electronic health information exchange (HIE) between interoperable HISs is quite limited. For instance, Denmark, which has one of the most efficient healthcare systems in the world, has a low rate of HIS interoperability, due to the fact that healthcare technologies were developed without coordination and a centralized approach.[12] Other countries have similar situations, resulting in large US and European initiatives that have been launched to accelerate HIE's implementation.[13] One of the most notable initiatives is Health Level Seven International (HL7; see www.hl7.org) that develops standards to facilitate information exchange among healthcare systems.

In reviewing the HIE issue, Patricia Fontaine and her colleagues[4] identified four types of benefits and five types of barriers towards interoperability within primary care. Benefits included improved quality of care and cost savings, while barriers included costs, security and privacy issues, and liability. In the Netherlands, an interview study was carried out regarding healthcare professionals' views on the benefits and problems associated with the introduction of an interoperable EHR.[14] Benefits mentioned were the availability of up-to-date information and improved quality of care, while potential problems included privacy risks, information overload, and liability issues. None of these studies, however, listed the requirements that healthcare professionals have for implementing interoperable technologies into their daily practice.

Methods

To better understand the healthcare professionals' perspective, we identified requirements and barriers by means of a two-step approach. First, we sent online surveys to healthcare professionals at seven primary healthcare centers. In this survey, we questioned participants about demographics, digital skills, technology use within their primary care center, their understanding of the scope and value of eHealth, and their experiences with (and expectations of) such technologies.

Examples of questions we used in the online survey are What is the ideal percentage of your working time in IT usage? and What is the actual percentage of your working time in IT usage? We aimed to find out if there's a discrepancy between participants' ideal and actual IT usage. Another question we used is To what extent does the use of computer software facilitate your working processes at this moment? We anticipated that peoples' current experiences with IT would predict their acceptance of new technologies, and might serve as a trigger for them to discuss possible barriers towards eHealth's implementation.

After completing the online survey, we interviewed most of the participants. These interviews were semistructured: a first set of questions was adapted or supplemented by questions brought forth by each completed survey. For example, a general practitioner addressed in the online survey that online triage before online scheduling by a patient is a crucial functionality, which resulted in the interview questions What is the reason why this is important, as this can also be done by the assistant? and Can you describe this online triage scenario you have in mind? To encourage participants to talk about certain topics and identify where new technologies can benefit working processes, we started each interview with asking the participant to describe his or her normal working day.

The basic interview setup addressed the following topics:

- describing the schedule of a typical day at work;
- describing the process of a specific task that could be facilitated by means of eHealth;
- specific characteristics of the primary healthcare center that possibly influence the deployment of new technology;
- the center's technical infrastructure (addressed if the participant was knowledgeable on this topic);
- characteristics of the patient population (percentages of patients with a chronic disease, socio-economic state, educational level, and so on);
- IT skills of colleagues;
- decision making concerning IT and eHealth purchases;
- positive and negative work-related experiences with IT; and
- future expectations of eHealth implementation.

We audio recorded and transcribed all of the interviews. We imported these texts, along with the participants' responses to the online survey items, into Atlas.ti (a software package for performing qualitative data analysis).

Next, we applied thematic analysis using Virginia Braun and Virginia Clarke's guidelines.[15] We created a first coding scheme based on the interview scheme and aimed at describing the interviewees' technical infrastructure, and wishes for and problems with eHealth technology. During the data analysis, we derived new codes from the data, in which case we added them to the code scheme and reconsidered all previously assigned codes. After the thematic analysis, we linked and visualized all the themes in a thematic map (see Figure 2).

Once we coded all the data, we determined the number of times an item was identified among the interviewees. In this context, an item is a functional requirement, a nonfunctional requirement,

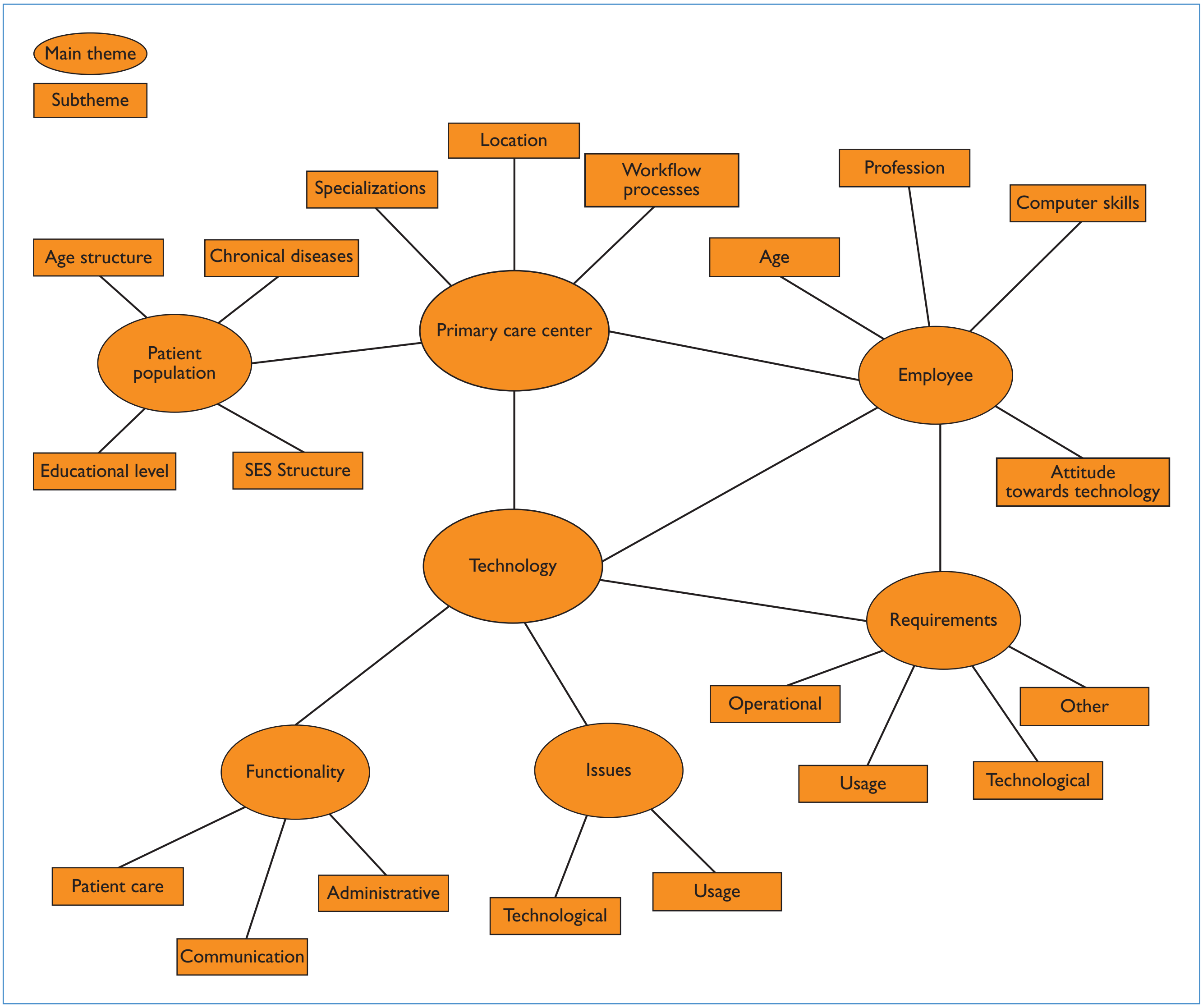

Figure 2. Final thematic map, showing the main themes. The themes are related to each other, as indicated by the lines used in the thematic analysis. For example, a primary care center may already use technology with certain functionalities and issues. Also, the healthcare professionals in this center have requirements on (new) technologies. The found data on this center are then labeled according to these themes.

or a barrier. We didn't count the number of times an item was mentioned by each interviewee participant, as some were verbose, while others weren't. Counting the number of times an item was coded, instead of the number of participants who mentioned it, would therefore skew the results.

Results

Now that we detailed the methods used, let's review the results.

Participant Characteristics

In total, 33 healthcare professionals, working in seven different Dutch primary care centers, participated in our study. Twenty-seven of the participants are healthcare professionals: nine general practitioners, eight nurse practitioners, nine physiotherapists, and one district nurse. This was the main target group of this study. The other six participants support some of these healthcare professionals during their working processes, namely five doctor's assistants and one pharmacy assistant. From these 33 participants, 25 people (76 percent) both filled in the online survey and were questioned during an interview; three (5 percent) only filled in the online survey, and five (9 percent) were interviewed only. Most of the participants were between the ages of

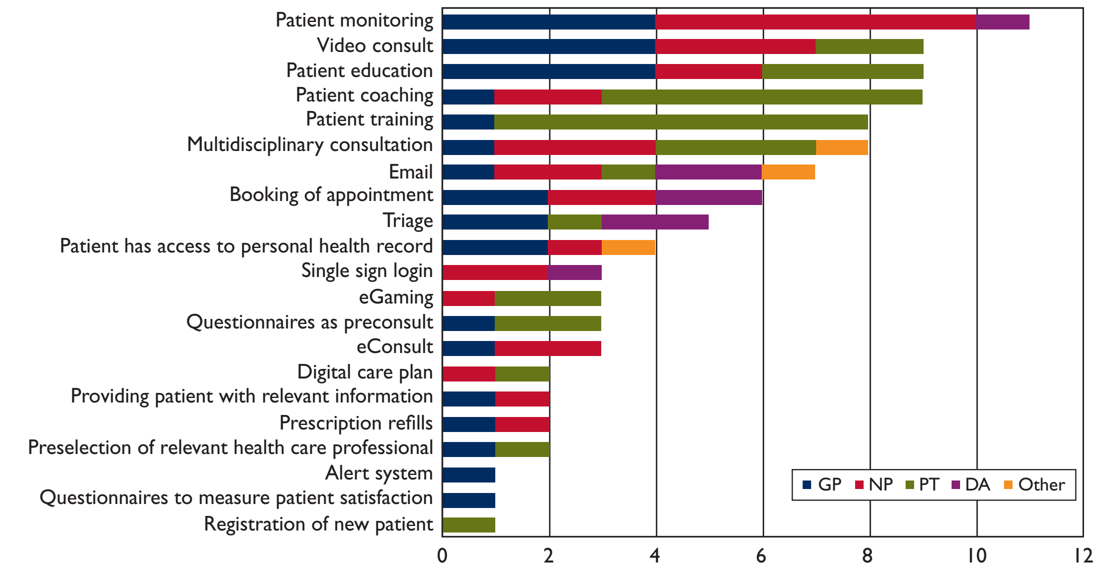

Figure 3. Functional requirements brought forth by general practitioners (GP), nurse practitioners (NP), physiotherapists (PT), doctor's assistants (DA), and other professions.

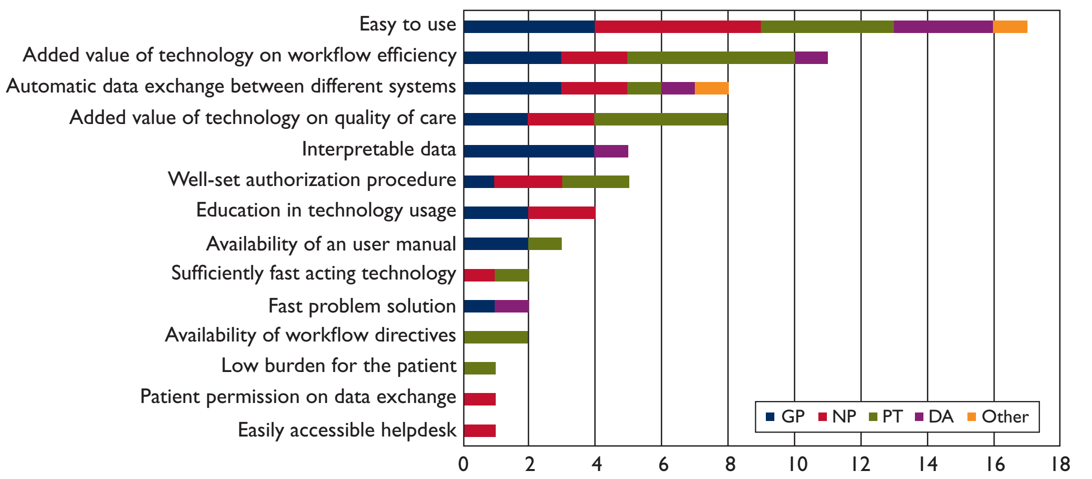

Figure 4. Nonfunctional requirements brought forth by GP, NP, PT, DA, and other professions.

40–49 (30 percent), with slightly more than half of the participants being women (54 percent), and most participants being highly educated (78 percent completed degrees at a university or college).

Requirements and Barriers

Figure 3 presents the functional requirements identified by participants. Figure 4 presents the nonfunctional requirements, and Figure 5 presents the barriers.

Functional requirements. The analyses resulted in 21 functional requirements. The functional requirement identified most was "patient monitoring." This implies self-monitoring of health parameters by the patient (such as blood values, heart rate, electrocardiogram, and spirometry) with automatic

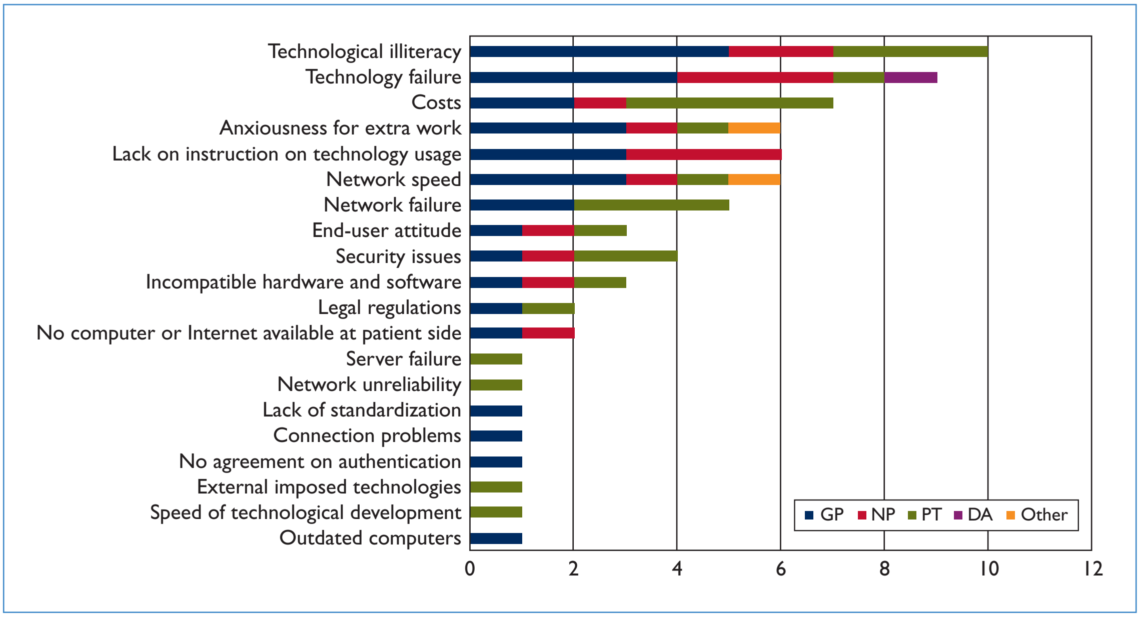

Figure 5. Barriers brought forth by GP, NP, PT, DA, and other professions.

HIE from patients' homes to the primary healthcare center. Nurse practitioners were especially interested in these requirements, as they guide patients with a chronic disease and thereby the general practitioners. Based on the measured values, the healthcare professional can decide to see a patient earlier or later than planned.

The top five functional requirements also show "patient coaching," and "patient training." These terms are often used interchangeably. The term "coaching" here refers to the activity that the patient is coached in, such as smoking cessation or weight loss. "Training," on the other hand, concerns the availability of an online training program that provides physical or mental exercises by means of movies, pictures, or just text. Physiotherapists identified both "coaching" and "training" as the most important functional requirements.

Finally, the list contains the functional requirements "booking of appointment," "prescription refills," and "eConsult." These are often part of a patient portal that's integrated with websites of primary care centers. Although these functionalities are already available in most centers, often these functionalities weren't integrated yet in the current IT infrastructure. This means that data obtained from a portal still must be imported manually into other systems, leading to extra actions in working processes, and therefore interviewees indicated these functional requirements in the context of interoperability.

Nonfunctional requirements. Besides 21 functional requirements, the analyses also resulted in 14 nonfunctional requirements. Figure 4 shows that the requirement "easy to use" is clearly first place in the list and named by all professions. Participants mentioned such terms as "user-friendliness," "clarity of the technology," and "as few as possible steps on the screen to perform a task" in this context.

The list also shows the nonfunctional requirements added value of technology on workflow efficiency and added value of technology on quality of care. "Added value of technology on workflow efficiency" means that the technology should improve the working processes by, for example, decreasing the amount of necessary steps taken during a working procedure. "Added value of technology on quality of care" means, for example, providing the healthcare professional with timely up-to-date health information of patients to improve patient care.

Identified barriers. Our analysis resulted in identifying 20 barriers. The barrier identified most was users' technological illiteracy. The participants used words such as "computer skills of end users," "time needed to learn new technology," and "unaccustomed end user" in this context. The participants indicated that a lack of skills in using technology leads to ineffective usage, or even nonusage. Close to the barrier of users' technological illiteracy is the barrier of the end user's attitude. One often-mentioned factor with regard to the end user's attitude was that the end user explicitly must see the benefits of the technology's use — otherwise, he or she won't use it.

Participants also mentioned "technology failure" as a barrier. Some of them had negative experiences with IT solutions, due to technological failures. In most cases, they didn't try this IT solution again. When the use of said technology was imposed, they were reluctant to use these IT solutions. Another important barrier found was costs. It appears that in each visited primary care center, there's no clarity regarding the reimbursement by patients' medical insurers. This restricts healthcare professionals in implementing new technologies. One participant put it this way: "If financing was not a problem, we would have been many steps further with the implementation of eHealth technologies." None of the respondents had mentioned cost savings as a nonfunctional requirement. Probably, the participants were more focused on the investments that must be made, not realizing that this, on the other hand, might also lead to cost savings — for example, by reducing paper-based workflow processes.

Requirements, barriers, and interoperability levels. We can subdivide the identified requirement and barriers to the interoperability model's various levels (see Figure 1). Table 1 shows the results. The indicated levels specify with which goal a close cooperation among different stakeholders is needed to achieve the implementation of interoperable eHealth technologies that meets these requirements and overcomes these barriers.

During the interviews, not all the processes mentioned by the interviewees were care processes. For example, the requirement "Easily accessible helpdesk" refers to the handling of a helpdesk procedure in case of a technical problem. Therefore, we translated the level "care process" in the model into "workflow process."

Discussion

This study identified functional and nonfunctional requirements for, and barriers towards, interoperable eHealth technology from the perspective of healthcare professionals in primary care. Most barriers we identified were of a legal, literacy, financial, or technical nature and are similar to those found when implementing the electronic HIE.[4,14]

Based on these legal, literacy, financial, and technical issues, we related the identified requirements and barriers to the interoperability framework, developed within the European Antilope project.[8] This framework has six interoperability levels, namely legal and regulatory, policy, care process, information, applications, and IT infrastructure. Each one represents a level in which different stakeholders must cooperate on agreements to achieve a well-organized information exchange. (These stakeholders are also shown in the gray part of Figure 1.) The different interoperability levels, however, strongly affect each other, and some stakeholders are involved at different interoperability levels. Consider, for example, the following scenario:

> A nurse practitioner wants to monitor the blood pressure of a patient at home as part of her care process (the workflow process level). This blood pressure should be expressed according to a semantic standard (the information level), so this information can be used in an unambiguous way in different systems. An application for monitoring patients' blood pressure at home (the application level) sends its data automatically to the center through the Internet (the IT infrastructure level).

In this example, agreements on standards between different stakeholders are needed at all levels. At the level of the working process, healthcare professionals must adopt workflow directives in the care process. These workflow directives must ensure a standardized working process on remotely monitoring patients' blood pressure and describe the units in which these blood pressure values should be expressed.

At the information level, these blood pressure values should be expressed in an unambiguous way and in a certain context based on the agreements made at the workflow process level to achieve semantic interoperability. Stakeholders involved in semantic interoperability are information architects and business analysts, together with healthcare professionals. In healthcare, a commonly used terminology standard to achieve semantic interoperability is SNOMED CT.[16]

An application that enables remote monitoring of patients' blood pressure at home must be able to process information as defined at the information level. Therefore, at the application level decisions are made about setting up technology that meets the requirements

Table 1. Requirements and barriers related to interoperability levels.

Interoperability level	Functional requirements	Nonfunctional requirements	Barriers
Legal and regulatory	–	Patient permission on data exchange	Legal regulations
Policy	–	–	Costs External imposed technologies Speed of technological development
Workflow process	Patient monitoring Patient education Patient coaching Patient training Multidisciplinary consultation Triage Questionnaires as preconsult eConsult Digital care plan Providing patient with relevant information Preselection of relevant healthcare professional Alert system Registration of new patient	Added value of technology on workflow efficiency Added value of technology on quality of care Education in technology usage Fast problem solution Low burden for the patient Easily accessible helpdeskw	Users' technological illiteracy Anxiousness for extra work Lack of instruction on technology usage End user's attitude No agreement on authentication
Information	–	Interpretable data	Lack of standardization
Applications	Video consult eMail Booking of appointment Patient access to personal health record Single-sign login eGaming Prescription refills Questionnaires to measure patient satisfaction	Easy to use Availability of a user manual Availability of workflow directives	–
IT infrastructure	–	Automatic data exchange among different systems Well-set authorization procedure Sufficiently fast acting technology	Technology failure Low network speed Network failure Security issues Incompatible hardware and software No computer or Internet available to the patient Server failure Network unreliability Connection problems Outdated computers

for information processing (as defined at the information level). Stakeholders involved in achieving interoperability at the application level are information analysts, coders, system architects, and system engineers.

Finally, at the IT infrastructure level, there should be an agreement on the standard used for electronic data exchange. In healthcare, HL7 is an organization that provides a comprehensive framework and related standards for the exchange, integration, sharing, and retrieval of electronic health information that supports clinical practice and the management, delivery, and evaluation of health services.

The example scenario shows interaction between stakeholders at the following interoperability levels: workflow process, information, application, and IT infrastructure. Table 1 shows that the largest part of the identified functional and nonfunctional requirements and barriers found in our study are related to these levels, and are in control of the healthcare professionals, together with IT professionals. However, Table 1 also shows one nonfunctional requirement and four barriers at the legal and regulatory and policy interoperability levels. These levels are beyond the control of healthcare professionals and must be addressed by policymakers, regulators, advisors, and healthcare managers.

When comparing our results to the literature, we see some similar results. Fontaine[4] and Marieke Zwaandijk and her colleagues[14] both identified benefits and barriers. In our study, we used the term "nonfunctional requirement" instead of "benefit," because we also identified functional requirements. We didn't find literature on functional requirements on eHealth technology from the viewpoint of healthcare professionals. Nonfunctional requirements that we identified, that were also found previously, are the added value of technology on workflow efficiency and quality of care,[4,14] and the importance of the availability of useful workflow directives.[14] Barriers that were previously identified, and which are reconfirmed in this study, are costs and a lack of instruction on technology usage by a lack of IT training and support,[4] and the limited speed of the network for electronic information exchange.[14]

Fontaine[4] also mentions the benefit of cost savings. Surprisingly, the respondents in our research didn't mention this, probably because (as we mentioned previously) our participants were more focused on the investments needed to purchase new technology, and not realizing that conversely this also might lead to cost savings by reducing paper-based workflow processes. Zwaandijk[14] also mentioned barriers we didn't identify — namely, the possibility of information overload, and the unclear regulation regarding liability of the healthcare professional for information from outside sources. We can only conclude that such concerns (which are valid) don't live among healthcare professionals in primary care. This can be due to the fact that they're unfamiliar with these issues, or don't consider them important. A new, previously unidentified, barrier we found is the concern about the speed with which new technology develops. Often, once purchased, technology is soon overtaken by new solutions, making it difficult for healthcare professionals to decide which technologies to purchase and at what time.

As we mentioned, we performed our study in Dutch primary healthcare centers. And although the organization of healthcare differs from one country to the next, we firmly believe that the requirements and barriers we identified can be generalized to other countries. The problems that healthcare systems in the Western world face are similar: They must deal with an aging population and an increasing number of patients with a chronic disease. Although worldwide eHealth technology has been named often as a possible solution for coping with the growing demand on healthcare at reasonable costs, societal issues that hinder or increase the success of interoperability are alike. Applications are developed as silos and don't communicate. The policies that are developed to integrate these technologies (such as those developed by the Ministry of Health in the Netherlands and that of the National Health Service in the UK) are similar. An important note that this research adds is that such policies should incorporate solutions to satisfy the needs and take away the barriers at all the different levels (legal, organizational, semantic, and technical). Only then will healthcare professionals adopt eHealth in their daily work, so that we can reap the envisioned benefits of eHealth technology.

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References

1. S.G. Cunningham et al., "Definitions of eHealth," *eHealth, Care and Quality of Life*, Springer Milan, 2014, pp. 15–30.
2. C. Meijer et al., "eHealth: Extending, Enhancing, and Evolving Health Care," *Ann. Rev. Biomedical Eng.*, vol. 15, 2013, pp. 359–382.
3. W.L. Currie et al., "A Cross-National Analysis of eHealth in the European Union: Some Policy and Research Directions," *Information & Management*, vol. 51, no. 6, 2014, pp. 783–797.
4. P. Fontaine et al., "Systematic Review of Health Information Exchange in Primary Care Practices," *J. Am. Board of Family Medicine*, vol. 23, no. 5, 2010, pp. 655–670.
5. R. Rezaei et al., "Interoperability Evaluation Models: A Systematic Review," *Computers in Industry*, vol. 65, no. 1, 2014, pp. 1–23.
6. A.P. Sheth, "Changing Focus on Interoperability in Information Systems: From System, Syntax, Structure to Semantics," *Interoperating Geographic Information Systems*, M.F. Goodchild et al. eds., Kluwer, 1999, pp. 1–28.
7. P. Scott, "Meeting the Challenges of Healthcare Interoperability," *Healthcare IT Management*, vol. 4, no. 3, 2009, pp. 24–25.
8. V. van Pelt and M. Sprenger, "WP 1: Adoption and Take Up of Standards and Profiles for eHealth Interoperability," Iberic Summit, Antilope project presentation, 24 Sept. 2014; www.antilope-project.eu/wp-content/uploads/2014/09/8.-WP1_Adoption-and-take-up-of-standards-and-profiles-for-eHealth-Interoperability.pdf.
9. B.A. Eckman et al., "Varieties of Interoperability in the Transformation of the Healthcare Information Infrastructure," *IBM Systems J.*, vol. 46, no. 1, 2007, pp. 19–41.
10. J. Walker et al., "The Value of Health Care Information Exchange and Interoperability," *Health Affairs*, Jan.–June 2005, pp. 10–18.
11. D.J. Brailer, "Interoperability: The Key to the Future Health Care System," *Health Affairs*, Jan.–June 2005, pp. 19–21.
12. P. Kierkegaard, "eHealth in Denmark: A Case Study," *J. Medical Systems*, vol. 37, no. 6, 2013, pp. 1–10.
13. G.J. Kuperman, "Health-Information Exchange: Why Are We Doing It, and What Are We Doing?" *J. Am. Medical Informatics Assoc.*, vol. 18, no. 5, 2011, pp. 678–682.
14. M. Zwaanswijk et al., "Benefits and Problems of Electronic Information Exchange as Perceived by Health Care Professionals: An Interview Study," *BMC Health Services Research*, vol. 11, no. 1, 2011; doi:10.1186/1472-6963-11-256.
15. V. Braun and V. Clarke, "Using Thematic Analysis in Psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, 2006, pp. 77–101.
16. The Int'l Health Terminology Standards Development Organization (IHTSDO), *SNOMED CT: The Global Language of Healthcare*, 2015; www.ihtsdo.org/snomed-ct.

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