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Increasing oxygen prescribing during the COVID-19 pandemic

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ABSTRACT

Valid oxygen prescriptions for hospital inpatients have been a long-standing problem and have been described extensively in *BMJ Open Quality* with numerous quality improvement projects (QIPs) with the aim of improving compliance with oxygen prescribing.

The British Thoracic Society recommends that all inpatients should have oxygen target saturation set on admission: this is motivated by risks of both undertreatment and overtreatment with oxygen. The discrepancy between the recommendation and the reality produced a number of interventions studied in QIPs over the past years, all aiming at bringing the local ward teams closer to the target. This has become even more important during the COVID-19 pandemic, where non-standard oxygen saturation targets and oxygen scarcity led hospital systems to rethink their internal guidelines on the subject.

We propose three novel interventions to improve compliance: a remote, personally directed email communication to a ward pharmacist, a similar communication to ward nurses, and a remote, personally directed WhatsApp communication to junior ward doctors. We undertake a QIP which compares novel interventions developed in-house with the most successful interventions from oxygen prescribing initiatives that have previously been published by *BMJ Open Quality*. The main outcome measure was the proportion of patients with valid oxygen prescription on a ward.

The series of novel interventions in three plan, do study, act cycles led to improvement in the outcome measure from 0% at baseline to 70% at the end of the QIP. The successful interventions from previous QIPs were ran in parallel on a similar ward and achieved improvement from 17.9% at baseline to 55.6% at the end of the QIP.

This QIP demonstrates adapted interventions performed in context of social distancing aimed at members of multidisciplinary team which achieve superiority in increasing proportion of patients with a valid oxygen prescription, when compared with previously described methods from *BMJ Open Quality*.

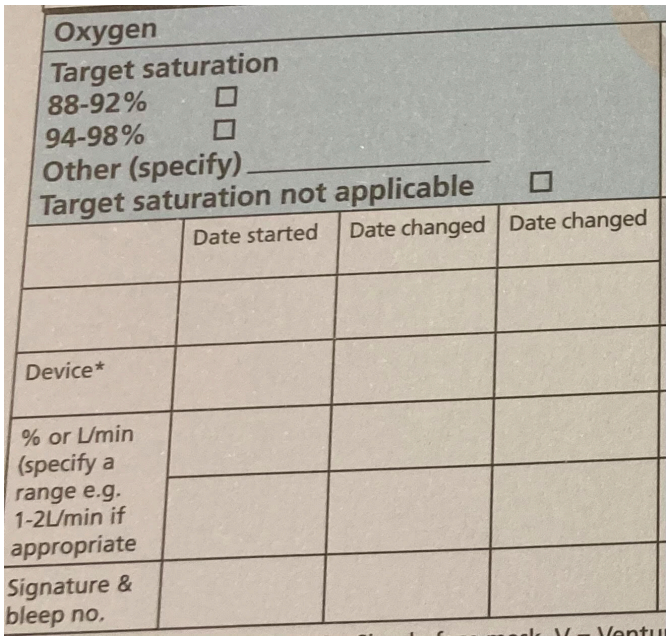
PROBLEM

Prior to the start of this quality improvement project (QIP), it was evident that many patients at North Middlesex University Hospital (NMUH) receiving oxygen did not have a valid prescription. This became even more noticeable during the COVID-19 pandemic when almost every hospital patient was being administered oxygen as part of their treatment for COVID-19.

The aim of this QIP was to improve the proportion of hospital patients on two medical wards with a valid oxygen prescription over a 6-week period to 95%, in line with British Thoracic Society (BTS) national improvement objectives.[1] For an oxygen prescription to be deemed valid, it would require documentation of a target oxygen saturation range, a device with which to administer oxygen and a doctor's signature (figure 1). At NMUH, the specific target saturation ranges were 92%–96% in patients with COVID-19, or 88%–92% in those with COVID-19 but also at risk of hypercapnic respiratory failure.

NMUH is located in Edmonton, North London, and serves a diverse population with a large minority ethnic community, particularly patients of eastern European and Mediterranean descent. There have been previous instances of poor oxygen practice at the hospital which have made headlines in national news outlets.[2] Specifically, a patient was refused oxygen by nurses after requesting it, despite his doctor prescribing oxygen in his drug chart. This demonstrates the poor culture surrounding oxygen administration at NMUH and the impact that this was having on patient safety, highlighting the importance of conducting a QIP with the aim of improving compliance with valid oxygen prescribing.

There have been several previous projects published by *BMJ Open Quality* that have attempted to tackle the issue of poor compliance with valid oxygen prescribing.[3–6] This QIP is unique in that it aims to rectify this widespread issue during the COVID-19 pandemic when the National Health Service (NHS) was placed under the greatest stress, and also during the period when there was the greatest emphasis on appropriate oxygen prescribing as almost all patients were receiving oxygen, and there were widespread mainstream media reports on the issue of oxygen in hospitals, most notably around the scarce supply of oxygen and the very real concern that hospitals would run out of oxygen supply.[7] Providing a complete oxygen prescription, particularly with appropriate


Oxygen

Target saturation

88-92% ☐

94-98% ☐

Other (specify) _____

Target saturation not applicable ☐

	Date started	Date changed	Date changed
Device*			
% or L/min (specify a range e.g. 1-2L/min if appropriate			
Signature & bleep no.			

Figure 1 Oxygen prescribing section on paper drug chart.

target saturation, would help to relieve the concern surrounding oxygen scarcity.

This QIP will compare novel interventions with the most successful interventions from oxygen prescribing projects that have previously been published by *BMJ Open Quality*. Two medical wards, almost exclusively constituting of patients with COVID-19, were involved in this QIP. New interventions unique to this project were trialled on one ward, while the most successful interventions from previous projects were trialled on the other ward, with the relative successes of the interventions compared.

BACKGROUND

The BTS 2015 Emergency Oxygen Audit Report suggested that 14% of UK hospital patients were using oxygen, however only 57.5% of these patients had a valid prescription.[1] This falls short of the BTS target of all patients who are admitted to hospital having an oxygen target saturation range prescribed, and that a prescription for oxygen be given prior to administering the drug, except in sudden illness.[8]

There are potentially grave dangers for patients not having an appropriate oxygen prescription with a target saturation range. Physiological homeostatic response to hypoxaemia leads to increased ventilation, pulmonary vasoconstriction, increased cardiac output and increased cerebral blood flow due to vasodilation. This, in turn, poses risks of pulmonary hypertension, myocardial infarction, confusion and delirium.[8] If patients are hyperoxaemic, the physiological effects are the inverse, potentially leading to ventilation/perfusion mismatching and myocardial ischaemia.[8]

Previous QIPs attempting to address the same issue of poor compliance with oxygen prescribing have been previously published in *BMJ Open Quality*.[3–6] These QIPs used a broad spectrum of interventions to varying degrees of success; examples include prompts at morning meetings to check oxygen prescriptions, presenting at teaching sessions for doctors on the importance of prescribing oxygen and pharmacist reviews of inpatient drug charts.[3–6] Prior to starting this QIP, the success, or lack thereof, of previous projects was dissected, and helped to inform the planning of interventions for this study. It was noted that the successful interventions on previous projects tended to be those that were specifically targeted to remind doctors to prescribe oxygen, whereas those targeted at other healthcare professionals (such as nurses) tended to be less successful.

MEASUREMENT

Data were collected from two medical wards (ward A and ward B). These were previously orthogeriatric and stroke wards, respectively, but during the pandemic were repurposed as general medical wards for COVID-19-positive patients. There was a 2-week interval between each intervention, with data collection taking place on 5 days during this period, usually twice in the first week and thrice in the second week. All medical patients on the two wards were included for data collection. Of note, none of the medical patients on either ward were chronic oxygen users.

Data collected from each patient were:

- Medical history of conditions increasing the risk of hypercapnic respiratory failure, found on the daily handover list.
- Current oxygen saturation, found on the observation chart.
- Whether target oxygen saturation and device were prescribed and signed, found on the patient's paper drug chart.
- Whether or not there was a current oxygen requirement, and if so, how much and via which device, found by observing the patient at the bedside.

The outcome measure was whether a patient had a complete oxygen prescription in their drug chart. This required target oxygen saturation and a device for oxygen delivery to be prescribed, as well as a valid signature from a doctor.

The process measure was whether a patient's oxygen saturation on pulse oximetry was within their target saturation range; this would indicate that improvement in the prescribing of oxygen was contributing to a meaningful difference for patients in ensuring they are not at risk of the dangers of hypoxaemia or hyperoxaemia.

The baseline measurement on ward A indicated that 0% of patients (0 of 35) had a valid oxygen prescription, and that 60% of patients (3 of 5) were within their target saturation range. The baseline measurement on ward B indicated that 17.9% of patients (10 of 56) had a valid oxygen prescription, and that 80% of patients (16 of 20) were within their target saturation range.

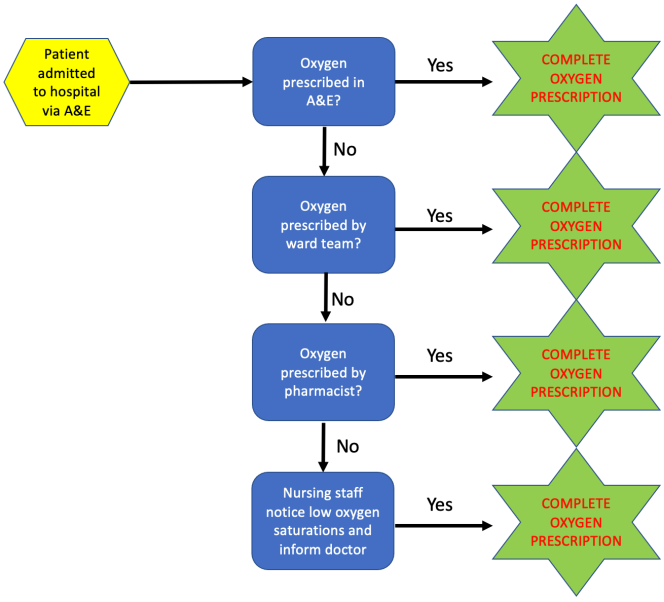


Figure 2 Process mapping exercise. A&E, Accident and Emergency.

DESIGN

This QIP used three PDSA (plan, do study, act) cycles over a 6-week period.

The project team consisted of two foundation year 1 (FY1) doctors (newly qualified doctors completing their first year of postgraduate training after completion of their medical degree), with one doctor assigned to each of the two medical wards, and responsible for data collection and implementation of interventions on their respective ward. These same two FY1 doctors were responsible for the inception of the QIP and planning the project prior to data collection, as well as analysing the data afterwards. A process mapping exercise (figure 2) was completed prior to starting the project in order to delineate areas that we could target in order to improve compliance with oxygen prescribing. Then, it was important to discuss the planned interventions with the ward's matron and the nurse in charge of the ward; this was to gain permission to implement our interventions and to ensure that they complied with health and safety protocols in view of the project taking place in the context of the COVID-19 pandemic.

Ward A used novel interventions that were thought to improve compliance with oxygen prescribing. A literature search of previous oxygen prescribing QIPs provided inspiration for interventions, particularly by learning from the perceived limitations of these previous projects.[3–6] Each PDSA cycle was targeted at the different members of the multidisciplinary team (MDT) in order to involve the different healthcare professionals who are involved in ensuring the safe delivery of oxygen to hospital patients (nurses, pharmacists and doctors). The interventions focused on the dissemination of information via mobile devices to different members of the MDT. In the context of the COVID-19 pandemic, with healthcare professionals being introduced to a variable and constantly changing working environment, it was thought to be important to ensure that information was readily available. Furthermore, with social distancing and infection control protocols in place, it was essential that interventions were able to be implemented remotely and not be perceived to be a hazard to infection control or pose an unnecessary safety risk to the healthcare professionals. At the end of each PDSA cycle, feedback was sought from those on whom the intervention was targeted in order to inform future PDSA cycles.

Ward B implemented interventions that were deemed to be the most successful from oxygen prescribing QIPs that had previously been published by *BMJ Open Quality*.[3–6] A simple literature search on the *BMJ Open Quality* website followed by an analysis of the quality improvement reports suggested that the three most efficacious previously described interventions for increasing rates of oxygen prescribing were: an education session at the morning handover meeting, a visual reminder on the ward and an email to the doctors on the ward. The interventions on ward B provided a comparison with the novel interventions on ward A and by the end of the project would determine whether the interventions of this QIP are superior to those described in previous QIPs with a similar aim.

STRATEGY

PDSA cycle 1

The first intervention on ward A was an email to the nursing staff on the ward. An email was drafted and sent to the ward manager who then disseminated the information to all of the nurses working on the ward. The email was sent on 18 January 2021 and contained information on the aims and rationale of the QIP, the results of the baseline measurement and a reminder to nurses to ensure that they only administer oxygen to patients who have a valid prescription. While an effective intervention, there were concerns over its sustainability due to the movement of nurses between wards, particularly during the COVID-19 pandemic when the nursing workforce was stretched. Furthermore, feedback from doctors suggested that nurses were not asking them to prescribe oxygen for patients who required it, which was the rationale behind asking nurses to check the prescription chart prior to administering oxygen to their patients.

The first intervention on ward B was an educational session at the morning handover meeting, as shown to be effective in a previous oxygen prescribing QIP.[6] The intervention was also effective in this QIP, and involved describing to staff at the meeting the importance of having a valid oxygen prescription prior to administering the medication. Due to COVID-19 and social distancing restrictions, only six members of the team were allowed to participate in the meeting, meaning that not everyone was privy to the information disseminated during the meeting.

PDSA cycle 2

The second intervention on ward A was an email to the ward pharmacist who, at the time of intervention, was also an independent prescriber. The email was sent on 1 February 2021 and contained information on the aims and rationale of the QIP, the results collected thus far, and a reminder to the pharmacist to check that the oxygen prescription had been completed on the inpatient drug charts as part of their routine screening of drug charts on a daily basis. This intervention led to a slight improvement in the outcome measure. The intervention was hoped to be sustainable beyond the completion of this QIP, however upon completion of the QIP, the prescribing had left the hospital and was replaced by a non-prescribing pharmacist. This leads to an additional step in ensuring valid oxygen prescriptions for patients as rather the non-prescribing pharmacist would now need to find a doctor to complete the prescription. Feedback from the ward pharmacist suggested that they were uncomfortable prescribing target oxygen saturation as they were not always confident of the appropriate target oxygen saturation, particularly in the context of the COVID-19 pandemic when guidelines and trust protocols were constantly adjusted in line with emerging evidence, making it difficult to remain up to date with the most recent advice.

The second intervention on ward B was a visual reminder placed next to the oxygen tap at the patient's bedside which had been shown to be effective in previous oxygen prescribing QIPs.[3–5] The intervention was also effective in this QIP as the signs placed by oxygen taps provided a reminder to members of the MDT that for oxygen to be administered, an appropriate prescription is required. Staff on the ward reported that the signs were removed from the oxygen taps when a deep clean was performed after a room or bay had housed a patient with COVID-19, as the signs were deemed to be an infection control hazard due to their potential as a fomite for the spread of COVID-19, thus making them an unsustainable intervention, especially during the COVID-19 pandemic.

PDSA cycle 3

The third intervention on ward A was a WhatsApp message to a group chat containing all of the junior doctors (doctors below the level of consultant) working on the ward. The message was sent on 15 February 2021 and contained information on the aims and rationale of the QIP, the results collected thus far, and a reminder to doctors to ensure that oxygen was prescribed for all patients, and what constituted a valid oxygen prescription. This was a successful intervention, and feedback from junior doctors suggested that it was the most appropriate intervention as it was aimed directly at those who are able to prescribe oxygen and would be routinely checking the inpatient drug chart every morning as part of their daily ward rounds.

The third intervention on ward B was an email to the doctors working on the ward with an update on the progress of the QIP.[6] The intervention was effective although there were reports from several junior doctors that they did not receive the email; the reasons identified were that there were last minute changes to the deployment of staff on the ward with external locum staff not included on departmental mailing lists making it difficult to include them in any emails. These were issues that were prevalent during the COVID-19 pandemic and were representative of this period with the increasing redeployment of medical staff between departments and clinical areas, and reduced greatly once the pressures faced by staff reduced once the pandemic eased.

Table 1 Baseline and PDSA cycle measurements

	Proportion of patients with a valid oxygen prescription (%)		Proportion of patients within their prescribed target oxygen saturation	
	Ward A	Ward B	Ward A	Ward B
Baseline	0.0	17.9	60.0	80.0
PDSA 1	47.1	26.2	66.7	67.9
PDSA 2	55.9	44.4	77.8	100.0
PDSA 3	70.0	55.6	80.0	100.0

PDSA, plan, do study, act.

RESULTS

The results of the data collection during the baseline measurement and each PDSA cycle are displayed in table 1. The information is also displayed graphically in figure 3, which shows the change in the outcome measure with each PDSA cycle, and figure 4, which shows the change in the process measure with each PDSA cycle.

LESSONS AND LIMITATIONS

Over the course of the QIP, there was a steady improvement in the outcome measure, suggesting that interventions were effective and sustainable over the course of the project. The superior performance of interventions in ward A compared with ward B suggests that the novel techniques employed during this QIP are better than the successful interventions from previous similar QIPs. While the aim of achieving 95% compliance with valid

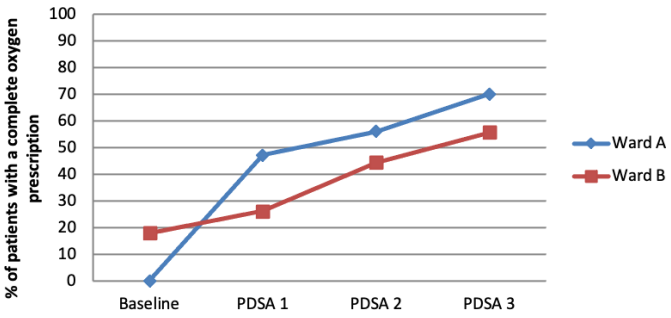


Figure 3 Change in outcome measure. PDSA, plan, do study, act.

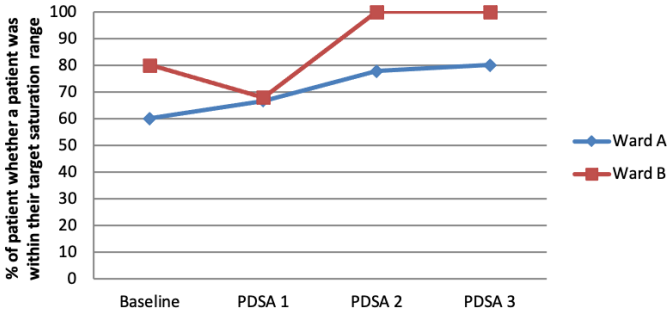


Figure 4 Change in process measure. PDSA, plan, do study, act.

oxygen prescription was not attained, the project was still valuable with several important lessons.

This QIP demonstrated that FY1 doctors are able to make positive change within a healthcare system. While the most junior members of the medical team, and having worked as doctors for less than a year, the two FY1 doctors working on this QIP were able to impact oxygen prescribing practices in a positive manner. This shows that despite the rigid hierarchy found in a hospital, it is feasible for FY1 doctors to collaborate and implement change, even among their senior colleagues who it may be expected to be less amenable to change when enforced by a more junior colleague.

The interventions were directed at different members of the MDT, and were all able to lead to positive change, although to a different extent. This provides a good example of including healthcare professionals from different disciplines in prima facie strictly medical QIP. Data obtained during interventions clearly indicate that such multidisciplinary collaboration encouraged positive outcomes for patients. While in previous similar QIPs, interventions tended to be directed towards doctors, this project demonstrates the importance of including other members of the MDT, and the positive results this can yield. The evidence of sustained improvement in outcomes which stems from targeting different parts of the pathway from prescribing a medication to administering it to a patient is a significant strength of this QIP.

This QIP demonstrated that change can be made over a very short period of time, in this case, 6 weeks. While the aim of the project was not met, significant positive change was achieved over a short period of time. Although a short project makes it harder to assess the long-term sustainability of the interventions, it evidences their immediate efficacy. This was particularly important in the context of providing care during the COVID-19 pandemic, where it was unsure how long the current wave of infections, or indeed the pandemic as a whole, would last. It was therefore essential to be able to make prompt change with an immediate impact on the quality of care provided to patients, in line with emerging evidence, which this QIP demonstrated.

All of the novel interventions were possible to implement remotely, as long as the user had a mobile phone or laptop, and an internet connection. As the QIP was focused on improving oxygen prescribing during the COVID-19 pandemic, it was essential that interventions could be enacted while maintaining social distancing rules and following infection control protocols. As shown on ward B, successful interventions from previous similar projections were not able to be implemented appropriately during the pandemic, and consequently were outperformed by the novel interventions on ward A.

Future iterations of this project could have interventions more specifically targeted at members of staff who are based solely on the ward being studied, for example, ward manager or nurse in charge. During the COVID-19 pandemic, there was frequent redeployment between departments and between wards, with it not being uncommon to be working with a new team of colleagues on each day of the week. While this issue was exaggerated during the COVID-19 pandemic as the healthcare system and its staff were reaching a breaking point, it is still common practice outside of the pandemic.

A key limitation of this QIP was that in the context of COVID-19, there was a greater emphasis on oxygen prescribing than prior to the pandemic. The clinical staff were receiving regular emails from the hospital's oxygen lead regarding updates on oxygen usage, and the most recent trust guidelines on appropriate target saturation for patients with COVID-19. This was likely to be a confounding factor which may exaggerate the impact of our interventions. Even when accounting for this, the QIP still shows the superiority of the interventions of ward A compared with ward B. It would be interesting for future projects with a similar aim to implement the novel interventions after the COVID-19 pandemic when healthcare professionals are not acutely aware of the oxygen requirement of all of their patients.

CONCLUSION

Unfortunately, this QIP did not achieve its aim of 95% of patients having a valid oxygen prescription, in line with BTS guidelines.[1] By the end of the project, 70% of patients had a valid oxygen prescription, up from the baseline measurement of 0%. All of the individual interventions were shown to work to a different extent, with the email sent to nursing staff proving to be the most successful. Each intervention provided incremental improvement in the process measure; at baseline 60% of patients were within their target saturation range, this was 80% at the end of the project, showing that the interventions were contributing towards a positive change in practice.

The novel interventions used in the project were more successful than those described in the literature and used as a comparison. While the previously described interventions were efficacious in a different setting, they may have been hampered in the context of social distancing and new ways of working during the COVID-19 pandemic.

This QIP is unique in that it was aiming to improve oxygen prescribing compliance during the COVID-19 pandemic. It was therefore important for interventions

to be successful in this unique and challenging time; as shown in this study, interventions that have been described as successful previously were not as effective in this context compared with interventions which were able to comply with infection control protocols and social distancing rules. It would be informative for a future project to implement these interventions once the threat of COVID-19 has subsided. The interventions are far easier to implement than those described in previous projects, and can be implemented remotely, thus providing a scope to improve oxygen prescribing compliance.

Given the simplicity of the project, there is no obvious reason as to why it could not be replicated in a different environment or by a different group of healthcare professionals. Given the nature of the QIP and its focus on COVID-19, there was an effort to implement interventions which had an immediate impact given the urgency of the threat of COVID-19, therefore sustainability was not necessarily a priority when designing interventions. The improvements seen over the course of the project suggest a degree of sustainability although this would need to be confirmed by a project conducted over a longer period of time.

The literature search made it evident that the issue of poor oxygen prescribing is a long-standing one within hospitals, and one that will be challenging to rectify. The work on this QIP will continue with discussions with the team who are trying to implement electronic prescribing to NMUH. This is a new platform to replace the paper drug charts, that was scheduled to be released in early 2020, but was delayed by several months due to the COVID-19 pandemic. The online platform requires several mandatory assessments to be performed prior to prescribing a patient's medications: this includes an allergy assessment and a venous thromboembolism (VTE) prophylaxis proforma. Early discussions with the team organising the rollout of electronic prescribing have suggested that there is potential to also include a compulsory proforma for oxygen prescribing which would include information such as target saturation, and allow doctors to prescribe a device and rate of oxygen delivery. This has the potential to ensure all hospital patients have a valid oxygen prescription, and is something we look forward to working on in the coming months after completing this QIP.

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