Co-creation with Stakeholders: A Web 2.0 Antibiotic Stewardship Program

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Abstract - **Patient Safety needs a rethinking about medicine due to the aging society, increase in chronic diseases and infections and a decrease in available budget for healthcare. Besides, patients are the driving force behind transparency of healthcare decisions. Participative Medicine supported by technology is promising to innovate medical thinking and workflows. In this paper we discuss a holistic eHealth development approach for participative medicine. We show, using the case of antibiotic stewardship, how participation of stakeholders can be used to co-create a digital platform with applications to support decision–making and collaboration. We demonstrate that participation of stakeholders (healthcare workers, providers, policymakers, management, patients) is needed to co-create eHealth technologies that make sense by being accessible, affordable, applicable, manageable and enjoyable.**

Keywords–eHealth; Antibiotic Stewardship; Holistic Development.

I. INTRODUCTION

Most eHealth interventions are designed and implemented without taking the exact needs of the end-users and other stakeholders into account. This leads to a suboptimal adoption of the interventions and therefore sorts less favorable effects. In the wake of Health 2.0 and Medicine 2.0 initiatives, a growing number of studies have emphasized the importance of a *participatory development* process involving (end-) users, and other stakeholders like payers, decision-makers, insurers, and government officials to increase the uptake of eHealth interventions [1]. To support a participative development process, we introduced a Holistic development guideline, the CeHReS (Centre for eHealth Research and disease management) roadmap [1].

Using this roadmap, we describe the development process of an Antibiotic Stewardship Program (ASP), that is part of Infection Manager, a cross-border Web-based platform for infection management [2]. The platform is available in Dutch, German, English and soon also in French.

The goal of ASPs is to improve antibiotic prescribing and utilization in institutional care settings worldwide. This is an urgent need; it is estimated that around 30%–50% of the antibiotic use in hospitals is unnecessary or inappropriate [3, 4]. A dramatic increase in antibiotic utilization is observed in several studies, resulting in multi-drug resistance among microorganisms and causing treatment complications [5, 6]. At the same time, no new pharmaceutical agents for effective antibiotic therapies are developed (due to high investments

costs and long development time). So, antibiotic resistance is a growing threat for patients. This threat increases even more due to the aging society and increase in chronic diseases and infections [7]. Additionally, antibiotic resistance has a substantial economic impact as a consequence of the need for more expensive drugs and longer hospital stays associated with therapy failure [8, 9].

ASPs have been introduced as a solution to overcome the overuse and misuse of antibiotics in hospitals [10]. The focus of these ASPs is to support the prescribing behavior of healthcare workers (HCWs) via diverse interventions aimed at 1) prescribing narrow-spectrum antibiotics instead of broad-spectrum [11], 2) optimizing dose, type, and duration of therapy, 3) education of HCWs to change their behaviour regarding prescribing antibiotics, and 4) guidelines to support decisions.

Some promising results are known of such ASPs, for example, reduction in costs (shorter hospital stays, shorter courses of drugs/therapies) and a decrease in antimicrobial resistance, such as MRSA [12-14]. However, several barriers hinder the effective implementation of ASP-interventions such as a lack of resources knowledge, poor adherence, and lack of management support [12, 15-17].

Academic literature suggests to increase the adoption and implementation of ASP-interventions via a stakeholder-driven development approach and the use of innovative technologies to support decision making (providing support at the right moment, right place, and in the right format) [10]. Like with other eHealth interventions, most of the ASP-interventions are expert-driven rather than taking HCWs' and patients' needs and demands into account [1, 6]. Contrary to what, for example the Centers for Disease Control and Prevention (CDC) recommend, most ASP-interventions are still developed by infection control experts. Stakeholders from various disciplines (pharmacists, physicians, nurses, patients, payers, and government agencies) are scarcely involved and often eHealth specialists are not consulted. We know from prior research that socio-cultural and socio-economic factors and management support are important determinants for successful implementation of medical interventions [18]. By applying the CeHReS roadmap, we show how ASP-interventions can be developed that make sense to all stakeholders and that can overcome the aforementioned barriers.

The aim of the Infection Manager platform is to provide applications for HCWs, managers and other stakeholders to

improve decision-making and to facilitate knowledge sharing and collaboration. The Infection Manager is a Web-based platform in which we can offer applications for communication, information, and coordination of infection control. The Joomla architecture supports flexible and dynamic development of applications by means of templates and modular expandability.

Based on prior research about the development of a web-based application called MRSA-net [18, 19], we know that HCWs need a layered structure for infection control: *Communication* to consult medical experts and each other, to discuss interventions (forums), and to contact the research and development team of the portal. Modules for *coordination* are used to support the (care) process, for example by offering an infrastructure for information sharing or communication, or by offering tools for monitoring resources and benefits. *Documentation* or information modules refer to the guidelines and protocols that ground the applications and are made available on the platform. Besides we learned from prior research that stakeholders should be involved to create ownership and commitment for adherence to infection control interventions [18, 20]. In this paper we discuss the participatory development with stakeholders, focusing on the development of a Web-based ASP as one of the applications of the Infection Manager by involving stakeholders.

The next section includes a short explanation of the CeHReS roadmap that we have developed [1, 21]. This roadmap was used as a guideline for the development process. In Section III, the research methods that we used for the development of the Infection Manager and the ASP-interventions are described. After that, in Section IV, the research results are described. In the last sections, the results are discussed, and our plans for the operationalization and evaluation of the ASP-interventions are explained.

II. HOLISTIC DEVELOPMENT FOR EHEALTH; THE CEHRES ROADMAP

Internationally, (EU eHealth, European Center for Public Policy) the need has been explicitly emphasized for a holistic and interdisciplinary eHealth approach for durable technological interventions and sustainable innovations in healthcare [22]. A holistic approach would account precisely for the issues of finance, management and the one-sided technology-driven approaches. It constructs a productive fit through the integration of social sciences, engineering and business modelling.

The CeHRes roadmap [1, 21] is developed as an answer to the need for a holistic and interdisciplinary approach. The foundation for the roadmap is based on reviews in the field of eHealth, multidisciplinary theories from social sciences and engineering, business model theories, and empirical research applying the framework [1, 23, 24].

The roadmap serves as a practical guideline to plan, coordinate and execute the participatory development of eHealth technologies. It is meant for developers (for example, technicians, designers, or healthcare professionals), researchers and policy-makers, and also for educational purposes (for example, students and healthcare providers). It also serves as an analytical instrument for decision-making about the use of eHealth technologies.

The roadmap integrates *persuasive technology design, Human-Centered Design* and *Business Modelling.* Persuasive and Human-Centered Design are applied to make technologies tailored to stakeholders needs, capacities and capabilities so that behavior change is enhanced. Business Modelling is interwoven with the development of eHealth technologies to foster dialogue and ownership by co-creation and to construct business cases to implement eHealth technologies. We use Business Modelling to assess the needs of all stakeholders and transform these needs into a value-driven implementation by making a business model [25]. The Business Model Canvas, introduced by Osterwalder, acts as a blueprint and can be used to compose a business model [26]. The business model has to ascertain that the technology sustainably reaches its intended goals and effects.

The roadmap consist of 5 cycles; contextual inquiry, value-specification, design, operationalization and evaluation. These cycles are explained in depth elsewhere [1, 21], in this paper we will describe the methods we applied in the first cycles of the roadmap.

III. METHODS

Different methods are used for the development of the infection manager and ASP-interventions.

A. Development of the Infection Manager

To create a starting-point and explore the possibilities of eHealth technology to support infection management, the CeHReS roadmap was applied in a lean and mean way. Hereto, first ideas were researched and explored roughly while creating modules that can be adjusted with iterations later on in the development. The contextual inquiry, value specification and design phase are completed and described below. In the discussion, in Section A, future research activities (operationalization and evaluation phase) are described. Figure 1 shows how the Infection Manager research activities fit into the CeHReS roadmap; the roadmap phases are shown in the blue blocks, and the methods that were applied in each phase are shown below each phase, in orange blocks (Figure 1).

For the contextual inquiry, a quick scan of the literature on antibiotic stewardship was performed. The stakeholders (HCWs, consultant clinical microbiology, hygienists) were selected based on the literature scan and expert validation. The contextual inquiry phase was further combined with the value specification and design phase via interviews. To optimize the understanding of the context and needs as identified in the literature scan, interviews were held with
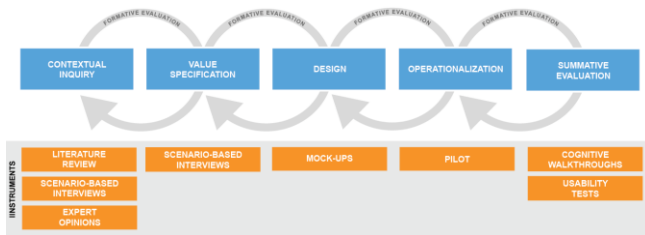
Figure 1.   First development process: The Infection Manager

stakeholders (HCWs; physicians, consultants clinical microbiology, hygienists). During these interviews the value specification was performed by inquiring about the need for a layered infection management platform (communication, coordination, documentation). Three different mock-ups, that gave an impression of the possible lay-out and functionalities of the Infection Manager, and a number of scenarios, description of situations in which the Infection Manager could be useful, served as input for the semi-structured interviews. The comments made about the mock-ups served as input for the design process.

B.   Development of the ASP-applications

The CeHReS roadmap was applied for a second iteration for the development of the ASP applications in the Infection Manager. For the ASP applications, we completed the contextual inquiry and value specification. Figure 2 shows the applied methods in orange blocks below each phase. The remaining roadmap phases (design, operationalization and evaluation) are described in the discussion, in Section A: Future research activities.

In a local hospital three sites were selected, based on the urgency for patient safety and ASP: pulmonary diseases, surgical sites, and urology. In this paper we focus on the research activities carried out at the pulmonary ward. During the contextual inquiry, a literature scan identified the cornerstones for ASP as mentioned in the introduction of this paper. After that, the stakeholders of the ward to be included in the focus group were defined, based on a more in-depth literature scan [27]. The following stakeholders participated in the focus group:

- HCWs (consultants clinical microbiology, pharmacists, chest physicians, residents, nurses)
- Management (nurse manager, general manager, staff member of management)
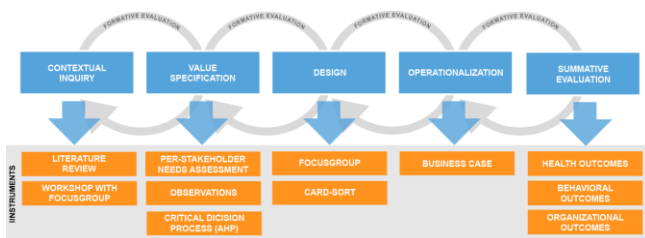

Figure 2.   Second development process: ASP applications

In the focus group, the contextual inquiry was completed and value specification was performed. Via assignments and discussion the current workflow and work practices regarding antibiotics and the roles and tasks of the involved stakeholders came to surface. A number of other topics were discussed: the coordination flows and communication involved in the care process regarding antibiotics, problems that are encountered, and potential solutions.

IV.   RESULTS

The results of the contextual inquiry, value specification and design phase of the Infection Manager, and the results of the contextual inquiry and value specification of the ASP application are described in the following paragraphs.

A.   Infection Manager Results

In the interviews, the stakeholders expressed specific needs for communication, coordination and documentation regarding infection management in their work practice. Their preferences indicated a platform with applications, featuring at least functionalities such as document sharing, a forum for collaboration, and useful links to information resources. Also, the three different mock-ups were evaluated and criticized regarding their design. This resulted in a stakeholder preference for a dashboard-style design, with textual and pictorial operating buttons. The results were summarized and were incorporated in the (working) prototype design. Figure 3 shows the current prototype of the Infection Manager. The three rows represent the applications for communication, coordination and documentation. Each button represents a specific application. For example, MRSA-net informs and educates the general public and HCWs about the prevention of MRSA.
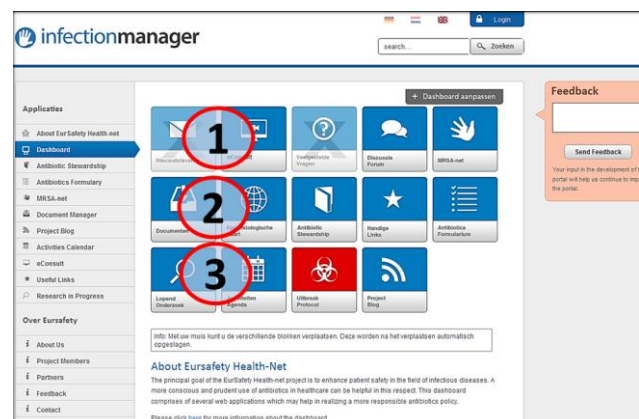

Figure 3.   Screenshot of the Infection Manager website
1: applications for communication (e.g., forum); 2: applications for documentation (e.g., document manager); 3: applications for coordination (e.g., calendar)

B. ASP contextual inquiry results

The literature scan suggests that ASPs that are supported by technology, consist of either a single or multiple strategies and can have positive effects, especially on the costs level and appropriate antibiotic use [27-30]. Especially for the hospital management these are interesting effects. Other effects that are also beneficial for the patient are shorter Length-of-Stay or a quicker shift from intravenous to oral antibiotics [30, 31].

The focus group with the stakeholders resulted in more insight into the roles of the different stakeholders, and in an overview of their problems and needs.

1) Defining key-stakeholders

During the focus group, the stakeholders were asked to define their role and tasks in the care process regarding antibiotics. Together, they defined the key-stakeholders as the chest physician, resident, and nurse. On a secondary level, consultants clinical microbiology, pharmacists, infectiologists and other consultants need to be involved. Lastly, management and support staff are not directly involved, but have support and managing roles. According to the participants in the focus group, missing stakeholders in the focus group were an infectiologist, and a dietician. Since they are not the key-stakeholders in antibiotic stewardship, their absence was not considered problematic.

2) Problems with the current use of antibiotics

During the focus group, the stakeholders mentioned several problems regarding their work practice with antibiotics that may threaten patient safety, see Table 1.

Problems refer to the lack of access to information regarding the treatment or the patient status (including test results), or in other words, problems with the patient

TABLE I.   WORKSHOP RESULTS: PROBLEMS

Problem Category	Problems
Knowledge & Skills	1. Unfamiliarity with guidelines and (new) procedures 2. Inexperienced nurses and residents
Documentation	1. ICT systems for protocols, 2. Reference books are inaccessible and not user-friendly
Patient-information flow	1. Uncertainly regarding prescribed medication (due to prescribing program and transfer of information) 2. Test results are unclear or not findable in the information system 3. Patient data or status inaccessible to consultants 4. Insufficient or no feedback to consultants about the effects of treatment 5. Swabs or screening materials are lost during logistics
Communication, consultation	1. Consultation about patients over the phone is inadequate 2. Consultants lack necessary patient information to give accurate consults
Resources, personnel	1. There is no 24/7 consultant occupation or service 2. Lack of resources and personnel for asp
Coordination, responsibility	1. Overview/coordination of patient care process is sometimes unclear
Commitment, adherence to treatment plans	1. Treatment plans are not always as timely executed as was decided 2. New programs or ICT systems do not receive hospital-wide commitment

information flow. Another problem that was mentioned, was insufficient cooperation and consultation between the physician and pharmacists, microbiologists or other consultants, due to insufficient information sharing and unstructured procedures for consultation. Further, insufficient knowledge of (new) procedures or medication application poses a problem.

3) Stakeholders' Needs

As demonstrated in Table 2, most urgent needs include the key-stakeholders' (chest physician, resident and nurse) wish for more structured cooperation and consultation about antibiotic use in patient care. All stakeholders expressed a need for quick, easily accessible information regarding the patients' former and most recent status, including test results and treatment plans, in other words, better patient-information flows. This way, HCWs are able to act, decide, or give consultations based on complete, up-to-date information. Importantly, the physician and residents are considered to be the main 'hub' in patient-information flows, because they need a good overview and they carry end responsibility. Usability and compatibility of ICT systems with work practice, and better accessible protocols, guidelines or other procedural information are also highly needed by all stakeholders even though they are most relevant to the key-stakeholders.

TABLE II.   WORKSHOP RESULTS: NEEDS

Need category	Needs
Knowledge & Skills	1. Increased knowledge exchange among HCWs 2. Adequate instruction & education
Documentation	1. Accessible information regarding medication, guidelines or procedures 2. User-friendly documentation
Patient-information flow	1. Well-arranged patient information sharing and accessibility 2. Structured consultation and feedback 3. Well-organized screening/swab logistics and feedback
Communication, consultation	1. Face-to-face (bed side) microbiology consults 2. Adequate patient information sharing 3. Feedback on treatment effects to consultants
Resources, personnel	1. Nightly and weekend availability of consultants to make policy 2. Management commitment to provide resources
Coordination, responsibility	1. Chest physician has overview of patient care process 2. Need to know who principal consultant is.
Commitment, adherence to treatment plans	1. Hospital wide commitment to new programs 2. Clarity about treatment plans and insight in status of its execution

4) ASP Value Specification

During the workshop, the added values of an ASP were discussed. The stakeholders discussed and agreed on several values that were categorized as follows:

- ASP that is compatible with current ICT systems and work flow and practices (one login with access to all types of information/communication).
- ASP that saves time and procedures that correspond with medical practices (no extra system; no extra work).

- ASP that is flexible and dynamic, tailored to HCWs and management needs and preferences.
- ASP that is available for HCWs, regardless of time and place, to support decision making (critical points of care).
  - Quality of Care; treatment decisions based on evidence/data.
  - Timeliness; patient receives timely and accurate care.
- ASP that supports cooperation and consultation among HCWs (physician, nurse, consultants).

V. DISCUSSION

The results of the applied methods show that including stakeholders in the development process, renders a holistic view on problems and the accompanying values that need to be taken into account during development. Especially the stakeholder focus group resulted in a holistic view, for both researchers and stakeholders. By discussing stakeholder roles and values in an ASP, a broad understanding among the participants was created and solutions that have a reach beyond their own tasks were discussed. In addition, early in the development process it became clear that a one-fits-all solution in this case (to support infection control and ASP) is almost impossible. However, tailoring and designing with and for specific user-groups can help to fulfill specific needs. Applications should be adjusted for user groups to fit their specific needs and fit in their context. Thus, the technology that is used needs to be modular, because formative evaluations and adjustments to accommodate other user groups (other care facilities or types of HCWs) require easily adaptable applications. We have experienced that the roadmap offers the tools to involve stakeholders in different phases of the design process. The per-application development ensures that different needs can be met. By bundling the applications in the Infection Manager, overview is created and the stakeholders are able to see how the (different) applications could be helpful to them. So in this sense, a one-fits-all solution might still be possible.

A. Future research activities

Since the Infection Manager and its applications (including the ASP application) are still under development, the last roadmap cycles need to be completed, future research focuses on the application of these remaining cycles to the Infection Manager and the ASP applications.

1) Infection Manager Operationalization

For the Infection manager, a selected user group (project members of EurSafety Health-net) is approached to try-out the Infection Manager. Based on the feedback of these first users, the system will be evaluated formatively and upgraded, so that it better fits the needs of the users. At the same time, the Infection Manager needs to be filled with applications for communication, coordination and documentation. Based on research, applications (such as the ASP applications), will be developed.

2) Design and operationalization of ASP applications

The ASP applications will be designed according to the identified problems, needs and values. To accommodate stakeholder needs for education, an ASP education application will be developed. During the literature scan, essential content of such an application was identified, validated by infection control experts and summarized in an ASP guideline (handbook). This ASP education document is currently available in PDF format in the Infection Manager. However, to fit HCW needs regarding structure and content, the guideline will be translated into a web-based, more interactive version via a *card sort* study.

Further, an application will be designed to support prescribing behavior through information sharing and consultation regarding *dose, duration* and *type* of antibiotics. This application is an important start in view of the stakeholders (experts, management) to support HCWs and show the potentials of ASPs in order to increase commitment of HCWs to an ASP, to foster ownership and to clarify responsibilities. Thus, this application supports the coordination of care. The content of the application will be expert-driven, and via interviews and/or a focus group functional requirements for the design will be determined with the key-stakeholders. After field-testing and final adjustments the application will be ready for use.

Besides education about ASP, HCWs expressed a need for *interactive information or communication* about procedures or specific cases regarding ASP. An application will be designed together with HCWs to increase the access and usability of information. The precise content and functionalities will be determined by studying current work-processes via a focus group and field observations. The resulting topics (of ASP related information) will be prioritized by HCWs via a critical decision system, the Analytic Hierarchy Process [32]. Lastly, the application's content will be organized using methods such as card sorts, as this approach has proven to be useful in the development of MRSA-net; a web-tool for practical information based on medical protocols [18]. The design is further established by using mock-ups and usability tests.

To facilitate decision making, the effects of the ASP applications are evaluated and will be made available to the necessary stakeholders via a *communication* system to enable discussion among key-stakeholders and to support decision making.

3) Infection Manager Business Model

Meanwhile, a business model will be developed for the implementation of the Infection Manager and its applications. Preparing the implementation of an eHealth intervention such as the Infection Manager should start as early as possible in the development. Many eHealth interventions fall short as the attention for the implementation starts too late, usually ex post development [24]. Therefore, already in the contextual inquiry the problems are defined and the stakeholder network is made. In the value specification the values are determined, and in the design phase, implementation scenarios are developed with stakeholders. In the operationalization phase, the business model is really put to effect. In this stage, the

business model and technology have become concrete enough to detail out the implementation and introduce the technology into practice. Currently, we are forming business models on a per-application basis to find sustainability for these applications, as well as a business model for the Infection Manager as a whole. Thus, we investigate how we can offer the Infection Manager to various stakeholders in a cross-border setting.

4) Evaluation

To assess the benefits of the ASP we will measure the effects using a combination of qualitative and quantitative instruments. Which effects are to be measured will be determined by the results of a systematic review that is currently being carried out to find all clinical and financial effects of ASP, and the methods used to measure this. The review outcomes will be used for the evaluations of the Infection Manager and ASP. A formative evaluation will be carried out continuously to get insights in the accessibility, applicability, and usefulness of the Infection Manager and its applications. We will use standard usability methods for prototyping and evaluations [33].

VI. CONCLUSION

In this paper, we have discussed how an eHealth technology can be developed with involvement of various stakeholders using a holistic approach. The first two ASP-applications (for guideline communication and prescribing behavior) will be available in December 2011. Future research involves the development of the applications for education and evaluation. The development procedure will be carried out simultaneously in other wards (urology, surgery) of Dutch and German border region hospitals.

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