Unmasking the Contributing Factors to **Oxygen Disruption Events** in the Inpatient Environment and Emergency Department

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Abstract

Background: Medical oxygen is frequently used in healthcare settings. Challenges with oxygen disruption, such as oxygen tanks running out due to communication issues between staff or tanks not being set up properly, have been noted in the limited existing literature. Challenges and patient safety issues associated with oxygen disruption persist. Utilizing a human factors approach, our study aims to understand the contributing factors and context of oxygen disruption–related patient safety event reports in the inpatient setting and provide person-based and system-based solutions.

Methods: Through keyword matching, we identified and then qualitatively analyzed 298 patient safety event reports to understand the factors contributing to oxygen disruption, patient location when the oxygen disruptions occurred, hand-off breakdowns by healthcare team member role, and whether high supplemental oxygen was being administered.

Results: The most frequent contributing factor to oxygen disruption was the patient not being transferred to another source of oxygen (n=135 of 298, 45.3%), followed by tank found empty (n=107, 35.9%), patient connected to a functioning oxygen source, no oxygen flowing (n=25, 8.4%), oxygen delivery device malfunction (n=22, 7.4%), and no oxygen available (n=9, 3.0%). Over one-third of all oxygen disruption events occurred on the unit where the patient was admitted (n=109 of 298, 36.6%). Roughly 40% of reports involved a hand-off breakdown (n=123 of 298, 41.3%) and the most frequent breakdowns occurred between a nurse and a patient transporter (n=47 of 123, 38.2%). Almost one quarter of reports involved a patient with high supplemental oxygen requirements (n=74 of 298, 24.8%).

Conclusion: Oxygen disruption events can have serious patient safety implications. Many of the oxygen disruption events we reviewed occurred due to lack of situational awareness and hand-off breakdowns. Combining person-based solutions, such as paper-based tools and checklists, with system-based solutions involving central monitoring and supervisory systems may help reduce the risk of oxygen disruption events.

Introduction

Medical oxygen has been identified by the World Health Organization as an essential medicine used in the treatment of patients across the entire spectrum of healthcare.[1] Its administration as a medical intervention has become one of the most frequently employed treatments for patients experiencing acute health challenges. Given the vital role of oxygen therapy in patient care, oxygen use in hospital settings has been the subject of healthcare literature for several decades. Key focus areas within the hospital setting include oxygen use in acute care and other inpatient care areas, oxygen therapy guidance, and delivery systems and routes of administration.[2-4]

Literature concerning patient safety has focused on oxygen prescribing practices and evolving challenges within oxygen therapy and resultant harm, as well as the enhancement of oxygen administration practices and oxygen delivery systems.[3,5-14] Within the literature identifying issues associated with oxygen therapy, issues related to inappropriate administration of oxygen, improper dosing leading to hypoxia and hyperoxia, and oxygen therapy interruptions have been described.[3,5,8,13,15,16]

Disruption in oxygen therapy is mentioned in the existing literature surrounding intrahospital patient transport events. The literature describes challenges with oxygen therapy interruptions, patient oxygen desaturation due to communication issues between staff, oxygen tank depletion, tanks not being turned on, and oxygen flow set below patient needs.[15-18] While oxygen tank depletion is identified as a concern, this safety risk is the subject of very little literature. In a *Pennsylvania Patient Safety Advisory* article from the Patient Safety Authority (PSA) on supplemental oxygen for intrahospital transport, the Pennsylvania Patient Safety Reporting System (PA-PSRS)[a] was queried for events from a 10-year period from January 2005 through December 2014. Analysts identified 393 oxygen tank–related events, 360 of which were associated with unintended interruptions in the administration or management of oxygen. Among events involving interruption, 303 events were associated with depleted oxygen tanks.[16] In a PSA safety column discussing the standardization of tasks involving supplemental oxygen to prevent therapy disruptions during transport, PA-PSRS events were presented indicating oxygen disruptions due to tanks emptying, along with oxygen sources not being turned on and disconnected oxygen tubing.[15]

The majority of proposed solutions are primarily tailored towards mitigating intrahospital transport events overall, providing some guidance to address the occurrence of oxygen-related events involving interruption and tank depletion. Specifically, proposed solutions have included standardizing hand-off communication and procedures, education of transport personnel, and use of transport checklists.[15-17,19-21] Solutions specific to the maintenance of oxygen during transport include training transport personnel in oxygen use, conducting checks of oxygen tank levels prior to transport, performing calculations using calculator apps, formulas or lookup tables, and use of a transport form providing details on the available minutes within a portable oxygen cylinder.[15,16,19-21]

As limited literature focuses on oxygen disruption and oxygen tank depletion issues, in this study we sought to identify factors contributing to disruption of supplemental oxygen in inpatient settings. Further, we build upon previously proposed solutions, which tend to be person-based, and propose human factors–based system solutions that may be more durable.

Methods

We analyzed patient safety event (PSE) reports submitted to PA-PSRS between January 1, 2022, and July 31, 2023[a]. All nonfederal, acute care facilities in Pennsylvania are required to report patient safety events through PA-PSRS. We identified potentially relevant reports by searching the free-text fields of each report for at least one of the following keywords or keyword stems: "oxy tank," "oxy canister," "O2 tank," and "O2 canister." A total of 528 reports were identified for initial manual review. The reports retrieved from keyword matching were further constrained. Reports were included in the analysis if they met all of the following criteria:

- The event occurred in the inpatient environment or the emergency department (ED)
  - The PA-PSRS field Care Area Type and the context of the report were utilized to determine where events occurred. There were 28 reports that occurred in the ED that were assigned the PA-PSRS Patient Status of Unknown (n=11 of 28) or Outpatient (n=17 of 28). They were reassigned as Inpatient for the purpose of analysis.
  - There were an additional 17 reports of events that occurred in care areas other than the ED that were assigned the PA-PSRS Patient Status of Unknown (n=14 of 17) or Outpatient (n=3 of 17). From the context of the report, it was clear that these events had occurred in the inpatient environment. They were reassigned the Patient Status of Inpatient and included for analysis.
- The report involved the use of supplemental oxygen provided by the healthcare facility via tank or wall
- The patient used a nasal cannula, high flow nasal cannula, non-rebreather mask, continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP), ventilator, or extracorporeal membrane oxygenation (ECMO) to receive supplemental oxygen
- The patient's flow of supplemental oxygen was disrupted (i.e., oxygen temporarily ceased to flow to the patient)

Reports were excluded from the analysis if:

- The report described an issue with supplemental oxygen equipment other than disrupted airflow (e.g., an oxygen tank fell on a patient's foot)
- The patient was using oxygen from home
- The patient was in respiratory distress not due to disrupted airflow from supplemental oxygen
- The report described oxygen tank delivery or education at discharge
- The report described an oxygen tank that ran low but was caught before airflow was disrupted

[a]PA-PSRS is a secure, web-based system through which Pennsylvania hospitals, ambulatory surgical facilities, abortion facilities, and birthing centers submit reports of patient safety–related incidents and serious events in accordance with mandatory reporting laws outlined in the Medical Care Availability and Reduction of Error (MCARE) Act (Act 13 of 2002).[29] All reports submitted through PA-PSRS are confidential and no information about individual facilities or providers is made public.

For the reports that met the inclusion criteria, the structured fields of Event Classification (incident[b] or serious event[c]), and Care Area Group were analyzed. Care Area Group indicates the broader care area group associated with the reported PSE based on the Care Area Type assigned by the reporting facility. The event description free-text field was qualitatively analyzed using a grounded theory approach. Using this approach, researchers analyze existing data to form theories and hypotheses. Grounded theory is an inductive approach to research as opposed to a deductive approach, which formulates a hypothesis and then analyzes data to prove or disprove it.[23]

The coding taxonomy was iteratively developed by two human factors subject matter experts and a clinician. The taxonomy definitions and examples are described in **Tables 1–4**. For purposes of coding, we defined wall oxygen as the patient receiving oxygen via tubing or device connected to a source built into the wall. Oxygen tank refers to the patient receiving oxygen via tubing or device connected to a portable pressurized oxygen tank. Reports were independently reviewed and coded by two researchers. In instances where the coders did not agree, the report was reviewed jointly by the coders and discussed to arrive at a final consensus.

We first categorized each report into one of five general contributing factors to the oxygen disruption (**Table 1**). While there may be more than one factor contributing to an oxygen disruption, a single contributing factor was assigned to each report based on what the coders interpreted as the primary reason why the patient was temporarily deprived of supplemental oxygen.

Each report was also categorized into one of five patient locations on or off unit to better understand the context for when and where oxygen disruptions occurred (**Table 2**). If sufficient information was provided in the report, reports were then categorized into one of six hand-off breakdowns by healthcare team member roles (**Table 3**). Finally, for each report it was noted if the patient had high supplemental oxygen needs (**Table 4**).

Table 1. Frequency Counts, Percentages, Definitions, and Examples of Primary Contributing Factors to Oxygen Disruption, N=298

Primary Contributing Factors	Frequency Count (%)	Definition	Example
Patient not transferred to another source of oxygen	135 (45.3%)	The report described a patient who should have been transferred to wall or tank oxygen but was not.	A nurse went to a patient's room after they returned from an off-unit procedure. Per protocol, patients should be transferred to wall oxygen when they are returned to their room. The nurse found the patient was still hooked up to an oxygen tank instead of being transferred back to the wall oxygen. Due to the length of time the patient was connected to the tank, the tank was empty when the nurse discovered the patient.
Tank found empty	107 (35.9%)	The report described a patient who was connected to an oxygen tank that was discovered to have run out of oxygen.	A patient was transported to an off-unit procedure. Upon arrival the technician discovered that the patient's oxygen tank was empty.
Patient connected to functioning oxygen source, no oxygen flowing	25 (8.4%)	The report described a patient who was connected to wall or tank oxygen, but oxygen was not flowing for a reason other than a device malfunction (e.g., the wall flow meter was not turned on).	A patient arrived to an off-unit procedure connected to an oxygen tank. The technician discovered that the tank dial was set to 0 liters/minute.
Oxygen delivery device malfunction	22 (7.4%)	The report described a break or malfunction involving a device or part of a device that delivers supplemental oxygen (e.g., wall oxygen connector, oxygen tank, connective tubing, or ventilator).	A patient required an oxygen tank to be transported to an off-unit procedure. The tank liter flow did not show up on the digital display. A new tank had to be found.
No oxygen available	9 (3.0%)	The report described a patient who required an oxygen tank or a connection to wall oxygen but there was none available.	A patient required an oxygen tank to be transported to a new unit. There were no oxygen tanks available in the medical supply closet and the nurse had to leave the patient without oxygen to find one.

Note: Details of the PA-PSRS event narratives described in the Example column have been modified for readability and to preserve confidentiality.

[b]An incident is defined as "an event, occurrence or situation involving the clinical care of a patient in a medical facility which could have injured the patient but did not either cause an unanticipated injury or require the delivery of additional health care services to the patient."[22]

[c]A serious event is defined as "an event, occurrence or situation involving the clinical care of a patient in a medical facility that results in death or compromises patient safety and results in unanticipated injury requiring the delivery of additional health care services to the patient."[22]

Results

Of the 528 reports reviewed, a total of 298 (56.4%) reports met the inclusion criteria. These 298 reports served as the basis for all further analyses. Of the 298 reports, nearly all were incidents (n=296 of 298, 99.3%) and there were two serious events (0.7%). The three care area groups where oxygen disruption events occurred most frequently were the Emergency Department (n=86 of 298, 28.9%), Imaging/Diagnostic (n=51, 17.1%), and Medical/Surgical (n=37, 12.4%).

The most frequent contributing factor to oxygen disruption was the patient not being transferred to another source of oxygen when they should have been (n=135 of 298, 45.3%). The second most frequent contributing factor to oxygen disruption was tank found empty (n=107, 35.9%) followed by patient connected to functioning oxygen source, no oxygen flowing (n=25, 8.4%), oxygen delivery device malfunction (n=22, 7.4%), and no oxygen available (n=9, 3.0%). Frequency counts and percentages for primary contributing factors are shown in **Table 1**.

Over one-third of all reports occurred on the unit where the patient was admitted (n=109 of 298, 36.6%). Approximately one quarter of reports occurred upon the patient's return from off-unit care (n=66, 22.1%), and one-fifth of reports occurred upon the patient's arrival to off-unit care (n=53, 17.8%). Admission to a new unit and during off-unit care were the least frequently occurring patient locations to be impacted by oxygen disruption (n=38, 12.8% and n=32, 10.7%, respectively). Definitions and examples of patient location where the oxygen disruption occurred are shown in **Table 2**.

Because the patient not being transferred to another source of oxygen and the tank being found empty were the most frequent contributing factors to oxygen disruptions, these reports were further analyzed to understand them within the context of the location where the disruption occurred. Of the reports that involved a patient not being transferred to another source of oxygen when they should have been, over one-third of these occurred upon the patient's return from off-unit care (n=52 of 135, 38.5%). Of the reports that involved the patient's oxygen tank being found empty, over one-third of these occurred while the patient was on their unit (n=42 of 107, 39.3%).

Over one-third of all reports reviewed involved a hand-off breakdown (n=123 of 298, 41.3%). Frequency counts and percentages of hand-off breakdowns by healthcare team member role are shown in **Table 3**.

Table 2. Frequency Counts, Percentages, Definitions, and Examples of Patient Location Where the Oxygen Disruption Occurred, N=298

Patient Location	Frequency Count (%)	Definition	Example
On unit	109 (36.6%)	The report described an issue with oxygen disruption on the patient's unit where they were admitted (including the ED).	A respiratory therapist conducted a spot check of a patient's oxygen while the patient sat in their wheelchair in their room. The respiratory therapist found the wall flow meter was turned off and no oxygen was flowing.
Return from off-unit care	66 (22.1%)	The report described an issue with oxygen disruption upon the patient's return to the unit where they were admitted after completing a procedure, treatment, or test.	A patient was returned from radiology but the nurse was unaware that the patient had come back. The patient was not transferred back to wall oxygen and the nurse found that their oxygen tank had run out.
Arrival to off-unit care	53 (17.8%)	The report described an issue with oxygen disruption upon the patient's arrival to a procedure, treatment, or test taking place off the unit where they were admitted.	A patient arrived to radiology and as they were about to be taken to X-ray the technician discovered that their oxygen tank was empty.
Admission to new unit	38 (12.8%)	The report described an issue with oxygen disruption during the patient's transfer from one unit to another (e.g., the patient was transferred from the ED to the medical/surgical unit).	A patient was brought to the intensive care unit (ICU) from the ED without a respiratory therapist escort. When the patient arrived on the unit it was found that their oxygen tank was empty.
During off-unit care	32 (10.7%)	The report described an issue with oxygen disruption during a procedure, treatment, or test that the patient was receiving off the unit where they were admitted, or mid-transfer if it was not specified where the patient was being transferred to.	A patient required a high level of supplemental oxygen. There was no wall oxygen available while they were in X-ray and their oxygen tank ran out.

Note: Details of the PA-PSRS event narratives described in the Example column have been modified for readability and to preserve confidentiality.

Table 3. Frequency Counts, Percentages, Definitions, and Examples of Hand-Off Breakdowns by Healthcare Team Member Roles, N=123

Healthcare Team Member Roles	Frequency Count (%)	Definition	Example
Nurse/Patient Transporter	47 (38.2%)	The report involved a breakdown in communication or hand-off protocol between a nurse and a patient transporter.	A patient was returned to their room after a computed tomography (CT) scan by patient transport. The nurse was not aware and the transporter did not hook the patient up to wall oxygen.
Unknown Roles	32 (26.0%)	The report involved a breakdown in communication or hand-off protocol but there was insufficient information to determine the roles of the team members involved.	A patient arrived to a new unit with a nasal cannula in their nose but was not connected to the oxygen tank that was with them.
Nurse/ Technician	20 (16.3%)	The report involved a breakdown in communication or hand-off protocol between a nurse and the technician responsible for the patient's care during an off-unit procedure, treatment, or test. If the report described a patient undergoing an off-unit procedure, it was inferred that the person responsible for the patient was a technician unless explicitly stated otherwise.	A patient was transported back to their room after a CT by the CT technician. The technician did not connect the patient to wall oxygen and their oxygen tank ran out.
Nurse/Nurse	11 (8.9%)	The report involved a breakdown in communication or hand-off protocol between a nurse and another nurse that assumed responsibility for their care. This could be as a result of the patient's transfer to another unit or because the patient's primary nurse was unavailable.	A patient was transported to a new unit. The receiving nurse was given a report that the patient was supposed to be on oxygen but the patient arrived without any supplementary oxygen equipment.
Nurse/Therapists	11 (8.9%)	The report involved a breakdown in communication or hand-off protocol between a nurse and a physical, occupational, speech, or respiratory therapist.	A patient was transported to the ICU by a nurse without an RT escort to manage their BiPAP. The RT checked the patient and saw that the patient's oxygen tank was empty.
Patient Transporter/ Technician	2 (1.6%)	The report involved a breakdown in communication or hand-off protocol between a patient transporter and the technician responsible for the patient's care during an off-unit procedure, treatment, or test.	Patient transport brought the patient to CT. The technician was unaware of the patient's arrival and the patient's oxygen tank ran out.

Note: Details of the PA-PSRS event narratives described in the Example column have been modified for readability and to preserve confidentiality.
Sum of percentages may not equal 100 due to rounding.

Table 4. Frequency Counts, Percentages, Definitions, and Examples of High Supplemental Oxygen Requirements, N=298

High Supplemental Oxygen Requirements	Frequency Count (%)	Definition	Example
Yes	74 (24.8%)	The report described a patient who was on more than 6 liters of oxygen via nasal cannula or that the patient was utilizing a device indicative of their need for high levels of supplemental oxygen, including high flow nasal cannula, non-rebreather mask, CPAP, BiPAP, or ventilator.	A patient was transported to an off unit procedure on 10 liters of oxygen. When the patient arrived at the procedure it was discovered that the patient's tank had run out.
No/Unknown	224 (75.2%)	The report described a patient who was on 6 liters or less of oxygen via nasal cannula or the oxygen requirement was not noted.	The patient arrived to physical therapy in the gym and the oxygen tank was empty. Pulse oxygen was 88% on room air. Patient was placed on 4 liters and recovered to 94% within 30 seconds.

Note: Details of the PA-PSRS event narratives described in the Example column have been modified for readability and to preserve confidentiality.

Because the patient not being transferred to another source of oxygen and the tank being found empty were the most frequent contributing factors to oxygen disruptions, these reports were further analyzed to understand them within the context of hand-off breakdowns. The majority of the reports that involved a patient not being transferred to another source of oxygen involved a hand-off breakdown (n=87 of 135, 64.4%). Of the reports that involved the patient's oxygen tank being found empty, over one-fifth of these reports involved a hand-off breakdown (n=24 of 107, 22.4%).

One quarter of reports reviewed involved a patient with high supplemental oxygen requirements (n=74 of 298, 24.8%). Frequency counts and percentages of high supplemental oxygen requirements are shown in **Table 4**.

Discussion

Supplemental oxygen is a life-saving medication, yet limited literature exists studying the nature of oxygen disruptions in the inpatient environment. The literature that does exist has identified oxygen tanks running empty and patients being transferred within the hospital as major factors contributing to safety events. Our findings support the literature on this topic and further identify that patients not being transferred to another source of oxygen when they should be is the most frequent contributing factor to oxygen disruptions, followed by tanks being found empty.

When thinking about how to solve the safety issues identified related to oxygen disruptions and developing interventions, there are at least two important human factors concepts for consideration. The first is the concept of situational awareness, which is one's ability to perceive, understand, and respond to the changing environment.[24] Shared situational awareness is a team's ability to have the same understanding of the environment. If a patient is picked up by a transporter and dropped off with a radiology technician, there is ambiguity of when the patient stops being the responsibility of the transporter and starts being the responsibility of the radiology technician. Therefore, there is also ambiguity of who is responsible for connecting and disconnecting the patient from their oxygen source. To mitigate this risk requires a high level of individual and shared situational awareness.

The second concept is that humans have limited cognitive resources and these resources are stretched when complex and simultaneous tasks, such as knowing the oxygen level in the tank, monitoring the patient, and performing other job duties, come into play. The design of most oxygen tanks, the processes needed for healthcare workers to manage them, and the patient's oxygen flow require a high level of cognitive resources. Calculating the amount of oxygen in the tank even without all the other interruptions and simultaneous tasks would be difficult and requires extensive working memory load. Reducing the cognitive burden is critical to addressing the underlying patient safety issues. These concepts are important to consider when designing any kind of intervention to address oxygen disruption issues.

Addressing these oxygen-related patient safety issues, with an emphasis on situational awareness and cognitive burden, will require both person-based and system-based solutions. Person-based solutions typically focus on individual training and behavior change, while system-based solutions focus on improvements to the overall work system.[25] Person-based solutions tend be less expensive to implement but are less durable, while system-based solutions tend to be more expensive and more durable.[26]

Person-Based Solutions: Enhancing Oxygen Delivery Protocols

The existing literature recommends interventions that are more person-based and focused on improving hand-off communication.[16,1,20,21] Additional person-based interventions include:

- *Clarify the responsibilities of the entire care team during hand-offs (e.g., nurses, transporters, procedure technicians, and therapists):* Hand-off breakdowns occurred in 41.3% of reports reviewed. Facilities should review their protocols associated with hand-offs. The protocol should include the specific tasks expected of each role in relation to preparing the patient to be transported off the unit and when the patient is returned to the unit (e.g., the nurse must complete necessary paperwork, check patient's oxygen tank, and have face-to-face communication with the transporter, while the transporter must fetch the patient's oxygen tank, have face-to-face communication with the nurse, and reconnect the patient to the wall when returning the patient to their room). Ensure that any protocol includes whether the staff member is expected to connect or disconnect the patient from their oxygen source (e.g., is the transporter expected to connect the patient to wall oxygen after returning the patient to their room?). If no protocol exists, consider involving frontline staff to clearly define roles in collaboration with each other.
- *Conduct oxygen rounds in the ED and imaging:* Oxygen disruption events occurred most frequently in the Emergency Department (n=86 of 298, 28.9%) and Imaging/Diagnostic (n=51, 17.1%). In both locations, patients may be expected to wait for long periods of time before receiving individualized attention. Wait times may be unpredictable and wall oxygen may not always be available, which puts patients on oxygen tanks at increased risk of the tank running out. Conducting rounds to specifically check oxygen tank levels while patients are awaiting care would increase staff's situational awareness and may catch patients whose tanks are close to emptying before their flow of oxygen is disrupted or who have not been transferred to another source of oxygen when they should be.
- *Evaluate the design of oxygen delivery devices for usability when procuring new products:* A small number of reports (n=25 of 298, 8.4%) involved an oxygen disruption in which the patient was connected to working supplemental oxygen, but the oxygen did not flow. For example, a patient was connected to a working oxygen tank, but the dial was not turned and therefore oxygen did not flow. While there was insufficient information in the reports to determine to what extent the usability of the supplemental oxygen devices impacted these events, it is possible that design-related issues may be misattributed to user error and not accurately reported. It is worth considering the usability of supplemental oxygen products before implementation. For example, when considering the procurement of new oxygen tanks, the legibility of the gauge, the volume of the alarm, and the intuitiveness of the markings on the dial should be evaluated.

A System-Based Solution: Supervisory Control for Oxygen Tank Monitoring

One potential system-based solution is to develop a supervisory control structure to address oxygen tank depletion. Supervisory control is a process used to monitor different components that may be distributed across a larger work system.[27] The standard process of a supervisory system begins with the communication process, with field devices sending their data to the central software core responsible for distributing and managing data flow to various modules until it is presented to the system operator in the desired format. This format allows the operator to monitor the status and progress of the devices.[28] A concrete example of a supervisory control structure in healthcare is centralized telemetry monitoring for patients who are at risk for cardiac arrythmias. Centralized telemetry has been found to reduce the risk of alarm fatigue for the on-site care team while maintaining a safe level of detection of cardiac rhythm changes.[29] While centralized monitoring presents its own challenges with visual fatigue and attentiveness, the benefit of a centralized team that is charged with supervising is that it can be highly specialized and focused specifically on the task of monitoring.

Currently, supervisory systems are sometimes used to monitor oxygen tank supply and location, but there is limited technology developed to monitor oxygen tank levels. The technology that is available to monitor oxygen tank levels appears to be designed for single tanks and is typically for home use. A more robust solution for the future state of oxygen safety in the inpatient environment is to design a supervisory system that monitors individual tank oxygen levels (e.g., pounds per square inch, rate of oxygen flow, and likely time until empty) and tank location, and sends a message to a centralized display that is actively monitored. When an individual tank is near emptying, a message would be generated indicating the tank's specific location and how much time is left before the tank runs out. The patient's care team member could be notified if an issue is detected. It may also be beneficial to provide notifications to the patients themselves so that those who are able can advocate for their own care and practice the skills they may need to monitor personal use of oxygen at home.

Limitations

We examined PSE reports which represent a single data source from one state (Pennsylvania), so results may not be generalizable across other data types or states. Also, despite mandatory reporting laws in Pennsylvania, reported events may not represent all events that occurred. In addition, due to limited descriptive information in some PSE reports, we were unable to understand the larger context of the error reported, and we did not follow up with facilities to gather additional information about each report. Finally, our keyword search may have limited the number of reports that fit our inclusion criteria.

Conclusion

Oxygen disruptions frequently occur due to lack of situational awareness and hand-off breakdowns. Existing solutions include improving hand-off communications and providing paper-based tools and checklists. Drawing on the concept of central monitoring in healthcare and supervisory systems in human factors may provide more durable, technology-based solutions to prevent oxygen disruptions and reduce harm to patients. As a next step, clinical, patient safety, and information systems leadership should be engaged to assess what existing technology can be leveraged, what new technology must be acquired or developed, and whether to design a central monitoring workflow. Additionally, patient safety and supply chain professionals should consider working with oxygen tank vendors and policy leaders to develop standards for an optimal oxygen tank design.

Note: This study was approved by the MedStar Health Research Institute institutional review board.

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