

Quality Attributes in Telemedicine Video Conferencing

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Abstract

Video conferencing is used increasingly in many telemedicine applications, including medical personnel education, peer consultation, patient education, and direct patient care. Advances in technology and changes in medical care delivery have enhanced the ability to develop effective telemedicine video conferencing systems. Measures of effectiveness for technology systems rely on identified requirements for system quality. In this research, we propose a comprehensive model of quality attributes for telemedicine video conferencing systems. The quality attribute model is developed from an extensive literature review, direct observations of telemedicine encounters, and structured interviews with telemedicine experts. The model contains four quality attribute groups: Technical, Usability, Physical Environment, and Human Element. Interview citations are used to justify the importance of these individual quality attributes. Both researchers and practitioners can make use of the model to understand, design, and evaluate telemedicine video conferencing systems.

1. Telemedicine Video Conferencing

As an integral component of telehealth, high bandwidth video conferencing is used in medical personnel education, peer consultation, patient education, as well as direct patient care. Telemedicine video conferencing has experienced rapid growth in the last five years primarily due to advances in technology (e.g., increased bandwidth; new cameras, monitors, and coder/decoders (CODECs)) and changes in the medical care environment (e.g., increased outpatient care, remote surgeries) [5].

From a patient care perspective, medical video conferencing patient consultations are now frequently used in the domains of dermatology, cardiology, wound care, neurology, drug screening, diabetic training, and psychiatry. High bandwidth video conferencing is necessary for many medical exams requiring invasive procedures (e.g., telesurgery), real-time motion-detection (e.g., cardiac monitoring, ultrasonography), and real-time specimen analysis (e.g., scan and pan pathology). There

is widespread interest in utilizing this technology, as an economical method to provide expert medical service to patients in remote or awkward locations, like prison systems. However, in spite of increasing use and interest in video conferencing, generalized standards of quality that encompass the patient consultation experience have not emerged.

Standards exist for health care in the form of legislative and regulatory pronouncements (e.g., Joint Accreditation of Healthcare Organizations), for telecommunication and information systems (e.g., International Multimedia Telecommunications Consortium, Inc. – ITU-T sector standards for multimedia teleconferencing, T.120, H.320, H.323, and H.324), and for general systems quality (e.g., International Standards Organization 9000:2000). Such standards provide a relevant foundation for quality requirements in the telemedicine field. However, these guidelines do not provide sufficient detail to facilitate the actual evaluation of a telemedicine system as an antecedent to patient outcome assessment. Nor do they provide an integrated model for the utilization of videoconferencing in telemedicine which can be used to develop a quality management program and assess gaps. Lastly, they do not provide the constructs necessary for researchers to methodically study medical video conferencing quality and to develop associated research tools. This void is recognized by telemedicine researchers who encourage the prospective, as well as retrospective, analysis of telemedicine by exploring such issues as: what variables should be measured and what factors have constrained or limited telemedicine success [18].

2. Quality Attributes in Telemedicine

Quality attributes are vital in system development because they establish requirements criteria that guide subsequent design, implementation, and testing activities [2]. System quality has long been recognized as a critical component of system success [6]. Quality is a multi-dimensional construct that does not contain a universal set of attributes, but instead is domain specific.

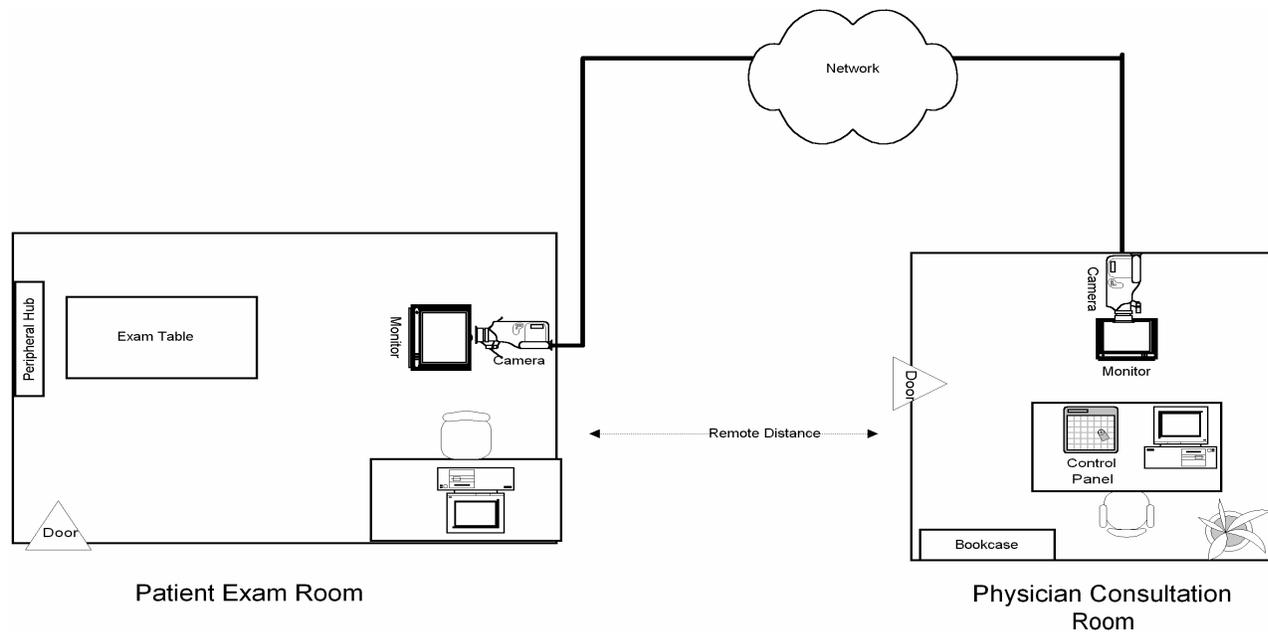


Figure 1: Medical Video Conferencing Equipment

In revisiting their seminal work on information system success, DeLone and McLean [6] urge researchers to pay careful attention to context in defining and measuring each component of success (system quality, information quality, service quality, system use, user satisfaction, and net benefits) and assessing inter-relationships between success constructs. Research also indicates that users prefer to tailor success constructs and measures to the type of system under evaluation to facilitate understanding and application [12]. Therefore, decomposition of a multi-dimensional construct, like system quality, under the auspice of domain characteristics and boundaries will provide a high degree of relevance and understanding to researchers and practitioners.

A taxonomy of telemedicine system quality provides researchers and practitioners with a connecting framework to facilitate system success by considering the extent, nature, and appropriateness for quality attribute levels in each situation of use. Without an understanding of system quality in the telemedicine environment, the potential for successful implementation of telemedicine systems is diminished.

The purpose of our research is to propose a taxonomy of telemedicine system quality for direct patient care using high bandwidth video conferencing (hereafter referred to as medical video conferencing). Figure 1 provides a view of the environment of medical video conferencing used in this study. Of all the uses of medical video conferencing mentioned (e.g., education and peer consultation), the use of video conferencing for direct medical care requires the highest degree of video conferencing quality, given its direct and immediate

impact on patient care.

Quality attribute models facilitate research by providing construct perspective, common terminology, and understanding of quality variables involved in a phenomenon. From a practitioner perspective, comprehensive knowledge of the characteristics of any system is essential to its implementation and utilization.

Unlike other forms of information systems and technology, in health informatics the patient is the icon that underpins each dimension of success and justifies each decision [1]. In reference to medical videoconferencing, a national telemedicine policy maker participating in this study stated:

“Start with the patient, what the clinical situation is...one of the reasons why projects fail to survive is they end up dealing exclusively with the technology. In my opinion, the technology is purely a conduit towards being able to do a clinical consultation. The projects that do start with the technology seem to fail. The ones that start with the patient, the clinical need of the patient, and then they fit the appropriate technology the clinical need of the patients seem to do well.”

Deploying systems in the health care setting involves multiple stakeholders from both the clinical and managerial perspective working towards the maintenance and improvement of human life. The pluralistic effort required to fulfill this objective demarcates health informatics as a discipline that necessarily integrates both social/human and scientific/technical factors for study [1, 13]. Integrating human and environmental elements introduces complexity into an information systems paradigm that is still dominated by data driven methodologies, tools, and techniques that produce technical solutions to

organizational problems and acknowledge humans (via user reference) in techno centric terms [1]. Despite the complexity associated with inclusion, studies supporting human factors can be a major factor in IS success and should not be ignored [3, 8, 11, 15]. In response to this issue, we adopt a socio-technical perspective in presenting a taxonomy of medical video conferencing quality. We enumerate attributes from the perspective of medical professionals using telemedicine for direct patient care.

Our goal is to facilitate understanding and management of the comprehensive set of quality attributes affecting direct patient care in the context of medical video conferencing encounters. We keep this model at the level of patient encounter use and do not directly expose policy, legislative, or other organizational level social influences.

3. Research Design and Quality Attribute Model Development

We draw upon three sources for the development of a quality attributes model: a literature review, direct observations, and interviews with telemedicine experts.

3.1 Literature Review

The preliminary model for this research was developed by identifying quality attributes and existing standards for medical video conferencing mentioned in the telemedicine, information systems quality, and software engineering literatures. Review of the abstracts in the Telemedicine Bibliographic Database (<http://tic.telemed.org/bibliographic.asp#search>) pertaining to quality (approximately 450 abstracts were retrieved by a search on the key word "quality" in the text of the article) did not provide a clear definition for telemedicine system quality. Most abstracts that mentioned quality were case studies typically constrained to one medical discipline.

Using insights developed from reviewing telemedicine literature, we then consulted information systems (e.g., [10]) and software engineering (e.g., [2]) quality literature. Quality attributes found relevant to telemedicine were initially organized into three categories – technology, usability, and physical environment – with multiple quality attributes under each category.

3.2 Direct Observation and Expert Interviews

We directly observed, for over 32 hours, telemedicine video conferencing rooms and segments of video conference sessions for representations of quality attributes and issues. We also captured video and photographic images of the observations for further analysis. The results of these observations further refined the initial quality attributes model.

For a richer understanding of medical video conferencing, nine telemedicine experts were interviewed. Our experts included the following telemedicine roles:

- Telemedicine coordinator – responsible for the selection of equipment, installation, scheduling encounters, and operations of the telemedicine system.
- Telemedicine administrator – responsible for the design of telemedicine policies and procedures.
- Telemedicine researcher – responsible for collecting data and analyzing the use of telemedicine systems.
- Video conferencing vendor, specializing in telemedicine – responsible for technical aspects of equipment selection, implementation, maintenance, support, and telecommunication coordination.
- Video conferencing technician – engineer responsible for operating and maintaining telemedicine systems.
- Telemedicine educator – responsible for training telemedicine users and stakeholders.
- Telemedicine users – doctors and nurses responsible for direct patient care and patient orientation involving medical video conferencing.

All interviews were reflexive and exploratory in order to solicit high quality information and not restrict the breadth of information expressed by the individuals. The evolving quality attribute model served as the basis for the interview questions. All experts were asked the following questions:

- What technology attributes/characteristics are necessary for medical video conferencing system quality?
- What usability attributes are necessary for medical video conferencing system quality?
- What attributes are necessary in the physical environment for medical video conferencing system quality?

Responses to these questions guided the remaining interviews. Participants were probed for further explanations, examples, and applications regarding individual attributes mentioned. Given the varying backgrounds of the subjects, the specific language used to elicit details had to be customized to best match the subject's perspective. Interviews lasted from 30 to 70

minutes. All interviews were taped and later transcribed. We coded the interview transcripts to reveal the various quality attributes expressed by the informants.

4. Model of Telemedicine Quality Attributes

Analyses of interview transcripts and direct observations led to the quality attributes model shown in Figure 2. Each of the attributes is supported by a chain of evidence gathered in the interviews, observations, and reassessment of pertinent literature. The initial model was expanded to include a new human element group. This section discusses each of the quality attributes and provides a trail of evidence via interview quotes.

4.1 Technology Attributes

Technology quality attributes are those features of medical video conferencing equipment and telecommunication processes utilized for medical video conferencing encounters. The level of technology quality of the specific equipment deployed is application dependent. As stated by one participant, *“when someone is doing mission critical telemedicine applications, they’re buying high end products...high resolution cameras, high resolution monitors, full T1 pipes...they’re not cutting costs.”*

Motion Handling: Most participants identified motion handling as a key technology attribute. Video conferencing is typically conducted at 30 frames per second (i.e., television standard). As explained by one of the participants, *“frames per second affect the flow of the image (amount of jerkiness).”* Though the frames per second are important, low image precision (pixelization) and blurring may present greater challenges. If constant motion exists, a coder/decoder (CODEC) is in a constant process of refreshing the image.

Greater bandwidths and powerful CODECs reduce pixelization, motion artifacts, and frame dropping, which negatively affect video quality. Experts recommend hardware CODECs for a faster and cleaner image. Increased motion handling quality also minimizes “mosquitoing”, which are the blurring effects along the perimeters of high contrast areas (e.g., a person’s silhouette as compared to the wall). Mosquitoing results when *“the CODEC is trying to blend pixels in the high contrast areas to prevent jagged edges.”*

The importance of motion handling is of greatest significance when viewing rapid movement, like a fetal heart beat or an angiogram of an adult heart [14], both of which would prove to be challenging at lower (128 kbps) transmission speeds. A participant provided the following example in reference to a neurological exam:

“During those times it is a little tougher to distinguish

the tremor and to distinguish reflexes which is something that is pretty key for me. Visually you are losing the ability to see a reflex which is a very small amplitude in movement and also you lose some sense of the tremor which is also another small amplitude of movement.”

Image Resolution: Resolution quality refers to image representation using a storage bit rate capacity that affords the best possible fidelity [4]. In medical video conferencing, image resolution quality is determined by the resolution of the camera receiving the image and the monitor projecting the image. Hand-held specialized cameras used to zoom in on conditions such as skin lesions have the higher chip sets, which increase video quality. Resolution quality requirements may vary across specific patient conditions and medical specialties as represented by the following quote:

“You have to be able to see the variability and the colors have to be true, and the elevations of the surface that you’re looking at have to be apparent to you. And so the detail of vision in dermatology or in wound care would be far different from a slight loss of definition in detail if you’re doing a face-to-face interview in a mental health encounter.”

Audio Clarity: Sound levels from each person should be as close to the natural audio level as possible [17]. A high quality standard would mandate no loss of words or breakup, a high signal to noise ratio, and no feedback. Squibb [17] recommends separate microphones for each person in a room. Other microphone recommendations provided by our experts include using condenser microphones and boundary microphones. Speakers are also important to audio clarity. Speakers should have an adequate frequency range to promote a clear signal. Higher levels of audio clarity are required with specialized equipment like electronic stethoscopes:

“You want to be able to hear the right thing at the right time. ‘ You don’t want to have questions like “Is that the (heart) murmur of the patient or was that a hiccup in the communication line?’ We want to be sure we are receiving exactly what was sent.”

Synchronization: Premium quality systems deliver synchronized audio and video in real time. Our experts linked delay and lack of synchronization to disruptions in quality patient care:

“It is very distracting to people who are not used to this to have long delays between the time they finish talking, you see the patient waiting until the end of the time, so that the video and audio speed of transmission ought to be as close as possible. I understand that’s more expensive but, in my mind, if you’re doing an encounter, particularly for example in mental health, or in wound care, it is absolutely critical that the power of the transmission be such that the audio and visual are very closely synchronized.”

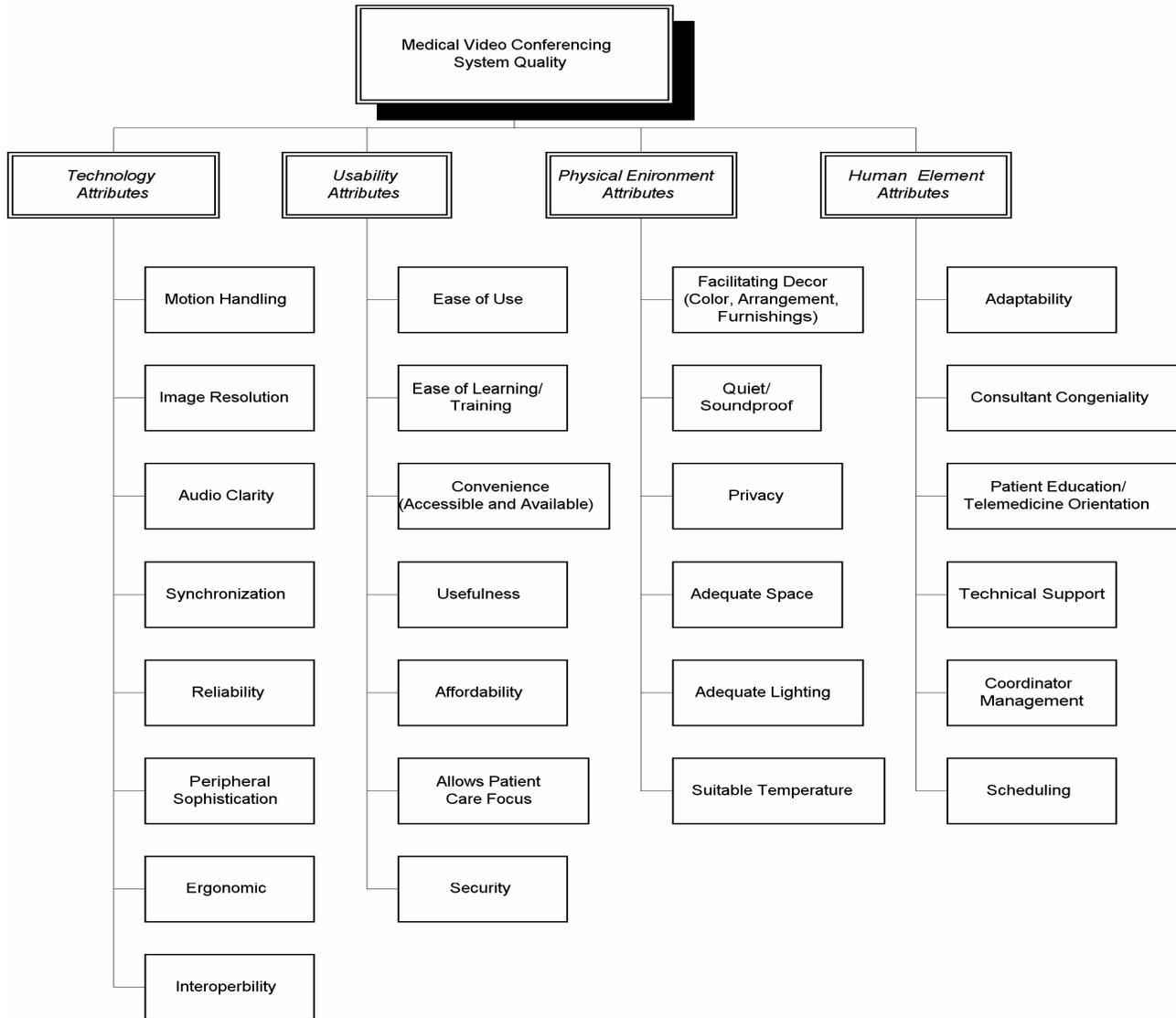


Figure 2: Medical Video Conferencing Quality Attributes

Reliability: Telemedicine equipment must consistently function as designed. A lack of reliability can negatively impact telemedicine use and acceptance. Not only does poor reliability impact the specific encounter in which it occurs, but it also leaves a long lasting impression on both the patient and the physician, reducing acceptance of the technology by both parties.

“When we have patients ready on the table and we are prepared, we have a surgeon gowned and gloved and then we have some problem with our T-1 line, it becomes not only very frustrating but it impairs and impacts patient care.”

Peripheral Sophistication: Peripheral sophistication refers to technology that allows adaptation and extension of basic medical video conferencing equipment to various medical situations. Peripheral devices (e.g.,

electronic stethoscope, dermatology camera, retinal camera, electronic electrocardiogram, etc.) enhance medical capabilities and introduce the sophistication required to expand the complexity and types of exams that can be performed. Most equipment can accept numerous peripherals.

“Peripherals are needed to suit the telemedicine application. A hand-held general exam camera may be a peripheral that adequately serves a multitude of purposes without having to buy each individual scope. However, the precision required for a specified purpose may dictate that a more sophisticated peripheral is needed.”

These devices may also facilitate time efficiency. For example, in reference to a microscope device one participant comments:

"It saves the time from having to take the slide, snap a picture of it, and ...e-mailing. Or otherwise sending a specimen to the doctor."

Ergonomic: To promote quality, medical video conferencing equipment should be ergonomic (mobile and efficient design) [18]. To facilitate exams of the human body, medical professionals need to be able to easily maneuver the equipment. Experts indicated that present equipment is cumbersome: *"Some of the equipment is quite bulky. It's heavy to roll around if you need to move it."*

Most exam rooms are small and this seems to exacerbate the problem. One participant recommends that users should move away from equipment that has to be transported from room to room; instead, users should investigate pre-wiring rooms, using touch panels for navigation, and using a simple wall jack for peripherals.

The following quotes relate to another ergonomic property, efficient design:

"Cameras and scopes should fit into one hand and you should be able to control the camera options (zoom, freeze and position) with your four fingers on top of the camera."

"You should not have to look through an eyepiece to see where you are moving the camera, the view on the screen should be your eyepiece."

Interoperability: Interoperability quality refers to equipment as well as to telecommunication connections. Experts emphasize that all of the medical video conferencing components (e.g., monitors, cameras, network CODECs) need to work together. They hope that stronger telecommunication standards may facilitate interoperability.

4.2 Usability Attributes

The usability quality attributes address operational characteristics users experience with medical video conferencing technology. Usability attributes may have great impact on the extent to which technology is used, accepted, and understood.

Ease of Use: Ease of use supports quality by providing an intuitive and friendly interface that facilitates end-user effectiveness in operating equipment. In reference to ease of use, the experts acknowledge that clinicians and physicians vary in their level of proficiency with computers and video equipment. They feel that a quality system should be operable by all user levels. However, one participant states that *"everybody is intimidated until they are trained on how to use it"* and recommends that ease of use be judged post-training. The desired system features to facilitate ease of use include:

- Auto focus cameras and scopes
- Intuitive software
- Remote control devices that facilitate responsive and precise equipment navigation

- Transparent connections
- Autonomy in operation (minimal requirements for technical assistance to operate equipment)

Ease of Learning/ Training: *"If you are looking to change the way healthcare is being delivered there has to be a trained workforce to be able to do it,"* comments one participant. They reference training for the spectrum of stakeholders – administrators, clinicians, and technicians - for their particular task and cross training, to a lesser degree, for awareness.

After initial training session users should be able to operate equipment and understand the functions to perform in the different clinical exams. However, participants also emphasize the importance of practice for training transfer and maintenance of skills:

"If you practice (telemedicine procedures) for a week, I think you will be able to learn them. However, you need to 'be able to go back...on it many, many times after that.' Training also involves practice."

Regarding the scope of training and performance improvement, participants mention the importance of:

- Self-education
- Job aids (labeling equipment)
- Patient presentation
- Supplementing camera views of a patient's body with verbal descriptions of location
- Verbal commands regarding equipment to clinicians
- Patient interaction training

Additionally, communicating overall purpose and perspective is mentioned as an important aspect of training:

"Invoking training and core rationale for why we are adopting this technology is important. So not only do they get the technical training, the hands-on training, they get an overall organizational perspective as to why this technology is being adopted, and why is it critical, and what we do on a daily basis."

Convenience (Accessibility and Availability): Convenience encompasses appropriate equipment placement, easily accessed medical devices, and an easily accessed locale. To quote one doctor:

"The physician should know in advance that he's going to conduct a (medical video conferencing) clinic. There may be several patients from several different sites. So that he can stay in one place and do his evaluations, have available the equipment that he needs, the computerized record system at his fingertips, and be able to sit there while the camera moves from patient to patient."

Other participants made remarks that equipment should be in a "ready to use" state so that the physician or medical staff member has minimal software interaction and equipment placement adjustments before beginning the encounter.

Usefulness: Usefulness is described as the degree to which telemedicine devices function as intended and

contribute to patient care in a clinical environment. The equipment provides a direct link to promote real time exams of patients and should become *“another tool in the medical bag that can provide remote care”*. An expert adds that usefulness also relates to the provider and patient relationship, *“did both parties feel an emotional level of satisfaction with the encounter?”* Both parties will walk away with a *“feeling of success.”*

Security: Panel members include security as a quality attribute with reference to access (who can use) and location (to prevent equipment damage). In referring to access, one panel member states that appropriate access should not be taken lightly as it has medical, legal, and cost implications when people do unauthorized medical video conferencing. Research indicates security should also be considered during a consultation (transmission security) and post-consultation (electronic storage security) [18]. As a security measure, medical providers are advised to obtain informed consent from patients before any teleconsultations that are recorded and stored as part of the patient medical record.

Affordability: Though perhaps not intuitively thought of as a quality attribute, experts regard affordability as a quality attribute. Participants reference affordability in terms of equipment costs, transmission costs, and patient reimbursement. Affordability is a realistic constraint and goal that affects a system’s usability. To quote a few of the panel members:

“Why a number of telemedicine projects fail to survive, is that they are projects, and in the end they either have to raise the quality of the clinical care to live, or they have to lower costs. If you end up using the ideal sometimes and you go to very high-end applications then you could end up costing the service out of your ability to be sustainable.”

The overall message regarding costs seems to be that quality must be affordable to be implemented and medical video conferencing deployment should adapt to budget realities.

Focus on Patient Care: Technology should not get in the way of either the provider (e.g., doctor) or the consumer (e.g., patient). The medical care provider should be able to focus on patient care, rather than figuring out technology. One participant describes an awkward situation:

“If you could have less of a need to be looking at what you are doing with your hands while you are interacting with the screen... Currently, I have to manipulate the tablet and poke on arrows to try and get the camera down where I want it which means that I’ve got to disassociate eye contact from the screen.”

4.3 Physical Environment Attributes

The physical environment quality attributes address conditions in medical video conferencing surroundings (both the patient exam room and the physician consultation room). Physical environment quality

attributes may differ between the patient exam room and the physician consultation room. The discussion below refers to the patient exam room, unless otherwise stated.

Facilitating Décor (Color, Arrangement, Furnishings): Décor that facilitates comfort, exam room navigation, and video precision can enrich quality. This can include color, arrangement and type of furnishings [9]. From the perspective of visual clarity, participants mention color as a décor feature that could impact diagnosis:

“The worse thing you can do is use any strong colors in the environment because colors ‘spill’ back onto the skin.” You do not want any change in hue on the patient. Color shifts may change diagnosis if the physician is examining a wound, for example. You want to stay with neutral hues (earth colors) in medium tones versus ‘real bright colors’ or ‘real dark colors’.”

Participants mentioned using “white cards” or color wheels to test for color accuracy.

Surface material may also affect visual quality. During direct observation, one researcher notes that metal furnishings and equipment produce a blurred “halo” rather than a precise image with clear pixels. Given that medical equipment and instruments are often metal-based, this condition may require situational consideration.

With regard to arrangement, navigation is enhanced when equipment cabling and wiring are not strewn about like *“spaghetti.”* A panel member also suggests that equipment have a designated space and not require major repositioning for use.

Medical conferencing may require that a physician be stationary for an extended period of time as they virtually move from exam to exam. Panel members acknowledge this and recommend that the physician consultation room be furnished with comfortable seating, a table for writing, and a computer for medical documentation.

Panel members also state that décor should emulate a natural setting in a face-to-face environment (particularly in the physician consulting room). For example, one expert explains, if a consultation would normally take place in a physician’s office,

“There should be a desk, or a bookcase with some books in it, or perhaps some diplomas on the wall behind the physician. So that it has the feeling of a physician’s office.”

Quiet/Soundproof: Both the patient exam room and physician consulting room should provide the proper acoustical environment for optimal sound to improve both audio clarity and privacy. Participants should be able to participate attentively without noise distraction. Conversely, conversations within the rooms at normal tones of voice should not be audible outside of the rooms. To facilitate soundproofing, some facilities avoid rooms with windows or use heavy curtains, utilize acoustical tiles, equip rooms with heavy doors, and use sound soak or acoustical blankets.

Privacy: Quality from the perspective of privacy means that neither the exam room nor physician consulting room is available to walk-in intrusion or is accessible visually or audibly to walk-by traffic.

"You want to ensure privacy on the patient side so that any anxiety regarding disrobing or the discussion of emotional issues is not escalated."

Privacy is also mentioned in reference to the undesirability of having technicians on site to operate equipment:

"You want to be able to be in this encounter just with you and just with the patient, and not to have to have a third party involved. Often, medical problems are of such a sensitive nature that one or the other of the participants is going to be uncomfortable if there's someone just out of camera range, but obviously there. So I think that it's important that the technician can set it up and after that, the people involved in the encounter have nothing much else to do except focus on what they're there for and each other."

Adequate Space: Adequate space and room size is dependent upon the function of the exam, patient comfort, and the equipment in the room. This dependency does not mitigate the importance of this attribute in considering quality. A rectangular room may be favored over a square room as a rectangular room allows the physician to adjust the depth of space as needed. To quote one panel member:

"The room size is actually quite important. The room size should be large enough to properly accommodate the equipment, camera angles, and the type of exam. For example, additional space is necessary to properly capture a range of motion on video. However, the exam room should be small enough that the patient does not feel an extreme lack of intimacy with the encounter."

Adequate Lighting: Providing the proper amount of light to examine the patient and also to illuminate the physician is important to a successful encounter. When a physician is examining a patient:

"... there needs to be a soft-filling light, so that there is no hidden areas of dark contrast."

Angled fluorescent lighting may provide the side lighting needed to augment overhead lighting and to avoid dark contrast and shadows. Cool lighting may provide better illumination than warm lighting. An expert also adds that different clinical exams might require specialized lighting to best demonstrate the medical conditions.

Suitable Temperature: Room temperature should suit both the equipment and patient comfort to provide a quality setting. Some medical video conferencing equipment produces heat. Without ventilation and air conditioning, the equipment life expectancy will be compromised. Suitable comfort levels of temperature for the equipment may be in conflict with patient comfort levels however. As such, panel members recommend adjusting temperatures to patient comfort levels only

during the actual performance of patient exams.

4.4 Human Element Attributes

Human elements address interactions among physicians, patients, other stakeholders, and the telemedicine system in preparation for and during the exam. It became quickly evident as we constructed the quality attributes model that human elements were a rich area with multiple underlying attributes, that merited a separate category rather than aggregation as one or more attributes under usability.

Adaptability: Medical video conferencing capabilities will vary. Variations do not preclude the delivery of medical video conferencing, but may require physicians to adapt or modify the extent or nature of their services to provide maximum effectiveness. Thus, adaptability refers to a willingness to adjust procedural processes to the medical video conferencing situation:

"You do exams in a little bit different way... you have to learn how to think before the exam how you are going to structure it because you want it to flow and its got to be just a little bit different than with the standard medical exam is just because of the fact that you are not in the room with the patient... We did a couple of dry runs so that we can see what we could see over the TV versus what we couldn't see over the TV."

Consultant Congeniality: To achieve high quality, the consultant and medical staff should strive for "telepresence".

"You know, to me it was cold, physically cold and cold from an interaction perspective. You just didn't have that personal touch... there was the technician, there was the patient, and it was matter-of-factly done."

Panel members provide indications that "interaction coldness" can be overcome or at least managed in a medical video conferencing setting:

"You have to learn how to interact with the patients in a different way; I think that there is a way to interact over the TV that makes people feel at ease... You have to make the patient feel comfortable, not let him be intimidated. They are already intimidated by seeing a doctor. You have to smile at them, acknowledge that the TV is there, and perhaps say something to make the patient feel at ease and then you can do your exam."

Panel members indicate that camera placement facilitates telepresence. The objective is to position the camera in the consulting room to create the image of virtual "eye contact" and patient focus. Experts recommend placing the camera at least three feet from the consultant to achieve this virtual contact.

Patient Education/ Telemedicine Orientation: Patient education/orientation supplements quality by facilitating patient comfort and understanding. An informant describes this quality issue and recommends addressing it as follows:

"Patients need education. And see, the thing about

telemedicine is that, at least in the states where I've looked at it, telemedicine is really targeted at rural areas. That population of people by and large is not educated health-care consumers. You want to have some introductory material there so you can hand (it) out ...in very readable terms... Have someone sit there and explain before you just go into the encounter and say, okay, these are the things that will happen, here's the technology, here's how it works."

Technical Support: Technical support provides the function of offloading technical issues from the physician and medical staff. The level of facilitation may include: proactive pre-exam activities, like equipment checking and "refresher" training, active participation, such as assisting with the operation of peripheral devices during the exam - as well as reactive trouble shooting.

To ensure quality, technical support has to be readily accessible, as exemplified by the following quotes:

"Technical support personnel can not adopt an "I'll get to it" attitude...this is medicine now, so you have to get to it right away as far as response time and maintaining control of the telemedicine system."

Coordinator Management: In essence, coordinators provide quality by serving as the catalysts in the implementation and diffusion of telemedicine practices. A medical video conferencing coordinator is an equipment specialist or medical media person who has a thorough understanding of the equipment and uses for medical practice. The coordinator manages the medical video conferencing experience and sets guidelines such as how the encounter may be terminated (assuming no potential danger to health) if either party (patient or physician) is uncomfortable with the process at any point during the examination. The coordinator may work with the physician to involve a nurse practitioner or mid-level practitioner in the exam to facilitate procedures performed in the patient exam room. Additionally, the coordinator may facilitate training or other interventions to enhance acceptance and ease with the equipment and medical video conferencing process.

"I think the clinic coordinator is the heart and soul of it all. If they don't feel comfortable, and they're not using the equipment well, the specialist will never want to do a consult with them again; the doctor will never want to refer (a telemedicine consult) because the patient feels uncomfortable that it didn't go well. You need a person with very good people skills, customer service skills. If they're not keeping the docs happy and the patients happy, well then, it's just not going to happen."

Scheduling: Medical video conferencing involves integrating the schedules of multiple stakeholders (e.g., patients, doctors, nurses, nurse practitioners, technical staff). A scheduler that effectively sets and stages the logistics can greatly influence the quality of the medical video conferencing experience.

"Well, just to put it simply, if it doesn't work

smoothly, and there are a lot of parameters to that, not only is that encounter not going to go well but you will have difficulty enticing the physician back to another encounter, or the patient back to another encounter. So it's important that everybody be there at the same time."

5. Contributions and Future Research

Applying success models (and logically, the components thereof) to empirical research requires contextual specification [16]. Broadly, we hope this effort promotes the investigation and adoption of domain-relevant quality models to a variety of IS environments and provides an exemplary process for the development of a domain-specific model. This call for specification is not a superficial one in a health care environment. The quality attribute model in Figure 2 provides an important initial step in explicating the attributes of medical teleconferencing quality in an organized fashion for future research and utilization in practice. This taxonomy highlights quality attributes (social/human as well as technical) to be considered in emergent telemedicine research frameworks. In order to further validate this model additional work is being conducted. This work includes:

- Conducting a Delphi study to take advantage of group input from our panel of experts. Through interviews, we solicited the isolated views of experts on medical video conferencing quality. Presenting the aggregate model to panel participants in the form of a survey should provide further insight regarding the relevance of each attribute included in the model, the accuracy of attribute definitions, the appropriateness of attribute classifications and the comprehensiveness of the model. Refinement processes can continue until expert panel consensus is achieved.
- Conducting focus groups with patients to discern their perspective on those aspects of medical video conferencing quality (e.g., physical environment and human elements) that they directly experience. If patients are icons in this utilization of technology, then medical staff can be thought of as expert proxies who operate equipment on behalf of patient interests. Therefore, eliciting patient insight is appropriate to model validation.
- Conducting sort procedures to assess the classification (dimensions) of model attributes. The dimensions presented in the current model were derived through interview coding procedures. Sort procedures, which allow participants to aggregate attributes, label (or classify) collections of attributes, and rank attributes as they deem appropriate, may provide further insight regarding attribute relationships and model dimensionality.

In addition to further work on the validation of the model, future research needs to focus on connecting various success factors and outcome dimensions to this

taxonomy. In a discussion of the impact of diagnostic technologies, Fineberg, Bauman, and Sosman [7] distinguish several process and outcome dimensions that might appropriately be used by telemedicine evaluators to explore the relationships between quality attributes and telemedicine success. These dimensions include:

- Diagnostic accuracy – whether a technology contributes to a correct diagnosis
- Diagnostic impact – whether a technology provides diagnostic information that is useful in making a diagnosis
- Therapeutic impact – whether a technology influences patient management or therapy
- Patient outcome – whether a technology improves patients' health and well-being

It is conceivable that various levels and dimensions of system quality could affect each of these outcome dimensions as well as other contributing success factors, such as system use and user satisfaction. Future research would include developing measurement instruments related to medical teleconferencing quality to determine the interrelationships between attributes and assess the impact of these quality attributes on the various dimensions of medical video conferencing success.

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