



HEALTHCARE SAFETY
INVESTIGATION BRANCH

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PIPED SUPPLY OF MEDICAL AIR AND OXYGEN

Healthcare Safety Investigation 12018/017

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INVESTIGATION BRANCH





ABOUT HSIB

The Healthcare Safety Investigation Branch (HSIB) began operating on 1 April 2017. HSIB offers an independent service for England, guiding and supporting NHS organisations on investigations and also conducting safety investigations.

HSIB aims to improve patient safety through effective and independent investigations that do not apportion blame or liability. This is delivered through:

- **Learning for improvement** – by using findings to address causes and contributory factors and provide support to increase the capability within local NHS systems.
- **Diffusing learning** – through effective communications and engagement with the wider health and social care system.

HSIB's investigations are conducted by a team of professional investigators from a range of safety-critical backgrounds, including the NHS, transport and the military. The HSIB also draws on additional expertise when required, including Human Factors advisors.

HSIB investigates up to 30 safety incidents each year to provide meaningful safety recommendations and share learning across the whole of the healthcare system for the benefits of everyone who is cared for by it and works in it.

HSIB works with patients and their families and carers, healthcare staff, trusts, hospitals and other healthcare providers across England.

HOW HSIB DECIDES WHAT TO INVESTIGATE

HSIB welcomes information about patient safety issues for potential investigation from individuals, groups or organisations. The decision to investigate could relate to a single event, a series of events or a problem uncovered during investigation.

HSIB investigations will not replace local investigation of patient safety incidents. HSIB's purpose is to identify national learning from such events and consider the wider systems and processes. It considers the following criteria when deciding whether to start an investigation:

OUTCOME IMPACT

Assessing the impact or potential impact on people is a crucial part of the process. HSIB considers the physical and/or emotional harm suffered by anyone involved. The impact on services and whether the safety issues have reduced the ability to deliver safe and reliable care is also assessed. HSIB considers whether an incident has caused a loss of confidence in the healthcare system.

SYSTEMIC RISK

HSIB reviews the system-wide risk associated with the safety issues. How common or widespread is the problem? Does it span different areas of healthcare and/or multiple locations?

LEARNING POTENTIAL

HSIB exists to support improvements in patient safety. Its purpose is to show how investigations can produce new information about safety and to identify meaningful, influential and effective recommendations designed to benefit everyone working in or being cared for by the healthcare system.

HSIB investigators use a range of approaches to focus on identifying risk and the cause(s) of incidents.

INVESTIGATION APPROACH

HSIB never attributes blame or liability. Its focus is solely to identify opportunities to learn and to improve patient safety. HSIB does not investigate on behalf of families, staff, organisations or regulators. It may investigate similar incidents in different locations, or incidents that have occurred across different organisations.

HSIB is funded by the Department of Health and hosted by NHS Improvement. HSIB is independent from regulatory bodies, including the Care Quality Commission. Its aim is to bring a new perspective.

HSIB will identify safety actions taken and make safety recommendations and safety observations to organisations or bodies that can influence and support change.

Safety Recommendations are directed to an individual or organisation for action. The recommendation(s) are based on information from the investigation and/or other eligible sources, including safety studies. Recommendations are made with the intention of preventing similar events.

Safety Observations are directed to a specific individual or organisation for consideration. Observations are made when there is a lack of information on which to make a definitive safety recommendation but HSIB believes its findings warrant attention.

Safety Actions are actions taken during the course of the investigation as a response to the issue under investigation.

A NOTE OF ACKNOWLEDGMENT

HSIB would like to thank the patient and her son, for their time in sharing their recollection of events and experiences which are central to this report.

EXECUTIVE SUMMARY

The reference event

An 85-year-old woman was admitted to hospital at 13:00 hours on a weekday afternoon via the Emergency Department (ED) after she fell at home. She suffered from chronic lung disease and was usually breathless at rest. On assessment in the ED her blood oxygen saturations were recorded as 93% breathing room air. A plan was made for her to receive supplementary oxygen as required if oxygen saturations fell below 92% breathing room air.

At 18:30 hours she was transferred to a ward where at 21:29 hours her oxygen saturation level was recorded as 98% breathing room air.

At 07:18 hours the following morning a nurse, who was coming to the end of her shift, was undertaking routine observations and recorded an oxygen saturation level of 84% breathing room air. In keeping with the previous plan, she administered what she thought was oxygen at a rate of 2 Litres per minute (L/min) via nasal cannulae connected to a wall-mounted supply. She then asked for a medical review.

At 08:35 hours another nurse, who had just come on duty, discovered that the patient's oxygen saturations had fallen to 76% and that she was being administered air, not oxygen, from the adjacent wall-mounted supply. An air flowmeter flap was in place.

The nurse administered 2L/min oxygen and organised a medical review. The oxygen saturations quickly recovered to 93% and the patient suffered no apparent long-term adverse effects from this episode.

The national investigation

The Healthcare Safety Investigation Branch (HSIB) was made aware of a safety issue relating to a persistent risk in hospitals of connecting oxygen tubing to wall-mounted air flowmeters despite the release of a Patient Safety Alert by NHS Improvement (NHSI) in 2016 and a Rapid Response Report from the National Patient Safety Agency (NPSA) in 2009 intended to address this issue.

HSIB identified the reference event and with the support of the Trust commenced a scoping investigation. The findings were considered against the HSIB investigation criteria, and a decision was made to progress to a national investigation. The

national investigation collected evidence relating to the reference event, published material associated with the 2016 NHSI Patient Safety Alert, and information related to implementation of the alert. This investigation also considered the assurance processes there were to ensure that trusts undertook appropriate action in response to the alert, how they understood the requirements for piped medical air and oxygen in hospitals and how those requirements were met.

Findings

The national investigation found:

- There is a lack of clarity on the requirement for piped medical air in hospitals.
- Some trusts have misinterpreted the direction given in the NHS Improvement (NHSI) Patient Safety Alert to remove air flowmeters and cap air outlets in areas where there is no need for medical air and to deliver nebulised medication using nebuliser boxes.
- Financial considerations may be a barrier to trusts switching from piped air delivered through Medical Gas Pipeline Systems (MGPS) to nebuliser boxes, due to the cost of purchasing the required number of nebuliser boxes and the capping of the wall terminals, particularly in Private Finance Initiative (PFI) hospitals.
- Local assurance processes relating to the implementation of this alert were not effective in this case. The ability to nationally record trusts' specific actions in response to this and other alerts exists but requires further enhancement to support trusts and national oversight.
- The movable flap fitted to air flowmeters and removal of the flowmeter when not in use has reduced the risk of human error but not prevented it.

HSIB MAKES THE FOLLOWING SAFETY RECOMMENDATION:

Safety Recommendation to National Patient Safety Alert Committee

Recommendation 2019/027:

The National Patient Safety Alert Committee should set standards for all issuers of patient safety alerts that require an assessment for unintended consequences, the effectiveness of barriers in the alert, and the advice the alert issuers give providers on implementation and ongoing monitoring.

HSIB MAKES THE FOLLOWING SAFETY OBSERVATION:

Observation:

The Central Alerting System gives providers the opportunity to supply information on actual actions taken alongside recording that actions have been completed. However, the functionality could be developed to require providers to give further detail and this would allow a more effective way of nationally reviewing this information.



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1 BACKGROUND AND CONTEXT

1.1 Supplemental oxygen

- 1.1.1 The British Thoracic Society (BTS) guideline [1] identifies three main requirements for administration of oxygen in hospitals:
- administration to correct hypoxaemia (low blood oxygen levels).
 - administration to prevent possible hypoxaemia.
 - administration to alleviate breathlessness.
- 1.1.2 Since ‘oxygen is probably the commonest drug used in the care of patients who present with medical emergencies’, the guideline indicates that it should be prescribed by a doctor and a written record kept. [1]
- 1.1.3 Prescribing oxygen in advance enables nurses to take action if a patient’s oxygen saturation levels fall unexpectedly, without the need to wait for a doctor to attend and prescribe oxygen. [1]
- 1.1.4 Failure of oxygen saturation levels to respond to treatment may indicate that insufficient oxygen has been given, that the clinical situation has deteriorated or that a problem exists with the oxygen delivery system itself.

1.2 Medical air

- 1.2.1 Medical air is supplied through high-quality drying and filtration equipment. [2]
- 1.2.2 The main uses for medical air in hospitals are as follows:

‘Driving nebulisers. A nebuliser is a device that converts medication solutions into aerosols suitable for inhalation. Nebulisers are widely used in the treatment of respiratory diseases, e.g. asthma, chronic obstructive pulmonary disease (COPD) and cystic fibrosis. While piped medical air can be used to nebulise medication, machines that compress atmospheric air are widely available and some sites use ultrasonic

nebulisers. Therefore, piped medical air has become obsolete in some areas that use these alternatives.

Driving ventilators¹ and resuscitaires². Patients sensitive to oxygen toxicity are given air to lower their exposure to oxygen, e.g. neonates, patients with chronic hypoxaemia (as in severe COPD) and those with acute pulmonary problems with severe hypoxia.

Power source for driving surgical tools. These tools require high flow and high pressure air (‘surgical air’). These power sources cannot be mistaken for oxygen outlets as they have different connections.

Carrier gas for volatile anaesthetic agents in anaesthesia.’ [3]

1.3 Delivery methods for oxygen and medical air

- 1.3.1 The delivery methods for air and oxygen are as follows:
- Pipelines built into the hospital infrastructure, called the Medical Gas Pipeline System (MGPS)³.
 - Machines can connect directly to the terminal unit⁴ to deliver the required gas.
 - Flowmeters (see page 12) connect to the terminal unit. An oxygen flowmeter has a connector specific for the oxygen terminal unit and cannot accidentally be connected to the air terminal unit and vice versa. In a ward a flowmeter is required to connect the tubing from the patient mask and to specify the flow rate of gas to be delivered.
 - Portable air or oxygen cylinders with a flowmeter or a regulator.
 - For air only, compressed or ultrasonic nebulisers.
- 1.3.2 Many hospital wards have an MGPS for delivering oxygen and air to wall outlets adjacent to each bed.

- 1.3.3 In 2006 the Department of Health and Social Care released a Health Technical Memorandum (HTM) in relation to MGPS. [2] [4] It stated: *'An MGPS is designed to provide a safe and effective method of delivering medical gases, medical air and surgical air from the source of supply to the appropriate terminal unit [or 'outlet'] by means of a pipeline distribution system.'* [2]
- 1.3.4 The HTM does not set out the need for MPGS to deliver air, rather the standards that must be applied for fitting and maintenance of systems if they are deemed to be required.
- 1.3.5 Ventilators, resuscitators, surgical tools and anaesthetic machines can be connected directly to the air and oxygen supply and a flowmeter is not needed.
- 1.3.6 In the UK and Europe, oxygen flowmeters are coloured white and air flowmeters are coloured black (Figure 1).

FIG 1 OXYGEN AND AIR FLOWMETERS



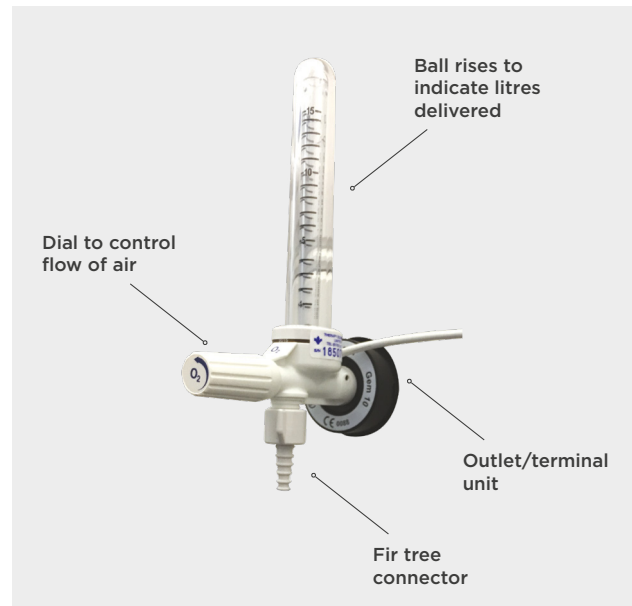
- 1.3.7 In hospitals the terminal unit for oxygen is situated next to the terminal unit for air. HTM (O2-01) [2] states that in all installations the oxygen terminal unit should either be to the left of or above the air terminal unit.

1.4 Air flowmeters

- 1.4.1 The connectors between the wall outlets and the flowmeters for oxygen and air are different. They have been designed like this

to prevent inadvertent connection of the oxygen flowmeter to the air outlet. However, the connectors between the flowmeters and the tubing which connects to the patient administration device are identical. Both have fir tree connectors (Figure 2) which means that oxygen tubing can inadvertently be connected to an air flowmeter and vice versa.

FIG 2 COMPONENTS OF A FLOWMETER



1.5 National Patient Safety Agency Rapid Response Report

- 1.5.1 In 2009 the National Patient Safety Agency (NPSA) issued a Rapid Response Report in relation to oxygen safety in hospitals [5] recommending that *'the risks of confusing oxygen and medical compressed air are assessed and action plans developed (e.g. removing the medical air flowmeter from the wall outlet when not in regular use).'* [5]

1.6 NHS Improvement Patient Safety Alert

- 1.6.1 In 2016, NHS Improvement issued a Patient Safety Alert (PSA): NHS/PSA/D/2016/009 titled *'Reducing the risk of oxygen tubing being connected to air flowmeters'* (see appendix). [6] The PSA stated: *'Three barriers to human error have already been recommended by the NPSA and British Thoracic Society but continuing incidents suggest they have not been universally implemented.'* These three approaches to

reducing the risk of connecting oxygen tubing to air flowmeters described in the alert were:

'Medical air terminal units (wall outlets) are covered with designated caps in areas where there is no need for medical air. Medical air outlets were traditionally built into most clinical areas for the delivery of nebulised treatment but not all areas need them (e.g. they never have patients who need nebulisers, or they have access to electrically driven compressors or ultrasonic nebulisers).

Medical air flowmeters are removed from terminal units (wall outlets) and stored in an allocated place when not in active use. Removing unnecessary equipment is a more effective method of reducing human error than adding labels or warnings alone.

Air flowmeters are fitted with a labelled, movable flap. The lettering on the flap is larger and more visible than on the flowmeter itself and this flap has to be lifted to attach a tube. This acts as a further barrier to unintended connection if staff occasionally forget to remove medical air flowmeters after a period of active use.' [6]

1.6.2 The alert required providers to complete the following actions by 4 July 2017:

- Identify a named individual who will take responsibility for co-ordinating the delivery of the actions required by this alert.
- Implement systems to ensure that the three barriers to human error described in this alert were all in place in all relevant clinical areas.
- Establish ongoing systems of audit or equipment checks to ensure the barriers are maintained.

1.7 British Thoracic Society (BTS) guideline

1.7.1 The BTS guideline for oxygen use in adults in healthcare and emergency settings states: *'Air flowmeters are never required in an emergency and should be removed from wall sockets or covered by a designated 'hood' when not in use.'* [1] The BTS guidelines also

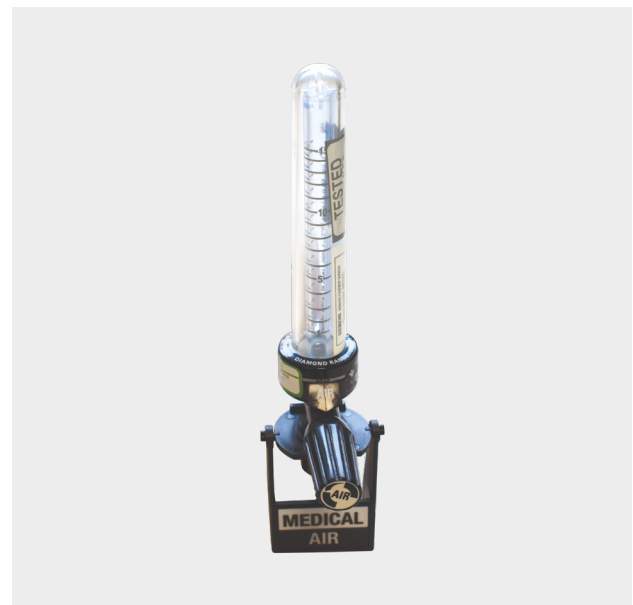
recommended that organisations implement measures to stop inadvertent connection to air instead of oxygen.

1.8 Air flowmeter flaps

1.8.1 The supporting information that accompanied the 2016 PSA stated: *'In theory, flaps would not need to be fitted if the other two barriers are always put into practice. If all 'out of use' medical air outlets are covered and all flowmeters are always removed from the outlet after active use, the risk of inadvertently attaching an oxygen tube to an air flowmeter would be low. However, we know that there will be occasions when air flowmeters might accidentally be left in situ, eg when staff are distracted or not fully aware of local arrangements.'* [3]

1.8.2 The PSA recommended that movable flaps were fitted to all air flowmeters that were still in use (see figure 3). The rationale was that *'First, the flap is labelled 'medical air' in lettering larger than that on the flowmeter itself, making it more visible to staff. Second, the flap has to be lifted to attach a tube, which is an additional step to prompt the user to check the outlet supplies the correct type of gas.'* [3] This supporting information highlighted that this would have a *'limited impact on reducing human error when implemented on their own.'*

FIG 3 AIR FLOWMETER WITH MOVEABLE FLAP



1.9 Nebuliser boxes/ultrasonic nebulisers

- 1.9.1 Nebuliser boxes and ultrasonic nebulisers are portable machines that convert liquid medicine into aerosols for inhalation. They are an alternative to using medical air through the MGPS for this purpose. The PSA stated that *'unlike oxygen, flowmeters for medical air are never required in an emergency. Therefore, withdrawing 'immediate' access to medical air would not introduce risks to patients. Of course, any action plans to do this would need to ensure alternative arrangements are in place to meet patient needs (e.g. increased stocks of compression or ultrasonic nebulisers).'*' [6] The main barrier to their widespread use has been cost; an individual nebuliser box typically costs £80-100. Individual trusts are responsible for identifying the number of nebuliser boxes required for each clinical area and ensuring that they are maintained and replaced as required.

1.10 Never Events

- 1.10.1 Never Events are defined as incidents that are *'wholly preventable, where guidance or safety recommendations that provide strong systemic protective barriers are available at a national level and should have been implemented by all healthcare providers.'* [7]
- 1.10.2 Unintentional connection of a patient requiring oxygen to an air flowmeter has been considered a Never Event under the NHS Improvement Never Events list, published in January 2018.

1.11 NHS Improvement alert follow-up

- 1.11.1 On 1 June 2018 The Medical Director and Nurse Director of NHS Improvement wrote to all acute trust medical directors and nurse

directors stating: *'Almost all trusts have stated they have complied with the NHS Improvement Alert that required removal of air flowmeters from routine use by July 2017. In almost all clinical settings, power driven nebulisers can be used instead, and all air flowmeters can be permanently removed and disposed of, with air outlets blocked off. In the rare clinical setting where it is impossible to use power-driven nebulisers due to lack of space, air flowmeters need to be separately stored and should be brought out of storage only for the ten minutes or so required to deliver the nebuliser. Unintended connection to an air flowmeter for a patient requiring oxygen therefore became a Never Event in February 2018. Since then, 15 trusts have reported Never Events related to unintended connection to air flowmeters, and what is particularly concerning is that most of these make no reference to how the trust had implemented the Alert and suggest air flowmeters had not been removed and remained constantly in wall outlet.'* [8]

1.12 Central Alerting System (CAS)

- 1.12.1 *'The Central Alerting System (CAS) is a web-based cascading system for issuing patient safety alerts, important public health messages and other safety critical information and guidance to the NHS and others.'* [9] All patient safety alerts are released through the CAS and each organisation will have a staff member who is responsible for receiving and disseminating the alerts. Where actions are required in response to an alert each organisation is required to sign off the actions as complete in the CAS system.

2 THE REFERENCE EVENT

2.1 Patient story

- 2.1.1 An 85-year-old woman was admitted to hospital at 13:00 hours on a weekday afternoon via the Emergency Department (ED) after she fell at home. She suffered from chronic lung disease and was usually breathless at rest. On assessment in the ED her blood oxygen saturations were recorded as 93% breathing room air. A plan was made for her to receive supplementary oxygen as required if oxygen saturations fell below 92% breathing room air.
- 2.1.2 At 18:30 hours she was transferred to a ward where at 21:29 hours her oxygen saturation level was recorded as 98% breathing room air.
- 2.1.3 At 07:18 hours the following morning a nurse, who was coming to the end of her shift, was taking routine observations and recorded an oxygen saturation level of 84% breathing room air. In keeping with the previous plan, she administered what she thought was oxygen at a rate of 2 litres per minute (L/min) via nasal cannulae connected to a wall-mounted supply. She then asked for a medical review.
- 2.1.4 At 08:35 hours another nurse, who had just come on duty, discovered that the patient's oxygen saturations had fallen to 76% and that she was being administered air, not oxygen, from the adjacent wall-mounted supply.
- 2.1.5 The nurse administered 2L/min oxygen and organised a medical review. The oxygen saturations quickly recovered to 93% and the patient suffered no apparent long-term adverse effects from this episode.
- 2.1.6 The air flowmeter had been fitted with a flap, and the flap was still in place.



3 INVOLVEMENT OF THE HEALTHCARE SAFETY INVESTIGATION BRANCH

3.1 Notification of the reference event

3.1.1 The Healthcare Safety Investigation Branch (HSIB) was made aware of a safety issue relating to the risk of connecting oxygen tubing to air flowmeters.

3.2 Decision to investigate

3.2.1 Following preliminary information gathering, HSIB concluded that the safety issues represented by this event and supported by national data, met the criteria for investigation, which the Chief Investigator authorised.

3.2.2 A summary of the analysis against the high-level criteria is given below.

Outcome Impact – What was, or is, the impact of the safety issue on people and services across the healthcare system?

There is a risk of severe harm or death if air is administered rather than oxygen. This has been highlighted in previous alerts from the National Patient Safety Agency in 2009 and NHS Improvement in 2016.

Systemic Risk – How widespread and how common a safety issue is this across the healthcare system?

Unintentional connection of a patient requiring oxygen to an air flowmeter became a Never Event on 1 February 2018. From February to June 2018, 32 cases were reported nationally.

Learning Potential – What is the potential for an HSIB investigation to lead to positive changes and improvements to patient safety across the healthcare system?

This issue continues to occur despite the 2009 and 2016 national alerts and the designation of this as a Never Event in 2018. There is potential for HSIB to examine how national recommendations are developed and translated into local practice including the mechanisms available to redesign systems to reduce risks.

3.3 Evidence gathering and methodology

3.3.1 Methods used in this investigation included:

- Review of patient clinical records, hospital policies and procedures relating to management of Patient Safety Alerts (PSA) and relevant meeting records.
- Interviews with the staff involved in the incident and wider decision-making surrounding implementation of the PSA.
- Interview with the affected patient and her family.
- Review of the Trust's serious incident reports for each of its four recent cases.
- Review of 32 relevant serious incidents reported to the Strategic Executive Information System (StEIS) on national incident reporting databases between 1 February and 30 June 2018.
- Research literature review.
- Communication with subject matter experts and those involved in the development of the PSA.



4 ANALYSIS

4.1 Piped medical air in hospitals

4.1.1 There is a lack of clarity about the circumstances in which piped medical air is required in hospitals. The Patient Safety Alert (PSA) states that *'medical air outlets were traditionally built into most clinical areas for the delivery of nebulised treatment.'* [6]

4.1.2 NHS Improvement (NHSI) Patient Safety Team were confident that the only use for piped medical air via an air flowmeter was for the delivery of nebulised medications and that this need could be met using nebuliser boxes. Intensive Care Unit (ICU) consultants told the investigation that there could be other circumstances in which a piped air supply through a Medical Gas Pipeline System (MGPS) would be required on general wards to provide patient ventilation (for example, when ICU patients require care on a lower dependency ward, during a major incident, or pandemic flu).

4.1.3 There is a requirement for medical air in neonatology, operating theatres and high-dependency areas, such as ICUs. In these areas the medical air is delivered through an integral system(s) and does not require an air flowmeter.

4.2 The NHS Improvement Patient Safety Alert: NHS/PSA/D/2016/009 Reducing the risk of oxygen tubing being connected to air flowmeters

4.2.1 NHS Improvement (NHSI) stated that the intention of the 2016 PSA was for trusts to remove all air flowmeters and replace them with nebuliser boxes except in areas where this was not feasible (for example emergency department (ED) cubicles without space for a nebuliser box).

4.2.2 Recognising that providing nebuliser boxes may not be feasible in all areas immediately, NHSI Patient Safety Team expected that trusts should remove air flowmeters from the outlet when not in use and have a moveable flap in place to act as a physical prompt.

4.2.3 The PSA contained an action that trusts should implement systems to ensure

that *'the three barriers to human error described in this alert are all in place in all relevant clinical areas.'* [6] Despite that, the investigation identified that some trusts interpreted the three barriers as options from which they could select those they felt were required locally.

4.2.4 A review of 32 Never Events reported to StEIS between 1 February and 30 June 2018 found that many trusts that experienced Never Events opted only for the third barrier; installing a flap over the air flowmeter connector. While others did report removing air flowmeters and/or replacing these with nebulisers after the Never Event, there was no consistent response. Other responses to the Never Events included raising awareness of the issue with staff, capping of piped medical air supplies, replacing piped medical air with nebuliser boxes and removing air flowmeters when not in use. Evidence from these events showed that the removal of air flowmeters after each use was not sustained and so did not provide a strong barrier to preventing further incidents.

4.2.5 The supporting information that accompanied the PSA [3] provided three case studies which showed that the wall outlets were capped. It also included illustrations on the installation of movable flaps. These illustrations may have led some trusts to focus more on the installation of flaps than the other barriers.

4.2.6 The Trust involved in the reference event told the investigation that at the time it received the 2016 PSA, it considered the alert and decided to install moveable flaps on all its air flowmeters but to take no other actions. The Trust believed that was all the alert required it to do. It recorded the alert as *'action completed'* in the Central Alerting System (CAS). The Trust then had a Never Event involving the unintended connection of a patient to an air flowmeter. As a response to this the Trust reminded staff that air flowmeters should be removed when not in use and to ensure that moveable flaps were in place. Following two further Never Events, the Trust instigated audits to ensure that air flowmeters were removed when not in use, and hourly checks by ward leaders. A fourth Never Event occurred; the Trust declared

'air permissible areas' where air supply via MGPS could still be used, and purchased nebulisers for all other areas. The Trust successfully secured funding from its charity to enable this purchase.

4.3 Financial considerations

- 4.3.1 The investigation found that cost may be a barrier to trusts implementing all recommendations in the PSA.
- 4.3.2 The investigation observed that nebuliser boxes varied in cost when purchased through NHS Supply Chain or directly from manufacturers. Trusts explained that each box can cost between £80-100, and one Trust reported that it relied on charitable funding for the purchase of these to cover all clinical areas.
- 4.3.3 The investigation was made aware that in trusts with Private Finance Initiative (PFI) buildings, capital works, such as capping air wall outlets, could require renegotiation of contracts which would incur additional expense.

4.4 Assurance processes for Patient Safety Alerts

- 4.4.1 The internal assurance process for taking the appropriate action in response to a PSA has not been effective in this instance. The Trust had declared compliance.
- 4.4.2 The CAS provides a free-text feedback box which healthcare providers can use to detail what actions they have taken in response to alerts issued through the system. However, whilst the system mandates that a response is selected (for example '*action completed*') it does not mandate that the provider supply any detail. There is no current option for documents to be uploaded (for example action plans) by providers, and uploading documentation rather than completing a free-text box may be a more practical way of gathering this type of feedback. NHSI Patient Safety Team, supported by literature from the Care Quality Commission, [10] stated that systems within healthcare providers for acting effectively on alerts are currently not always robust.

HSIB MAKES THE FOLLOWING SAFETY RECOMMENDATION:

Safety Recommendation to National Patient Safety Alert Committee

Recommendation 2019/027:

The National Patient Safety Alert Committee should set standards for all issuers of patient safety alerts that require an assessment for unintended consequences, the effectiveness of barriers in the alert, and the advice the alert issuers give providers on implementation and ongoing monitoring.

HSIB MAKES THE FOLLOWING SAFETY OBSERVATION:

Observation:

The Central Alerting System gives providers the opportunity to supply information on actual actions taken alongside recording that actions have been completed. However, the functionality could be developed to require providers to give further detail and this would allow a more effective way of nationally reviewing this information.

4.5 Medical Gas Pipeline System connector design

- 4.5.1 Air and oxygen flowmeters connect to tubing using the same connector design; this represents a further source of risk.
- 4.5.2 An air flowmeter cannot be connected to an oxygen outlet and an oxygen flowmeter cannot be connected to the medical air outlet as the connectors are incompatible. However, the fir tree connectors that connect both the oxygen flowmeter and air flowmeter to the tubing are the same.
- 4.5.3 The International Organization for Standardization (ISO) draft standard ISO-80369-2 relates to breathing systems and for driving gases applications.
- 4.5.4 At the time of writing, the standards for ISO-80369-2 remain in draft form. Initially the proposal was for the fir tree connectors, tubing and mask to be different between medical air and oxygen, but product manufacturers considered this would not be achievable. The current proposal is for a

specific air mask and oxygen mask with a unique connection to the tubing, although the end user would still be able to attach the same tubing to the fir tree on the flowmeter. The end user would also have to select the correct type of mask for the required use.

- 4.5.5 The investigation concluded that the new ISO standards for piped medical air connectors are unlikely to fully prevent the risk of unintentionally connecting the patient's oxygen tubing to medical air instead of oxygen.

4.6 The design of moveable flaps

- 4.6.1 The moveable flap was designed and developed by a hospital team in Australia [11] and marketed under the brand name

AirGuard. The team recognised that the flap was an error-reducing solution rather than error-proofing solution.

- 4.6.2 A small-scale study at the institution where it was developed found a reduction in the number of reports of misconnection incidents when the AirGuard was used, [12] although some incidents still occurred. It is unclear to what extent the AirGuard has been further tested and evaluated.

- 4.6.3 Staff from the Trust involved in the reference event told the investigation that the moveable flap was not an effective barrier to reduce the risk of connecting oxygen tubing to the air flowmeter.

5 SUMMARY OF FINDINGS AND RECOMMENDATIONS

5.1 Findings

The national investigation found:

- There is a lack of clarity on the requirement for piped medical air in hospitals.
- Some trusts have misinterpreted the direction given in the NHS Improvement (NHSI) Patient Safety Alert to remove air flowmeters and cap air outlets in areas where there is no need for medical air and to deliver nebulised medication using nebuliser boxes.
- Financial considerations may be a barrier to trusts switching from piped air delivered through Medical Gas Pipeline Systems (MGPS) to nebuliser boxes, due to the cost of purchasing the required number of nebuliser boxes and the capping of the wall terminals, particularly in Private Finance Initiative (PFI) hospitals.
- Local assurance processes relating to the implementation of this alert were not effective in this case. The ability to nationally record trusts' specific actions in response to this and other alerts exists but requires further

enhancement to support trusts and national oversight.

- The movable flap fitted to air flowmeters and removal of the flowmeter when not in use has reduced the risk of human error but not prevented it.

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6 APPENDIX PATIENT SAFETY ALERT

Classification: Official



Improvement



Patient Safety Alert

Reducing the risk of oxygen tubing being connected to air flowmeters

4 October 2016

Alert reference number: NHS/PSA/D/2016/009

Alert stage: Three - Directive

Severe harm or death can occur if medical air is accidentally administered to patients instead of oxygen. A Rapid Response Report (RRR) issued by the National Patient Safety Agency (NPSA) in 2009¹ highlighted the risk and requested that trusts develop action plans to prevent these incidents. However, events continue to occur. Since January 2013 the National Reporting and Learning System (NRLS) has received two reports of fatalities, two of severe harm, and over 200 of incidents resulting in moderate, low or no harm. A recent report reads:

"...Patient arrested a further time secondary to hypoxia. It was then discovered that patient was inadvertently being ventilated with medical air from piped supply for up to ten minutes. The medical air and the oxygen outlets were side by side, both with flowmeters attached. It was very difficult to tell which flowmeter was which, particularly in an emergency situation."

Air and oxygen flowmeters can be difficult to tell apart and as they both have universal outlets, oxygen tubing can be attached to both. International connector standards are being developed for breathing systems and driving gases applications.² However, it is unclear at present whether these new connectors will differentiate oxygen and medical air. Even if they do, it can take industry many years to adopt a new design. Other solutions are required in the meantime.

Three barriers to human error have already been recommended by the NPSA¹ and British Thoracic Society (BTS)³ but continuing incidents suggest they have not been universally implemented:

- **Medical air terminal units (wall outlets) are covered with designated caps in areas where there is no need for medical air.** Medical air outlets were traditionally built into most clinical areas for the delivery of nebulised treatment but not all areas need them (eg they never have patients who need nebulisers, or they have access to electrically driven compressors or ultrasonic nebulisers).
- **Medical air flowmeters are removed from terminal units (wall outlets) and stored in an allocated place when not in active use** Removing unnecessary equipment is a more effective method of reducing human error than adding labels or warnings alone.
- **Air flowmeters are fitted with a labelled, movable flap** The lettering on the flap is larger and more visible than on the flowmeter itself and this flap has to be lifted to attach a tube. This acts as a further barrier to unintended connection if staff occasionally forget to remove medical air flowmeters after a period of active use.

Air flowmeters are never required in an emergency situation (eg a cardiac arrest) and the lack of immediate access to medical air does not introduce risks to patients. See supporting information improvement.nhs.uk/news-alerts/reducing-risk-oxygen-tubing-being-connected-air-flowmeters for further details, other potential barriers and local implementation examples.

Actions

Who: All hospitals (or any other sites) providing NHS funded care that supply medical air using medical gas pipeline systems (MGPSs)*

When: To begin as soon as possible and to be completed by 4 July 2017.

- 1** Identify a named individual who will take responsibility for co-ordinating the delivery of the actions required by this alert.
- 2** Implement systems to ensure that the three barriers to human error described in this alert are all in place in all relevant clinical areas.
- 3** Establish ongoing systems of audit or equipment checks to ensure the barriers are maintained.
- 4** Share what you learn from implementing this alert or locally developed good practice resources by emailing patientsafety.enquiries@nhs.net

See page 2 for technical notes, supporting information and references

*Although this alert is directed at sites that use piped medical air, there is still useful learning in the supporting information for those that use cylinders to provide air and oxygen.

Patient Safety
improvement.nhs.uk/resources/patient-safety-alerts

Contact us: patientsafety.enquiries@nhs.net

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7 REFERENCES

- 1 British Thoracic Society. (2017) BTS guideline for oxygen use in adults in healthcare and emergency settings. Thorax, 72(s1): i1-i90.
- 2 Department of Health and Social Care. (2006) Medical gases. Health Technical Memorandum 02-01: Medical gas pipeline systems Part A: Design, installation, validation and verification. [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/153575/HTM_02-01_Part_A.pdf
- 3 NHS Improvement. (2016) Supporting information for Patient Safety Alert: Reducing the risk of connecting oxygen tubing to air flowmeters. [Online] Available at: https://improvement.nhs.uk/documents/407/Supporting_information_for_air_flowmeter_PSA1.pdf
- 4 Department of Health and Social Care. (2006) Medical Gases. Health Technical Memorandum 02-01: Medical gas pipeline systems Part B: Operational Management. [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/153576/HTM_02-01_Part_B.pdf
- 5 National Patient Safety Agency. (2009) Rapid Response Report NPSA/2009/RRR006 Oxygen safety in hospitals. National Patient Safety Agency.
- 6 NHS Improvement. (2016) Patient Safety Alert. Reducing the risk of oxygen tubing being connected to air flowmeters. [Online] Available at: https://improvement.nhs.uk/documents/408/Patient_Safety_Alert_-_Reducing_the_risk_of_oxygen_tubing_being_connected_to_a_bDUb2KY.pdf
- 7 NHS Improvement. (2018) Never Events policy and framework. [Online] Available at: https://improvement.nhs.uk/documents/2265/Revised_Never_Events_policy_and_framework_FINAL.pdf
- 8 McLean, K and May, R. (2018) Letter: NHS Improvement Patient Safety Alerts and Never Events.
- 9 Medicines and Healthcare products Regulatory Agency. (2018) Central Alerting System Homepage. [Online] Available at: <https://www.cas.mhra.gov.uk/Home.aspx>
- 10 Care Quality Commission. (2018) Opening the door to change. [Online]. Available at: https://www.cqc.org.uk/sites/default/files/20181224_openingthedoor_report.pdf
- 11 Mason, P, Young, J and Taylor, D. (2007) Preventing Wrong Gas Delivery to Patients. [Poster] Australasian Conference on Safety & Quality in Health Care, Brisbane. [Online] Available at: http://www.fbe.com.au/AirGuard/AirGuard_files/Preventing%20wrong%20gas%20delivery.pdf
- 12 McEwen, M, Kennett, G, Smith, A and Woolford, R. (2009) AirGuard decreases the prevalence of air/oxygen misconnections. [Poster] Engineering and Physical Sciences in Medicine, Canberra. [Online] Available at: http://www.fbe.com.au/AirGuard/AirGuard_files/AirGuard%20decreases%20prevalence%20of%20air%20oxygen%20misconnections%20Poster%20ABEC%20Canberra%202009.pdf

ENDNOTES

- ¹ Ventilator – a machine that supports breathing for patients who cannot breathe themselves or require additional support to breathe.
- ² Resuscitaire – a machine used for babies that provides respiratory support and temperature regulation. That is, the resuscitaire helps the baby to breathe and keeps the baby warm. Resuscitaires are connected to both the MGPS oxygen and medical air supplies.
- ³ Medical Gas Pipeline System (MGPS) – a system designed to provide a safe and effective method of delivering medical gases, medical air and surgical air from the source of supply to the appropriate terminal unit by means of a pipeline distribution system.
- ⁴ Terminal unit – the end point of the MGPS which can be connected to a device to access the gas from the MGPS. Terminal units are also called ports. The gas cannot be extracted from the MGPS without connection to an appropriate device (such as a flowmeter, resuscitaire or ventilator).



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