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Considerations of interface efficiency in scaling up telehealthcare systems

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Abstract

One of the most important promises of telehealthcare is that of increasing care provider productivity in managing patients, which is essential for dealing with the changing demographics. Amongst other factors, this is currently put to the test by several European projects trialling large scale implementations of telehealthcare systems. Any minor interface problem which affects productivity at small scale may prevent a care provider from managing more patients at large scale. This makes interface efficiency, a component of its usability, an essential criterion to consider in the evaluation of telehealthcare. This paper describes a post-deployment usability evaluation study of a telehealthcare system conducted in Lothian, Scotland, the findings of which revealed important efficiency issues. Using these findings, and experience from two older studies, it concludes on interface design decisions which could be taken to avoid efficiency issues for telehealthcare solutions.

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Keywords: telehealthcare; telemonitoring; usability; efficiency; long-term conditions; qualitative research; template analysis

1. Introduction

The world's population is ageing, due to factors such as increasing longevity, decreasing fertility and the ageing of 'baby boomers' [1]. In Scotland, it was estimated that the number of people aged over 75 will increase by 85% between 2014 and 2039, from 0.43 million to 0.8 million [2]. Long-term conditions being prevalent in the older age, this will lead to growing numbers of adults suffering from, sometimes multiple, long-term conditions [3].

The increasing demand for care of people suffering from long-term conditions is also compounded by the shortage of human resources in healthcare, reported by the European Commission ever since 2001 [4]. Due to demographic changes, it is expected that there will be fewer workers per dependant in general, and therefore even unpaid carers, whose life is already burdened by the care for family or friends, will be in shorter supply [3].

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Telehealthcare was proposed as a solution for coping with the demographic changes. Together with important care and cost benefits, it offers the promise of a more efficient interaction between patient and care provider, by substituting face-to-face consultations with remote monitoring and the provision of care at a distance[5,6]. Telehealthcare can improve the productivity of care providers in managing each patient, and thus make it possible for fewer additional members of staff to deal with the increasing numbers of patients.

To thoroughly assess these and other claims, several European countries are currently planning and developing large-scale telehealthcare pilots. Examples are the Renewing Health European project[7], ITTS (Implementing Transnational Telemedicine Solutions[8], and DALLAS (Delivering Assisted Living Lifestyles at Scale[9]) in the UK which includes the 'Living it Up' programme in Scotland.

In scaling up a telehealthcare system, care providers will repeat common operations for more patients. At the level of the interface, even minor delays in their work may then escalate and affect their possibility to manage more patients. This makes efficiency, a component of usability, an important factor to consider ever since a telehealthcare system is trialled in small scale pilots. Efficiency is defined by the ISO 9241-11 standard as "*resources expended in relation to the accuracy and completeness with which users achieve goals*"[10].

Three post-deployment usability studies of telemonitoring systems were conducted by the author in 2010 and 2013 in Lothian, Scotland. The findings of the first two (from 2010) were described in[11]. This paper, based on the author's PhD thesis[12], focuses on the last study (from 2013) and its results on efficiency, to draw conclusions on interface design decisions which could help avoid efficiency issues in telehealthcare systems. A discussion about whether the conclusions are supported by similar findings in past studies is included.

2. Description of the 2013 usability evaluation study

2.1. The system

Using lessons learned from one of the Telescot trials[13], the telemonitoring system which constituted the object of the 2013 usability study was the product of a collaboration between NHS Lothian and NHS 24 the purpose of which was to develop a mainstream telehealth service for the home based telemonitoring of patients suffering from COPD (Chronic Obstructive Pulmonary Disease) and CHF (Congestive Heart Failure) in Lothian. The service development was gradual, and its continuous evaluation, including that of the technology, was seen as key.

By using an application running on a tablet installed in their home and wireless measurement devices, patients could take physiological measurements (e.g. of oxygen saturation and pulse for COPD) and answer a daily health survey. The measurements were sent by Bluetooth to the tablet and then, together with the patients' survey answers, via the Internet to a remote secure server. Alerts were computed based on pre-existing algorithms which attributed scores to symptoms, or if physiological measures were outwith previously agreed parameters. All of the resulting data was made available to monitors on a **telemonitoring website**. Every day, one non-clinical NHS 24 call operator (CO) would monitor patients on the website between 9 am and 1 pm. She would complete an **alerts Excel spreadsheet** with each patient's alerts and take an appropriate action as directed by it. These actions could be: call the patient to find out more about her health and, if necessary, to ask her to retake her measurements for a reassessment; send an email to the patient's care provider team (by using an **email client**), attaching the alerts spreadsheet, if the patient's state was not improving or getting worse, or if she had not succeeded in contacting the patient ('Contact Care Provider' outcome); or conclude that the patient did not require an intervention ('No Action' outcome). The CO would record the action on the website by changing the status of the alerts appropriately. She would also record at the end of her shift statistical data (the number of patients monitored that day, the outcome of her monitoring, frequency and duration of calls, etc.) by using a separate table, also an Excel spreadsheet (the **statistics Excel spreadsheet**). If alerted by the CO email (through the same email client system), the patient's care provider would log onto the telemonitoring website to reassess the patient's condition, and contact the patient to discuss her health, offer her advice and change her treatment if necessary. In addition, the care provider would sometimes need to use the patient's paper or electronic record (a separate system) to record data about the patient, prescribe medication or obtain patient test results. To communicate her actions as regards the patient to the COs or to her colleagues, the care provider would also change the status of the patient's alerts on the website. A representation of the monitoring process is provided in Fig. 1

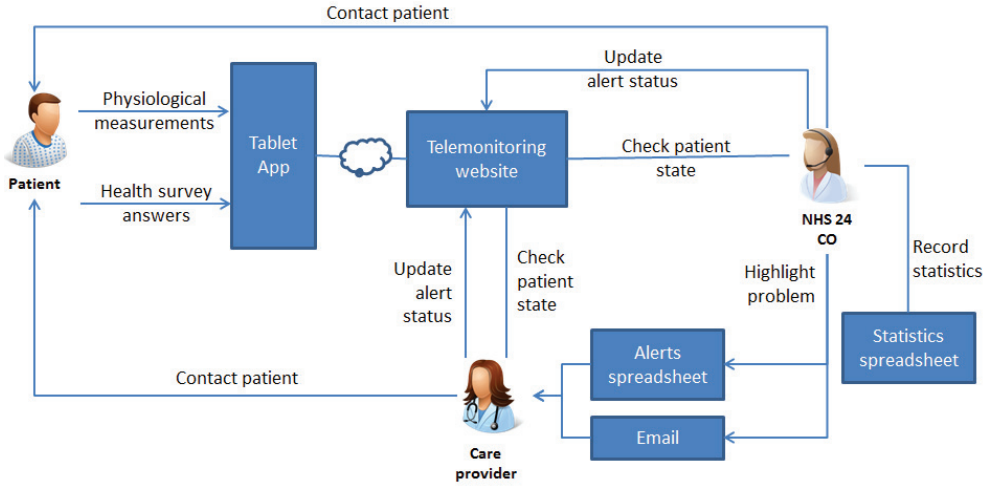

Fig. 1. The monitoring process

The telehealthcare 'system' therefore consisted of four applications which were used for patient monitoring, all of which were considered for the usability evaluation: the telemonitoring website used by both COs and care providers, the alerts Excel spreadsheet filled in by the COs and, sometimes, sent to the care providers, the email facility used by both COs and care providers and the statistics Excel spreadsheet used only by COs at the end of their shift.

2.2. Participant recruitment

Because they were all involved in the service and contributed to its evaluation, the system users from the different teams have all kindly agreed to participate to the study, in the limit of their availability.

The usability evaluation study was split into two parts. In the first, with the help of the NHS 24 team leaders, the NHS 24 office was visited every morning when a different CO was working on the system, and additionally for the team leaders themselves. This made it possible to involve all of the NHS 24 users, apart from one who was not doing home monitoring at the given time. In the second part, care providers from the different teams were contacted for recruitment by telephone or email, after getting permission from their team leaders. As the teams were small, the purpose was to involve as many of the team members as possible. Overall, all but four of the care providers from the weekday telehealth monitoring teams, and one doctor who had more experience with the system from the Lothian Unscheduled Care Service weekend team, agreed to participate to the study and were visited. An overview of the teams involved and the total numbers of participants recruited for each is provided in Table 1.

Table 1. Teams and number of recruited participants

Team	Members	Study participants
NHS 24	10	9
Edinburgh Community Respiratory Team (CRT)	7	7
East and Midlothian COPD Team (EMACS)	1	1
West Lothian Intensive Case Management Team	4	2
Heart Failure Nurses	4	2
Lothian Unscheduled Care Service (LUCS)	4	1

2.3. Methods

The study made use of a mixed methods approach. During the first two weeks, all of the NHS 24 COs working on the system at the time were asked to fill in a **diary** recording any problems that they encountered. Subsequently,

the main methods used during visits were **observations** and **semi-structured interviews**. NHS 24 COs and care providers who had been notified of alerting patients that day were observed while doing their routine monitoring work on the system for one hour or the time that they spent if less than one hour, and notes were taken. With their approval, provided in a consent form, the computer screen (only) was video recorded during the observation. Following the observation, or without it in the case of NHS 24 team leaders or care providers who did not have any work on the system that day, participants were interviewed for half an hour. The interviews were semi-structured, following up interesting answers to an initial set of questions (the interview schedule) with additional questions which would elucidate new areas of interest for the study. The main questions were concerned with participant experience with the system, their perception of its usability and their suggestions for improving it, but also questions arising from observations (e.g. their motivation or contexts when using a certain functionality of the system or external tools). With the approval of the participants (also provided in the consent form), interviews were audio recorded, and additionally notes were taken.

In what concerned data analysis methods, the video recordings of the observations were watched in order to enrich the notes with new findings about steps taken by the participants in their work, the tools that they used and the difficulties that they encountered. Observations were also compared between users. The interviews were analysed qualitatively using the template analysis approach[14]. Starting from some high-level a-priori themes required for the purposes of the evaluation, 6 of the interview transcripts for each of the parts of the study were coded using open coding with a combination of descriptive, process and in-vivo coding, and then code mapping[15] to decide on an initial template consisting of themes and subthemes. The remaining transcripts for each part were then coded by fitting citations into the initial template's themes and subthemes, only amending the template where absolutely necessary.

Throughout the duration of the study, the author also had access to a test website, to two patient tablets (one for a COPD and one for a CHF test patient) which were used to input data onto the test website, and to the alerts spreadsheet to be filled in by COs. This allowed the clarification of the issues identified from observations and interviews through a hands-on investigation of the system.

2.4. Findings on interface design decisions which could help avoid efficiency issues in telehealthcare solutions

Efficiency issues were found to be frustrating to users. To ensure a more efficient telemonitoring system, and thus improve their productivity in managing patients, findings revealed that participants needed:

- On the homepage, **a summary list of patients which**:
  - **For the care providers, is ordered alphabetically according to patient names by default** (7/13 care providers). Care providers only needed to check patients whom they had received an email from the COs about. Alphabetical ordering would have therefore allowed them to quickly deduce where the patient name was in the list, instead of needing to scroll down or sort the list looking for it:
    "you think, somebody's with their last name begins with an 'A' and you need to scroll down to the bottom of the second page to get it." (respiratory physiotherapist, COPD)
    A similar suggestion was made by more than half of the participants of one of the telehealthcare systems evaluated in 2010, which did not offer default alphabetical ordering, or the option for it.
  - **For each care provider, contains only the patients whom their team manages** (8/13 care providers). This would have avoided the problem of needing to sort the patient list according to the team, and then scroll down or even go to another page to find the wanted patient name within their team's list, and overall reduced their effort for searching for a patient:
    "Each time you go into it you have to click on 'City' [to sort according to the teams], and we're lucky cause ours [the team] is at the top, but I am sure that the people that are these ones [belong to teams the names of which are placed on the bottom of the page] would get quite annoyed at having to go click on it and all the way down." (respiratory physiotherapist, COPD)
    One of the previously evaluated systems only presented patients for the user's team, while the other offered default alphabetical ordering of a small number of common patients, and there were no similar comments.
  - **Saves the last sort, such that the patient name is kept at the same position in the list when the user returns to the homepage, and there is no need to resort and/or go to another page to find the patient name again** (3/13 care providers, with 4 more commenting on the problem).

Overall, both the participants who commented on the list of patients for this study, as well as those from one of the 2010 studies, where a similar list was used, pointed out that scrolling and using pagination to search for patients, sometimes combined with a slow internet connection, was time consuming for them.

- **Information about patient measurement thresholds and functionality to change them available next to measurements** (3/13 care providers) **or one click away** (1 care provider). Care providers needed to see the thresholds to understand how critical the patient state was, and they often changed thresholds. COs needed to provide threshold information in their outcome on the alerts spreadsheet.
  "I personally feel it would be really good to have a separate 'Threshold' button, because that is actually what I tend to go into the most, and particularly if you have a new patient who goes onto telehealth, you're playing with their thresholds all the time while you're learning what's normal for them." (COPD nurse)
  During one of the 2010 studies, most of the participants also noted the importance of having patient information, including thresholds, as easily accessible within the website. Similarly, a few participants would have liked the thresholds as directly displayed next to measurements, or the page to include at least an indication of whether measurements are above or below them. For the second system, participants only used fixed thresholds for the purposes of the trial, so there were no similar comments.
- **The functionality for updating a patient's status to also be available on the same page with that of activating/deactivating the patient from the system** (2/13 care providers), to reduce navigation as participants often needed to use them both (e.g. when the patient was admitted or dispatched from hospital).
  Users were not required to activate or deactivate patients on previously evaluated systems, so there were no similar suggestions.
- **One-click navigation between the patient's different results pages (measurements, alerts, survey answers)** (5/8 care providers who commented on navigation, and 1 CO regarding navigation from alerts to surveys), **if the grouping of related results on a common page would clutter the page too much**. The website only allowed navigation from the homepage to the different results pages. One care provider explained the importance to frequently go from alerts to measurements to be able to decide on the patient's state:
  "[referring to alerts] So all that that gives you there is information on... that it's over threshold, doesn't give you any information about what's happened over the last week. And that's really the important part, so you have to come out of there [back to the homepage], back into Patient Monitoring [to see measurements], and have a look." (CHF nurse)
  Most of the participants of one of the systems evaluated in 2010 suggested the use of a summary page to present a 7-day summary of patient results, which also reflected their need to retrieve such information quicker. Such a summary page was available within the other evaluated system, and participants found it useful.
- **For COs, all of the information needed for filling in the alerts spreadsheet available from one webpage - the Alerts page - instead of needing to navigate through the website** (2/7 COs).
  Only one of the previously assessed systems involved non clinical monitors who, similarly to COs in this study, filtered out patient alerts. However, they recorded their findings directly in notes attached to measurements or survey responses, and did not need to move information between applications, which may explain why there were no similar comments.
- **The Alerts page to either summarise different red flags within one single alert** (6/13 care providers)**, or to present each red flag in a new alert (as was the case) and allow for all of the alerts for the day to have their status changed at once** (5/13 care providers, 3/7 COs and 1 NHS 24 team leader). These suggestions were made because users only needed to make one status decision for the day, considering all of the red flags, while the website was built to enter a decision for each red flag, represented as a different alert:
  "There are too many alerts there, you could generate, so four alerts on any one day but we're only ever acting upon... any one of them." (respiratory physiotherapist, COPD)
  One of the previously evaluated systems used a separate webpage to summarise all of the patient results. Alerting results were initially presented as red flags, and the user could use an acknowledgement function to change their colour to orange, similar to changing their status in the current system. Users wishing to acknowledge the red flags for a day also needed to do this for each one in turn. However, nobody complained about this or provided suggestions. This may have been due to their protocol not imposing this process, unlike for the current

system, where changing the status of the alerts was seen as a means of communication between COs and care providers.

- **The possibility to have a quick look at the latest notes on alerts, instead of needing to open up the notes of each of the alerts in turn** (2/13 care providers). One of the care providers suggested having a history of these notes available one click away from the Alerts page, or having some alerts open by default, and the other agreed with the second suggestion.
  Only one of the previously evaluated systems included a note facility for red flags, and similarly required the opening of each note in turn. Some participants also found this as time consuming.
- **By default, a table representation of the last measurements taken by the patients, instead of a graphical one**. According to observations, COs always used a table mode, and 9/13 care providers preferred it, which is why this was included in the latest version of the system:
  "changed to table mode, cause that's the one we use, so it's... it saves a step from having to change from graph to table mode, it's better to just go straight into... to table mode." (NHS 24 team leader)
  Previous evaluated systems used a table representation for measurements by default.
- **Regarding the table representation for measurements, some participants also suggested**:
  - **Grouping related measurement types in a familiar way, to save some time for looking through**. The CHF nurses preferred blood pressure and pulse measurements to be presented in the familiar order systolic-diastolic-pulse. Moreover, one care provider from a COPD team and one CO suggested having oxygen and pulse measurements grouped together, as they were used to recording them this way.
  - **Ordering the different types of measurements according to when they had been taken** (3/13 care providers and 1 CO), to save time for looking through and comparing measurements:
    "I think there were two oxygen at the top, and then two pulse rates, so I had to look a wee bit to work out what time each one had been done, and mark out what was the most recent one." (CO)
    2 participants (1 care provider and 1 CO) suggested using columns or spaces to group related types of measurements and order them according to time.

  Previously evaluated systems represented measurements in a standard way, and ordered according to time, which was seen as useful by the participants.
- **More information to be provided together with the latest survey answers (presented by default on the Surveys page) to reduce the time and effort for**:
  - **Comparing the answers for consecutive days, which is useful for care providers** (3/13 care providers). The care providers proposed adding information to indicate which answers have changed:
    "So, in a perfect system, it would maybe be... on today's survey, it would be saying 'question 1 is different from yesterday', 'question 2 is the same as yesterday', 'question 3 is the same"." (COPD nurse)
    One of the previously evaluated systems also involved patient surveys. In that case, surveys from different days were presented in inverse time order on the same page as closed by default, and users needed to open each of them. More than half of the participants also pointed out the importance to compare survey answers, and suggested that either some of the latest surveys, or all of them, be opened by default.
  - **Deducing how the total survey score was computed, which is useful for care providers** (3/13 care providers). 2 of the care providers suggested having the alerting symptoms as highlighted on the survey:
    "He's said 'yes' there, if somehow that was in bold or different colour or something would be helpful, I think." (CHF nurse)
    The previously evaluated system involving surveys used such highlighting, which was considered useful.
- **All of the details of patient results to appear on the same page, without the need to scroll down or to the right**. This comment was provided by participants in relation to survey answers (4/13 care providers) and the details of alerts (3/13 care providers, 1 CO and 1 NHS 24 team leader), which in particular care providers needed to check all.
  The previously evaluated systems did not require scrolling for looking at patient results, so there were no similar comments.
- **Ideally, the integration of the 4 applications which constituted the system** (all of the COs, more than half of the care providers). In the given setup, the users needed to move in between the tabs of the different applications and, in the case of COs, move information from one to the other, which was perceived as time consuming but

also error prone. To speed up their work, several participants were observed or mentioned writing information down on paper, or decreasing the sizes of the windows for the different applications.
"it would be nice if it was more streamlined (. . .) you know how you've got the telehealth system of the patients, and then you've got your email system, and then you've got your form, your home monitoring form, it would be good if you could just have that onto one system." (CO)
In particular, several suggestions were made:

- **Integrating the website and the alerts spreadsheet**: Amongst the COs and their team leaders, some proposed including into the website the empty alerts spreadsheet (2/7 COs), or an alerts spreadsheet which is automatically filled in with information about the patient (1 team leader, 2/7 COs):
  "If I went into a page, well I. . . the patient triggered an alert, then I can go into my system and say 'right, all that's done' [the patient demographics], I don't have to fill out anything, because all the information's there, all I'll gonna have to do is put in what they've triggered as alert, and then I can run through the call." (NHS 24 team leader)
  Amongst the care providers who commented on integration (7/13), 2 suggested that the alerts spreadsheet could be available on the homepage from a link for the alerting patient, while another proposed replacing the alerts spreadsheet altogether with a better notes facility where COs could record their conclusions:
  "(. . .) the notes that you add on at the moment, I think that could be better, and I think that could be integrated with what NHS 24 want their Excel spreadsheet to be." (respiratory physiotherapist, COPD)
- **Integrating the website and the email facility**: More than half of the participants to the first part of the study, including the two team leaders (5/9) suggested the functionality of automatically generating the email for the care providers from within the website. One of the COs, and the team leaders, also wanted this email to be pre-populated with patient information. Almost all of the care providers who commented on full integration (6/7) suggested that the emails from COs could be replaced by the website indicating the patients whom they need to check, by highlighting these patients in colour (3/6) or by using 'Alert' icons (2/6). Some of the care providers (3/6) still wanted to have access to the text of the emails:
  "(. . .) highlight the patients in red who need an action, and then you click on them, they [the NHS 24 COs] would send essentially what they send in the email, saying, you know, this is 'for information only', this 'needs action', 'this patient hasn't transmitted'." (respiratory physiotherapist, COPD)
  Some of the care providers (3/6) also suggested placing alerting patients at the top of the patient list to ease navigation.
- **Integrating the website and the statistics spreadsheet**: One CO had proposed this to her manager, and other 3 COs agreed that it would be useful:
  "I did say to [the team leader] one day the other day, would there be any way that they would be able to count the alerts that we've worked that day and whether we have signed into 'care provider for action' or 'no action', because, you know, we are taking a list of these, wouldn't it [the system] be able to count them and what we are doing with it? Yeah, I think that would be quite a good idea, and it would also get accurate statistics." (CO)

As previously evaluated systems only involved one application - the telemonitoring website - there were no similar comments on application integration.

3. Discussion and conclusion

A post-deployment usability evaluation study of a telemonitoring system used in Lothian for the management of COPD and CHF patients was performed in 2013. This paper described the study and its findings in terms of interface design decisions which could help avoid efficiency issues in telehealthcare systems. Moreover, it compared the findings with those of two past studies. Similar findings can be considered as guidelines for the developers of telehealthcare systems. They could be used to ensure that the interface does not delay users in their monitoring work, which becomes critical as these systems are scaled up to more patients. Dissimilar findings are due to differences in interface design, protocols and work processes. They support the importance of usability studies for best understanding user needs in each context.

This and previous work[11] are to the author's knowledge the first to discuss and propose solutions for enhancing efficiency in the context of monitoring interfaces for telemonitoring systems which are used by both clinical and non-clinical monitors. While some standard user interface guidelines, including considerations of efficiency, are available for EHRs (electronic health records, e.g.[16]) and EMRs (electronic medical records, e.g.[17]), this is usually not the case for other types of clinical applications including telehealthcare systems. Moreover, this paper is the first to raise awareness as to the importance of efficiency in the context of scaling up telehealthcare systems.

Important limitations of the study were the fact that it was performed post-deployment and with a relatively small number of participants. Although a pre-deployment evaluation with novice users would have been preferable, the fact that participants identified efficiency problems during routine use shows that experience could not overcome them. The great majority of the system users were recruited for the study which makes their views representative.

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