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Quantifying beliefs Regarding Telehealth: Development of the Whole Systems Demonstrator SUTAQ

– Service User Technology Acceptability Questionnaire (WSD-SUTAQ)

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Abstract

Introduction: Telehealth (TH) is a potential solution to the increased incidence of chronic illness in an ageing population.The extent to which older people and users with chronic conditions accept and adhere to using assistive technologies is a potential barrier to mainstreaming the service. This study reports the development and validation of the Whole Systems Demonstrator (WSD) Service User Technology Acceptability Questionnaire (SUTAQ).

Methods: Questionnaires measuring the acceptability of TH, quality of life, well-being and psychological processes were completed by 478 users of TH. The 22 acceptability items were subject to principal components analysis (PCA) to determine sub-scales. Scale scores, relationships between scales and other patient reported outcome measures (PROMs), and group differences on scales were utilised to check the reliability and validity of the measure.

Results: PCAs of SUTAQ items produced 6 TH acceptability scales: enhanced care, increased accessibility, privacy & discomfort, care personnel concerns, kit as substitution, and satisfaction. Scale scores indicated, individuals with long term conditions held beliefs.

Significant correlations within these beliefs and between these scales and additional PROMs were coherent and the SUTAQ subscales were able to predict those more likely to refuse TH.

Discussion: The SUTAQ is an instrument that can be used to measure user beliefs about the acceptability of TH, and has the ability to discriminate and predict individual differences in beliefs and behaviour. Measuring acceptability beliefs of TH users can provide valuable information to direct and target provision of services to increase uptake and maintain use of TH.

Introduction

A TH service allows healthcare professionals (HCP) to monitor patients' condition remotely and enables the patient to receive remote care from the comfort of their homes and where appropriate direct healthcare intervention in a timely manner. Patients are provided with kit appropriate to their condition that require users to measure vital signs (e.g. blood pressure, blood glucose, blood oxygen levels). These readings are electronically sent back to HCPs, who via computerised algorithms and professional experience, examine changes in the patients conditions and take action if necessary including direct response to the patient. (1)). The monitoring system defined above has been referred to with different terms within the literature (e.g. telecare, telemonitoring, telemedicine), but we use the term TH as defined within the Whole Systems Demonstrator (WSD) Telehealth study (3).

TH aims to reduce the burden upon the healthcare system through reducing the rates of high cost services, reducing travel costs and identifying potential problems early before they become serious medical episodes (2). Furthermore from the patient perspective TH also can be perceived as increasing access to services, a means of reducing health concerns, and a tool enable them be more actively involved in their health care (3).

One potential obstacle to the widespread adoption of TH is that potential users may not find the use of these devices acceptable. For example the WSD Telehealth study

(4) found that >13% actively rejected the kit after a short period (3-4 months). Patients may refuse to have TH or fail to continue using devices, for a variety of reasons, such as patients' perceptions of the equipment (5). Therefore when introducing telehealth services it can be useful to measure patients' beliefs or expectations of the service, with follow-up measures taken to evaluate its impact. While models such as the Technology acceptance model (6) and its variants (7) focus on *predictions* of technology acceptance and the *effects* that acceptance of technology may have on other outcomes such as intentions and actual behaviour resultant from acceptance; here we aim for a more detailed investigation of the specific construct of technology acceptance rather than the precedents or consequences of the acceptance or the comprehensive modelling of technology acceptance within a larger framework. These constructs can be used to assess specific aspects of acceptability in a number of models, but are not specific to the TAM or any other model, or used independently of these models.

A number of measures have been developed to assess user beliefs (8-14). However these questionnaires have predominantly focused on: (i) client satisfaction and (ii) telemedicine – which is a distinct type of intervention focusing on remote consultations. Additionally, there are methodological weaknesses, such as small self-selected samples, poor questionnaire design, lack of studies of validity and evaluation, and conducting interventions in artificial contexts. This limits drawing any clear conclusions (15).

There is currently no robust and psychometrically sound measure of user acceptability in the specific context of TH as defined in the Whole Systems Demonstrator trial. This paper presents the development of a questionnaire that explores the beliefs about the acceptability of TH.

METHODS

Subjects and Design

Cross-sectional analyses were conducted on data from Whole Systems Demonstrator Telehealth Randomised Control Trial (1). Of the 839 patients who received TH at baseline within this trial, n=558 (66.5%) also completed a short-term follow-up questionnaire. Of these 478 (85.7%) participants had TH installed for a minimum of 90 days (median duration experience with kit - 125 days; Inter-Quartile Range (IQR) = 111 to 140), thus were considered to have sufficient experience of the TH kit for their data to be included in these analyses. Full details of recruitment and questionnaire response rates are reported elsewhere (2).

Questionnaire Measures

The Service User Technology Acceptance Questionnaire (SUTAQ) was designed specifically for the WSD study. Following a review of the literature and previous research interviews (5, 16), areas important in the TH context were identified; these included - accessibility; comfort; usability; privacy and security; confidentiality; satisfaction; convenience; health benefits; and self-care (8-10, 12, 13, 15).

An expert panel *(of researchers and clinical and healthcare professionals involved in the care of individuals with long term conditions using technology)* compiled a pool of (31) items referring to TH kit in general addressing the important areas of TH acceptability through mapping and amending appropriate items from existing measures and composing items where none were available. A pilot study identified ambiguous or poorly worded statements and highlighted if any acceptability areas were poorly addressed; and a team of psychologists assessed the items for *face validity (e.g. a subjective assessment, that the items measure what they purport to do so).* Appropriate changes were implemented. Participants completed the SUTAQ questionnaire that consisted of 22 statements with both negatively and positively worded items. Respondents rated their level of agreement with each statement on a 6-point Likert agreement scale (scored 1 to 6). Readability statistics for the total questionnaire were electronically determined as satisfactory (Flesch reading ease=66.2; Flesch-Kincaid Grade level=7.4).

The questionnaire pack consisted of the: Short-Form-12 Physical and Mental QoL component summary scores; (17); EuroQual (EQ-5D) (18); State Trait Anxiety Inventory (STAI-6) (19); Centre for Epidemiologic Studies of Depression (CESD-10) scale (20); and selected Health Education Impact Questionniare (heiQ) (21). In addition, demographic information including age, gender, ethnicity, the number of co-morbid conditions and the highest level of education achieved were recorded. Level of deprivation, as assessed through postcodes, was used to allocate an Index of Multiple Deprivation (22).

Statistical analyses

When analyses contained variables with >5% missing data, multiple imputation procedures were to be utilised (23, 24). Ten imputed datasets were generated to manage missing data. When variables had <5% missing data, the first imputed dataset was used with usual data analysis methods. Details of imputation processes are available from the authors.

For SUTAQ development, acceptability items were subjected to an exploratory principal components analysis (PCA) with Direct Oblimin rotation. During PCA, Bartlett's Test of Sphericity (BTS) and the Kaiser-Meyer-Olkin (KMO) index measure of sampling adequacy (MSA) were utilised to evaluate if items should remain in the analysis. To maximise the KMO index, an anti-image correlation matrix (AICM) was generated and the MSA on the major diagonal was examined for individual items. Items with MSA<0.60 were removed from the analysis and the matrix regenerated. This process was repeated until all items had a MSA>0.60. The remaining items were employed in the PCA.

Eigen values >1 determined the number of factors to extract. Items with loadings >0.400 in each component of the matrix were retained for scale construction, following appropriate reversal of items based on polarity of loadings (i.e. some items may be negatively worded with regards to the definition of a scale, thus needed to be negatively scored when utilised to calculate scale scores). Cronbach's-α assessed

scale reliability. Scale scores were calculated using the mean score of items within a scale, with higher scores (towards 6) representing increased agreement with scale construct's definition and lower scores (towards 1) representing greater disagreement with the construct.

Relationships between sub-scales and/or items were examined using Pearson's r (and the coefficient of determination, r^2). Correlations were considered significant when $p<0.01$. These correlation will be used for establishing concurrent validity (e.g. the extent to which correlates with known measures or assessments). Group differences were assessed using the χ^2 test for frequency data (e.g. gender differences between LTC) and one-way Analysis of Variance (ANOVAs; Brown-Forsythe adjustment implemented when necessary), with post hoc tests (Tukey-Kramer for equal variances or Dunnett's T3 for unequal variances) for scalar quantities. P-values were set at <0.01. The differences were used to assess discriminant validity (e.g. the measurements ability to distinguish between groups that it theoretically should be able to distinguish between). To determine which acceptability components would predict rejection of TH kit within the WSD trial, univariate logistic regressions were undertaken in order to assess predictive validity of the sub-scales (e.g. make predictions about outcomes that the sub-scales should theoretically do so).

RESULTS

Missing value analysis and multiple imputation:

Within SUTAQ items 93 of 10516 items (0.88%) were missing; thus the first imputed dataset was utilised for PCA. At the scale level within the SUTAQ and scales utilised to validate the SUTAQ, there were 71 (0.25%) missing data-points (scale scores). All scales had <2% missing data, thus a single imputation was utilised.

Preliminary analyses: The mean age of the sample was 70.9 years (SD=9.93). The majority of the sample was male (296, 61.9%), of white ethnicity as per ONS (25) (433, 92.7%) and a high proportion had had little formal educational qualifications

(255, 53.3%). Three conditions were the subject of the study, and individuals were recruited if they had diabetes, chronic obstructive pulmonary disease (COPD) or congestive heart failure (CHF). On average the participants had 1.74 (sd=1.78) co-morbidities over and above their index condition. The sample had a deprivation index (IMD) score of 24.45 (SD=13.54). Their mean experience with the kit was 125.7 (SD=23.9) days; with p*articipants receiving an average of 2.71 (0.61) items of kit.*

The proportions of males and females in each of the illness groups were COPD: 124 males, 91 females; Diabetes: 55 males, 40 females; CHF: 117 males, 51 females; (χ^2=6.546, df=2, p=0.038; ϕ_c=0.117).

SUTAQ factor analysis, sub-scale reliability and scores: The item-participant ratio for the acceptability items was ≈1:22 for the component statements prior to the factor analysis procedure; within the acceptable levels defined by Kline (1993). The first analysis of this data produced a significant BTS (Approx. χ^2=4325.16, df=231, p<0.001) and a KMO measure of MSA of 0.904. All MSA from the AICM were above 0.80. Eigen values >1 plot indicated that 5 components should be extracted. The resultant components accounted for 60.7% of the variance and are presented in Table 1. Items forming each factor were then subject to their own PCA (same methods) to determine if second order factors existed. Only the first factor of the first analysis indicated multiple scales. This showed a significant BTS (Approx. χ^2=2020.704, df=36, p<0.001) and a KMO measure of MSA of 0.913. All MSA from the AICM were above 0.80. Two factors were revealed, representing 64.1% of the variance. These are presented in Table 2.

The components from the above principal component analyses were labelled (i) '*enhanced care',* (ii) '*increased accessibility*', (iii) '*privacy and discomfort',* (iv) '*care-personnel concern*', (v) '*kit as substitution',* and (vi) '*satisfaction*'.

All subscales are interpreted such that a higher value reflects a higher degree of agreement with the subscale. Two of the subscales *privacy and discomfort* and *care*

personnel concerns are based on negative statements in the items. Therefore, high values on these subscales reflect high degrees of agreement with these negative aspects of the kit. Internal reliability (Cronbach's alpha), mean scores, and distribution for each of the sub-scales are presented in the Tables 1 & 2.

Insert Table 1: (component structure 1) about here

Insert Table 2: (component structure 2) about here

Concurrent Validity: Correlations within SUTAQ sub-scales are shown in Table 3A; and correlations between the SUTAQ sub-scales and demographics and patient reported outcome and mediator variables (e.g. QoL, psychological well-being, and psychological processes) are shown in Tables 3B&C.

Insert Table 3: (Correlations) about here

Insert Figure 1: (SUTAQ sub-scale score by Long term Condition graphs) about here

Discriminant Validity: A series of ANOVAs were conducted to detect group differences (i.e. gender, long term condition) on the six sub-scales. This revealed no significant differences based on gender (all $p>0.05$). However, the 'increased accessibility' and

'privacy & discomfort' scales, showed significant differences between long term conditions (LTC). Diabetic participants believed the kit gave them significant greater accessibility than CHF patients ($f_{(2,379.906)}$=3.367, p=0.036); and significantly greater privacy and discomfort beliefs than the COPD group ($f_{(2,475)}$=3.372, p=0.035). Figure 1, shows mean scores on SUTAQ scales in each LTC.

In the current sample 30 TH participants rejected the intervention and 414 undertook the intervention; the remaining 34 cases withdrew for other reason (e.g. passed way, moved to residential home) (4).

Predictive Validity: Univariate logistic regressions examining if each acceptability belief predicted rejection of the TH intervention (original odds of rejecting TH=0.07), showed all but one subscale of the SUTAQ predicted the likelihood of rejecting kit. Stronger beliefs regarding enhanced care, increased accessibility, kit as substitution and satisfaction beliefs all decreased the odds of rejecting kit, with one point increases in score approximately halving the odds for each variable. In contrast, stronger beliefs about privacy and discomfort almost doubled the odds of rejection. Care personnel concerns did not significantly predict rejection of kit, see Table 4.

Insert Table 4: (Univariate Log Reg) about here

Discussion

The aim of the present study was to develop a tool to measure patients' beliefs about the acceptability of TH and test the performance of the measure with regards to its internal reliability and validity (e.g. face, concurrent, discriminant, predictive).

The results indicate that six important dimensions of TH user acceptability can be delineated (and taken as a definition of TH acceptability), each with satisfactory internal reliability. These are: (i) 'enhanced care' – beliefs about how the kit can improve the care patients received from HCP, (ii) 'increased accessibility' – beliefs indicating how the kit has facilitated the receipt of care from HCP, (iii) 'privacy and discomfort' – beliefs regarding the concern patients have with how the kit impinges upon them and safety of information monitored by the kit, (iv) 'care-personnel concern' – beliefs regarding concern about the skills and continuity of the personnel looking after a patient, (v) 'kit as substitution' – beliefs about how the kit may be an alternative to regular care; and (vi) 'satisfaction' – beliefs indicating acceptance and satisfaction with the kit and service provided. Items within each subscale were shown to have face validity when tested in a TH user group; and internal reliability statistics (Cronbach's alpha) did not indicate the need to remove any item from the subscales.

The subscales revealed encompass the a priori themes identified in past research (e.g. accessibility; comfort; usability; privacy and security; confidentiality; satisfaction; convenience; health benefits; and self-care), although there is a slight reconfiguration, between privacy, security and discomfort themes; and the manner in which TH benefit on care processes are conceptualised. These results however, provide an initial empirically validated, coherent structure for TH acceptability beliefs. They encapsulate many of the scales from previous measures, moving beyond simple unidimensional measures of satisfaction, and examining the nature of the service being provided, how it impacts upon the care received and facets of that care not previously included in acceptability scales. Furthermore this scale was produced focusing on a specific form of assistive technology, telehealth defined in the WSD programme as, the remote exchange of data between a patient and health care professional to assist in the diagnosis and management of a health care condition (1).

These subscales/dimensions related to each other in a logical, coherent manner (contributing towards concurrent validity). For example, users who believed the TH would enhance their care or increase accessibility to services saw the kit as a substitute for usual care and were generally satisfied with it. They also had fewer concerns with privacy and discomfort or care personnel issues. Fewer concerns on these later two scales were also related to greater satisfaction and belief in the kit as an alternative to usual care.

Means scores on the sub-scales across the TH sample indicated a generally positive tenor across beliefs. In general the sample TH users are satisfied with the service they are receiving (as seen in much past research during healthcare evaluations), believe that TH devices enhances the care they receive and are unconcerned about privacy and discomfort implications of the kit. They are mildly unconcerned regarding the skills of HCP administering the TH and less certain that kit will increase the accessibility to care from HCP. However, TH users were equivocal to whether the kit could act as a substitute for their usual care; rather they see it as an adjunct (i.e. high enhanced care scores). This pattern of beliefs can have important implications for user acceptance of kit and the manner in which it is introduced to potential users, e.g. providing realistic expectations; reassurance with regards to sensitive data. The satisfaction, enhanced care and privacy and discomfort scales did reveal skewed distributions. However this may have been a function of the sample, who were service users that had continued to use the telehealth for >4-months, prior to the acceptability assessment -thus excluded those who may have rejected the kit early on. Use of the acceptability questionnaire on users with little experience to capture those with low acceptability before they dropout may re-distribute score on these scales to be more normal.

The introduction of TH is commonly believed to have the potential to pose problems for elderly users who may not be as experienced with technology. However, the results indicate that acceptability of kit is largely unrelated to age ($p>0.01$ with all subscales). Furthermore other factors, such as deprivation scores, experience with kit and gender were also found to be unrelated to acceptability beliefs or failed to show significant group differences; indicating these are not critical to the acceptance of TH. However, it must be acknowledged that this sample was selected for its homogeneity in experience with the kit within a relatively early time-period since installation, thus they have short-term experience with it. Subsequent analyses when the participants have had greater experience may reveal different patterns of relationships and changing patterns of acceptance; as may evaluation of acceptability beliefs in patients who reject the kit in a shorter time frame than this sample.

Also informative for expectations on the impact of TH introduction are the findings that acceptability beliefs are generally unrelated to quality of life outcomes (as measured by EQ-5D and SF-12), although partially related to emotional/psychological wellbeing

outcomes (anxiety and depression), in particular user concerns with care personnel and beliefs that the kit is a substitute for current usual care. This may indicate that shorter term benefits of TH are primarily psychologically reassuring rather than impactful on physical outcomes. Longer term benefits which may provide time for TH to have impact on physical outcomes and self-care behaviours are not examined in the current analyses but are to be reported in subsequent papers.

Variables showing interesting patterns of correlation with the acceptability sub-scales (thus evidence of concurrent validity) were related to education levels. Participants with higher levels of education believed less in the ability of the kit to enhance their care (and showed trends revealing they did not think TH could act as a substitute to care or increase access to care). Furthermore individuals with greater skills in acquiring and utilising health education (as measured through the heiQ subscales), consistently demonstrated they would be able to gain the most from a TH installation; e.g. use it to enhance their care, increase accessibility, use the kit as a substitute for care and be less concerned about privacy and care personnel). These results provide insight into the potential training required by individuals before receiving TH. Although user with overall lower education individuals are more accepting of the kit; those with better ability to utilise health education are most likely to benefit from the TH, indicating that where required (possibly identified via screening tools), individuals may need to be trained or thoroughly inducted to provide them with abilities to acquire skills and techniques, self-monitor, navigate health services and gain support in order to gain the maximum potential benefits from TH kit. A potential mechanism of this process is their increased acceptability of a TH intervention, through increased confidence and self-efficacy (26), although this requires further investigation.

Important group differences were found on subscale scores between differing LTCs, indicating the subscales' discriminant validity. The diabetes group had significantly more concerns about privacy and discomfort than the COPD group; (although it must be acknowledged that overall levels on these concerns were low). Diabetic user also believed that the TH significantly increased their accessibility to healthcare in comparison to CHF users. These differences can be related to the different monitoring regimens required by each LTC (e.g. the demands, frequency and invasiveness of measures) and the belief that health behaviours/outcomes (e.g. blood glucose levels) are being monitored by HCP. The lack of group differences on the

'enhanced care' beliefs in comparison to the 'increased accessibility' beliefs (along with the differing overall mean values) provides support for the division of the original perceived benefits subscale.

The final set of analyses examined the predictive validity of TH acceptability beliefs. Individually acceptability subscales were capable of predicting longer term (up to 12 months) active rejection of TH interventions. The direction of effect was as expected given the interpretation of the subscales, with positive beliefs regarding the acceptability of kit almost halving the odds of rejecting kit and the privacy & discomfort scale doubling the odds.

Identifying participants expectations of TH using a screening tool, and intervening (see above) to prepare service user expectations may be able to reduce the levels of TH rejection/increase acceptance and usage of TH services. The results of this analysis however need to be interpreted with caution as the initial odds for rejection were low as, relatively few individuals rejected TH within this sample.

Strengths and Weaknesses

The results of this study to validate a newly developed questionnaire are based on one of the largest studies to evaluate TH using participant-reported outcome measures, and address a gap in the evidence base, where there was a lack of studies with large sample size, participants of a wide clinical need and socio-demographic background receiving services across a range of provision models. The questionnaire development process utilised robust methodological and statistical methods, which affords greater confidence in the reliability of the findings (e.g. face validity; negative and positive valence item (which did not all load onto the same factors; and demonstrations of good internal reliability, construct validity and predictive validity.

Implications and future research direction

This assessment has implications for the deployment of TH into mainstream services. The assessment can be used to identify individual differences in acceptability of TH with good validity and reliability. Future work is required to assess beliefs about acceptability earlier on in the process before patients have had experienced using the

devices, in order to examine unhelpful beliefs that may lead to refusal to use TH. This would have potential to increase recruitment and retention in TH interventions.

Conclusions

Partly due to the recruitment and retention issues in TH, we have developed a reliable and valid assessment that is able to discriminate between groups of patients at greater risk of drop out due to rejecting TH services. The acceptability of TH was associated with patient's health education scores and mood, to a greater extent than older age or lower education identified in previous literature. In order to increase effective deployment of TH and increase the potential effectiveness future research should consider individual differences in acceptability of TH services.

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Competing interest statement

All authors conform to a competing interest statement and declare: support from the Department of Health and the University College London Hospitals, University College London and City University London; several authors have undertaken evaluative work funded by government or public agencies but these have not created competing interests; no other relationships or activities that could appear to have influenced the submitted work.

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Field Code Changed