Feasibility Assessment of a New Surveillance Tool for Respiratory Protective Devices Used in U.S. Healthcare

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ABSTRACT

Background: Respiratory protective devices (RPDs) are used for infection prevention in healthcare settings during routine patient care and public health emergencies. In recent years, healthcare systems have experienced shortages of RPDs during outbreaks of infectious diseases, in part due to a lack of information about their availability. New tools to track RPD inventories may improve accessibility during an emergency. Investigators at Vanderbilt University have identified four major themes that influence RPD use for infection prevention: hospital preparedness, responsiveness to airborne pathogens, potential exposure outcomes, and infection control practices related to respirator effectiveness. Based on these findings, an RPD surveillance tool (RST) was developed to collect and share near real-time data about RPD supplies in healthcare facilities. The objective of this study was to conduct a feasibility assessment of this RST.

Methods: The new online surveillance tool was implemented at four large, urban, acute care U.S. hospitals in January 2014; data was collected about RPD inventory, tracking systems, hospital characteristics, and utility of gathered information.

Results: The RST was implemented successfully and without difficulty at hospitals that had 78 to 90 percent occupancy rates. Participating hospitals reported that the RST (1) provided value for benchmarking their RPD supply, (2) promoted understanding about RPD accessibility among hospital systems engaged in infection control, and (3) served as a means to assess RPD program quality.

Conclusion: Implementation of this newly developed RST is feasible and appears to have utility in U.S. hospitals for tracking and understanding RPD use for routine healthcare delivery and public health emergencies.

Keywords: Respirator use and supply; Respiratory protective devices (RPDs); Feasibility assessment; Hospital setting; PPE surveillance system; Respiratory protective device surveillance tool (RST)

INTRODUCTION

Healthcare accounts for nearly one-sixth of U.S. national spending and employs more than 18 million workers (CMS, 2016). Healthcare personnel (HCP) experience one of the highest rates and total counts of nonfatal occupational injuries and illnesses in the U.S. workforce (BLS, 2016). To prevent workplace injuries and illnesses, a hierarchy of infection control measures are used to decrease exposures to hazards, including administrative controls, engineering controls, and personal protective equipment (PPE) (NIOSH, 2016). When administrative and engineering controls cannot sufficiently reduce exposure to an airborne hazard, respiratory protective devices (RPDs) are often worn to protect workers in accordance with the Occupational Safety and Health Administration's (OSHA) regulation CFR 1910.134 (NIOSH, 2015). Healthcare facilities, among other organizations, are required to provide appropriate PPE, including RPDs to employees who may be exposed to airborne hazards (OSHA, 2011). Healthcare is a major user of RPDs, having five times as many RPD users compared to other service industries (Doney et al, 2005). The models and types of RPDs used by healthcare organizations greatly vary, although certain types are more commonly used (Wizner et al, 2016).

During recent public health emergencies, such as the 2003 Severe Acute Respiratory Syndrome (SARS) outbreak and the 2009 H1N1 influenza pandemic, HCPs have experienced shortages of RPDs (IOM, 2011; Lautenbach et al, 2010; Polgreen et al, 2015; Patel et al 2017). Knowing RPD inventory is an important component of health system readiness for routine operations and emergency responses, such as a surge in infectious patients, to ensure there is enough PPE for HCPs to provide patient care safely. However, national emergency planning efforts have been hindered by a lack of information on current PPE supplies in hospitals, variability in regional distribution, and the number and types of PPE required for emergency capacity (ASTHO, 2014). Modeling of RPD need during a severe contagious respiratory pandemic suggests that demand may exceed supply and that alternative strategies should be explored (Carias et al, 2015; Radonovich et al, 2009; Baracco et al, 2015). While local and regional health systems and coalitions have utilized a variety of ways to monitor RPD supplies, there is no national tracking system that uses standardized metrics (Oke et al, 2009; HHS, 2012).

Researchers at Vanderbilt University Medical Center (VUMC) conducted an analysis on respirator-related standards, guidelines, and advisories to identify four major themes that influence healthcare RPD use for infection prevention: hospital preparedness, responsiveness to airborne pathogens, outcomes of potential exposures, and infection control practices related to respirator effectiveness. Based on these findings, which include published respiratory protection standards, public health guidelines, and professional society recommendations, a prototype electronic RPD surveillance tool (RST) was designed, developed, and iteratively refined to house and share near real-time data about RPD inventories to facilitate effective and efficient healthcare operations (Yarbrough et al, 2016). Beginning in 2010, the National Personal Protective Technology Laboratory (NPPTL) at the National Institute for Occupational Safety and Health (NIOSH) collaborated with VUMC in this effort.

The objective of this study was to conduct a feasibility assessment of this new RST. The RST was implemented and evaluated for functionality and utility in four U.S. hospitals to assess its potential value and limitations.

METHODS

The RST focuses on N95 filtering facepiece respirators and powered air-purifying respirators (PAPRs), the two most commonly used types of RPDs in U.S. healthcare. Excluding hospital demographic questions, the RST consists of a maximum of 145 questions: 47 questions as baseline measurements and 98 questions designed as monthly follow-up questions. The online survey used branching logic to offer only questions that were relevant to participants based on their baseline responses, eliminating unnecessary or repetitive questions. Response answers included multiple choice, yes/no, numeric fields, and text boxes. Baseline and follow-up survey questions pertained to RPD models used, infection prevention and control practices, HCP and hospital patient demographics, RPD inventory numbers, RPD storage locations, and metrics routinely recorded for national surveillance, such as Centers for Disease Control and Prevention (CDC) compliance guidelines, OSHA standards, and state or federal regulatory directives. RPD program specific variables included respirator types and models, fit testing methods, and the percent of HCPs who were fit tested. This study was deemed non-human subject surveillance by the NIOSH Human Subjects Review Board (protocol number 15-NPPTL-NR02) and the Vanderbilt University Institutional Review Board (protocol number 130024).

After initial pilot testing, the RST was implemented at four large, acute care hospitals located in four different states: Tennessee, Ohio, Georgia, and North Carolina. Each site utilized the RST and provided feedback about the ease of implementation, the operational value of information gathered, and if the electronic platform filled gaps in knowledge about RPD inventory.

Following recruitment, assessment sites were instructed how to use the online survey tools. Data was collected at each site during January 2014 using the electronic data capture platform REDCap (Nashville, TN), a secure, Internet-based application hosted by Vanderbilt University. Tableau Software (Seattle, WA), an interactive data visualization tool, used a dashboard display to visualize site's data and de-identified aggregate data from the other assessment sites for comparison purposes. Aggregate data tables summarized individual reports.

De-identification was used because some participating hospitals indicated that RPD purchasing and storage strategies were considered proprietary and/or sensitive. Variables in the analysis were rounded, as necessary, to anonymize the participating hospitals. "On-site" inventory was defined as RPDs on hand for routine patient care, fit testing, and training, but did not include emergency stockpiles.

RESULTS

The four participating assessment sites were large (>300 staffed beds), urban, tertiary, acute care hospitals. Across the sites, the annual mean patient-day census was 320,000 with the workforce ranging from 7,500 to 28,000 persons. During the one-month implementation period, the hospitals had 78 to 90 percent occupancy rates and patient admissions ranging from 1,741 to 5,026.

Hospital facilities housed RPDs in three locations based on intended use: (1) hospital "par" utilizing a central storage location, often called "central supply," for use during patient care, (2) the occupational health or industrial hygiene service department(s) for use during fit testing procedures, and (3) warehoused stockpiles for use during emergencies or a surge in RPD demand. Data was gathered differently at each of the facilities, as determined by the systems in place at each hospital. While one person or group was responsible for directly entering the data into REDCap, a variety of groups, departments, and/or specialists were consulted to compile data from paper and digital sources.

Information collected about RPD inventory, fit testing, and infection control practices is shown in Table I. The primary RPDs used for training and fit testing HCPs were the 3M™ brand 1860/1860s N95 respirators. Three of the hospitals had alternative N95 respirator brands or models. For PAPR, all the hospitals used the 3M™ Air-Mate model. Additionally, one hospital had an alternate PAPR model. The number of N95 respirators on-site at the hospitals ranged from 2,200 to 20,000 and accounted for approximately one to 40 percent of the total N95 respirators owned by the hospital. PAPRs were fewer in number, ranging from 20 to 99, which was less than one percent of the total number of all RPDs held in inventory. The ratio of RPDs available per HCP (i.e., the number of RPDs on-site at the hospital divided by the number of HCPs at the hospital) at each hospital ranged from the 0.19 at Hospital A to 1.40 at Hospital C. Hospitals' stockpiles held the majority of the RPDs available at each facility, ranging from 62 to 99 percent of the total RPD holdings. Two sites monitored their stockpiles for manufacturer-specified expiration dates and rotated products through their primary hospital to prevent wastage. One site periodically checked expiration dates, but did not rotate supplies. All four hospitals identified local programs that utilize state or federal RPD supply caches to replenish stockpiles in case of emergency depletion.

Between 77 and 100 percent of HCPs who were eligible for respirator use had reportedly completed an OSHA-accepted annual fit test at the time of the survey. Three sizes of N95 respirators were used for fit testing: universal, small, and medium.

During the one-month implementation period, replenishment rates (the number of RPDs purchased divided by the total number available on-site) varied widely. Hospital A ordered 28% more respirators during the study month than the total number of on-site RPDs, a replenish rate of 128%. Hospital B ordered the equivalent of half of their RPD supply, a replenish rate of -56%, meaning they had fewer respirators at the end of the study period. Hospital C ordered no RPDs during the study period. Hospital D ordered three-quarters of their total on-site RPD supply (a replenish rate of -27%). No PAPRs were ordered during the study period at any of the sites. Participants reported the number of patients requiring airborne isolation, ranging from seven to 17 during the one-month study. The notifiable infectious disease reported to public health authorities included varicella/disseminated zoster and tuberculosis. Influenza vaccination rates ranged from 60 to 98%.

Regarding tracking methods for managing infection control information, all of the hospitals reported using at least one type of electronic reporting method, with only one hospital reporting additional use of a manual data collection system (Table II). Hospital-acquired infections were tracked by all four sites using the CDC's National Health Safety Network (NHSN). Nobilis™ Risk and Safety Management Alert System (RASMAS) was used for tracking supply recalls at all four sites.

Table I. Responses of Four Participating Hospitals to a Respiratory Protective Device (RPD) Surveillance Tool (RST) during a One-Month Testing Period

	Hospital A	Hospital B	Hospital C	Hospital D
Respirators Available				
N95 models at facility	- 3M™ 1860/1860s - 3M™ 1870 - Kimberly Clark™ 46867 - Sperian/Wilson™ N9520F	- 3M™ 1860/1860s - Kimberly Clark™ 46827/46727	- 3M™ 1860/1860s	- 3M™ 1860/1860s - 3M™ 1870
PAPR models at facility	- 3M™ Air-Mate	- 3M™ Air-Mate - IRT™ Flex-Air	- 3M™ Air-Mate	- 3M™ Air-Mate
N95s on-site+	2200	5800	20000	17000
PAPRs on-site	50	25	20	99
N95s purchased+	2800	2500	0	12400
# of respirators in stockpile+	202000	82100	32000	51000
Fit Testing				
% HCPs fit tested & trained	77%	91%	77%	100%
N95 respirator sizes used for fit testing	Universal, Small	Universal, Small	Universal	Universal, Small, Medium
Infection Prevention & Control Measures				
# of airborne order patients	12	7	*(no response)*	17
Notifiable diseases seen	Varicella/ disseminated zoster	Tuberculosis	None	None
Influenza vaccination rate	81%	98%	96%	60%

Powered air-purifying respirator (PAPR), healthcare providers (HCPs)
+Numbers rounded for anonymity. Percent HCP trained was calculated as the number of HCPs that completed trainings over the number of HCPs eligible for respirator program.

Characteristics of RST reported as valuable by participating hospitals included emergency preparedness implications, recognizing the different hospital systems involved in RPD data, and de-identified benchmark information made available by other participating hospitals visualized in the dashboard displays. However, participants did not find value in questions they deemed unrelated or unimportant to respiratory protection or variables that required multi-department input, such as soliciting a hospital's finance department for data. All four sites agreed that RPDs should be tracked more frequently (weekly, daily, or multiple times per day) during a pandemic or public health emergency.

Table II. Record Keeping Systems Used for Tracking Safety-Related Hospital Data

Data	Recording	System
Occupational Safety and Health Administration (OSHA) fit test data	Electronic	Agility, proprietary
Hospital medical records	Electronic	-
Airborne isolation orders	Manual, Electronic	-
Lab reports	Electronic	-
Supply recalls	Electronic	Risk and Safety Management Alert System (RASMAS), Food & Drug Administration (FDA) alerts
Notifiable infectious diseases	Manual, Electronic	Epic Systems, state specific system+
Hospital-acquired infections	Electronic	National Health Safety Network (NHSN)
Blood borne pathogens	Not reported, Manual, Electronic	PeopleSoft, internal system
Hospital beds/supply availability	Not reported, Electronic	State specific system+, Ebed, internal system

+generalized for anonymity.

DISCUSSION

The objective of this project was to better understand hospital RPD inventories and the feasibility of implementing a newly developed RST at four large, acute care hospitals in the U.S. This feasibility assessment found the tool to be successful at collecting and aggregating RPD and infection control data to inform healthcare operations. Implementation shed light on the wide range of groups involved in respiratory protection in U.S. hospitals. While policies and practices vary from one hospital to another, there were commonalities, such as brands of RPDs used and utilization of national electronic data tracking systems, such as NHSN and RASMAS. Key differences between the implementation sites included respirator numbers available on-site and strategies for stockpiling and ordering RPDs.

A majority of use for RPDs in hospitals is for training and as a preventive measure when ruling out disease; actual airborne disease in routine care is not common, making the measurement of effective use problematic. Understanding the respirator brands, sizes, available counts in hospitals, and how on-site caches and stockpiles are replenished is important for emergency preparedness. Each hospital had a different ratio of on-site to emergency stockpile RPDs that anecdotally was influenced by supply chain logistics, funding mechanisms, roles in regional supply caches, and purchasing practices at the hospital. The role that each facility plays in their community (e.g., a regional or system-wide PPE holder or distributor) and PPE funding mechanisms (e.g., grant funding) also likely contributes to the RPD supply system used.

Standardization of data and electronic reporting systems is important to streamline data sharing between local, state, and federal programs, particularly during an emergency (IOM, 2011). While many systems are moving towards electronic reporting, the organizations in this feasibility assessment were integrating data from a variety of national, state, and hospital-based systems to track attrition and purchasing to inform decision-making. A standardized electronic data collection and sharing tool integrated in an existing surveillance system or specifically dedicated to collecting RPD information may help improve decision-making capacity and rapidity within and among healthcare institutions, public health agencies, and private sector stakeholders.

The research team gained an understanding of the complexity of healthcare operations, including how routine high patient occupancy rates affect response time for research projects. The pilot project required both executive-level buy in and an internal advocate within each of the hospitals to ensure that the data was collected, as this research was beyond the staff's normal job duties. This feasibility assessment also provided an opportunity for the design team to modify the RST for future use, including improving language clarity in the questions.

Participants in this feasibility assessment reported that implementation of the new RST provided value for benchmarking respirator supply, promoted understanding of internal hospital systems engaged in infection control, and provided a framework for assessing respirator program quality control. The participants liked the data dashboard displays as they were helpful in identifying the hospital's RPD purchasing strategies. Knowledge gained may help hospitals evaluate and improve their routine respiratory protection programs and advance development of their emergency preparedness and response plans.

Barriers for participants to provide data included the confidential nature of the information and the need to create data collecting infrastructure to complete the survey questions. Similar to findings by Yarbrough et al. 2016, respiratory programs were widely distributed across sectors, units, and departments, which proved to be an organizational challenge for the study. Participants in this feasibility assessment cited multi-department time constraints and confusion regarding respirator styles, makes, and models as reasons for less participation.

The primary limitation of this study is that a small number of hospitals were involved, which restricts generalizability to other healthcare facilities. Data compiled by this RST has an inherent self-reporting bias and had limited time-trend comparison ability due to the short data collection period. Further research is needed to determine the long-term value and broader applicability of the RST.
Future steps for this project could include expanding the RST to additional sites, expanding the content to different types of PPE, or observing additional hazards beyond airborne infectious agents to help healthcare understand and maximize effectiveness of PPE supply and use.

CONCLUSIONS

Implementation of this newly developed RPD surveillance tool is feasible and appears to have utility in U.S. hospitals for tracking and understanding RPD use during routine healthcare delivery and public health emergencies.

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Disclaimer

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