"Get that Camera Out of My House!" Conjoint Measurement of Preferences for Video-Based Healthcare Monitoring Systems in Private and Public Places

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Abstract. Facing the healthcare challenges of an aging society, the expansion of AAL system implementation in private and public environments is a promising way to improve healthcare in future smart homes and cities. The present study evaluated preferences for different video-based medical monitoring scenarios, which comprised the attributes medical safety (improved detection of medical emergencies), privacy (handling of video information), type and location of camera in a conjoint analysis. Medical safety was identified as key driver for preferences. Acceptance for video-based medical monitoring systems in public places was comparably high, given that privacy was protected. In contrast, acceptance for video-based monitoring in smart home environments was rather low due to privacy concerns. Based on the findings, recommendation for AAL system design and implementation were derived.

Keywords: Medical monitoring · Video cameras · Smart homes · Smart cities · Acceptance · Privacy · Medical safety · Conjoint analysis

1 Introduction

The demographic change in western societies puts enormous pressure on societies and healthcare systems. In 2010 the proportion of people aged 65 and older was 15% and it is predicted to raise to 25% by 2050, so it is the fastest-growing segment of the population [1]. Due to an increased life expectancy, improved medical healthcare in combination with a higher living standard as well as reduced fertility rates, a growing number of frail older persons will require long term care provided by health care systems [2]. Moreover, today's older adults have a more active and mobile lifestyle [3], therefore societies need to consider the special needs of older and frail people in the design of living environments, i.e. their homes but also of public spaces for future livable cities.

Ambient assisted living (AAL) systems provide a successful and promising way to meet this demographic challenge and to improve quality in healthcare. In AAL systems, the combination of ICT and health monitoring devices allows for an autonomous and unobtrusive recording and transfer of medical data from patients to remote healthcare providers [4].

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One major goal of AAL is the detection of emergencies, such as falls. Among seniors aged 65+ falls are one of the most serious health risks, which affect more people than stroke and heart attacks [5]. A fast detection of falls and immediate help reduce the risk of death by more than 80% [6]. Accordingly, most healthcare information collected and transferred by AAL systems is time- and life-critical [7], therefore the capturing and delivering of healthcare information in future smart homes and cities should be further expanded.

1.1 Video-Based Monitoring Systems in Healthcare

A huge variety of AAL solutions already exists (e.g. for an overview [8, 9]). Especially video-based monitoring systems are increasingly being developed. One advantage of video-based monitoring by stationary cameras is that they enable contactless observation without the need for additional equipment of patients, e.g. wearing a wireless help button or a tag. Leijedeckers et al. [10] developed a personalized smart homecare system, which mainly uses smart phones, wireless sensors, web servers and IP webcams. Fleck [11] proposed a SmartSurv 3D Surveillance System Prototype, a distributed and smart camera based approach, which covers geo-referenced person tracking and activity recognition for the detection of falls. To this day, many more video-based health monitoring systems for smart homes were developed, which primarily focus on fall detection (e.g. [12–14]).

Despite of the benefits provided by medical monitoring systems for healthcare and medical safety, most of the systems impose one problem: they ignore privacy of the person being monitored. Privacy is the right on protection of people’s personal information [15], i.e., confidentiality, anonymity, self-determination, freedom of expression, and personal control of data. Especially in the context of video surveillance privacy is a highly important issue, since persons in the area covered by cameras have no possibilities to avoid being monitored. Some of the homecare approaches mentioned above proposed attempts to protect privacy, e.g. usage of video surveillance only at times of emergency or for scheduled meetings [10] or by not recording the camera feed if no accident was detected [14].

Privacy is one important determinant of AAL system acceptance (e.g. [16]). The understanding of these determinants that affect technology acceptance is essential for its successful adoption [17]. The most influential and best-established theoretical approach to explain and predict the adoption of technologies is the Technology Acceptance Model (TAM) [18], which was also adapted to the healthcare context [19]. However, these models cannot be easily transferred and applied to the design and implementation of video-based monitoring systems due to several reasons. First, technology acceptance models focus on an evaluation of complete technical systems or applications. They do not provide information about the evaluation of single technical characteristics of a system. Accordingly, practical design guidelines for AAL system design cannot be derived, e.g. “at which places video monitoring should be installed?”, “which type of camera should be used?”, or “for what purposes should video data be further used?”. Second, in most user studies about AAL system acceptance, the design process of the product is usually finished and users are being confronted with technically mature prototypes, where only marginal changes can be made. In order to optimally support the acceptance of AAL systems, user needs and requirements should be assessed earlier in the system design life cycle [20]. Third, technology acceptance is highly context-specific. Depending on the usage context, identical technical systems or functions are perceived differently by users, e.g., users associated with a wireless mobile system in a job-related ICT-context mainly the fear of health damage caused by EMF radiation or data privacy concerns and, in contrast, in the AAL context the fear of technical unreliability [21]). Accordingly, existing knowledge about video-based crime surveillance systems cannot be applied to the design and implementation of video-based monitoring systems for healthcare purposes. Since most AAL applications and research activities focus on the private home environment, little is known about the acceptance and design requirements of video-based healthcare monitoring systems in public places.

To sum up, the design, implementation and acceptance of video-based monitoring systems in healthcare could be improved, if designers and planners knew about preferences of users. The goal of our study was, therefore, to capture preferences for video-based healthcare monitoring scenarios in the private and public environment under consideration of different camera types, locations of camera installation, benefits in terms of improved medical safety, and privacy concerns due to different data handling purposes.

2 Method

2.1 Conjoint Analyses

In the present study the conjoint measurement method was used to study respondents' preferences. Conjoint analysis (CA) methods, which combine a measurement model with a statistical estimation algorithm, were developed in the 1960ies by the psychologist Luce and the statistician Tukey [22]. Compared to survey-based acceptance studies, which are still the dominating research method in information systems and acceptance research, CA allow for a more holistic and ecologically more valid investigation of decision scenarios. They were predominantly used in market research, but nowadays they are widely used for evaluating the adoption of information system innovations or to understand acceptance patterns for existing technologies such as mobile communication network systems [23]. In CA, specific product profiles or scenarios are evaluated by respondents, which are composed of multiple attributes and differ from each other in the attribute levels. The analysis of conjoint data allows for the simulation of decision processes and the decomposition of preferences for a scenario as a combined set of attributes into separate part-worth utilities [24]. CA deliver information about which attribute influences respondents' choice the most and which level of an attribute is preferred. Preference judgments and resulting preference shares are interpreted as indicator of acceptance.

In the present study, a choice-based-conjoint (CBC) analysis approach was chosen, because it closely mimics complex decision processes, where more than one attribute affects the final decision [25].

2.2 Selection of Attributes

In the study we assume that respondents' preferences are influenced by a set of attributes that possess the highest utility. Based on literature analysis and expert interviews we selected relevant impact factors for video-based medical monitoring system acceptance:

Medical Safety, as major benefit of AAL system implementation, which was operationalized in terms of an improved detection of medical emergencies.

Privacy, as major concern or barrier of video-based AAL system acceptance, which was operationalized by different ways to process or use video data (e.g. archiving or face recognition).

Type of camera, which did not refer to specific technical solutions, but mainly to features of size, visibility and obtrusiveness of technology.

Location, where the private home environment as place of camera installation was contrasted to different public locations of camera installation.

2.3 The Questionnaire

The questionnaire was developed with SSI web Software [26]. The questionnaire consisted of four parts. First, demographic data was assessed (age, gender, education, type and area of residence, health status). Second, participants were introduced into the scenario. The scenario dealt with the installation of video cameras for medical monitoring purposes at different locations, i.e. own home (private), market place, shopping mall or train station (public). In the scenario, the cameras were able to record vital function data and – in case of a medical emergency – to send an emergency signal to a medical institution (e.g. hospital). In the fourth part, the CBC choice tasks with the following attributes (No. 1-4) and their respective levels (a-d) were presented:

1. Medical Safety - Improved detection of medical emergencies
   a. 0% (no improvement),
   b. +5%,
   c. +10%,
   d. +20%
2. Privacy - Handling of video information
   a. Face recognition (i.e. storage of video material which allows for face recognition)
   b. Determination of position (i.e. storage of video material which allows for determination of position),
   c. Archiving of video data by health insurance company,
   d. Archiving of video data in a patient data base (allows for faster medical therapies in case of emergencies)
3. Type of camera
   a. Conventional CCTV camera (big, obtrusive or visible camera)
   b. Dome camera (big, but more unobtrusive camera)
   c. Mini dome camera (small, unobtrusive camera)
   d. Integrated camera (integrated, invisible camera)

4. Locations
   a. Own house or apartment
   b. Shopping mall
   c. Market place
   d. Train station

Participants were asked to decide under which conditions and at which locations they would accept the installation of cameras. An example for a choice task is shown in Fig. 1.

Fig. 1. Screenshot of a choice task

Since a combination of all corresponding levels would have led to 256 (4x4x4x4) possible combinations, the number of choice tasks was reduced, i.e., each respondent rated 10 random tasks and one fixed task. A test of design efficiency confirmed that the reduced test design was comparable to the hypothetical orthogonal design (median efficiency of 99%).

2.4 The Sample

Data was collected in an online survey conducted in Germany. Participants were invited to participate in the study via e-mail and were forwarded to the questionnaire. Completion of the questionnaire took approximately 30 minutes. In total, 194 participants took part in the study. As only complete questionnaires (no missing answers) were used for further statistical analyses, only 120 data sets were analyzed.

The mean age of the participants was M=28.68 years (SD = 11.78, range 18-75 years) with 47.5% females. Asked for their residence, 14.2% reported to live in a detached, 4.2% in a semi-detached and 15% in a terraced house. The majority of 67% reported to live in an apartment building. The participants were also asked for their housing conditions: 50.6% reported to be the house owner and 49.4% reported to rent. Regarding their area of residence, the majority (60%) reported to live in a city, and 29% in suburban area. Asked for their highest educational achievement 39.2% answered to have a university or a polytechnic degree, 45% answered to have a General Certificate of Secondary Education, and 5% reported to have a completed apprenticeship.

Regarding health status, a comparably healthy sample was under study: the majority reported to be in a very good (38.3%) or good (48.3%) health status, 13.3% reported health problems. Being asked for their experience with medical emergencies, 15.8% already experienced a medical emergency, and 48.3% witnessed a medical emergency in their family or in their closer circle of friends (34.2%). No experiences with medical emergencies at all reported 29.2%.

2.5 Data Analysis

Data analysis, i.e. the estimation of part-worth utilities, segmentation and preference simulations, was carried out by using Sawtooth Software (SSI Web, HB, SMRT). First, part-worth utilities were calculated on the basis of Hierarchical Bayes (HB) estimation and part-worth utilities importance scores were derived. They provide a measure of how important the attribute is relative to all other attributes. Part-worth utilities are interval-scaled data, which are scaled to an arbitrary additive constant within each attribute, i.e. it is not possible to compare utility values between different attributes [24]. By using zero-centered differentials part-worth utilities, which are scaled to sum to zero within each attribute, it is possible to compare differences between attribute levels. Finally, preference simulations were run by using the Sawtooth market simulator, which estimate the impact on preferences if certain attribute levels change within a specific scenario [27]. Preference simulations allow specific "what-if"-considerations, e.g. the effect of different camera locations within a public or private environment on respondents' preferences within a predefined scenario.

3 Results

In this section, the relative importance scores for the four attributes are presented, followed by part-worth utility estimation findings for respective attribute levels, and the simulation of preferences.

3.1 Relative Importance Scores

To evaluate the main impact factors on preferences for medical monitoring scenarios, the share of preference was calculated by applying Hierarchical Bayes Analyses. The relative importance scores of the attributes examined in the present study are presented in Fig. 2. The attribute "detection of medical emergencies" had the highest importance score (29.15%), followed by “handling of video material” (26.85%) and “locations” (26.65%). The least important criterion was “type of camera” (17.35%). The results indicate that improved medical care is the most dominant attribute to influence acceptance. The handling of data and the location where cameras are installed, were also important, but to a slightly lesser extent. Interestingly, the type of camera, especially the feature of its visibility, was the least important.

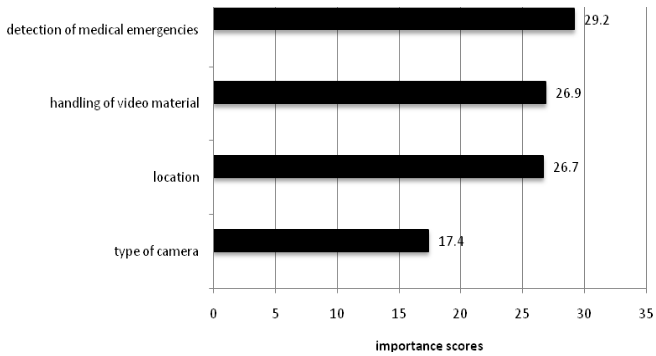

Fig. 2. Importance scores for attributes in the CBC study

3.2 Part-Worth Utility Estimation

The average zero-centered diff part-worth utilities for all attribute levels are shown in Fig. 3. The attribute “detection of medical emergencies” displayed the highest range between part-worth utilities, which caused the high importance scores (see 3.1). Focusing on absolute utility values, the attribute level “20% improved detection of medical emergencies” reached the highest utility value, whereas “camera location in the own house” received the lowest utility value.

Looking at the different attributes, an “improved detection of medical emergencies” by 20% reached the highest utility value, an improvement by 10% was also rated positively meanwhile 5% and 0% (“no improvement”) reached the lowest utility values. Regarding “handling of video material”, determination of position was preferred the most, followed by archiving in patient data base, archiving by health insurance companies and – to a much higher extent – face recognition was rejected. For “camera location” the own home was distinctly rejected, shopping mall, market place and train station were evaluated positively in ascending order. Looking at “type of camera”, the dome camera (big, but unobtrusive) was preferred to the conventional camera (big, visible) and the mini dome-camera (small, unobtrusive). The only attribute level, which was rejected, was the integrated camera (invisible).

The most preferred scenario (“best case”) – based on the highest utility ratings for each attribute – was a dome camera (big, but unobtrusive), installed at a train station, which allows for the determination of patients’ position and leads to an increase in the detection of medical emergencies by 20%. The least preferred scenario (“worst case”) was an integrated camera (small, invisible) with face recognition, installed at home, without improvements in detecting medical emergencies.

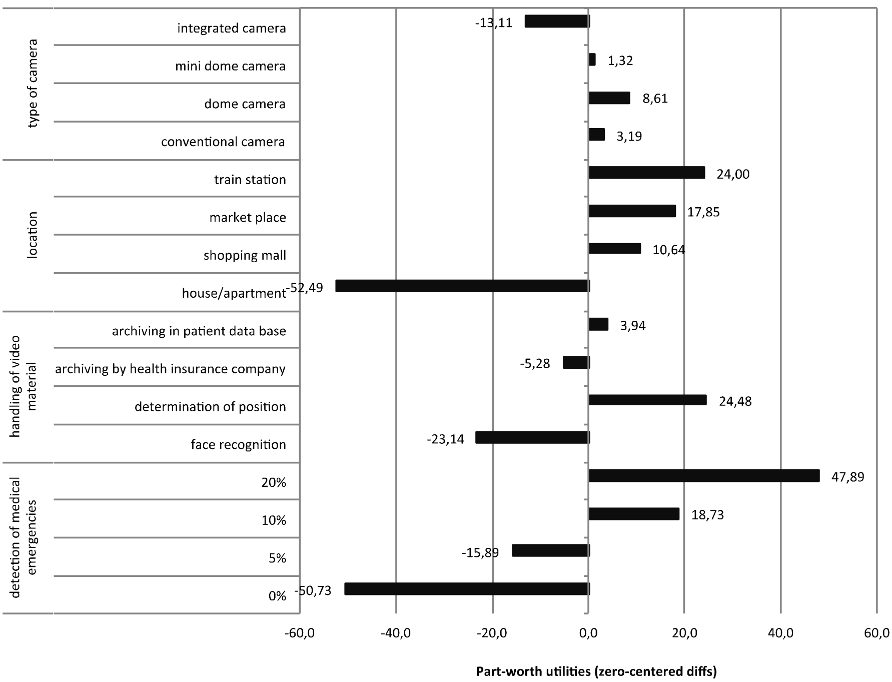

Fig. 3. Part-worth utilities (zero-centered diffs) for all attributes and levels in the CBC-study

3.3 Simulation of Preferences

In the next step, sensitivity simulations where carried out by using the Sawtooth market simulator [27]. In the simulation we investigated, to which extent the relative preferences of respondents change, when single levels of an attribute change while all other attribute levels are kept constant. Based on the identified preference patterns, a scenario was constructed, which focused on the installation of medical monitoring technologies at *public vs. private locations,* and sensitivity analyses were run.

The scenario investigated preference changes for three constant locations (public: train station, semi-public: shopping mall, private: home) for different levels of "improved detection of medical emergencies" (medical safety), handling with video material (privacy), and type of camera (Fig. 4).

The *public scenario*, i.e. the installation of cameras for medical monitoring purposes at a train station reached the highest relative preference (64.58%), compared to the semi-public (installation in shopping mall, 21.96%) and the private scenario (at home, 13.46%). For all single attribute levels, the preference for a public application of medical monitoring systems was higher than for the other two scenarios. The acceptance in the public scenario even increased, when video material was used for determination of position, i.e. privacy needs of respondents were considered (78.8%). The acceptance of the public scenario dropped to 57.64%, when the video data was used for face recognition, which indicates that face recognition is rejected in public areas since it apparently violates privacy needs. The type of camera did not play an important role in the public scenario, preferences decreased to 59.76% in case of integrated (invisible cameras), the most preferred camera type in public was the dome camera (big, more unobtrusive, but still visible, 64.58%). Regarding medical safety, i.e. the detection of medical emergencies, the highest improvement, (a detection rate +20%) was – not surprisingly – the most preferred (64.58%). The highest acceptance "leap" (+16.89%) was reached, when the detection rate of emergencies (medical safety) was raised from +5% (37.96%) to +10% (54.85%) by applying medical monitoring systems. But even if medical safety was not improved by installing medical monitoring systems (i.e. detection rate +0%), the acceptance of the public scenario was higher than in the semi-public or private scenario (26.45%).

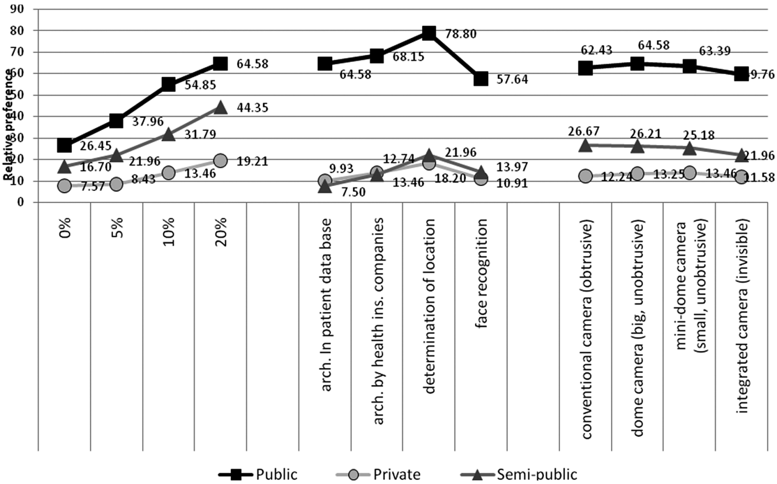

Fig. 4. Relative preference simulation for the scenario "installation of medical monitoring technologies at *public vs. private locations*"

In the *semi-public scenario*, in which cameras were installed in a shopping mall, the highest preference leap was reached by increasing medical safety, i.e. the higher the detection rate; the higher were preferences (up to 44.35% for +20% medical safety). Regarding the handling of video data, acceptance was the highest for determination of position (21.96%), but it decreased for face recognition to 13.97%, and – and even stronger – for archiving of video material by health insurance companies to 7.5%. Looking at the camera type, big and visible cameras were preferred, e.g. conventional cameras (26.67%) or dome-cameras (26.21%). However, more unobtrusive or invisible cameras did not lead to substantial preference drops (e.g. 21.96 for integrated cameras).

Looking at the *private scenario*, the total preference for camera-based medical monitoring was the lowest (13.46%). Only two attribute level changes slightly increased preferences: first, determination of position by using video material was perceived positively (18.2%) and second, very high levels of medical safety, i.e. a detection rate of +20% increased preferences in the private scenario to a maximum of 19.21%. Changes in other attribute levels further decreased preferences, e.g. to 8.43%

if medical safety was only increased by +5% or if video data was used for face recognition (10.91%) or for archiving purposes (9.93%). The type of camera did not strongly affect preferences; a mini-dome camera was preferred the most (13.46%), whereas integrated cameras were the least preferred (11.58%).

4 Discussion

Facing the healthcare challenges of an aging society, the expansion of AAL system implementation in private and public environments is a promising way to improve healthcare in future smart homes and cities. The present study evaluated preferences for different video-based medical monitoring scenarios, which comprised the attributes medical safety (improved detection of medical emergencies), privacy (handling of video information), type and location of camera in a conjoint analysis.

4.1 Perception and Acceptance of Video-Based Monitoring Technologies for Healthcare

In general, video-based medical monitoring technologies and scenarios were evaluated positively – under the condition that specific scenario criteria where met.

Medical safety was the most important factor in respondents' decisions for or against video-based medical monitoring scenarios. Acceptance increased linearly with improved medical safety. Accordingly, communication strategies should focus on this key benefit to support the adoption of AAL monitoring systems. The conjoint preference simulation findings also gave insights into expectations or benchmarks for healthcare improvements. Preferences shares were above 50% when the detection rate of medical emergencies in the public scenario was improved by 10%. In turn, in the private environment, even an improved detection rate by 20% was not sufficient to raise acceptance. Future studies will have to investigate if a higher detection rate in a smart home environment raises acceptance or if privacy, i.e. the way of data handling and processing, more strongly determines acceptance in the private context.

As indicated, respondents had well defined expectations regarding *privacy*, i.e. different ways of handling and processing captured video data. Privacy concerns were primarily related to the unwillingness of being visible or recognizable in health monitoring systems. In contrast, data privacy issues (e.g. due to archiving of medical monitoring data) caused less concerns. This shows that privacy is a multidimensional construct, and, that users' mental models about privacy in AAL systems need to be carefully uncovered and considered in system design. Determination of location, e.g. for fall protection systems, was accepted and preferred. In contrast, face recognition was clearly rejected, especially in the private scenario. This finding is especially important for AAL system design, where privacy protection should be taken on the agenda, when face recognition features are included. Moreover, a transparent communication of data usage and protection of privacy is highly important for the acceptance of video-based medical monitoring technologies.

The *location* of camera installation is also highly relevant: in *public* places video-based monitoring systems are comparably well-accepted – even in case of a rather low system effectiveness, i.e. low improvements of medical safety. However, preference differences for the public locations under study indicate, that respondents evaluate public locations differently, which should be addressed in further studies.

The more healthcare monitoring technologies invade into *private* spaces, the more they are perceived critically or even rejected. The most sensitive area is the own home, where our findings showed a comparably low acceptance of video-based medical monitoring. Especially privacy-related concerns reduced acceptance, i.e. face recognition and data archiving were "no-Go's" from the users' side. Since most AAL monitoring systems are developed for the private home care sector, future acceptance research is necessary to support long-term market success of AAL systems.

Technical features of *cameras* such as visibility or obtrusiveness were comparably unimportant. However, camera technology used for monitoring should be visible, but not too obtrusive or dominant. A seamless integration of monitoring systems into the home or public environment is therefore not desirable from the users' perspective.

4.2 Limitations and Future Research

In the present study a comparably young and healthy sample was under study. Since this might result in an underestimation of benefits, concerns and total preferences, future research should focus on older participants with health problems to include their specific demands and requirements into the design of AAL systems. A more detailed evaluation of private (e.g. sleeping vs. living room) and public locations (e.g. restaurants, transport hubs, parks, etc.) is necessary, since video-based monitoring system acceptance varied with respect to different public environments. A cartography of "acceptable" and "inacceptable" locations for camera installation and types of data processing would provide valuable planning support for AAL system designers and city planners. Moreover, cross-cultural analyses should be pursued to investigate if factors such as culture or literacy rate will have an impact on the outcomes. Finally, future conjoint analyses should focus on potential trade-offs between privacy and medical safety to optimally support AAL system design for future livable smart home environments and smart cities.

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References

1. World Health Organization (WHO): The European Health Report 2012: Charting the Way to Well-being. World Health Organization (2012)
2. Leonhardt, S.: Personal healthcare devices. In: AmIware Hardware Technology Drivers of Ambient Intelligence, pp. 349–370. Springer (2006)

3. Rosenbloom, S.: Sustainability and automobility among the elderly: An international assessment. Transportation. **28**, 375–408 (2001)
4. Denning, P.J.: The Invisible Future: The Seamless Integration of Technology into Everyday Life. McGraw-Hill, Inc (2001)
5. Rubenstein, L.Z.: Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing. **35**, ii37–ii41 (2006)
6. Gurley, R.J., Lum, N., Sande, M., Lo, B., Katz, M.H.: Persons found in their homes helpless or dead. N. Engl. J. Med. **334**, 1710–1716 (1996)
7. Gururajan, R., Murugesan, S., Soar, J.: Introducing mobile technologies in support of healthcare. Cut. IT J. **18**, 12–18 (2005)
8. Memon, M., Wagner, S.R., Pedersen, C.F., Beevi, F.H.A., Hansen, F.O.: Ambient Assisted Living Healthcare Frameworks, Platforms, Standards, and Quality Attributes. Sensors. **14**, 4312–4341 (2014)
9. Cardinaux, F., Bhowmik, D., Abhayaratne, C., Hawley, M.S.: Video based technology for ambient assisted living: A review of the literature. J. Ambient Intell. Smart Environ. **3**, 253–269 (2011)
10. Leijdekkers, P., Gay, V., Lawrence, E.: Smart homecare system for health tele-monitoring. In: ICDS 2007. First International Conference on the Digital Society, 2007, pp. 3–3 (2007)
11. Fleck, S., Strasser, W.: Smart Camera Based Monitoring System and Its Application to Assisted Living. Proc. IEEE. **96**, 1698–1714 (2008)
12. Chen, B.-W., Chen, C.-Y., Wang, J.-F.: Smart Homecare Surveillance System: Behavior Identification Based on State-Transition Support Vector Machines and Sound Directivity Pattern Analysis. IEEE Trans. Syst. Man Cybern. Syst. **43**, 1279–1289 (2013)
13. Yu, M., Rhuma, A., Naqvi, S.M., Wang, L., Chambers, J.: A Posture Recognition-Based Fall Detection System for Monitoring an Elderly Person in a Smart Home Environment. IEEE Trans. Inf. Technol. Biomed. **16**, 1274–1286 (2012)
14. Aghajan, H., Augusto, J.C., Wu, C., McCullagh, P., Walkden, J.-A.: Distributed vision-based accident management for assisted living. In: Okadome, T., Yamazaki, T., Makhtari, M. (eds.) ICOST. LNCS, vol. 4541, pp. 196–205. Springer, Heidelberg (2007)
15. Patton, J.W.: Protecting privacy in public? Surveillance technologies and the value of public places. Ethics Inf. Technol. **2**, 181–187 (2000)
16. Wilkowska, W., Ziefle, M.: Privacy and data security in E-health: Requirements from the user's perspective. Health Informatics J. **18**, 191–201 (2012)
17. Rogers, E.: Diffusion of Innovations. NY Free Press, New York (2003)
18. Davis, F.D.: Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q. 319–340 (1989)
19. Yarbrough, A.K., Smith, T.B.: Technology Acceptance among Physicians A New Take on TAM. Med. Care Res. Rev. **64**, 650–672 (2007)
20. Kowalewski, S., Arning, K., Minwegen, A., Ziefle, M., Ascheid, G.: Extending the Engineering Trade-Off Analysis by Integrating User Preferences in Conjoint Analysis. Expert Syst. Appl. **40**, 2947–2955 (2013)
21. Arning, K., Gaul, S., Ziefle, M.: ``Same Same but Different'' how service contexts of mobile technologies shape usage motives and barriers. In: Leitner, G., Hitz, M., Holzinger, A. (eds.) USAB 2010. LNCS, vol. 6389, pp. 34–54. Springer, Heidelberg (2010)
22. Luce, R.D., Tukey, J.W.: Simultaneous conjoint measurement: A new type of fundamental measurement. J. Math. Psychol. **1**, 1–27 (1964)
23. Arning, K., Ziefle, M., Kowalewski, S.: Health concerns vs. mobile data needs: Conjoint measurement of preferences for mobile communication network scenarios. Int. J. Hum. Ecol. Risk Assess. (2013)

24. Orme, B.: Interpreting the Results of Conjoint Analysis, Getting Started with Conjoint Analysis: Strategies for Product Design and Pricing Research. Res. Publ. LLC Madison WI. 77–89 (2010)
25. Chrzan, K., Orme, B.: An overview and comparison of design strategies for choice-based conjoint analysis. Sawtooth Softw. Res. Pap. Ser. (2000)
26. Orme, B.K.: SSI Web v7. 0 Software for web interviewing and conjoint analysis. Sequim: Sawtooth Software. Inc (2011)
27. Orme, B.: Market simulators for conjoint analysis. Get. Started Conjoint Anal. Strateg. Prod. Des. Pricing Res. Second. Ed Madison Res. Publ. LLC (2010)