Interaction and Mediation in Preadmission Clinics: Implications for the design of a telehealth stethoscope

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Abstract

A telehealth stethoscope would make it possible for doctors to perform physical examinations on patients at great distances. In order to develop a useful and useable telehealth stethoscope we have conducted fieldwork observations of existing anaesthetic preadmission clinics to understand how stethoscopes are currently used. Both face-to-face consultations and videoconference consultations have been studied. Our results indicate that the stethoscope plays a minor role in the consultation and that consultations are mediated by the administrative work that is the reason for the consultation. We suggest that a stethoscope plays an infrastructural role in the consultation. The implications of considering stethoscopes as infrastructure are explored and considered in the context of a future telehealth stethoscope.

Keywords

interaction, stethoscope, infrastructure, telehealth, expertise

We are developing a digital stethoscope for use with a telehealth communications network in order to allow doctors to examine patients remotely (a telehealth stethoscope). A future telehealth stethoscope for remote examination of patients will mediate the interaction between doctors' nurses and patients. Understanding this mediation and enabling good collaboration to take place is important if a telehealth stethoscope is to be effective. Though some research exists on telehealth stethoscopes (Belmont and Mattioli, 2003; Fragasso et al, 2007; Wong et al, 2004) it does not focus on interaction and is based on existing products. To ensure that the new device we develop will be appropriate we are conducting field studies of anaesthetic preadmission clinics in a major rural hospital in Queensland, Australia.

An anaesthetic preadmission clinic is a consultation that takes place approximately a week before a patient undergoes an operation. They meet with an anaesthetist who assesses the patient's general health and suitability for anaesthesia. Most of the preadmission consultation involves the doctor interviewing the patient about their general health and about specific aspects of their health that may affect the patient's response to anaesthesia. A small but important part of this assessment in face-to-face clinics is the process of auscultation or the examination of the patient's chest (heart and lungs) with a stethoscope. In telehealth preadmission consultations the interview proceeds as it does in a face-to-face consultation but no stethoscope is available. Consequently telehealth consultations are only offered to people who are known to be "low risk" -- that is patients who are young, generally healthy and who will not undergo particular sorts of high-risk operations. Patients who are deemed "high risk", typically the very old or infirm, must travel to the main hospital, sometimes for several hours, to have a face-to-face consultation. This travel is expensive and time-consuming. A telehealth stethoscope would allow remote consultations to take place for many people who would otherwise have to make long expensive journeys in advance of their operation.

In the studies reported here, we observed both face-to-face and telehealth consultations.

Research Methods

In order to understand the context in which a telehealth stethoscope will be used we conduct field studies of anaesthetic preadmission clinic consultations. In these consultations, doctors and nurses examine patients about a week prior to surgery in order to assess the patient's suitability for anaesthesia.

Our data is collected through video-recorded observation, think (talk) aloud protocol and retrospective protocols, interviews and focus groups. Noldus' The Observer (2008) software aids our analysis of video data. We also conduct retrospective protocol with the doctors and nurses we have observed in order to clarify their actions. We use Atlas.ti (2008) to analyse verbal data.

The coding scheme (Kraal and Popovic, 2009) we used was developed through close examination of the videos of consultations.

Initially we sought to understand how the stethoscope mediated interaction in consultations and the coding scheme that was developed reflected this (Kraal and Popovic, 2009). That approach led to a deeper understanding of the context and the subsequent redevelopment of the coding scheme to better reflect how preadmission consultations are conducted. The next section briefly describes our previous research.

Communication between doctor and patient

In our earlier research (Kraal and Popovic, 2009) we saw that the way doctors conducted face-to-face consultations and telehealth consultations was very similar. We had expected that the different types of consultation would be different. Instead our research showed that there was no discernable difference in how the communication between doctor and patient was conducted. The only noticeable difference was that telehealth consultations did not include the use of a stethoscope. In contrast to the existing literature on telehealth video conferencing (eg Kaplan and Fitzpatrick, 1997; Li et al, 2006) in which communication between participants in remote interactions is sometimes difficult we have found that communication between doctors and patients was similar in face-to-face and remote consultations (Kraal and Popovic, 2009). We speculate that the similarities between the two types of consultation occur because the doctor's goal is always to assess a patient's suitability for anaesthesia.

The use of a stethoscope in the observed face-to-face interactions is largely perfunctory and serves a confirming, rather than specifically diagnostic, role. Only when a patient is elderly or has pre-existing medical conditions that may hinder effective anaesthesia do the doctors make detailed use of a stethoscope. The lack of a stethoscope in the remote consultations has shown that in cases where the patient is generally fit and healthy a stethoscope is not needed. Patients who are remote but whose poor physical health necessitates a detailed examination are always seen in person, which requires them to travel to the main hospital.

We also observed that the tools the doctors use in the consultations, both face-to-face and telehealth, are more extensive than the stethoscope. The primary tools that the doctors use in the consultations are the questions they ask patients and the patient's medical record. These tools are, obviously, available in both types of consultation. It seemed that the questions and medical record were mediating the interaction between doctor and patient in consultations. We collected more data and analysed it using the new coding scheme (table 1) to obtain further data on this aspect of the interaction between doctors and patients.

Mediating Artefacts in Preadmission Consultations

In preadmission consultations there are different stages of interaction. These different stages are (i) the initial interview between doctor and patient, (ii) the physical examination of the patient by the doctor and (iii) the end of the consultation when the doctor summarises their decision about the patient's anaesthetic needs and invites questions from the patient. We have examined all three stages in this research. We anticipated, and our analysis has shown, that the stethoscope mediates interaction between doctor and patient during the physical examination. The doctor's actions during the physical examination draw strongly on tacit knowledge. It is this finding that most significantly impacts on the design of a future digital remote stethoscope since such a stethoscope will require doctor, nurse and potentially patient to work together in a way that requires high use of explicit knowledge.

Further analysis of the entire preadmission consultation has shown that the administrative aspects of providing a patient with anaesthesia mediate the entire interaction, most significantly during the initial interview. The artefacts of the administrative aspects of anaesthesia are the patient's (paper) medical record, a form on which the doctor records their interview with the patient and, occasionally, the computer on the desk in front of the doctor which is used to look up parts of the medical record which are stored electronically. Most of the time, the doctor requests information from the patient to confirm or elaborate on information that is contained in the medical record. For example, doctors often ask patients about their previous experiences of anaesthesia. In two instances we have observed the patient does not have an extensive medical record and the doctor must ask them more detailed questions about their general health to obtain the same information that is normally in the paper record.

To describe these activities a coding scheme was developed (table 1) which sought to capture the activities that occurred in the preadmission consultation in a more refined way than that used by Kraal and Popovic (2009).

Code	Description
Examination	Conducting a physical examination of the patient
Medical Record	Doctor's attention is on the patient's medical record
Computer	Doctor's attention is directed at the computer
Writing	Doctor's attention is directed at writing
Patient Conversation	Doctor's attention is directed at the patient

Table 1: Coding scheme

There are five codes in the scheme. The Examination code was used when the doctor performed a physical examination of the patient. Three codes, Medical Record, Computer and Writing, describe activities where the doctor is focussed on administrative activities. If the doctor was speaking with the patient and engaged in an administrative activity, only the administrative code was used. The Patient Conversation code describes when the doctor was focussed on discussion with the patient.

Figure 1 shows the average times spent on different activities during the preadmission consultations we have observed. The activity that takes the longest is the conversation between doctor and patient with an average of 00:05:17 minutes. Writing the record of the consultation took and average of 00:03:44 and the other activities, the physical examination, using the medical record and using the computer took approximately two minutes each. Averages presented are calculated on times where the code occurred. For example, examinations only took place during face-to-face consultations so that average is calculated on 9 episodes.

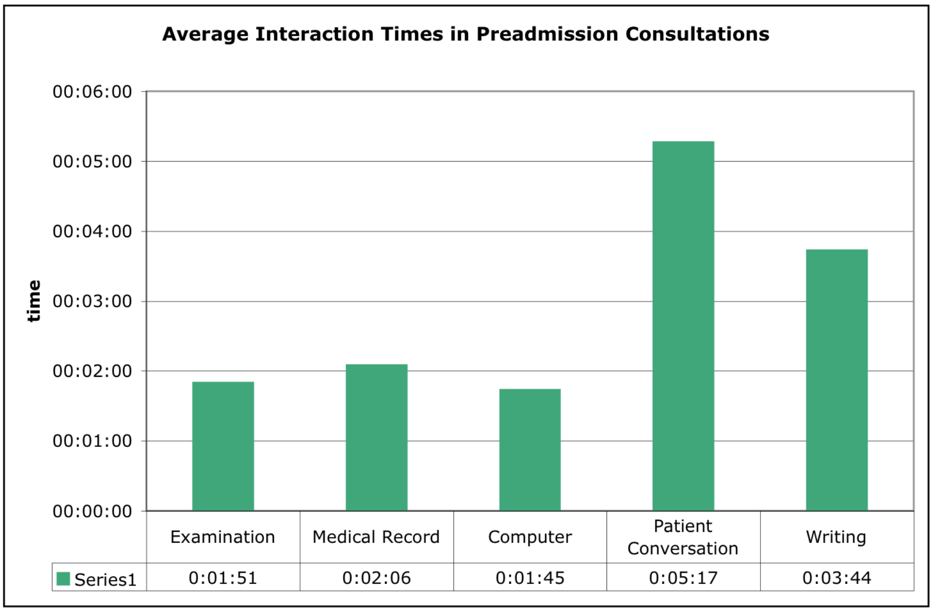
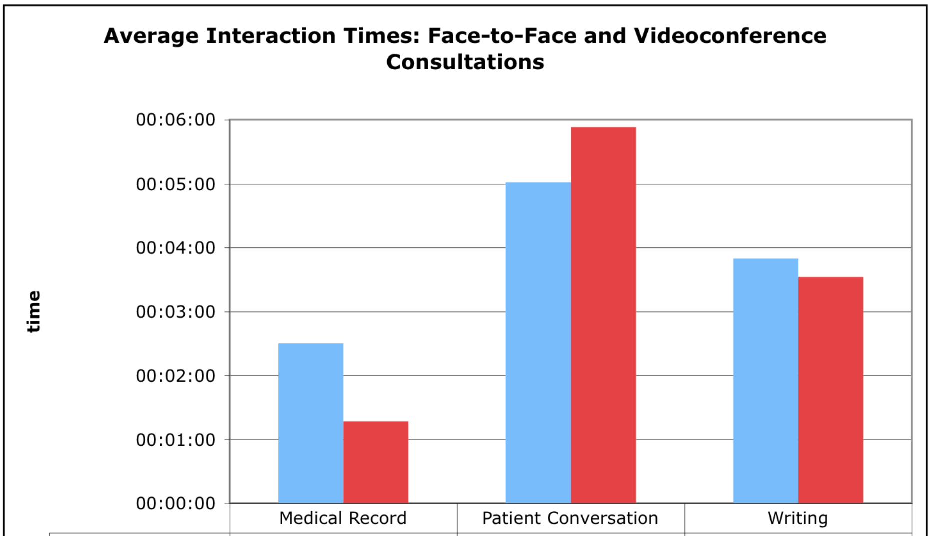


Figure 1: Average Interaction Times in Preadmission Consultations

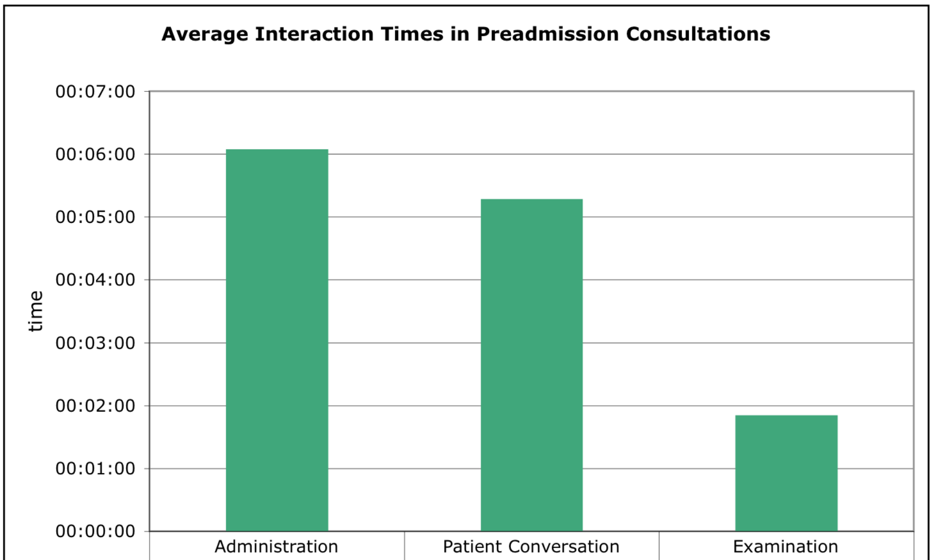
There were some differences between the face-to-face consultations and videoconference consultations that were observed (figure 2). Patient examination times are not shown in figure 2 as no patient examination occurs during videoconference consultations. Additionally, doctors did not interact with the computer while engaged in videoconference consultations so that data is also not shown in figure 2. While the average amounts of time spent on patient conversation and writing the consultation record were similar between the two types of consultation, the amount of time spent dealing with the patient's medical record was different. In face-to-face consultations the doctors spent an average of 00:02:30 minutes examining and working with the patent's medical record while they spent 00:01:17 with the medical record in the videoconference consultations. However, this difference is likely a result of the limited number of videoconference consultations that have been observed.

As figures 1 and 2 show, a lot of time is spent on interacting directly with the patient. Exactly how much time is shown in figures 3 and 4 which combine the medical record, computer and writing codes in "administration". Figure 3 shows that, considered in this way, administration makes up the largest block of time during a consultation an average time of 00:06:05 minutes, followed by conversing with the patient, 00:05:17 minutes, followed by the short time spent on the physical examination, 00:01:15 minutes.



	Medical Record	Patient Conversation	Writing
Face-to-Face	00:02:30	00:05:01	00:03:50
Video Conference	00:01:17	00:05:53	00:03:32

Figure 2: Average Interaction Times for face-to-face and video conference consultations.



	Administration	Patient Conversation	Examination
Series1	00:06:05	00:05:17	0:01:51

Figure 3: Average Interaction Times in Preadmission consultations, all administration activities collated

Figure 4 shows the administration and patient conversation times split by consultation type. The differences in the average times for administration tasks and patient conversation activity are likely to be due to the relatively small sample size, particularly of videoconference consultations.

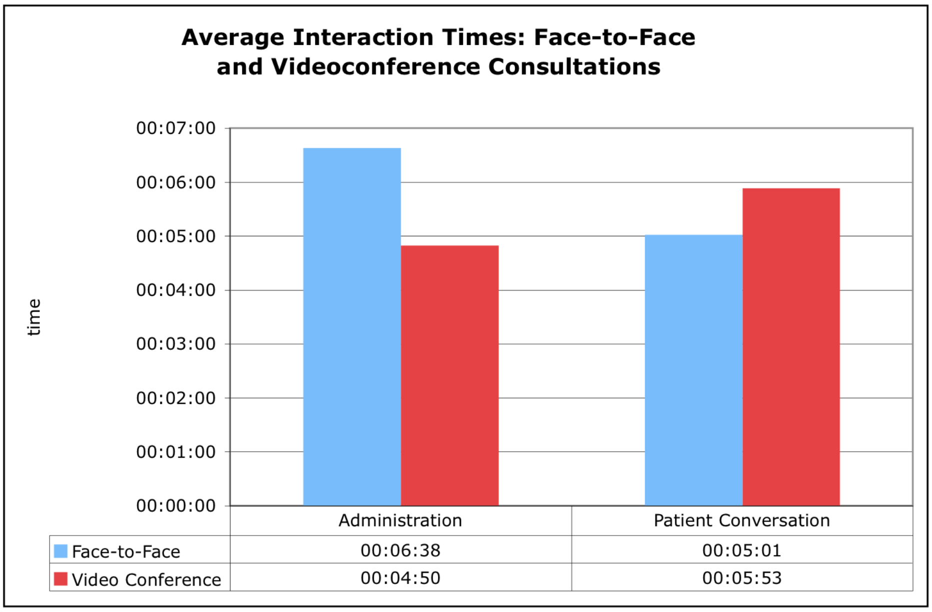


Figure 4: Average Interaction Times, all activities collated, by consultation type

These data show that in the consultations observed the doctors spend the most time dealing with the administrative elements of the interaction and that the physical examination is completed quickly. This is not to say that the physical examination is unimportant but that its importance, when measured by time taken, is not as significant as we had expected it to be. Only in cases where the patient is very high risk do the doctors spend a long time on the physical examination.

We have collected data from physical examinations of two high-risk patients. These patients requested that their entire consultation was not filmed, so there is no data on the length of the administration or patient conversation aspects of the consultation. In the high-risk consultations the examination lasted for 00:03:09 minutes in one case and 00:04:23 in the other. Stethoscope use was 00:01:11 and 00:02:32 respectively.

	Stethoscope Use	**Examination**
High-risk patient A	00:01:11	00:03:09
High-risk patient B	00:02:32	00:04:23
Average of other patients	00:01:06	00:01:51

Table 2: Examinations and stethoscope use in High risk patient consultations (Kraal and Popovic, 2009)

As table 2 shows, it is not possible to say that the doctors use a stethoscope for a significantly longer period of time during a “high risk” consultation than a “normal” consultation. However, it seems that the physical examination itself lasts for noticeably longer in the “high risk” cases than in the average of the other cases observed.

As these results have demonstrated, the interaction between doctor and patient is mediated by the doctor’s need to complete the paperwork that provides the record of the consultation and the advice to the doctor who will actually anaesthetise the patient. The stethoscope plays an important but subsidiary role in the consultation.

While the medical record always has a strong role in the consultation the stethoscope acts as a tool that is brought into use by the doctor as needed. Patients who are generally healthy receive a brief auscultation. Patients who are infirm or who have potentially dangerous existing conditions receive a similar length auscultation but a longer physical examination. The similar length of auscultation suggests that the skill of auscultation is in the interpretation of the sounds from the stethoscope and that very similar techniques are used to obtain the required sounds, regardless of the patient. The observations have shown that the doctors are able to use their stethoscope as it suits them and they use it with great fluidity, demonstrating great expertise. The fluid, natural, way that the doctors use the stethoscope and the subsidiary role it plays in a consultation has several implications for the design of a telehealth stethoscope.

Implications for the Design of a Telehealth Stethoscope

The results of this study, and our previous analysis (Kraal and Popovic, 2009), suggest that a good telehealth stethoscope will have two inter-linked properties. First, a telehealth stethoscope must be a good stethoscope and second, it must be as similar to an existing acoustic stethoscope as possible.

The first criterion, that a telehealth stethoscope be a good stethoscope, means that it must transmit sound from the patient’s chest to the doctor’s ears accurately. It is difficult to acquire the skill listen to the subtle sounds of the heart and lungs and doctors learn to expect to hear those sounds in particular ways. The second criterion, that a telehealth stethoscope be very similar to an acoustic stethoscope, means that the method of interaction with the telehealth stethoscope should fit with a doctor’s existing experience with stethoscopes. A telehealth stethoscope should therefore look and feel similar to existing acoustic stethoscopes.

Different Stethoscopes Sound Different

The first implication arises because all stethoscopes have slightly different frequency response -- that is, they sound different. Callahan, Waugh and Matthew (2007) have shown that the sound reproduction of acoustic stethoscopes differs markedly and that accurate sound reproduction is not correlated with price. Dolan, Oliver and Maurer (2002) tested one acoustic and two digital stethoscopes and also found that each had a different frequency response.

As doctors tend to acquire a stethoscope and use it for several years it can be assumed that they become familiar with the way their stethoscope sounds. This familiarity makes up a significant part of a doctors expertise in auscultation. A telehealth stethoscope will almost certainly sound different from a doctor’s own. It is unclear whether differences between stethoscopes result in less accurate diagnoses by doctors or even if the differences, while measurable, cause the doctors difficulties.

There seems to be no remedy to this problem. A telehealth stethoscope will necessarily sound different to any other stethoscope and as it seems there is no accepted or documented standard for what a stethoscope should sound like. Doctors will have to use the telehealth stethoscope in order to acquire expertise with it. However, even if it is carefully designed, it will be harder to acquire expertise with a telehealth stethoscope because it will be as much a system as it is an artefact.

Telehealth Stethoscopes are both Systems and Artefacts

An acoustic stethoscope, of the sort that the doctors we have observed use in consultations, is a relatively simple artefact consisting of a “head” comprised of a simple diaphragm that transmits sounds from the patient’s chest to the doctors ears through a few lengths of tubing. The addition of a “bell” to complement the diaphragm, as the bell and diaphragm are able to transmit different types of sounds, is often the most complexity seen on a typical stethoscope. Various types of digital stethoscope also exist and these are usually variations on acoustic models usually with some type of amplifier and volume control available on the main tube of the device. Both acoustic-analogue and digital types of personal stethoscope are largely self-contained – that is they can be engaged with as artefacts. However, a telehealth stethoscope will be both a system and an artefact and this duality could be problematic, particularly with regard to the research findings presented in this paper.

The most relevant finding is that the interaction between doctor and patient is mediated by the administrative aspects of the consultation and not by the stethoscope. That the stethoscope can play a subsidiary role reveals that the doctor and patient treat it as infrastructure. Star (2002) describes infrastructure as that which is "part of the background for other kinds of work" (Star, 2002, pg 116). The stethoscope acts as infrastructure because it aids the doctor in their work of completing the administrative actions that are the reason for the consultation. However, the stethoscope can only act as infrastructure because the doctor is able to use it so easily. The relationship that the doctor has with the stethoscope is what makes it act as infrastructure. If that relationship were broken or changed in some way, the stethoscope would cease to act as infrastructure and would become a thing to deal with in and of itself. A telehealth stethoscope must therefore be able to operate as infrastructure, allowing the doctor and patient to interact for the consultation and largely ignore the stethoscope.

Ignoring a telehealth stethoscope will be more difficult as it will be a system of physical artefacts and software. All elements of the telehealth stethoscope must work correctly to allow a doctor to treat it as a stethoscope. In order that an acoustic stethoscope functions correctly it must simply be in good repair with no cracks in the tubing and a diaphragm that is intact. In a face-to-face consultation (figure 5), auscultation is mediated by a very simple artefact. In contrast, a telehealth stethoscope places a large number of artefacts and systems between the doctor and patient and also requires new relationships between people in order for auscultation to be performed.

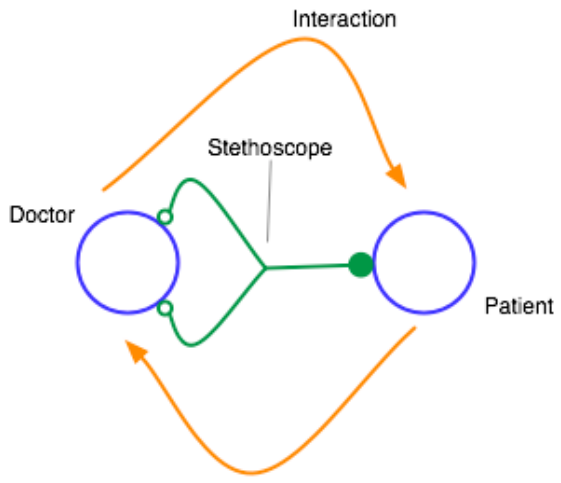


Figure 5: Face-to-face auscultation interaction

Figure 6 shows the mediations and interactions required for successful telehealth auscultation (teleauscultation). There are three participants in the teleauscultation shown, the doctor, the patient and the nurse. The nurse places the head of the digital stethoscope on the patient and has earpieces to listen to the patient's chest. The digital stethoscope is also connected to the telehealth infrastructure to transmit the patient's heart sounds to doctor. The doctor has earpieces that allow them to hear the patients sounds transmitted over the telehealth infrastructure. The doctor and the nurse must work collaboratively to listen to the sounds of the patient's chest. The additional interaction between doctor and nurse and the collaboration that is required to obtain good chest sounds is not currently taught to doctors or nurses and is something that will have to be learned in order to make a telehealth stethoscope useful. The collaborative work of using a telehealth stethoscope will need to become part of the infrastructure of the system in order to make the system work.

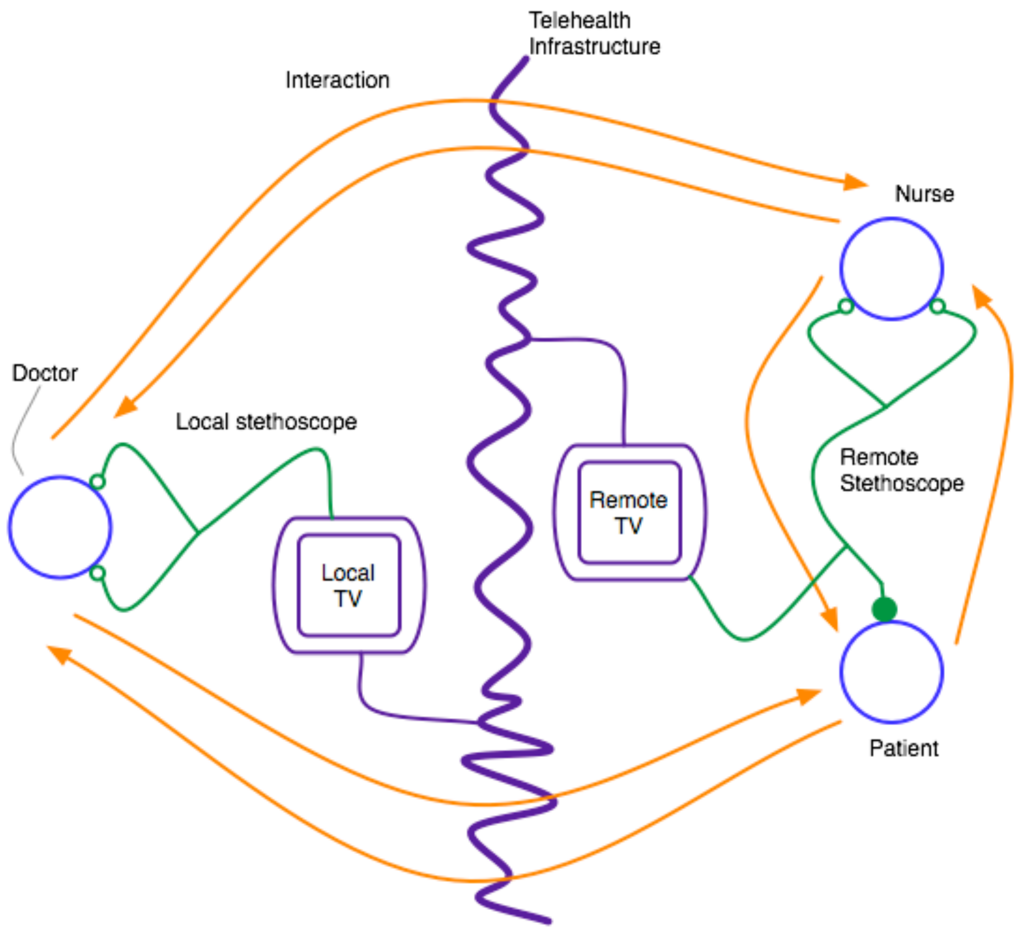


Figure 6: Telehealth auscultation interaction

Previous studies have shown that teleauscultation can be successful (Belmont and Mattioli, 2003; Fragasso et al, 2007; Wong et al, 2004). This research we have conducted has found that acoustic stethoscopes act as infrastructure in face-to-face consultations. The complexity of a telehealth stethoscope makes it more difficult to be used as infrastructure. The implication for design of this analysis is that designing the artefact of a telehealth stethoscope is not sufficient, what must be designed is the system that makes the use of the artefact possible.

In the context of our research, some elements of the system for teleauscultation already exist. The telehealth infrastructure is already in place. The findings described above suggest that the elements of the system that perform as stethoscopes should resemble stethoscopes. What must be designed is the interaction between the human actors in the system and the coherent functioning of the system as a whole.

Conclusions

The goal of this paper has been to examine how existing preadmission consultations are conducted, with a focus on how stethoscopes are used during such consultations. Analysis of the activity of doctors and patients during consultations showed that the majority of time during consultations is spent on administration and communication and that the physical examination of the patient is a minor aspect. We argued that the brief use of stethoscopes in preadmission consultations shows that doctors treat them as infrastructure, that is, as an artefact that allows work to be performed, rather than a site of work itself. We have then argued that if stethoscopes are infrastructure then that has implications for the design of telehealth stethoscopes.

The two implications for the design of future telehealth stethoscopes are related. First, a telehealth stethoscope will be a shared artefact, not a personal one. All acoustic stethoscopes reproduce the sounds of the chest slightly differently and doctors learn to interpret those sounds through their personal stethoscopes. A telehealth stethoscope will sound different to a doctor's own stethoscope and this may have an impact on their diagnostic and interpretative ability. Second, using a telehealth stethoscope will be much more complex than using an acoustic stethoscope because of the systems that must be created and sustained in order for a telehealth stethoscope to function. While some systems, such as the telehealth infrastructure, exist already, other systems and social protocols, such as how doctors, nurses and patients will interact, are yet to be created.

The conclusion of this work is that the design of a telehealth stethoscope must encompass the design of the artefact itself and the design of the systems that will make a telehealth stethoscope possible. Some of those systems exist already and will need to be appropriated into the design of the telehealth stethoscope. Others, such as the system that will allow accurate transmission of chest sounds, are yet to be created. And some aspects of the system that will make a telehealth stethoscope useful, such as the methods of interaction between doctor, nurse and patient, can be suggested but never truly designed.

These preliminary findings are significant because they provide new knowledge about the factors influencing the adoption of telehealth stethoscopes for remote patient assessment. If the systems that will support the use of a telehealth stethoscope are not adequate, then the telehealth stethoscope will not be able to be used. These findings allow a deeper understanding of what a successful tool will encompass and will ultimately lead to the production of an advanced telehealth stethoscope that will enhance the ability of doctors and nurses to conduct remote auscultation assessments.

Through careful analysis of current interactions we have been able to identify aspects of the new situation that must be carefully considered in a new design. This approach is adaptable to many situations and can contribute to the design of innovative systems and artefacts that can be readily inserted into complex situations. Our approach deals with important problems that are shared by significant application domains in rural health care. The new methods and techniques we are developing contribute to new knowledge within the domain of telehealth but also apply to other areas where the introduction of innovative tools must be studied. These methods and techniques are themselves new and contribute to the body of knowledge on conducting design research.

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