

# INNOVATIONS AND PROVOCATIONS

## The Isolation Communication Management System

### A Telemedicine Platform to Care for Patients in a Biocontainment Unit

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The 2014–2016 outbreak of Ebola virus disease (EVD) called for the urgent need to develop clinical care protocols and practices to ensure healthcare provider (HCP) safety when caring for potentially infected patients. Ebola virus is highly contagious and spreads primarily through infected bodily fluids, including diarrhea, vomit, and blood (1, 2). It can be transmitted by direct human-to-human contact or indirectly through contact with contaminated objects, such as bedding, clothing, and medical waste (1–3). Vomiting, diarrhea, internal bleeding, and external bleeding increase the likelihood of exposure for caregivers (1–3). By November 2015, a total of 881 HCPs in Guinea, Liberia, and Sierra Leone had contracted EVD, and 513 had died of EVD (4). HCPs were 21–32 times more likely to contract EVD than the general adult population, and HCP infections accounted for 12% of all EVD cases in July 2014 (5). Of the four cases of EVD diagnosed in the United States, two were in HCPs who cared for a patient in Texas (6). These events highlighted the critical need to develop tools that assist in the safe care of patients with EVD or other highly contagious and lethal infectious diseases.

Recommended personal protective equipment (PPE) for a HCPs who manage patients under investigation (PUIs)

for EVD includes a single-use impermeable gown or coverall, a powered air-purifying respirator or N95 respirator, a single-use full face shield, at least two sets of single-use examination gloves with extended cuffs, a head cover, single-use boot covers, and a single-use apron (7). Depending on the protocol, there are often 20 steps for donning and doffing PPE when providing care for PUIs for EVD who are clinically stable and do not exhibit bleeding, vomiting, or diarrhea; the necessary steps can exceed 30 when PUIs for EVD are clinically unstable or have bleeding, vomiting, or diarrhea (7, 8). Despite its critical importance for HCP safety, mistakes in donning and doffing PPE are common (9, 10). Unfortunately, enhanced educational efforts reduce but do not eliminate PPE donning and doffing mistakes (10, 11). Furthermore, PPE guidance was revised several times by the Centers for Disease Control and Prevention (CDC) and the World Health Organization during the 2014–2016 outbreak, further complicating training efforts (12). During the 2014–2016 outbreak, limited PPE supplies at some institutions were rationed to maintain reserves for the care of PUIs for EVD or patients with confirmed EVD during the outbreak, which constrained education and training efforts. Given the potential risks for exposure to the Ebola virus, reducing direct contact with patients with



EVD and PUIs for EVD to the least amount necessary to provide patient care is desirable. However, patients with EVD and PUIs for EVD require considerable supportive medical care in challenging clinical conditions.

Novel application of technology such as telemedicine (in this application, defined as real-time video-enabled interactive services) has the potential to reduce exposure risks for HCPs caring for patients with EVD while conserving PPE. Using commercially available hardware and software, we developed an internal network of telemedicine technologies, designated the University of Virginia Health System Isolation Communication Management System (iSOCOMS), to facilitate EVD care needs at our institution. In this paper, we describe our experience using iSOCOMS for patients with potential EVD and discuss its potential

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use for other care needs of patients with highly virulent, contagious diseases.

## Methods

The site of investigation was the University of Virginia Medical Center (UVAMC), a tertiary care center with over 600 beds and more than 28,000 inpatients annually. In August 2014, the University of Virginia Special Pathogens Workgroup began preparedness planning for the evaluation, treatment, and care of PUIs for EVD and patients with EVD. In October 2014 and December 2014, the Commonwealth of Virginia and the CDC, respectively, designated UVAMC as an Ebola treatment center.

In support of this designation, iSOCOMS was developed to provide immediate communication, assessment, and coaching tools within UVAMC. iSOCOMS uses secure, standards-based Cisco infrastructure to allow the integration of fixed endpoints, desktop videoconferencing, mobile telehealth, and online telehealth education through Southside Telehealth Training Academy and Resource Center (STAR Telehealth) (Table 1). The network was developed to provide expanded remote guidance, treatment, and supervision capabilities within the UVAMC biocontainment unit, termed the “special pathogens unit” (SPU), and a designated biocontainment room in the emergency department used for EVD evaluation. This comprehensive suite of telemedicine tools was intended to be a highly adaptable means to help care for patients with EVD and PUIs for EVD while enhancing the safety of HCPs.

The system was evaluated during the admissions of three PUIs for EVD to the UVAMC SPU over a 9-month period. iSOCOMS was used to monitor the movement of the patient, for example, from the ambulance to the SPU in the case of transfer of a PUI for EVD from another healthcare facility. Once the patient was in a biocontainment room of the SPU, an isolation camera (iSOCAM) and a monitor in the room allowed communication with HCPs outside the biocontainment room. The facilities, tools, and personnel were in place to manage multiple PUIs, but the three patients’ cases did not overlap in time.

## Results

Seven potential benefits for iSOCOMS were envisioned during its development and implementation:

1. iSOCOMS could be used to facilitate communication between providers in a biocontainment room and those outside the room in the SPU, thereby reducing potential HCP exposures.
2. iSOCOMS could be used to facilitate communication between a patient in the biocontainment room and providers outside the room in the SPU, which would also reduce potential HCP exposures.
3. iSOCOMS could provide a means to monitor both staff and patients outside a biocontainment room, either within the SPU or remotely.
4. Because the network was mobile, iSOCOMS could be used to facilitate transfers of PUIs for EBV or patients with EBV from outside the hospital to an Ebola care area (in the SPU or emergency department) using wireless devices.
5. iSOCOMS could provide a means for physicians who had not completed Ebola care training (including comprehensive PPE training) to provide consulting services.
6. iSOCOMS could be used by family members, counselors, and chaplaincy and/or other services to provide emotional support and counseling remotely.
7. iSOCOMS could facilitate involvement of students and other learners in the care of PUIs for EVD or patients with EVD without incurring risk of exposure.

We were able to assess four case use scenarios (1–4 in the list above), and we discuss the anticipated use for the other three (5–7 in the list above).

### Case Use Scenarios for iSOCOMS

**Use of iSOCOMS to facilitate communication and reduce staff exposure risk.** Although at least one HCP was in the biocontainment room with the PUI at all times, use of iSOCOMS avoided the need for two providers to be in the room at all times when caring for non-critically ill PUIs for EVD. By having a direct link to the room via iSOCOMS, the HCP in the biocontainment room was supported by another provider who served as an observer outside the room (Figure 1). The observer was able to monitor and assist in the care of the patient, such as

by coordinating collection and delivery of patient care items, managing integration of support services into the SPU and biocontainment room, and other tasks difficult for providers in the biocontainment room to perform. If the patient was critically ill, required a higher level of care, and/or had EVD, two or more staff members would have been placed in the room and remotely monitored via iSOCOMS at all times.

iSOCOMS also facilitated documentation of the clinical evaluation, including the patient interview and physical examination. The observer acted as a scribe during the interview, unencumbered by PPE. During the physical examination, auscultation was performed and recorded by the observer using an electronic stethoscope linked to iSOCOMS through a bedside computer (Table 1). The HCP in the biocontainment room would be instructed where and when to move the stethoscope by the observer outside the room. The iSOCAM was also able to zoom in and produce high-resolution images of sufficient quality to record components of the physical examination, such as examination of the skin, sclera, and nail beds.

Whether assisting in the clinical evaluation of a patient or facilitating communications between providers, use of iSOCOMS reduced the amount of PPE consumed by HCPs by decreasing the number of people needed to enter the biocontainment room and/or the frequency of entering the biocontainment room. This proved to be critical during the height of the EVD response when PPE supplies were critically short.

**Use of iSOCOMS to facilitate provider-to-patient communication.** iSOCOMS also aided in establishing a rapport with the patients. HCPs were able to introduce themselves to the patient through iSOCOMS, unencumbered by PPE, before entering the biocontainment room. HCPs’ names were displayed beside their faces on the video monitor. Later, when the HCPs entered the biocontainment room, they wrote their names on the front of their PPE so that the patients could connect the providers in PPE to the video image they had seen earlier. This helped counteract the dehumanizing nature of providing care in full PPE. Providers could also elect to interview the patient through iSOCOMS rather than at the bedside. Video-aided interviews were performed in the SPU, and the designated biocontainment room in the emergency department was similarly equipped with iSOCOMS to enable a

**Table 1.** Equipment and software used for Isolation Communication Management System telemedicine platform

Category	Product	Manufacturer	Location
Infrastructure	Unified Call Manager version 9.0	Cisco	San Jose, California
	Expressway Core	Cisco	San Jose, California
	Expressway Edge Version 8.1	Cisco	San Jose, California
	Expressway VCS Control	Cisco	San Jose, California
	Expressway VCS Expressway	Cisco	San Jose, California
Fixed endpoints	TelePresence MCU 4515	Cisco	San Jose, California
	TelePresence SX10 Video Camera	Cisco	San Jose, California
	TelePresence SX20 Video Camera	Cisco	San Jose, California
	CA700 Clinical Cart	Avizia	Reston, Virginia
Mobile endpoints	Desktop computers (various)	Hewlett-Packard	Palo Alto, California
	iPad version 2	Apple	Cupertino, California
Medical devices	MacBook Pro	Apple	Cupertino, California
	Laptop computers (various)	Hewlett-Packard	Palo Alto, California
	E-Scope Electronic Stethoscope	Cardionics	Webster, Texas
Software and training	Jabber for Windows 10.5	Cisco	San Jose, California
	Jabber for Mac 11.0	Cisco	San Jose, California
	http://www.startelehealth.org	Southside Telehealth Training Academy and Resource Center (STAR Telehealth)	Martinsville, Virginia

*Definition of abbreviations:* MCU = Multipoint Control Unit; VCS = Video Communication Server.

physician to interview and assess a patient potentially infected with Ebola virus before entering the room. This could even occur remotely, such as by an Ebola care specialist at a distant location within or outside the hospital using a secured mobile endpoint (e.g., an iPad; Apple). The University of Nebraska developed similar video-enabled Ebola care protocols for use in its emergency department (13).

**Improved monitoring of patient and staff.** Patient care was audited with iSOCOMS to ensure that the safety of team members and patients was upheld. Video monitoring by iSOCOMS allowed the observer to watch for and warn against breaches in PPE in real time during patient care. The iSOCOMS observer also performed periodic “buddy checks” of HCPs in the Ebola care room. For example, the iSOCOMS observer visually inspected the PPE for any defects using the iSOCAM and monitored HCPs in the biocontainment room to determine whether they were becoming uncomfortable or fatigued. HCPs expressed a great deal of gratitude for iSOCOMS-enabled monitoring, stating that they found that being continuously and closely monitored during patient care activities was reassuring.

**Monitoring of patient movement into the unit.** The second and third PUIs for EVD encountered at UVAMC were brought in by ambulance. iSOCOMS was used to monitor patient transport from outside the medical center through designated, secured corridors and elevators and into the SPU. Real-time monitoring using iSOCOMS provided HCPs and other team members a means to perform a primary assessment of the patient, surroundings, and care needs during the transition in medical care. Using iSOCOMS, the safety officer, hospital epidemiologist, SPU medical director, other HCPs, and the medical transport team entered a multiparty video conference using fixed and portable electronic devices (Figure 2). Transport through a secured route through the hospital was conducted with continuous monitoring by all users, including the incident command center, using multiple fixed and mobile video nodes stationed along the entire transport route.

**Video-enabled consultation.** Telemedicine technologies have been used to provide consultative medical services for more than 30 years (14). Over the last decade, the use of telemedicine consultation has exploded, fueled by

rapidly improving electronically secure video conferencing platforms, improved imaging, and the incorporation of web-based technologies (15). Telemedicine consultation (not to be confused with e-consultation, which is typically defined as provider-to-provider communication that can serve as an alternative to “curbside” conversations) has been used to facilitate consultations electronically in virtually all medical disciplines, including (but not limited) to dermatology, neurology, psychiatry, critical care medicine, and infectious diseases (16–20). However, to our knowledge, use of telemedicine for in-hospital clinical consultations by services physically present in the same hospital because of concerns regarding exposure to dangerous pathogens had not been described before the Ebola outbreak. We developed a program for specialty consultation using iSOCOMS in conjunction with the aid of a trained Ebola care physician who could perform components of a physical examination if needed. This allowed us to reduce the number of providers who needed to be trained in EVD special pathogen PPE use, conserving time and resources while still providing access to specialty medical



**Figure 1.** Use of Isolation Communication Management System (iSOCOMS) during the care of a patient under investigation (PUI) for Ebola virus disease (EVD). The picture demonstrates the video image of a nurse in full personal protective equipment ensemble caring for a PUI for EVD as seen at the iSOCOMS observer workstation outside the biocontainment room in the special pathogens unit.

services. Consultative care through iSOCOMS was a component of the Ebola action plan at UVAMC but was not used during the care of patients being evaluated for EVD during the outbreak.

**Patient support through family, chaplaincy, and counseling.** Because of concerns regarding Ebola virus exposure, family members, including parents, and other visitors were not allowed to enter the SPU (unless two family members, such as a parent and child, were admitted to the unit simultaneously). To facilitate psychological, social, and spiritual support, iSOCOMS was promoted as a means to facilitate Health

Insurance Portability and Accountability Act of 1996 (HIPAA)-compliant personal interactions between patients in the SPU and family members and other loved ones in a manner unencumbered by PPE. With use of secured telemedicine platforms, communication could occur either at the hospital in an iSOCOMS-enabled family visiting room outside the SPU or remotely with personal computers or smart devices with software available free of charge at electronic software distribution websites. Furthermore, other support services, such as hospital chaplaincy, other clergy, or counseling

services could provide spiritual support without entering the SPU. Although iSOCOMS-enabled communication to family members was offered to the patients, all three declined the offer, saying that they did not want to alarm their family, particularly family members who were far from Virginia, by telling them they were being evaluated for EVD.

**Facilitating student/learner involvement.** Although students and other trainees were not involved in our PUIs for EVD, iSOCOMS was envisioned as a platform that could be used to advance education without risking trainee exposure to Ebola virus. Nursing students, medical students, graduate medical trainees, and other learners could participate in the care of PUIs for EVD without entering a biocontainment room. Real-time observation and instruction of patient care performed by HCPs in PPE could be performed remotely. House staff and medical students on critical care, infectious disease, or specialty consultation services could participate in clinical consultation outside biocontainment rooms. Furthermore, with the consent of the patients, video footage could be saved and archived for future training purposes, such as in the event of a new outbreak of hemorrhagic fever disease.

**Costs**

UVAMC has a long history of using telemedicine to improve patient access and facilitate care. The University of Virginia Karen S. Rheuban Center of Telehealth has facilitated more than 50,000 patient encounters at more than 150 sites throughout Virginia and around the world over the last 20 years. The technical knowledge and expertise of the center was critical to the rapid development and deployment of iSOCOMS. However, the expense of developing and implementing iSOCOMS was not prohibitive. The total equipment cost for iSOCOMS for our SPU was approximately \$34,250.

**Potential Adverse Outcomes and Other Problems**

There are several potential adverse outcomes that we predict could arise from the use of video-enabled technology in the care of patients with EVD or other dangerous communicable diseases. A security breach or unauthorized disclosure of protected health information (PHI) likely represents the greatest potential adverse



**Figure 2.** Use of Isolation Communication Management System (iSOCOMS) during the admission of a patient under investigation (PUI) for Ebola virus disease (EVD). The image depicts the incident command center and its director using iSOCOMS to coordinate admission of the PUI for EVD. The laptop screen demonstrates arrival of the PUI for EVD via ambulance (top image; mobile endpoint) simultaneously with inset images (left to right) of an Ebola care physician (mobile endpoint), special pathogen unit medical director (fixed endpoint), incident command center (fixed endpoint), and biocontainment room (fixed endpoint).

event with iSOCOMS. A breach of PHI from video technologies would be considered to be a HIPAA violation, which could lead to penalties from the Office of Human Rights of the U.S. Department of Health and Human Services and potential civil or criminal prosecution by state attorneys general. Like other telemedicine platforms, iSOCOMS must use HIPAA-secure technologies and be supported by robust health information cybersecurity systems to mitigate this risk.

A potential unintended outcome could occur if iSOCOMS were to lead to an increased risk of Ebola virus exposure of HCPs. This could conceivably occur, for example, if HCPs became consciously or unconsciously overconfident in the ability of iSOCOMS-enabled observation to proactively identify risks for exposure. Waning self-awareness and self-monitoring during direct patient care or while donning and doffing PPE could prove to be catastrophic when working with select pathogens. Although possible, we predict this outcome would be unusual because most patient safety studies suggest that increased observation and monitoring lead to a reduced incidence of human factor errors and breaches of safety protocols (21, 22).

A final question is the degree of patient acceptance of iSOCOMS. Most studies have shown that patients are generally satisfied with video-enabled consultation and care (23–26). However, some authors argue that the evidence that patients find video consultation to be an adequate substitute for traditional medical care is limited (27, 28).

## Discussion

Telemedicine is a means to exchange medical information via telecommunication and information technologies, typically between geographically distant locations. Telemedicine connects health experts with patients in locations as remote as the International Space Station, and tele-epidemiology has been used to monitor vector habitats and patient populations during the Ebola epidemic in West Africa (29, 30). In the United States, a statewide videoconferencing network in Arkansas provided timely Ebola education and support to HCPs and the public (31).

Remote high-quality communication afforded by telemedicine has unique advantages when caring for patients with

potentially highly infectious diseases. Telemedicine can be used as a primary assessment tool in the care of these patients. Consultation services can also be delivered through telemedicine in a biocontainment unit, thus reducing the number of HCPs needed to perform clinical examinations and medical interventions. During the Ebola virus epidemic in 2014, a pediatric designated care facility in Washington, District of Columbia, incorporated telemedicine with the ability to help communicate and monitor pediatric PUIs for EVD (32). As was found with our program, they reported that implementing telemedicine in an institutional Ebola response plan required a complex effort.

We hypothesize that iSOCOMS is well suited to address the care of patients with other transmissible infectious diseases, especially those that are linked with high morbidity or mortality, including other viral hemorrhagic fevers (e.g., Marburg hemorrhagic fever, Lassa fever), Middle East respiratory syndrome, coronavirus disease (COVID-19), and tuberculosis. For some highly transmissible infectious diseases, such as measles or COVID-19, iSOCOMS could enable visiting providers to help care for patients in their own homes rather than in physicians' offices or in hospitals. In these cases, iSOCOMS could enable proper patient care while protecting other potentially vulnerable patients.

No videotaping or other electronic capture of personal information was performed during the care of our PUIs for EVD. If videotaping had been performed, collection and storage of that information would have occurred with the consent of the patient and in accordance with all existing institutional policies that safeguard PHI. Furthermore, iSOCOMS was used in a manner to protect personal privacy. For example, when patients were taking care of personal needs such as bathing, the observer monitoring the room turned the camera to the wall until the patient was finished. Because this technology can be unintentionally indiscreet, we feel that efforts such as these may help patients feel comfortable with the technology and reduce privacy concerns.

There are several limitations with the assessment of this pragmatic application of telemedicine technology. Given the expedited process of implementing iSOCOMS and the limited number of

PUIs for EVD evaluated in the University of Virginia Health System, some of the potential benefits of iSOCOMS regarding patient care, HCP safety, and training were not directly assessed. In addition, telemedicine may be met with skepticism or resistance by HCPs (33, 34). Furthermore, we were not able to determine how patients perceived iSOCOMS and whether they believed that it positively or negatively influenced their experience while being evaluated for EVD. Future studies are needed to explore the benefits, shortcomings, and potential harms of iSOCOMS in a systematic fashion.

In conclusion, we believe that iSOCOMS provided clear benefit to patient care and HCP safety during the evaluation of patients with potential EVD in our biocontainment unit. We were surprised by the number of case use scenarios that were built around iSOCOMS during Ebola preparedness planning, ranging from PPE use to supervision and support of direct patient care, healthcare worker safety, patient–team member communication, extension of consultation health services, patient–family communication, patient–support service communications, and trainee education. The sustained outbreak of EVD in the Democratic Republic of the Congo starting in August 2018 and the emergence of COVID-19 caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), in December 2019 demonstrate the ongoing need for innovative applications of technology to meet multiple challenges of high-consequence pathogens (35, 36). However, iSOCOMS has important limitations and expenses. In summary, the opportunities of incorporation of telemedicine into care for patients with highly virulent contagious diseases to enhance HCP safety, patient safety, the patient experience, and medical education are significant and could be considered during the care of other patients with EVD and other highly contagious and virulent infectious diseases. ■

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