Context Sensitive Health Informatics and the Pandemic Boost
A. Bamgboje-Ayodele et al. (Eds.)


doi:10.3233/SHTI230365

# Identifying Failure Modes in Telemedicine: An Instructional Needs Assessment

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**Abstract.** Technology failures in telehealth are common, and clinicians need the skills to diagnose and manage them at the point of care. However, there are issues beyond technology failures mediating the effective use of telehealth. We must teach best-practice procedures for conducting telemedicine visits and include in instructional simulations commonly encountered failure modes so students can build their skills. To this end, we recruited medical students to conduct a Healthcare Failure Modes and Effects Analysis (HFMEA) to predict failures in telemedicine, their potential causes, and the consequences to develop and teach prevention strategies. Sixteen students observed telehealth appointments independently. Based on their observations, we identified four categories of failures in telemedicine: technical issues, patient safety, communication, and social and structural determinants. We proposed a normalized workflow that included management and prevention strategies. Our findings can inform the creation of new curricula.

**Keywords.** telemedicine, needs assessment, medical education, health systems engineering, quality improvement, curriculum development, patient safety

## 1. Introduction

Despite the availability of telecommunication technology prior to the pandemic, COVID-19 triggered a rapid adoption of telemedicine in ambulatory care [1]. In response, the American Association of Medical Colleges (AAMC) produced a set of six domains and 20 telehealth competencies to guide medical schools and ensure that physicians provide safe and effective virtual care [2]. For example, for “Domain V: Technology for Telehealth,” the AAMC says experienced faculty physicians (i.e., 3–5 years post-residency) should be able to: (1) “Explain the risk of technology failures and the need to respond to them…Demonstrate how to troubleshoot basic technology failures and…Teach others how to troubleshoot basic technology failures…” [2].

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Applying and assessing these telehealth competencies present challenges for clinician educators. First, the AAMC's language can be interpreted in several ways (e.g., how do we define "basic technology failures"?). Second, faculty evaluators may not have a clear reference standard for evaluation. Finally, to provide appropriate training, we must know what use cases are most important in a rapidly changing telehealth ecosystem. Since technology, workflow, and patient expectations constantly evolve, conducting an instructional needs assessment for current students and practicing clinicians is imperative.

In prior work [3], we compiled examples of telehealth technology challenges (e.g., poor connectivity, usability concerns, workflow gaps) observed in practice or based on published research [1,4] to create sample scenarios and educational simulations. Although this was a pragmatic start, we needed a more systematic way to identify technology failures and prioritize teaching topics. We did not find any studies using systems engineering or human factors tools to generate an inventory of telemedicine failure modes. Therefore, we worked with faculty and students using a participatory (i.e., human-centered) approach to identify systems failures and the recovery strategies healthcare practitioners (HCPs) use. The objective of this study was to (1) describe how we used systems engineering methods to identify telemedicine failure modes, (2) identify commonly encountered failure modes, and (3) describe strong practices and recovery strategies clinicians use that we can incorporate into future curricula.

## 2. Methods

The American military first began using Failure Mode and Effects Analysis (FMEA), a systems engineering method, in the mid-1900s to investigate product and process problems or risks (i.e., failure modes), root causes, and the consequences resulting from failures [5]. Inspired by FMEA, Healthcare Failure Mode and Effects Analysis™ (HFMEA) is an extension of FMEA. HFMEA is proactive approach to identifying vulnerabilities potentially compromising patient safety [6]. Given HFMEA's versatility as a framework for diagnosing and improving health systems, it is a valuable quality improvement method for medical students to learn [7]. Our institutional review board issued an oversight exemption for this project as educational quality improvement work.

We adapted the HFMEA by only using the preliminary components for our study: team membership, diagramming process, failure mode and causes and simplified the remaining components by focusing on preventative strategies [6]. To begin, two researchers (BL, JH) developed and piloted data collection instruments during telehealth observation sessions. Our final instruments included an observation field guide and a semi-structured interview script. We then asked visiting medical students enrolled in a virtual medical informatics elective then used the instruments while watching a telemedicine encounter. Sixteen students from 12 medical schools observed telehealth appointments independently. They used the field guide to document workflow, clinician observations, and quotes about failure modes in telemedicine. After an observation session, they used the script to interview HCPs and identify additional failure modes or solutions. Students observed a range of encounter types, including different specialties (e.g., psychiatry, family medicine, internal medicine), different states (e.g., Arkansas, California, New Mexico, Illinois, Maine), and different software (e.g., embedded tool in an electronic health record tools and, third party videoconferencing software).

## 3. Results

Students identified strong practices HCPs commonly used in telemedicine, such as reviewing patient charts before encounters or writing prescriptions, orders, and referrals during (rather than after) encounters. However, students also identified categories and examples of failure modes from which we generated predicted effects, root causes, and prevention strategies (**Table 1**).

**Table 1.** Findings from Healthcare Failure Modes & Effects Analysis.

| Failure Mode | Predicted Effects | Root Causes | Prevention Strategies |
|---|---|---|---|
| **Technical Issues** | | | |
| a) Interrupted or lagging video/audio<br>b) Software crash<br>c) Patient struggles with software<br>d) Software updates cause delays | Encounter ends prematurely. Clinical time wasted. Need to connect using alternate method. May have to reschedule, causing care delays. Inability to bill for encounter. | Poor or unstable cellular or internet connection. Device battery died. Telehealth platform ended call. Patients not provided with standard instructions and FAQs. | Determine backup plan for connection failures. Record best phone number. Provide patients with instructions and FAQs. Have clinic staff test software with patient. |
| **Patient Safety** | | | |
| a) Patient's geographic location unknown<br>b) Patient is in an unsafe setting<br>c) Patient vital signs not collected<br>d) Patient location not HIPAA compliant<br>e) Patient located outside licensed practice geography | Unable to dispatch emergency services if necessary. Patient could be injured if driving. Possible breach of privacy and confidentiality. Missed opportunity for early detection of unstable clinical situation. Inappropriate medical triage. | No protocol to confirm patient location each visit. Patients not advised in advance about appropriate settings for the encounter. Healthcare team not trained to collect vitals remotely. Patient does not have home devices like blood pressure cuff. | Record patient's geographic location every encounter. Advise patients in advance about appropriate settings for telehealth encounters. Provide patients with equipment. Set clear policies for appropriate conditions for telemedicine care. |
| **Communication** | | | |
| a) Inability to see or hear patient<br>b) HCP does not make regular eye contact<br>c) HCP appears distracted when looking offscreen<br>d) HCP does not use a standard interview workflow<br>e) HCP cannot manage videoconferencing software and other tools simultaneously<br>f) Patient does not follow up | Time wasted for teaching or troubleshooting. Miscommunication of medical information. Inability to forge a therapeutic alliance. HCP may miss important clinical or situational cues. Delayed treatment or adjustment to plans. | Patient unfamiliar with technology or software (e.g., camera rear instead of front facing) or struggles with digital literacy. Camera and video feed not in same location. Lack of integration between videoconferencing software and other clinical tools like the EMR. Appointment is not scheduled in timely manner or during encounter. | Provide patients with an overview or tip sheet. Have patients practice using the software before the encounter. HCPs should test different workstation configurations. Use center-screen cameras. Incorporate a standard interview script into workflow. Integrate the follow up plan into the exiting/disposition process. |
| **Social and Structural Determinants** | | | |
| a) Did not determine if translation services were needed<br>b) Patient does not follow up | Unable to complete interview or high likelihood of miscommunication. Delayed in care. | Language needs not determined in advance. No integrated interpretation services. No social needs screening. | Conduct a pre-visit language and social needs check. Integrate interpretation tech or services into software. |

It is crucial to note that students saw a wide range of workflows. The degree of heterogeneity between encounters and providers seemed greater than in face-to-face encounters. Different team members completed different tasks depending on the healthcare organization. We used these observations to create a normative telemedicine workflow illustrating common tasks (**Figure 1**). We complemented this workflow with recommendations to strengthen the process and protect against future failures.

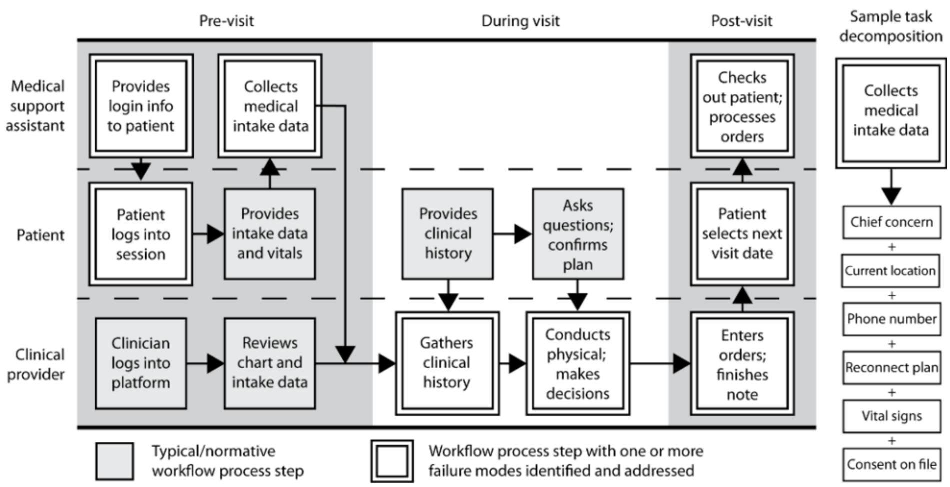


**Figure 1.** Typical or normative telehealth workflow with new tasks to proactively manage failure modes.

## 4. Discussion and Conclusions

### *4.1. Principal Findings*

We identified a range of telemedicine technology and workflow failure modes, classifying them into four overarching categories: (1) patient safety; (2) communication; (3) technical issues; and (4) social and structural determinants of health. From a safety perspective, we believe the most critical failure mode was not recording the patient's geographic location and contact information. This means the HCP would be unable to reconnect with the patient or family or dispatch emergency services to the patient in case of a communication failure or medical emergency. Some of the most common failures were related to connectivity issues. Our observations align with published literature indicating that HCPs convert nearly a quarter of telemedicine appointments to telephone encounters due to communication problems [4]. Although these issues may be unavoidable, they are best managed if the HCPs and patients establish an *a priori* backup plan. Finally, students observed practitioners struggling with webside manner or workflow challenges caused by the technology. For example, camera placement at the clinician's workstation made eye contact challenging. Also, the EMR was not always integrated with the videoconferencing software, complicating charting, order entry, and data review. The students suggested organizations should furnish new practitioners with a standard script encouraging a normative workflow that includes collecting informed consent to participate in telehealth and standard safety "pre-flight" crosschecks.

### 4.2. Implications for Future Telemedicine Curricula

Health systems engineering methods, such as HFMEA, provide a clear, pragmatic, and structured approach to assessing complex health system needs. Though typically used by safety specialists to identify organizational vulnerabilities and prioritize systems-based restructuring, these methods can be adapted for educational needs assessments, building empathy with healthcare consumers, and brainstorming innovative solutions. Our students could quickly learn and apply the HFMEA to a ubiquitous real-world scenario, diagnose process vulnerabilities, and propose practical solutions. In doing so, they acquired and demonstrated new system-based practice competencies.

This work provided insights into the gaps and opportunities in our telemedicine curriculum. By engaging students from across the US and collecting data from various telehealth settings, we sought to identify common issues and generalizable lessons learned. Based on our findings, we believe it is important to develop workflow scripts, didactics, and simulations demonstrating a "best-practice" workflow. These scripts and simulations could draw upon existing work on design patterns that has developed generic patterns to represent aspects of HIT connectivity and how use patterns differ across contexts [8]. We also need a more extensive database of failure modes to teach AAMC technology competencies related to telemedicine risks and technology troubleshooting [2]. By developing simulations that include technology failures, our students can practice these skills in a safe setting. We also need to explore team-based models of care and strategies for addressing health-related social needs.

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