International Journal of Technology Assessment in Health Care, 29:4 (2013), 378–383.

doi:10.1017/S026646231300041X

TELEMEDICAL VERSUS CONVENTIONAL HEART PATIENT MONITORING: A SURVEY STUDY WITH GERMAN PHYSICIANS

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Objectives: In this study, we explored crucial factors that explain a person's attitude toward and his or her assessment of telemedical systems. Special focus lies on the link between the perspective of physicians (telemedicine users) and technicians (telemedicine designers) to find potential barriers hindering the broad application of telemedical systems in hospitals and doctors' offices.
Methods: A survey among medical professionals ($n = 34$), technical professionals ($n = 39$), and a control group ($n = 44$) was conducted. The collected data were assessed in terms of domain knowledge, attitudes toward telemedicine, and potential implementation barriers.
Results: Participants favored the conventional method over telemedical monitoring in regards to privacy, security, and time efficiency. In contrast, telemedicine was preferred with reference to efficiency of data analysis, long-term care, and emergency adequacy. Significant differences between the professional groups were found regarding perceived cost effectiveness, patients' compliance, privacy protection, and false alarm sensitivity. Medical professionals exhibited the most reluctance toward using telemedical treatments.
Conclusions: The perceived drawbacks are attributed to a general uncertainty about the reliability of telemedical systems, in combination with concerns about personal data privacy, security, and loss of control. The reported fear of not being able to correctly use and handle the systems assumes a low usability of devices. To acquaint medical professionals with the benefits and limitations of telemedical systems, telemonitoring and tele-treatment should be included in the education of medical personnel at an early stage.

Keywords: Technology acceptance, Telemedicine assessment, Medical professionals

The rapid demographic change and increased urbanization in western societies bring along problems with healthcare availability. The growing discrepancy between rising numbers of patients and declining numbers of caregivers leads to considerable shortcomings in availability, accessibility, and quality of health care. Furthermore, the demographic shift entails an increase of age-related chronic diseases with considerable requirements regarding long-term treatment and health-monitoring (1).

Telemedicine and telemonitoring seem to be promising approaches in this context because they provide advantages for both patients and physicians regarding time and travel efforts. Fast and easy accessibility is an issue for patients requiring regular follow-ups and long-term monitoring, such as heart disease and diabetes patients (2). It has been reported that telemedicine can improve cost effectiveness in many cases (3;4). However, this is not a universal finding as the numbers of cases reporting cost efficiency and those reporting no cost efficiency are almost identical

Despite the advantages of telemedicine, the implementation rate of such systems has been low (5;6). Although telemedicine applications have been successfully tested in small case studies most of them have failed to survive beyond research phase. This raises the question, why a technology, which has proven to be a viable method of providing adequate health care when faced with logistic barriers, is not used more often in hospitals and doctors' offices (4).

Most of the approaches concerned with the distribution and adoption process of telemedicine focus on technical aspects of telemedical systems in a clinical environment thereby neglecting the human perspective (2;7;8). Studies that include the patients' perspectives show that the cognitive-emotional situation of the care receivers is of crucial importance for the acceptance of telemedicine (9–13).

However, no previous study examines the engineers' (developers) and physicians' (operators) perspectives on the usefulness and practicality of telemedicine.

This study aims at answering the following research questions: (i) Is there a relation between a person's professional domain knowledge (medical/ technical/neither medical nor technical) and the assessment of telemedical monitoring systems? (ii) What are potential barriers regarding the usage of telemedical systems for patients in hospitals and doctors' offices?

MATERIALS AND METHODS

Instrument

To answer the research questions, a questionnaire had been developed. The relevance of the questions had been taken from interviews with medical and technical professionals carried out

Authors thank all professionals for study participation. Simon Himmel and Luisa Bremen supported this research. The work was funded by the Excellence Initiative of the German federal and state governments.

before the questionnaire study. The first section assesses sociodemographic data, telemedical expertise, and attitudes toward telemedicine in general.

The second section explored criteria regarding the assessment of telemedical treatment compared with conventional care methods and aimed at identifying potential usage barriers.

Average completion time for a questionnaire was 15 minutes. Before the survey, a trial run was performed with six participants (two technical, two medical, two nonmedical/technical) to test the comprehensibility of questions.

Independent Variables

Independent variables were the participants' gender, age, and profession as well as their technical expertise. Technical expertise was defined by two different aspects: (a) technical self-confidence (TSC), measured by a standardized scale as an indicator for general technological affinity (14). Eight statements had to be answered (6-point Likert scale 1 = low, 6 = high) with a possible maximum score of 100 points. (b) Participants' self-reported domain knowledge in the area of telemedical technology was assessed (5-point Likert scale, 1 = no knowledge, 5 = high knowledge). Participants were asked about their general attitudes toward telemedicine (1 = negative, 5 = positive), their willingness to use telemedical systems for daily work, and if the usage of telemedicine "makes sense" for them in general.

Scenarios

The second section of the questionnaire started with the presentation of two scenarios for monitoring a heart patient. The use of a telemedical system (first scenario) and conventional treatment (second scenario) were contrasted. In both scenarios, participants were asked to take the role of the attending physician of a patient with an implanted Mechanical Circulatory Support Device. Health-related data (weight, temperature, blood pressure, coagulation) are required on a daily basis. In the first scenario, the patient is equipped with a telemedical system to automatically record his/her data and transfer them to the physician. Only in case of irregularities does the patient need to consult the doctor. In the second scenario, the patient uses the conventional way of documenting his/her data. S/he writes them down in a diary every day and consults his/her doctor once a month to check the data.

Dependent Variables

Dependent variables were the participants' judgments regarding the assessment of telemedical treatment compared with conventional care methods and the identification of potential usage barriers.

First, participants were asked to decide what kind of treatment, telemedical or conventional, they would choose regarding twelve criteria: "time efficiency," "treatment quality," "cost effectiveness," "false alarms," "convenience," "compliance," "data analysis," "data security," "privacy," "legal protection," "emergency adequacy," "long-term adequacy." The criteria had been identified as most important in previous focus groups with medical and technical professionals (10;11). An overall decision for one of the two treatment options was asked for, followed by a more detailed assessment of the chosen option on a 3-point Likert scale (weak – strong preference).

Second, participants had to identify barriers in the implementation process of telemedical systems in hospitals/doctors' offices (1 = low potential barrier, 6 = high potential barrier). The list of potential barriers contained 10 items which had been empirically identified in previous research (15): "medical personnel lacks technical competence," "patients lack technical competence," "poorly conceived technology," "poor usability of the devices," "medical personnel's fear of external control," "medical personnel has low trust in technology," "patients have low trust in technology," "medical personnel loses control over treatment," "shifting decisions from medical personnel to technology," "investment costs for hospitals." Items showed a good reliability (Cronbach's $\alpha = .81$).

Sample

Three professional groups were compared: medical professionals, technical professionals, and a control group (teachers, economists, clerks, etc.). Participants were recruited through advertisements in local newspapers in the region of Aachen, Germany (rural and urban regions). In addition, medical professionals were recruited *via* blackboard advertisements in forty-three medical practices and seven hospitals. No compensation was given for participation.

A total number of 117 participants ($n = 64$ women; $n = 53$ men) between 20 and 78 years of age took part. The sample was split by median into young professionals ($\leq$35 years; $n = 59$) and experienced professionals ($\geq$36 years; $n = 58$). The professional groups were made up as follows: technical ($n = 34$), medical ($n = 39$), and control ($n = 44$). Technical self-confidence differed considerably across groups (medical: M = 70.3/100 points max, SD = 15.6; technical: M = 84.5/100 points, SD = 7.8; control: M = 72.2/100 points; SD = 13.7). For further analysis each group was subdivided (median split) into groups of high and low levels of technical expertise.

RESULTS

To reflect current perceptions and attitudes of the professionals toward telemedicine usage, data are reported descriptively (frequency data in percentage points, M = means, SD = standard deviations). For nominally scaled data, chi-square tests are conducted. For ordinal- and interval-scaled data F-tests (MANOVA), and correlations (Spearman, Pearson) are used to determine significant differences between groups. The significance level is set at 5 percent.

Knowledge, Attitudes toward, and Experience with Telemedicine

First, participants' telemedical knowledge, their attitudes toward telemedicine, and the experience with it are reported for each professional group (medical/technical/control).

Medical professionals reached an average value of M = 2.7/5 points max (SD = 1.3) regarding the telemedical knowledge: 33 percent of medical professionals reported basic knowledge and 28 percent even had practical experience. Almost 40 percent reported to already use telemedical systems and 66 percent indicated the intention to use it. The majority of medical professionals (86 percent) perceived telemedicine as useful and judge it rather positively (M = 3.5; SD = 1.1).

Technical professionals scored with M = 2.1/5 points max (SD = 1), revealing only basic (41 percent) or even no (32 percent) knowledge and experience in the area of telemedicine; accordingly, only a few (12 percent) reported to actually use or intend to use it at work. In contrast, almost all technical professionals (97 percent) assessed telemedicine as generally useful and had a mainly positive attitude toward this topic (M = 3.8; SD = 0.8).

The control group reached the lowest mean value with respect to knowledge of and practical experience with telemedicine (M = 1.6/5 points max, SD = 0.7): 57 percent of the control group reported to have no experience and 32 percent reported to have basic knowledge of telemedical systems. Only 11 percent use telemedical devices and 20 percent intend to use it at work. However, the large majority (86 percent) perceived telemedicine as generally useful and associations were rather positive (M = 3.4; SD = 0.9).

Thus, regardless of professional background, there is a quite positive attitude toward telemedicine. However, medical professionals, who have the most knowledge and experience in this area, tend to have a less positive attitude compared with technical professionals, who might be driven by their greater enthusiasm for technology in general.

Conventional vs. Telemedical Approach: Preferences in Different Professional Groups

Here, participants' evaluations of the telemedical treatment compared with the conventional approach are reported. Categories were: time efficiency, treatment quality, cost effectiveness, false alarms, convenience, compliance, data analysis, data security, privacy, legal protection, emergency adequacy, and long-term adequacy. Also reported are findings regarding the overall treatment preference, telemedical or conventional. Significant group differences were revealed for cost effectiveness ($\chi^2 = 9.3$; $p = .045$), better patient compliance ($\chi^2 = 11.7$; $p = .02$), probability of false alarms ($\chi^2 = 9.6$; $p = .048$), and privacy protection ($\chi^2 = 10.3$; $p = .036$). 71 percent of the medical professionals assumed the conventional treatment to be less expensive than telemedicine, an opinion shared by 52 percent of the technical professionals. Regarding patients' compliance, technical professionals were very confident of the telemedical approach (71 percent), whereas the medical group was less convinced in this regard (46 percent). In terms of privacy protection, technical (93 percent) and medical professionals (71 percent) preferred conventional medicine to telemedicine; even the control group showed the same, although less pronounced, attitude (56 percent) with a high number of undecided people (32 percent).

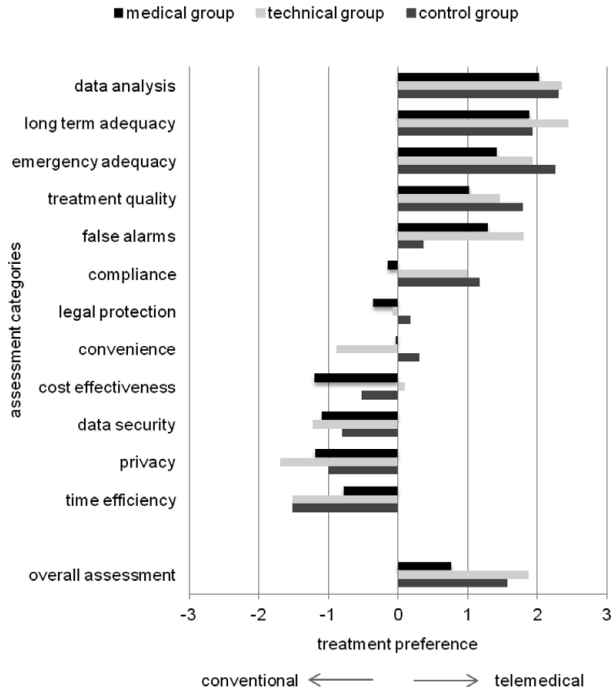

Figure 1. Preference judgments for two medical treatments (conventional vs. telemedical) on the basis of different usage criteria in three professional groups. Scale meaning: 1 = weak, 2 = medium, 3 = strong preference for the telemedical treatment; −1 = weak, −2 = medium, −3 = strong preference for the conventional treatment.

In addition to expressing a preference, conventional medicine vs. telemedicine, participants had to quantify their decision in each category (from weak to strong preference). Results are given in Figure 1. Mostly, a clear trend toward one of the two treatment options is visible. Across groups, a strong preference for telemedicine was found regarding "long-term adequacy" and "data analysis." Regarding "data security" and "privacy," the conventional approach is favored by all groups whereas the perception of telemedicine regarding "patients' compliance," "legal protection," "convenience," and "cost efficiency" differ strongly between the occupational groups.

Perception of Barriers for the Adoption of Telemedical Systems

Participants were asked to identify potential barriers hindering the implementation of telemedical systems. The largest barrier is the "patients' lack of technical competence" (Figure 2). Within both professional groups, this barrier ranks highest (medical: M = 4.8, SD = 1.0; technical: M = 5.0, SD = 0.9; max = 6.0). The control group, i.e., potential "patients," put the "lack of technical competence" only in second

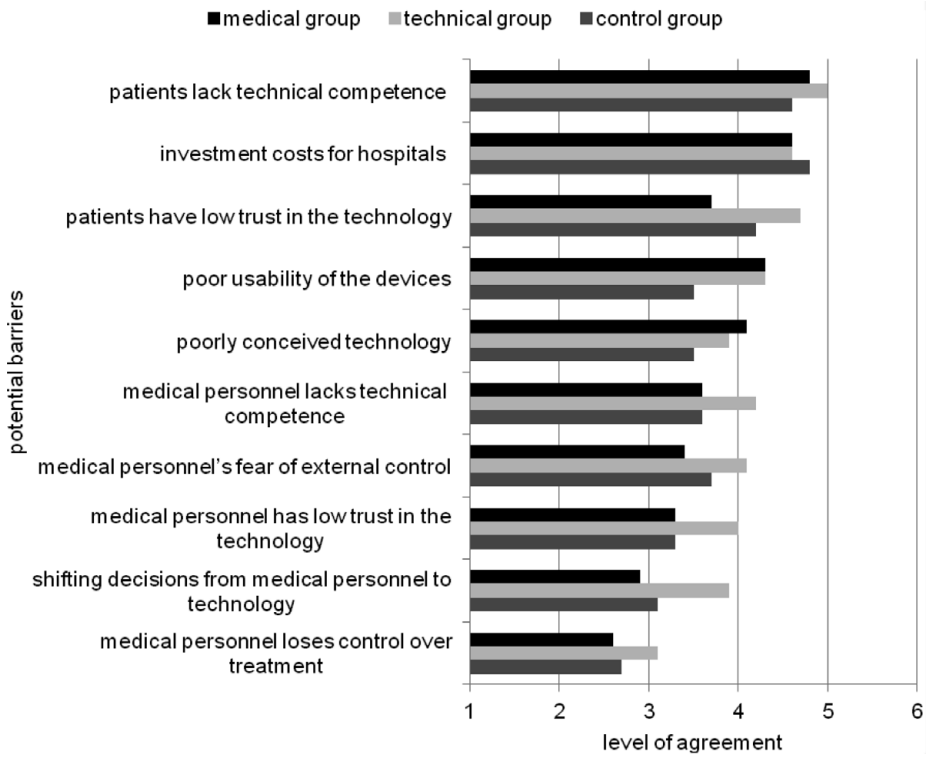

Figure 2. Distribution of perceived barriers for the adoption of telemedical services. Scale: 1 = very low, 2 = low, 3 = rather low, 4 = rather high, 5 = high, 6 = very high.

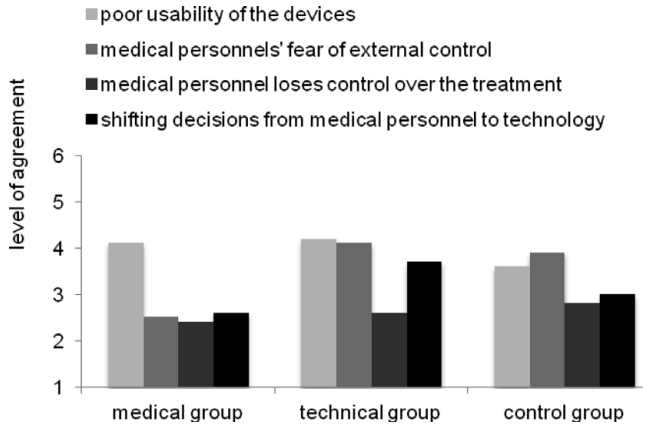

Figure 3. Main effects of professional groups on the perceived barriers for the adoption of telemedical systems. Scale: 1 = very low, 2 = low, 3 = rather low, 4 = rather high, 5 = high, 6 = very high.

place (M = 4.6; SD = 1.0) and the assumed "high investment costs" (M = 4.8; SD = 0.9) in first.

A MANOVA analysis was carried out, revealing significant main effects of age ($F(10.74) = 2.14$; $p = .031$) and profession ($F(20.150) = 1.83$; $p = .022$, Figure 3). Additionally, a marginal effect of technical self-confidence ($F(10.74) = 1.8$; $p = .072$) was found.

When looking at the barriers, the influence of age turns out to be particularly strong in the area of high initial investment costs ($F(1.83) = 4.6$; $p = .0012$). Differences are also evident regarding the loss of control over the medical treatment ($F(1.83) = 4.7$; $p = .0013$), this concern is stronger in older professionals and those with longer work experience ($M_{>=36\ years} = 3$, SD = 1.3; $M_{<=35 years} = 2.6$, SD = 1.1).

Furthermore, professional groups differed significantly regarding the assumed poor usability of the devices ($F(2.83) = 3.3$; $p = .026$; $r = .38$; $p = .003$), loss of control over the medical treatment ($F(2.83) = 3.4$; $p = .025$; $r = .68$; $p = .000$), fear of external control ($F(2.83) = 6$; $p = .00$; $r = 0.42$; $p = .001$), and a perceived shift to technology making medical decisions ($F(2.83) = 6$; $p = .00$; $r = 0.45$; $p = .001$). Gender effects could not be identified.

DISCUSSION

This exploratory study aimed at potential acceptance barriers for telemedicine by medical and technical professionals. To date, studies mainly focused on technical and formal factors of the implementation process (3;4;6). Recently, technology acceptance has been explored from the perspective of potential users (10–12). Yet, hardly any study considered the perspective of medical professionals. Physicians and care personnel, however, do represent a key stakeholder group that needs to be carefully studied regarding the acceptance of telemedical applications. The physicians' ability and willingness to use state-of-the-art telemedicine cannot be taken for granted. To gain a better understanding of medical personnel's attitudes toward telemedicine and the specific nature of potential benefits, we

compared the viewpoints of medical professionals to those of technical professionals and persons from nontechnical and nonmedical professions.

Even though all groups showed a high openness to telemedicine in general, medical professionals reported the lowest willingness to use telemedicine, in contrast to technical professionals (with the highest acceptance) and the control group.

Especially the perceived adequacy of telemedical treatment in emergency situations and the accuracy and quality of the data required for a precise and time-critical monitoring of vital parameters were named in favor of telemedicine. As drawbacks, all groups assumed a higher probability of false alarms in the telemedical approach. Furthermore, data security and privacy issues are perceived as more problematic in telemedicine. Of interest, all participants rate the conventional approach as more time-effective than the telemedical treatment. This seems counterintuitive because conventional consultation requires patients to travel to the doctor's office, with additional waiting periods on site. A closer look revealed the rationale behind this argumentation: all participants—but especially the medical professionals—expect low usability of and difficulties in handling the technology. This also explains the low evaluation of time- and cost-efficiency of the telemedical procedure. Additionally, medical professionals, in contrast to the other groups, perceive telemedicine counterproductive to keep patients compliant. Apparently, medical professionals' low trust in technology as a valuable support instrument for remote care also affects their belief in the usefulness of telemedicine for patients' compliance.

Characteristically, persons used to designing technology (technical professionals) have the strongest concerns regarding privacy and security issues in telemedicine and expect losing control over the medical treatment. They also assume a high frequency of false alarms, higher than medical professionals imagine. This might be due to technical professionals' expert knowledge regarding handling errors by users. It is noteworthy, however, that technical professionals' acceptance of telemedical applications is not affected by these concerns.

CONCLUSIONS

Concluding, this study revealed that medical professionals, especially those with long professional experience, and persons with low levels of technical self-confidence show a considerable reluctance to electronically mediated medical consultations. The key drawbacks refer to a general uncertainty about the reliability of telemedical systems, in combination with concerns about data privacy, security, and loss of control. Being unable to correctly use technical systems is a predominant apprehension, as is an assumed low usability of telemedical devices.

One could critically argue that the study does not provide a representative view as other factors impact perceived (dis)advantages of telemedical monitoring as well. For example, contexts (e.g., legal or financial) of medical treatment policies vary considerably across countries and cultures (5). Also, the level of acceptability of telemedical treatments is different between urban and rural areas (2;6). However, our goal was to understand prevailing perceptions among medical professionals to obtain strategies for a sensible distribution of information in this field. To date, no specific information and communication concept for medical technologies is available.

Medical professionals who are confronted with complex medical situations can only profit from telemonitoring systems if they are prepared for its use. The fact that technical experience influences the perceived usefulness of telemedical monitoring positively is a strong argument for teaching the use of telemedical monitoring and its impact during the education of medical students.

The findings suggest a twofold responsibility regarding the development of a sensible communication strategy. One responsibility lies in transparent information policies about benefits and risks of the telemedical approach as well as the development of communication strategies tailored to profession-specific concerns. The other is in the necessity to include potential stakeholders in an early stage of the telemedical implementation process, both in product development and the education of future stakeholders.

Overall it is definitively indispensable to include the key users- doctors and medical care personnel- into the development of telemedical applications to reach both: a higher usability and a higher acceptance for electronic mediated care systems.

SUPPLEMENTARY INFORMATION

Supplementary Questionnaire can be found online at: http://dx.doi.org/10.1017/S026646231300041X

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CONFLICTS OF INTEREST

All authors report they have no potential conflicts of interest.

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