Personal Health Systems Technologies: Critical Issues in Service Innovation and Diffusion

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> *"If I could time travel into the future, my first port of call would be the point where medical technology is at its best. Because, like most people on this planet, I have this aversion to dying."*
>
> Neal Asher
> Science fiction novelist

Personal health system (PHS) technologies can enhance public and private health service delivery and provide new business opportunities in Europe and around the world. Although much PHS technology has already been developed and could potentially provide virtually everyone with access to personalized healthcare, research driven primarily by a technology push may fail, because it fails to situate PHS within the wider health and social care service systems. In this article, we explore the scattered PHS research and innovation landscape, as well its relevant markets, using several types of analyses: bibliometrics, patent analysis, social network analysis, stakeholder workshops, and interviews. Our analyses aim to identify critical issues in the development and implementation of service systems around PHS technologies.

Introduction

Healthcare systems face well-known challenges: rising costs, ageing populations, increasing demand, and shortage of health care professionals, among others. Personal health systems (PHS) assist in the provision of continuous, quality-controlled, and personalized health services to empowered individuals. PHS involve a variety of patient groups, clinical specialties, technology fields, and health services. Hence, the development of PHS requires and can mobilize the emergence of novel cross-disciplinary and cross-sectoral innovation partnerships. For the purposes of this article, we build on earlier definitions (Codagnone, 2009) of PHS, which we define as consisting of:

1. Ambient, wearable, or in-body devices that acquire, monitor, and communicate physiological and other health-related data
2. Intelligent processing of the acquired information (i.e., data analytics), and coupling it with expert biomedical knowledge and, in some cases, knowledge of social circumstances and living conditions
3. Action based on the processing of acquired information, either applied to the individuals being monitored, or to health practice more generally, concerning information provision or more active engagement in anything from disease and disability prevention (e.g., through diet and lifestyle management) to diagnosis, treatment, and rehabilitation

We need deeper understanding of mismatches between the potential of, and need for, PHS, and current policy and innovation initiatives and framework conditions, for example, in terms of future technological opportunities and societal demands. To date, research in the area of PHS has often given little account of special pat-

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terns of innovation in the PHS sector (Cunningham et al., 2005). Knowledge and experience about implementing relevant research results into concrete policy and strategy development in health (particularly at the European level) remains in its infancy.

The main question of this article is why PHS technologies do not diffuse readily despite the advantages they offer to a variety of actors in the health and social care system.

This article is structured as follows. In the next section, we introduce the conceptual approach of this research by examining the concept of "service systems" and describe the shift to PHS as a system transition. Next, we discuss the various methods of investigation we applied to answer our research question, and then we present the results of our analyses. Finally, we discuss the implications of the results and present our conclusions.

Conceptual Approach: Service Systems

Services are often thought of as essentially person-to-person interactions, where the service "product" is co-produced in the course of a service relationship. But, we have become familiar with technology-to-person services, where instead of directly interacting with a member of staff of a service organization, the client interacts with technology – often through online and mobile communications, and sometimes through devices based at the premises of service organizations. The service is created within a "service system", involving the customer/client and the devices (and software) they are using, the service organization they reach through these interfaces, the personnel of this organization – some of whom they may interact with (front-office staff) and others who provide unseen support services (back-office staff) – and the technologies these organizations use, some for information processing and communication, some for surgery and other medical interventions, physical transport, and so on.

The concept of service systems is one that has evolved quite rapidly, with some specialist versions (often coming from the information systems community) being rather elaborate and restrictive. One well-known definition introduces the notion of POTI, or "people, organizations, technologies, and shared information", in which service systems are seen as "dynamic configurations of resources [POTI] that can create and deliver value to customers, providers, and other stakeholders" (IfM and IBM, 2008). Maglio (2010) sees these four key building blocks of service systems as varying on two dimensions: i) physical / non-physical and ii) possessing / not possessing rights. This view characterizes the various four resources of service systems as follows:

1. People (physical, with rights)

2. Organizations (non-physical, with rights)

3. Technologies (physical, without rights)

4. Information (non-physical, without rights)

Various authors, such as Karni and Kaner (2006), stress that, in service systems, as compared to many other sociotechnical systems, customers/clients are much more important parts of the "P" component – their participation and inputs are vital in service design and provision. They may also place limits upon what the (formal) service provider can do, and set standards for what should be achieved. In health and social care systems, the customers/clients can include not only the recipients of care, but also other stakeholders (such as family members), any of whom may make their own demands upon, and inputs into, the service.

People – whether consumers or service suppliers – are complex agents, with highly diverse cognitive frameworks, values and attitudes, physical and emotional needs, and so on. Service systems are thus complex to model and manage – but they may also be resilient and innovative. People can be empowered to act in non-mechanical ways, responding to unexpected circumstances and collaborating to solve problems. They can be linked together in new ways through new information technologies.

Now, what is the service that we are discussing in this study? Many levels of granularity could be considered: which level is chosen for analysis depends on the practical purposes at hand. For some purposes, the issue may be the immediate response to a particular event (e.g., the administration of a drug); for other purposes it may be the set of interactions immediately surrounding this specific service activity (e.g., a visit by the consumer to a clinic or other appointment or a visit by a health and social care professional to the person's house); or the broader treatment of the consumer in question over a series of interactions (i.e., "touchpoints") with the service organization across their "service pathway" or "service journey"; or the overall service to the community that is provided by a particular health and social organization (which may be a constellation of many of the specific services discussed above).

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System innovation and transitions

Rotmans (2006) has described system innovations as "organization-transcending innovations that drastically alter the relationship between the companies, organizations, and individuals involved in the system". Such ambitious innovations are required to address many of society's grand challenges, including those associated with active independent living and the introduction of PHS. System innovation often implies to the need for "transition management" (Schot & Geels, 2008), which enables breaking out of various locked-in heritages and organizational routines. There are costs as well as benefits in such changes, and protracted processes of learning and negotiation are liable to be involved.

The transitions approach argues for the need to take the interests and perspectives of numerous stakeholders into account. For example, hospitals are an important part of the health and social care chain, but hospital management may not benefit from the reduction of inpatient stays associated with the use of PHS. The approach suggests experimenting with and developing of strategic niche markets; determining "boundary objects" through which stakeholders can gain their own appreciation of the innovation; and developing transition pathways through which the new service system can be constructed.

The shift to PHS may be understood as a system transition in the sorts of terms established in transition management accounts and drawing on ideas from the approaches developed in "social construction of technology" and similar approaches to innovation studies. As an example, Broch (2011) provides a multilevel analysis of innovation around care services for the elderly.

Methodology

Figure 1 gives an overview of the different types of analysis that were applied in our research project. The first approach was to obtain a comprehensive overview of the various types of PHS projects through web-based research. Apart from purely technical research projects, PHS projects exist at different levels of aggregation and analysis:

1. **Meta-level PHS projects:** These are mainly research projects that have made considerable efforts in defining and demarcating the PHS area. They are academic projects that follow an analytical approach in their occupation with the field. They are mostly publicly financed and well documented.
2. **Meso-level PHS projects:** These projects combine an analytical approach with a strong applications focus. Typically, the project partners involved are from research and consulting organizations. Also, academic organizations are typically found on one side, and on the other side, the partners are based on various case studies distributed over Europe where actors from the private, public, and third sectors are involved in implementing local personal health systems. These projects are well-documented, especially on the single-case level.
3. **Micro-level PHS projects:** These are national/regional local bottom-up projects, primarily focused on application – they are PHS cases according to the definition applied in this article. Project partners develop out of their ecosystems and receive financing at some points in time. Typically, projects and follow-ups develop over at least one decade; it is often difficult to demarcate the start and end of these undertakings. A wide variety of these projects exist on the national and local levels. They are not well documented – in most cases there is not even a project website.

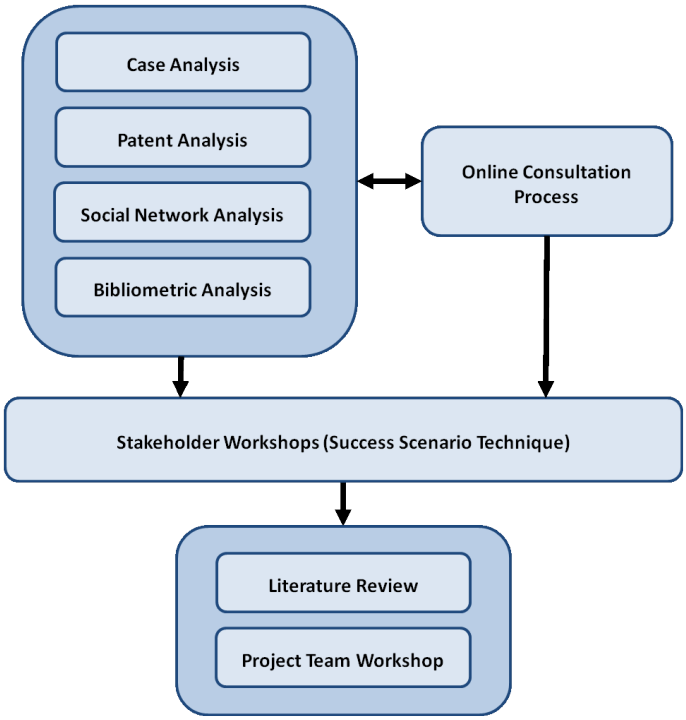

Figure 1. Methodologies applied in the course of the project

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At the outset, we conducted several small analyses to provide a first overview of the PHS area:

- A bibliometric analysis was used to explore the present state and future trends on the PHS topic.
- A small study analyzed the patents in the PHS field, using information obtained from the Derwent Innovation Index and the "Patent Citation Index".
- Social network analysis (SNA) tools and concepts were used to visualize R&D collaboration networks and central actors in the area of PHS on the European level, to move the focus beyond the individual social actors and toward the broader interaction contexts within which the actors are embedded.

The project website (phsforesight.eu) was deployed to establish an online platform for launching a structured and systematic online consultation process, with multiple phases for generating and clustering visions concerning breakthrough innovations and societal demands.

Two stakeholder workshops were organized in order to explore pathways for desirable future developments, and to use scenario analysis to deepen our understanding of how PHS might be configured and applied to specific health/wellbeing conditions over the coming decades up to a time horizon of 2030. In particular, we sought to deal with the challenging questions of system organization: what sorts of business model might be pursued and what is the organizational ecology of service provision? The scenarios were not intended to be predictions of what will happen, but to provide some idea of the range of plausible developments that might characterize the PHS field. The purpose of scenarios is to provide us with insight into the circumstances under which different developments might unfold, and the relations between different issues. Reality is liable to be a complicated and diverse mixture of different elements of these scenarios, varying over time, place, organization, and even medical conditions. The scenario workshop process involved alternating between plenary and break-out group discussions. The workshop, bringing together individuals with knowledge and expertise of the operation of health pathways, or of the potential of new PHS systems, and combining different perspectives (from academia, policy, industry, and society) discussed ways in which these pathways and systems might evolve over the next decade and beyond. Stakeholders invited to the workshops were identified via different channels: stakeholders registered via the PHS project website were asked to pass the word and invited their colleagues and networks to engage. Furthermore, outreach activities were established through social networks, printed leaflets, and targeted promotion (by way of emailing to the stakeholders of initiatives and through the website visibility with banners and hyperlinks). Coordinators or leading members of other projects in the PHS field were emailed. For the workshops, we took care of a roughly equal distribution of stakeholders with a research, business, policy, and third-sector background. For more information on the workshops, please see the report by Amanatidou and colleagues (2014).

Results from all previous analyses, the online consultation process, and the stakeholder workshops were then again cross-checked with existing literature and discussed and rounded up in a project team workshop.

Results

The various strands of analysis identified a number of critical issues and related governance deficits:

1. **Social acceptance of PHS:** issues that enhance the positive appraisal, and finally use, in stakeholder groups of PHS (e.g., patients, informal carers, medical professionals)
2. **Service systems of PHS:** issues such as systemic failures or lock-ins, including networks that are too weak (e.g., barrier to knowledge transfer, missing mutual understanding of actors' perspectives and roles) or too strong (e.g., causing incumbent actors to be dominant)
3. **Markets for PHS:** supply-side and demand-side issues; issues of interfaces between supply and demand; business models; and market opportunities
4. **Research and technological development of PHS:** covers research for technological solutions (i.e., precommercial), for standardization, but also for indicators about success of PHS
5. **Framework conditions of PHS:** cover institutional change, including the creation of new organizations/institutions, assigning new missions to existing institutions, regulation, and legislation

These critical issues can be the basis for possible policy designs to facilitate the adoption and diffusion of PHS technologies and services. We discuss each issue in greater detail in the subsections that follow.

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1. Social acceptance

Stakeholders with whom the PHS project engaged in interviews and discussions, as well as the literature reviewed, see individualization in healthcare and growing affinity for technology as drivers for PHS diffusion. The global dissemination of sophisticated technologies and mobile phones and consequently the use of these devices (e.g., Internet access, smartphones, and application development) is a strong trend that is reinforced as the senior part of the population becomes increasingly familiar with advanced ICT, having used it already in their professional and private lives (The Capital Region of Denmark & Health Care Innovation Centre, 2011). Technology affinity contends with technology skepticism: elderly individuals show hesitancy as to new technologies, frequently commenting, for example, that they are unable to use touchscreens. There is suspicion that technical devices may fail, through operating errors or technical deficiencies.

Social acceptance of technology includes also acceptance on behalf of professionals. Innovation-mindedness on a lower management level, and a positive attitude of care professionals, can be of vital importance for eHealth innovations. If there is a general fear of operating errors or hard-to-control alarms, this will slow down adoption rates of PHS service systems (Gkaitatzi et al., 2010; van der Plas & van Lieshout, 2012). These attitudes depend on several factors, including: levels of digital literacy in society; alleviation of public and professional concerns about confidentiality of health-related data; approaches to pricing of and payment for PHS use; and strategies concerning the "imposition" of PHS or changes in – or even the withdrawal of – the traditional services they may replace.

Social insurance funds have a culture of financing health services once the damage is done – providing healthcare services to prevent further damages is increasingly the role that is expected from them, but has not always been. Implementation of PHS may entail that actors in health and social care have to leave their predefined and expected roles; this is always likely to cause resistance. Physicians may be reluctant to engage in further services and training in order to empower patients and treat them as equals, as experts themselves; this reluctance may prevent PHS implementation and use. Patients are often expected to show more commitment, participation, and self-management, abandoning the traditional doctor–patient hierarchy: not all may be keen on this change of role. A further obstacle is medical professionals' primary mono-disease orientation.

A point of general concern in the workshops organized during the PHS foresight project was the issue of equity and equality of access to PHS. The equal distribution principle applied in hospitals (i.e., that all people should receive equal attention and treatment) may be harder to apply when healthcare is "brought out into society". More advantaged social groups will probably be able to afford more sophisticated services that can the less advantaged, but there is also the possibility of PHS directly contributing to social inclusion, for example by reaching out to remote geographical locations that have been less well served by centrally managed public health systems (Amanatidou et al., 2014).

Social acceptance of PHS is crucial for their widespread implementation and use. Discussions and analyses during the PHS workshops and interviews suggest that social acceptance relates to: digital literacy of the population as a whole; concerns about confidentiality; and issues around the pricing of and payment for PHS use. What is often neglected in discussions about social acceptance are fears that the introduction of new services relating to PHS technologies may be accompanied by a premature withdrawal of traditional services, or that access to other services (e.g., insurance) may be made conditional on the use of PHS.

2. Service systems of PHS

A wider systems approach takes into account the need to design complex architectures relating together people (e.g., recipients of care, care-givers, and others), organizational structures and processes (e.g., that determine divisions of labour and responsibilities and flow of resources) and technologies – especially the information technologies, but also other devices and software related to health and social care – and information.

One notion that has increasingly attracted attention in this context is the notion of ecosystems. Ecosystems consist of different stakeholders, each with its own goals, perspectives, and challenges. Stakeholders here include part of the science and technology system (e.g., firms, technology developers, the scientific community), the health and social care delivery system (e.g., public and private practitioners and managers, and also patients and their organizations and relatives). All of these stakeholders are heavily influenced by regulators and the institutional framework in general.

In order to introduce innovative ideas in healthcare successfully, it is often vital to take account of the ecosystem. Integrated service solutions require aligning

various actors in the ecosystem, and are hinged to the healthcare reimbursement and financing models, regardless of the differences in institutional set-ups of public health care in EU countries. Basically, there are two models of reimbursement in public health care: fee for service (e.g., reimbursement based on diagnosis-related group, or DRG, which is typical for hospitals), and fee per capita (e.g., number of patients treated, regardless of measures taken, which is typical for general practitioners). Both models for reimbursement applied in public health and social care systems can be problematic for the implementation of PHS and integrated service solutions for health and social care in general. Keeping patients out of hospital – through successful implementation of PHS – reduces the fee for services that hospitals receive, and hence reduces their incentives to adopt PHS. On the contrary, general practitioners who receive fees per capita may be unwilling to accept extra (and maybe unpaid) work that is associated with the additional PHS services (Abadie et al., 2011). These funding silos in residential and hospital care pose substantial difficulties to the introduction of PHS services, which often aim at linking the two or avoiding one for the other. Reductions in inpatient services can lower the burden on health and social care expenses, and technologically advanced outpatient services can help healthcare providers to deliver better and more individualized service. This situation suggests alternative funding mechanisms, additional fees (for PHS services), or other types of remuneration and financing. These new approaches are only likely to develop in the medium and long term.

But, this discussion also highlights some of the problems that a transition between service systems can involve. As already noted, the challenge of system innovation typically requires more than just excellent technological solutions, but also a multi-stakeholder process of service system design. Another major problem in health and social care is the division in many countries between healthcare and homecare practice and funding, which has severe consequences for the widespread introduction and adoption of PHS.

3. Markets for PHS

Reliable data on the markets for PHS are rare, despite the variety of reports by market research companies and consultancy firms that promote optimistic views of the markets, or particular market segments, of PHS (e.g., Baum & Abadie, 2013; Datamonitor, 2007; Frost & Sullivan, 2010; Khandelwal, 2010; Ludwig, 2009; Taga et al., 2011). Such reports tend to use a technology-driven market segmentation, and often are unclear as to their methodology and definitions of what units are actually counted in sales figures. Some of the reports note that ehealthcare investment has generally been proxied by ICT investment rather than healthcare investment (Baum & Abadie, 2013). In general, the perception of PHS markets by these market reports is skewed by a supply-side view.

There is an inherent difficulty in surveying the supply-side of the PHS market, as it is likely that supply is also characterized by individuals or very small companies. The advent of smartphones has significantly lowered the market-entry barriers for new producers, who can now rely on an existing platform and program an "app" at nearly marginal price (Baum & Abadie, 2013). The mHealth supply is dominated by individuals or small companies, with 30% of mobile app developer companies being individuals and 34.3% being small companies (defined as having 2–9 employees) (IDC, cited in European Commission, 2014).

In contrast, existing surveys of the PHS supply side suggest that most suppliers are large and medium-sized firms (e.g., Baum & Abadie, 2013). This finding points to the difficulties of identifying small-scale operations (e.g., individual programmers) and young firms, which can be assumed to also populate the supply-side of the PHS markets, especially in the mHealth and fitness realms.

Still, in terms of markets share it seems likely that most markets are dominated by large incumbents (Baum & Abadie, 2013). Purchasing decisions of public healthcare organizations may be powerful factors of success. Such customers typically have long innovation and adoption cycles of five to 10 years. Firms need certain characteristics to cope with such lengthy adoption processes, which often involve much adaption to customer needs. Furthermore, public healthcare providers need reliable partners over years or decades, which make them more likely to ally with incumbent supply firms with established track records and relationships.

Furthermore, the present research project suggests that that the optimistic market projections from market research and consultancy firms may fail to take into account the demand side and more general systems features. A wider systems approach led to the following considerations concerning the demand for PHS:

1. It seems to be a characteristic of demand in PHS markets that clients are on the one hand users and may on the other hand be patients, in which case the cli-

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ent may be a different kind of person/organization. This relationship depends of course on the type of PHS service solution, and accordingly, the literature on PHS markets is torn between the focus on users (i.e., an ICT focus) and on patients (i.e., a health focus). The question arises as to whether demand for PHS will rise substantially on the basis of out-of-pocket money from users/patients, on the basis of private insurances who acquire additional services for their clients, or from financing or spending decisions from public health care bodies (see also Abadie et al., 2011).

2. Another, issue impacting on demand in the PHS area is lack of confidence in individual applications. If many applications exist, which one should the user/patient as an individual trust? And does the physician trust the same one? How then, does a general need for change and efficacy in healthcare translate into demand for single PHS products and services?

3. Finally, this translation may be difficult, because it often involves systemic innovation which, as noted above, needs a multi-stakeholder process and thus takes time. Furthermore, PHS solutions are often related to age-based conditions, and demand for age-based innovations shows distinct features depending on the obviousness of the *age-specialization of the product or service* (Levsen & Herstatt, 2014). Products or services with a moderate to high age specialization face distinct challenges. First, that users are hard to reach when their autonomy has been substantially impaired, and their search for information and ability to make purchasing decisions are limited. Distribution via regular consumer channels may be significantly restricted, which results in costly and difficult sales processes. Second, if others, such as informal carers, take over the purchasing decision, these products and services bear the risk of non-acceptance by the targeted users. Third, if users do not suffer from significantly reduced mobility or cognitive abilities, products with moderate to high age specialization bear the risk of stigmatization, or of being non-prestigious at the least.

Stakeholders in the PHS area expect that new business models have to develop in order to gain value from PHS technologies (Amanatidou et al., 2014) – the logic being that valuable market opportunities for PHS solutions pass because of ill-defined value propositions for stakeholders. This shortcoming poses the question of why new business models in the PHS area do not develop readily. What prevents profit-seeking individuals or organizations from defining new value propositions and exploiting technological opportunities if they seem obvious?

The few studies of business models in health technologies indicate that the definition of value propositions may indeed be fraught with difficulties. Other than studies of the pharmaceutical industry and its alliances with biotech spin-offs, there is little examination of how business models and health technology co-evolve. One of the few exceptions is Lehoux, Daudelin, Williams-Jones, Denis, and Longo (2014), who stress that business model innovation may take time because a number of interacting factors are relevant: the development of a business model results from a "sequential adaptation to new information and possibilities" and articulates an innovation's value proposition and its market segment, the value chain, the revenue model, the value network, and the competitive strategy (Chesbrough & Rosenbloom, 2002: cited in Lehoux et al., 2014). It starts with a selection of one value proposition (out of several that are latent in the new technology). The definition of the market segment to which the (health) technology will offer value also has important consequences. There is an uneven distribution of benefits resulting from the new technology, and of ability and willingness to pay for these, from patients and their relatives, informal carers, physicians, nurses, health care managers, governments, employers, and third-party payers. Managing the value chain for creating and distributing the value(s) offered involves tradeoffs and affect different stakeholder interests (Lehoux et al., 2014). Hence, the development of a business model faces significant uncertainties regarding the innovation, its market, and its supplier (uncertainty being higher for a newly founded firms – especially those emerging from non-business spheres, but even firms emerging from the industrial sphere may face uncertainties reflecting the industry's dominant logic) (Sabatier et al., 2012).

Thus, the establishment of a business model may well involve successive synergistic readjustments – or even drastic reconfigurations of the original business model (Lehoux et al., 2014).

PHS technologies and services are associated with positive externalities – benefits accruing to others than those who pay the price. In case of PHS, many different stakeholders may experience benefits from the introduction of PHS, as suggested above, but which are priced depends on the business model. Economic theory sees this as one type of market failure that justifies

government action. If left to private producers, the product or service in focus is supplied insufficiently, which may slow the growth of PHS markets. Private firms expect investment by public actors, who face financial restrictions, and would have to engage in a process of system innovation in order to implement PHS service systems efficiently. The public actors expect investment by private firms. These mutual expectations may result in underinvestment on both sides.

4. Research and technological development of PHS
In the PHS workshops, the main role of public policy, in order to ensure quality of services and allow interoperability, was seen to be certification and standardization of hardware, software, devices, and systems. Processes for health and social care often engage many system players, in several different organizations: one way of dealing with the interfaces that arise in such contexts is promoting interoperability (i.e. the capability of systems to exchange data in a plug-and-play like fashion). Interoperability is generally thought to have at least three distinct levels:

1. Syntactic interoperability (e.g., Bluetooth, USB)

2. Semantic interoperability (e.g., IEEE X73, HL7 CDA)

3. Pragmatic interoperability

Most standards widely in use today are concerned primarily with the syntactic layer: they deal with data communication protocols and message composition. Standards for the semantic layer, which are concerned with the "meaning" of the data, are much harder to use and less mature today. Such standards are essential for enabling systems to understand each other. For example, decision support on a multi-modal data basis, taking into account information from clinical documents and data provided by patients directly via PHS, requires that these data can be meaningfully related together.

Finally, to achieve pragmatic interoperability means being able to orchestrate different healthcare providers (and their ICT infrastructures) into a continuous caring process, spanning the borders of healthcare organizations – or even, considering cross-border healthcare, whole healthcare systems.

Standards alone are often not enough to achieve higher levels of interoperability: this requires initiatives that guide the utilization of standards in the context of well-defined use cases. Major interoperability initiatives in the field of healthcare are the "Integrating the Healthcare Enterprise" (IHE) and the "Continua Health Alliance" (CHA) initiatives. IHE is an initiative by healthcare professionals and industry to improve the way in which healthcare IT systems share information. IHE promotes the coordinated use of established standards to address specific clinical need in support of optimal patient care. CHA's mission is to "establish an ecosystem of interoperable personal connected health systems that empower individuals and organizations to better manage their health and wellness" (Carroll et al., 2007). Neither organization creates standards itself, instead promoting clearly defined use cases in which existing standards are deployed.

Whereas IHE is primarily healthcare system focused and becomes relevant mostly in the last step while sending healthcare related data to EHR systems, CHA focuses on systems and devices close to the patient. CHA's mission is broader; it includes not only telehealth in terms of remote monitoring of vital signs but also systems more dedicated to wellness and fitness, as well as those supporting elderly people in terms of independent living (e.g., ambient assisted living) and those being cared for at home (e.g., telecare). As such, CHA is of prime importance to the PHS domain. IHE, however, is also essential in cases where PHS systems are to be linked to healthcare professionals and are not confined just to the patients themselves, informal care or consumer-oriented systems (i.e., "gadgets").

Market-entry barriers are a major concern for competition policy. Organizations promoting standards thus should construct open alliances that provide access to various types of firms and organizations in partnership; otherwise, market entry may be restricted.

Finally, research on PHS is not only necessary for technologies and standards, but also to analyze the benefits of PHS applications. This is the basis for comparing PHS applications and also for communicating success. The empirical investigation of efficacy and effectiveness of PHS implementation in turn is the basis for the wider diffusion of these technologies and development of new services around these technological solutions. However, further research on criteria for success and indicators is needed in order to compare either different service solutions or before-and-after situations.

Questions guiding this kind of research are likely to be:

- What are criteria for the successful implementation of PHS in new services?

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- How did PHS solutions impact health and wellbeing in society?

- Who benefits and how can this benefit be measured best?

5. Framework conditions
During the PHS workshops and interviews, it was often suggested that healthcare services will not be solely provided by traditional caregivers such as nurses or physicians. Many other qualifications will continue to emerge in health and social care. Policy makers need better evidence to assess these developments and take decisions to maintain a critical supply of the service workforce (see also MovingLife, 2012). New technologies require technically skilled experts able to implement, run, and maintain the systems and to train and support users (i.e., patients, nurses, doctors, relatives) for daily usage of such systems. By the same token, many caregivers who originally are not affiliated with modern technologies are facing new challenges when needing to adapt to their daily use. Different patients might need different technologies, with (multiple?) devices in people's homes and, in many cases, it is actually the caregiver rather than the patient using them. All players in the health sector will need to think how these additional skills can be achieved by the caregivers – and how they will be reimbursed.

How healthcare organizations deal with their accumulated digital information (i.e., big data) is crucial for the uptake of health ICT. Sharing sensitive patient data in a large, heterogeneous environment complemented by the use of web-based applications raises a number of privacy and security concerns. Case study evidence by OECD (2010) suggests that appropriate privacy protections must be integrated in the design of new health ICT systems from the beginning – they proved difficult to be introduced ex-post (OECD, 2010).

According to EHTEL (2008) the implementation of incident-reporting procedures – similar to those employed by the pharmaceutical industry – would also be welcome. Associated with such incident reporting should be ways of checking that eHealth information systems have been properly implemented and audit trails managed; this should be the subject of constant monitoring for incorrect operation or abuse. Despite standards for medical products on the basis of the Medical Device Directive (MDD; tinyurl.com/d7o56wj), there are apparently gaps with respect to service packages based on PHS technologies.

Discussion and Conclusion

The concept of PHS is often collapsed into the specific information systems that are constructed to support new health and social care services, or even into the specific devices that are employed within these information systems, such as wearable sensors to monitor health conditions or behaviour patterns. This article has argued the importance of a wider systems view, one that situates PHS within health and social care service systems. Such a wider approach takes into account the need to design complex architectures relating together people (i.e., recipients of care, caregivers, and others), organizational structures and processes, with their divisions of labour and responsibilities, flows of resources, etc., and technologies (especially information technologies, but also other devices and software related to health and social care). It also highlights some of the problems that a transition between service systems can involve – the challenge of system innovation. This challenge typically requires more than just excellent technological solutions, but also a multi-stakeholder process of service system design.

It is widely, and plausibly, argued that PHS can contribute to improved health outcomes *and* increase the efficiency of health services. In principle, there should be very substantial contributions, though early demonstrator studies are at best equivocal in displaying major gains and, in particular, cost-savings. This ambiguity reflects the fact that we are dealing with “wicked problems” involving numerous stakeholders and numerous specialized types of expertise – and indeed, a multiplicity of specific problems aggregated together under the health and social care rubric, and often intertwined in the circumstances of specific individuals and communities. PHS are emerging at a time when complex restructuring of health systems – and even of the notion of health itself – is being prompted by demographic, technological, and social changes. PHS will be part of this restructuring, and the extent to which the potential gains of PHS are achieved will be affected by the form it takes. Substantial challenges are involved in shaping this restructuring so that it can rapidly capitalize on the potential of PHS, while supporting equity, patient empowerment, and movement towards more healthy lifestyles.

Numerous stakeholders will be involved in this process, which involves building what participants described as "a PHS innovation ecosystem". It will be important to recognize the very real interests of different stakeholders – for avoiding deterioration in health outcomes; for main-

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taining and extending the equity and social inclusion elements of health systems; for stimulating the development of innovative and effective health interventions and medical technologies; for maintaining professional competences and social status; for rewarding entrepreneurial behaviour; and for protecting and for using personal data. At present, the emergence and potential of PHS has not been widely debated beyond expert communities. Much wider processes of consultation, dialogue, and vision creation will be required to ensure that interests can be articulated – and where necessary challenged – in a transparent manner.

Meeting these challenges will require experimentation, dialogue, and monitoring of change. This study indicated some of the major aspects of change that will need to be addressed. They range from the creation of new business models and partnerships between organizations of different kinds, through stimulating the acquisition of new skills and the emergence of new professions in health (and related) workforces, to putting regulatory frameworks into place that can allow for informed acceptance of evidence-based solutions. In all of these aspects of change, public attitudes will need to be taken into account, because citizens are crucial stakeholders in these processes. These processes will need to be the focus of much greater effort in the near future.

The present study is, hopefully, one step in the direction of adopting a holistic and combined approach in understanding PHS and establishing and sharing visions of the desirable futures that can be achieved with the use of PHS, and the problems that may be encountered and the ways in which these may be addressed, in the course of shaping these desirable futures.

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References

Abadie, F., Codagnone, C., van Lieshout, M., Pascu, C., Baum, P., Hokkainen, A., Valverde, J. A., & Maghiros, I. 2011. *Strategic Intelligence Monitor on Personal Health Systems (SIMPHS): Market Structure and Innovation Dynamics.* Joint Research Centre Scientific and Technical Reports. Brussels: European Commission. http://is.jrc.ec.europa.eu/pages/TFS/SIMPHS1

Amanatidou, E., Miles, I., Saritas, Ö., Schartinger, D., Giesecke, S., & Pombo-Juárez, L. 2014. *Personal Health Systems: A Success Scenario.* Personal Health Systems Foresight.

Baum, P., & Abadie, F. 2013. Market Developments – Remote Patient Monitoring and Treatment, Telecare, Fitness/Wellness and mHealth. In F. Abadie, M. Lluch, F. Villanueva Lupianez, I. Maghiros, E. Villabla Mora, & M. B. Zamora Talaya (Eds.), *Strategic Intelligence Monitor on Personal Health Systems.* Brussels: European Commission. http://is.jrc.ec.europa.eu/pages/TFS/SIMPHS2deliverables.html

Chesbrough, H., & Rosenbloom, R. S. 2002. The Role of the Business Model in Capturing Value from Innovation: Evidence from Xerox Corporation's Technology Spin-Off Companies. *Industrial and Corporate Change,* 11(3): 529–555. http://dx.doi.org/10.1093/icc/11.3.529

Codagnone, C. 2009. *Reconstructing the Whole: Present and Future of Personal Health Systems.* Brussels: PHS2020, 7th Framework Programme, European Commission.

Cunningham, P., C., G.-P., Green, L., Miles, I., Rigby, J., & Uyarra, E. 2005. In Sickness, in Health and in Innovation: NHS DIRECT – A Health Sector Innovation Study. *Administration,* 53(3): 42–65.

Datamonitor. 2007. *Telehealth Spending in Europe through 2012.* London: Informa.

European Commission. 2014. *Green Paper on mobile Health (mHealth).* Brussels: European Commission.

Frost & Sullivan. 2010. *European Remote Patient Monitoring Market.* Mountain View, CA: Frost & Sullivan.

Gkaitatzi, O., Bekiaris, E., Mourouzis, A., Lekka, E., Karavidopoulou, Y., Villagra, F., Schaller, P., & Sörgel, P. 2010. *Definition of REMOTE User Requirements and Use Cases. Deliverable D1.1 for Project ICT-Based Solutions for Prevention and Management of Chronic Conditions of Elderly People.* REMOTE Project Report AAL-2008-1-147.

IfM and IBM. 2008. *Succeeding through Service Innovation: A Service Perspective for Education, Research, Business and Government.* Cambridge, UK: University of Cambridge Institute for Manufacturing.

Karni, R., & Kaner, M. 2006. *An Engineering Tool for the Conceptual Design of Service Systems, Advances in Service Innovations.* New York: Springer.

Khandelwal, N. 2010. *The World Market for Telehealth – A Short and Long-term Analysis.* Wellingborough, UK: InMedica.

Lehoux, P., Daudelin, G., Williams-Jones, B., Denis, J. L., & Longo, C. 2014. How Do Business Model and Health Technology Design Influence Each Other? Insights from a Longitudinal Case Study of Three Academic Spin-Offs. *Research Policy,* 43(6): 1025–1038. http://dx.doi.org/10.1016/j.respol.2014.02.001

Personal Health Systems Technologies: Critical Issues in Service Innovation and Diffusion

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Levsen, N., & Herstatt, C. 2014. *Lead Markets in Age-Based Innovations. Technology and Innovation Management Working Paper 80.* Hamburg University of Technology.

Ludwig, S. 2009. *The Fitness Market.* Düssseldorf, Germany: Deloitte.

Maglio, P. P. 2010. Challenges in Service Science. Presentation at Cambridge Service Alliance Conference on Challenges in Services, based on work reported more fully in P. P. Maglio, C. A. Kieliszewski, & J. C. Spohrer (Eds). *The Handbook of Service Science.* New York: Springer.

MovingLife. 2012. MObile eHealth for theVINdication of Global LIFEstyle Change and Disease Management Solutions. D2.1State of Play in Mobile Healthcare. Accessed February 1, 2015: http://moving-life.eu/

OECD. 2010. Improving Health Sector Efficiency. The Role of Information and Communication Technologies. *OECD Health Policy Studies.* Accessed February 1, 2015: http://www.oecd.org/els/health-systems/improvinghealthsectorefficiency.htm

Rotmans, J. 2006. *Societal Innovation: Between Dream and Reality Lies Complexity.* Rotterdam: Erasmus University.

Sabatier, V., Craig-Kennard, A., & Mangematin, V. 2012. When Technological Discontinuities and Disruptive Business Models Challenge Dominant Industry Logics: Insights from the Drugs Industry. *Technological Forecasting and Social Change,* 79(5): 949–962. http://dx.doi.org/10.1016/j.techfore.2011.12.007

Schot, J., & Geels, F. W. 2008. Strategic Niche Management and Sustainable Innovation Journeys: Theory, Findings, Research Agenda, and Policy. *Technology Analysis and Strategic Management,* 20(5): 537–554.

Taga, K., Bohlin, N., Brennan, J. W., & Kuruvilla, T. 2011. *Capturing Value in the mHealth Oasis.* Boston: Arthur D. Little, Telecom and Media Viewpoint.

The Capital Region of Denmark & Health Care Innovation Centre. 2011. Discussion Paper for the mHealth Wworkshop on December 5th 2011: Theoretical Framework of Understanding. *MOVING LIFE Project.* Accessed February 1, 2015: http://www.moving-life.eu/viewpage.php?page_id=5

van der Plas, A., & van Lieshout, M. 2012. Strategic Intelligence Monitor on Personal Health Systems Phase 2 (SIMPHS 2) Country Study The Netherlands. In F. Abadie, M. Lluch, F. Lupiañez, I. Maghiros, E. Villalba, & B. Zamora (Eds.), *JRC Scientific and Technical Reports.* Brussels: European Commission. http://is.jrc.ec.europa.eu/pages/TFS/SIMPHS2

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