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Evaluation of Ambient Assisted Living Interventions – Which Tool to Choose?

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Abstract. This paper discusses suggested evaluation frameworks' appropriateness for a study introducing Ambient Assisted Living (AAL) interventions. Specifically, we look at how well proposals cover these dimensions: impact on society, impact on professionals, and impact on patients. We discuss three widely used approaches for such assessments: RE-AIM, MAST, and UTAUT. Our assessment showed careful selection of elements from all three models seems needed to sufficiently cover the dimensions. RE-AIM provides a broad framework; MAST adds aspects of transferability and ethics, and UTAUT adds perception of technology and future use. All these approaches lack pivotal aspects concerning inclusion of patients' or citizens' point of view in a study's planning phase. To ensure rigor and include meaningful use from citizens' perspective, we added these aspects to our study.

Keywords. Technology Assessment; Quality Assurance; Health Care; Informatics; Evaluation Studies as Topic

Introduction

In the midst of ongoing digital transformation, health care is constantly being presented with novel opportunities for service development based on new technological devices, which calls for assessment of their appropriateness, usefulness, usability, and overall impact on service development. We are seeking solutions to demonstrate that impact for the "Home Safety" (NO: *Trygghetspakken*) project. The goal of this project is to introduce useful, reliable, and simple e-Health tools that ensure dignity and enhance safety, to enable and to support people living longer in their own homes. In this paper, we will discuss whether use of the RE-AIM framework is sufficient for evaluation of our study, or if we should add dimensions from other models more specifically designed for technological assessment.

As health care's treatment repertoires develop to handle more complex conditions and people's life expectancy increases, a growing population of chronically ill and elderly people will be in need of more advanced services for a longer time. Hence, Norwegian public health care services are faced with increasing numbers of citizens who will require help and services. In line with international trends and efforts, our country's core policy for the future health care system is to develop strategies and

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services to enable the citizens to live safely in their own dwellings as long as possible, and to postpone admission to nursing homes, assisted living facilities, or hospitals [1]. Technologies as intervention for Ambient and Assisted Living (AAL) have been identified as solutions to help people remain their own homes and postpone or reduce their need for other services [2,3]. Despite a general expectation that implementation of technology would reduce costs in health care, findings from recent studies indicate no reduced costs in the group of people using welfare technologies compared to non-users, at least on a short-term basis [4,5]. However, use of technology has many other implications for society, health professionals, and citizens that need careful consideration.

The Home Safety project intends to identify useful and usable technologies that will increase safety and ease the everyday lives of patients and their families/significant others. Several AAL technologies, designed to improve safety directly or indirectly are piloted in real-life practices. The goal is to set up a suite of technologies that a municipality can offer people to support living at home, and postpone or reduce overall resources for community care. The user pilots include:

- *Safety alarms with GPS* built-in alarm button and GPS tracker that users can wear/carry with them. The device has a dual purpose: a) call for help in case of emergency, and b) track down a person if lost, but allow for freedom and physical activity despite cognitive decline and orientation problems.
- *Portable automatic pill dispensers* to assist people in taking the right medications at the right time. These alert the user when medication is scheduled and, if medicine is not taken on time, send a text message or e-mail to support personnel.
- *Electronic whiteboard* as a coordination tool for real-time information sharing among the team of health professionals, including updated patient overviews, room occupancy, and important information about patients to ease coordination, give an overview, enhance quality care, and reduce temporary stays in a facility.
- *Tablet computers* for social interaction or communication between health professionals and patients, to encourage physical activity or stimulate the elderly to eat by sending activity updates, menus, and meals provided by the municipality, and by using already available downloadable applications.
- *Sensors to support safe living*, including door sensors, water leakage sensors, movement sensors, light controls to prevent falls in the dark, and alarms to notify health professionals if someone is unable to get up.

Based on these real-life pilots, we sought an approach to examine factors like societal justification, e.g. societal benefits and disadvantages implementation of technology produces, professional change, e.g. how technology opens new services and impacts professional health care workers, and citizen impact, e.g. how implementation of this technology impacts safety and dignity. Hence, we need a good evaluation tool for this purpose. While we acknowledge there are numerous models available, we chose three models in particular for their frequency of use, and they have very different constructs and approaches. The "Reach Effectiveness Adoption Implementation Maintenance" (RE-AIM) model [6,7] was initially identified for this study. We then explored whether dimensions from other tools specifically developed for technology assessment should complement our approach. Therefore, we added the "Unified Theory

of Acceptance and Use of Technology" (UTAUT) [8], and the "Model for ASsessment of Telemedicine applications" (MAST) [9] to our considerations.

1. Methods

A mixed-methods approach will be used for the assessments [10]. The empirical data will be collected through focus group interviews, observation, informal interviews, and questionnaires, and we will use aggregated data about service utilization and changes in required and needed services when patients get access to AAL technology.

2. Results – presentation of the models

To include the most important aspects when piloting and assessing new AAL technology, we believe that it is pivotal to use an assessment model. To address which model(s) to choose, we looked into different models to learn how well they cover the chosen areas of impact: society, professionals, and citizens. We will discuss the three models, RE-AIM, UTAUT and MAST, and their contribution to assessment of a) societal benefits and disadvantages implementation of technology produces, b) practice change, how technology opens new services and impacts the care environment, and c) use of the specific technological tools in terms of safety, participation, and dignity.

2.1. RE-AIM

The RE-AIM framework was developed 14 years ago, and has been widely used ever since. The framework covers important methodological issues, outcome measures, and issues concerning generalizability [6], and has been suggested as an approach for evaluation of technology implementation [7]. However, RE-AIM was designed to "enhance quality, speed, and public health impact of efforts to translate research into practice" [11], and not specifically with technology interventions in mind. Therefore, we assessed its appropriateness with regard to the Home Safety project. While some studies have used only a portion of the framework, there are strong recommendations to use all applicable parts to reach its true potential [12]. Thus, we will consider using the framework as a whole. The five categories cover different aspects:

Table 1. The RE-AIM framework

Category	Aspects covered
Reach	"To identify target population of the intervention" [11]; describes inclusion and exclusion criteria, number of participants, and their characteristics compared to target population [12, 13].
Effectiveness	"The impact of an intervention on important outcomes, including potential negative effects, quality of life, and economic outcomes" [11]; measures primary outcome compared to health goal, robustness across subgroups, short-term attrition, and differential rates by characteristics or treatment condition [13].
Adoption	"The absolute number, proportion, and representativeness of settings and intervention agents who are willing to initiate a program" [11]; evaluate how setting might impact the intervention, characteristics of participating settings, excluded settings, and why, and percent of settings that participate. The same goes for staff participants [13].
Implementation	Description of adaptions made to the intervention during the study, cost in terms of time and money, consistency of implementation across staff, time, settings and subgroups, and percent of perfect delivery or calls completed [13].

Maintenance	"The extent to which a program or policy becomes institutionalized or part of the routine organizational practices and policies" [11]; primary outcome and broader outcomes addressed at least 6 months after final contact, including effects on different subgroups, measures of attrition, and if and how an intervention was adapted long-term [13].

It is advised to complement assessment with qualitative methods for further understanding. The RE-AIM framework presents a comprehensive and broad perspective to include assessment at many different levels. It is easy to understand, and therefore a very usable tool. The ambition to assess rather broad aspects might be too extensive for our study. The fact that several research articles only report use of a portion of the framework may indicate that RE-AIM is too comprehensive.

2.2. MAST

The MAST model, published in 2012, was developed through a systematic meta-review of articles reporting impact of telemedicine interventions, supplemented by workshops with users and stakeholders [9]. MAST is suggested for decision-making about use of telemedicine applications in Europe. The model's three elements – preceding considerations, multidisciplinary assessment, and transferability assessment – specify issues advised for consideration [14].

Table 2. The MAST model

Category	**Aspects covered**
Preceding considerations	Legislation – does the technology accord with national and regional legislation? Reimbursement – will new technology affect current tariff and reimbursement systems for health institutions' services? Maturity, safety, readiness for evaluation of effectiveness.
Multidisciplinary assessment	1) Health problems and characteristics of the application; 2) Safety – identification and assessment of harms; 3) Clinical effectiveness, health effect/benefits; 4) Patient perspectives on the technology; 5) Economic aspects, socio-economic evaluation; 6) Organizational aspects, resources and consequences; 7) Socio-cultural, ethical and legal aspects – where the application will be used, which ethical questions are raised, any legal barriers to use of this technology or legal obligations that must be met.
Assessment of transferability	Detailed information relevant for transferability of results across settings [9, 14].

MAST seems like a straightforward model with important aspects of technology implementation in health care. The discussion focuses on whether the model sufficiently covers ethical aspects of telemedicine interventions, such as attention to users' actual needs, wishes, and fears regarding technology, and clarification of responsibility and liability for errors caused by the technology [15]. The MAST model was developed explicitly for telemedicine; however, there are components appropriate for assessment of AAL technologies and other e-Health initiatives.

2.3. UTAUT

The UTAUT model, published in 2003, was developed through review, comparison, and consolidation of eight models on user acceptance [8]. The tool assists predictions of future technology use, addressing surrounding factors and user-evaluations. UTAUT presents four factors likely to influence a person's behavior and use of new technology:

Table 3. The UTAUT model

Category	Aspects covered
Performance expectancy	The perception of how useful the technology is.
Effort expectancy	The perception of how easy the technology is to use.
Social influence	The perception of the expectations of other people on own technology usage.
Facilitation factors	The perception of the degree of compatibility with own work processes and the degree of IT-support received.

UTAUT includes four factors mediating actual usage and behavior: gender, age, experience, and voluntariness of use. The UTAUT does, however, state that these dimensions are integral in the four core factors [8]. UTAUT is considered as state of the art in technology evaluation, and is cited by numerous articles on technology acceptance. Thus, UTAUT includes factors that seem worth considering for us as well.

3. Discussion

A very common approach when assessing new technologies is to look at the device itself, to focus on simplicity for potential users, and to evaluate factors that influence whether it is used. However, assessing technology in a health care setting requires going beyond the device to consider surrounding factors such as ethics, impact on quality of care, meaningful use, professionals' workload and workflow, economy, and social impact in terms of quality of life. We will therefore discuss how well the three selected models allow us to investigate aspects concerning impacts for society, professionals, and citizens in terms of simplicity, meaningful use, and justification.

Impact on society: This category focuses on assessment of the AAL technology in terms of how the technology fits with laws, regulations, and explicit priorities from the government. System justification in terms of whether a technology solves any problems or creates new problems needs to be addressed, as well as cost-efficiency and societal benefits and disadvantages. RE-AIM covers economic outcomes of an intervention, but the specifics about reimbursement that MAST presents are not directly addressed. RE-AIM suggests that the primary outcome of the intervention is compared to health goals. As for organizational factors, meaningful use of the devices plays a great role. The models cover this in very different ways. For example, RE-AIM describes to what extent the technology becomes part of routine practices and policies. This is an area where the UTAUT model may complement the RE-AIM model, suggesting assessment of factors that can predict certain outcome(s). Through MAST, we can learn what resources an implementation demands, and what consequences it can produce in an organization. MAST is the only one of the three models to focus on transferability. By detailed descriptions of issues relevant for transferability of the results, it will be much easier to achieve similar results in different settings.

Impact on professionals: This category concerns how the AAL technology affects professional practice and health care workers. Meaningful use, simplicity, impact on workload, workflow, and changes of tasks may very often be of interest, and it is important to investigate how such aspects impact professionals. The RE-AIM model focuses on professional participation in terms of how many staff members participate and their characteristics, and suggests qualitative research methods to understand staff participation. MAST addresses impacts on professionals through the lens of organizational aspects, and practice changes the intervention may produce. Here,

changes in professionals' work, their attitudes, and perceptions of specific tools are suggested outcome measures. Therefore, UTAUT adds important dimensions.

Impact on citizens/patients: Implementation of AAL technology will have significant impact for citizens/patients, and will contribute to the ongoing migration of health care activities from organized settings. Therefore, considerations of ethics and safety, and clarification about which problems this technology is intended to solve, are important. Preferably, patients' participation is sought, and their point of view should be taken into consideration when planning and evaluating AAL technology. The evaluation could include simplicity, benefits, disadvantages, and effects on physical and mental health. RE-AIM does not address ethical issues. MAST, however, advises consideration of ethical issues raised by the technology in itself, and by consequences of implementing it or not. Both RE-AIM and MAST consider safety issues, but the patients' point of view is addressed very differently. RE-AIM addresses impacts on patients' quality of life and related factors. MAST thoroughly describes the patients' point of view during and after implementation. UTAUT gives the patient's perception of and experiences with the device an important role. However, none of the models includes the patient's voice, thoughts, and wishes in the planning process of an intervention. This is an important aspect that will be addressed, i.e. the question of which problems the patients wants a solution to.

Summing up, the RE-AIM framework has been widely used, and has proven to endure the "test of time". However, this does not mean that it is sufficient for AAL technology assessment. MAST and UTAUT add important aspects to our research efforts. Although the models have overlapping aspects, they seem to complement each other. Of great concern for our specific purpose, all of them lack dimensions to cover the patient's point of view sufficiently before introduction of the AAL technology. It does not matter if the AAL technology is well perceived or working perfectly if the patient does not use it. Our assessment would therefore require including the patients' perspective in the processes of planning and assessing specific AAL technologies in our study and suggesting a suite of technology for safety.

4. Conclusion

The differences in initial purpose in the presented models are apparent when looking at RE-AIM, MAST, and UTAT in more depth. RE-AIM suggests important constructs for planning and executing an intervention in a health care setting, but lack some coverage of issues specifically connected to technology assessment. Therefore, we include aspects like ethics, patient perspectives, and transferability from MAST, and core questions from UTAUT to assess whether or not the technology is likely to be used. Our research involves several municipalities and several AAL technology devices. The selected aspects will help broader coverage of specifics of real-life practices, ensure rigor and that research is conducted in accordance with state of the art methodology and research in this field. Overall, there seems to be too little focus on involvement of citizens/patients in the planning process of technology interventions in health care. Therefore, this is an aspect we will elaborate on further and add to our study to ensure that simplicity and meaningful use of the AAL-devices are fully covered.

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