

# Can we improve the prescribing and delivery of oxygen on a respiratory ward in accordance with new British Thoracic Society oxygen guidelines?

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## ABSTRACT

The British Thoracic Society recommends oxygen delivery to achieve target oxygen saturation range between 94% and 98% for medically unwell adult patients, and 88% to 92% in patients at risk of hypercapnic respiratory failure. Interviews with our medical and nursing staff suggested that oxygen was sometimes being given to patients without a valid order and there was a failure to titrate oxygen to the stated oxygen saturation range. Our aim was to improve appropriate oxygen delivery to 90% of our patients on a 30-bedded respiratory ward within 3 months. We identified several key steps to safe oxygen delivery on our ward. These include the recording of target oxygen saturation range, the prescribing of an oxygen order on drug chart and the correct bedside delivery of oxygen to the patient. To help improve compliance of these key steps, the following plan-do-study-act (PDSA) interventions were undertaken: (1) Educational announcements at board rounds. (2) A communication oxygen poster. (3) Highlighting improvement progress to teams via email. (4) Pharmacist review of inpatient drug chart. (5) Display of target oxygen saturation range at patient bedside. At baseline, only 50% of drug charts had a recorded oxygen order and 60% of drug charts had a set target oxygen saturation range. Following PDSA interventions, both measures improved to 93%. Our main outcome measure of appropriate oxygen delivery to the patient improved from a baseline of 20% to 80% on completion. Our quality improvement programme has shown simple interventions can improve oxygen prescribing and appropriate delivery of oxygen to the patient. The most effective PDSA interventions were sharing our measurements via email and displaying target oxygen saturation ranges by the patient bedside. We aim to provide future oxygen educational sessions at induction to our staff and scale our quality improvement programme to other wards including our acute medical unit.

## PROBLEM

The British Thoracic Society 2015 national oxygen audit found that 42% of hospital patients using oxygen were doing so without an oxygen order. Even when an order was available, patients did not always receive what was specified on the oxygen order with significant numbers of patients recording oxygen saturations either below or above the stated

target range.<sup>1</sup> Similar concerns were raised by our medical and nursing staff when patients arrived onto the respiratory ward in our institution.

Barking, Havering and Redbridge University Hospitals National Health Service Trust serves a population of approximately 750 000 and has two acute sites with emergency departments. There are two 30-bedded respiratory wards at Queen's Hospital. Patients on these wards comprise mostly of respiratory and general medical patients. The wards are usually well staffed with training grade doctors and nurses but have limited respiratory physiotherapy staff. Patients' care is facilitated by a daily 09:00 multidisciplinary board round meeting. There are consultant-led patient ward rounds on all 7 days.

Medical patients arrive in our emergency department and are referred to the on-call medical team if an admission is required. Initial clerking is performed by a trainee medical doctor. The inpatient drug chart has a specifically designed oxygen section (figure 1A). The section has an area to set the target oxygen saturation range and an area to write the oxygen order. The oxygen order comprises both the oxygen delivery device and the flow rate (stated as litres per minute or fraction of inspired oxygen). A medical consultant review then takes place in our emergency department or acute assessment area before the patient is assigned to the appropriate medical specialty ward.

After a patient arrives on the respiratory ward, a senior respiratory review is undertaken (this is usually either by a respiratory consultant or registrar). A further evaluation of the inpatient drug chart and the nursing observation chart (figure 1B) should take place. The assigned nurse for the patient would read the oxygen order and target oxygen saturation range set on the inpatient drug chart and titrate the delivered oxygen at the patient's

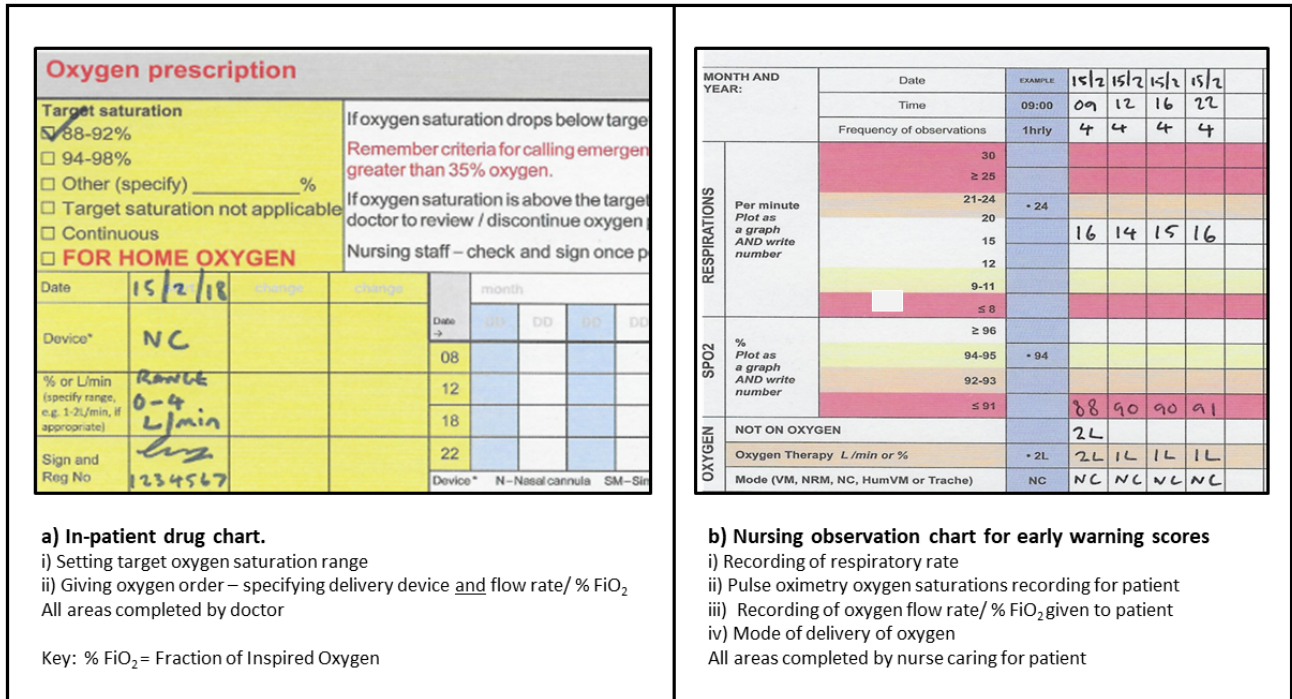


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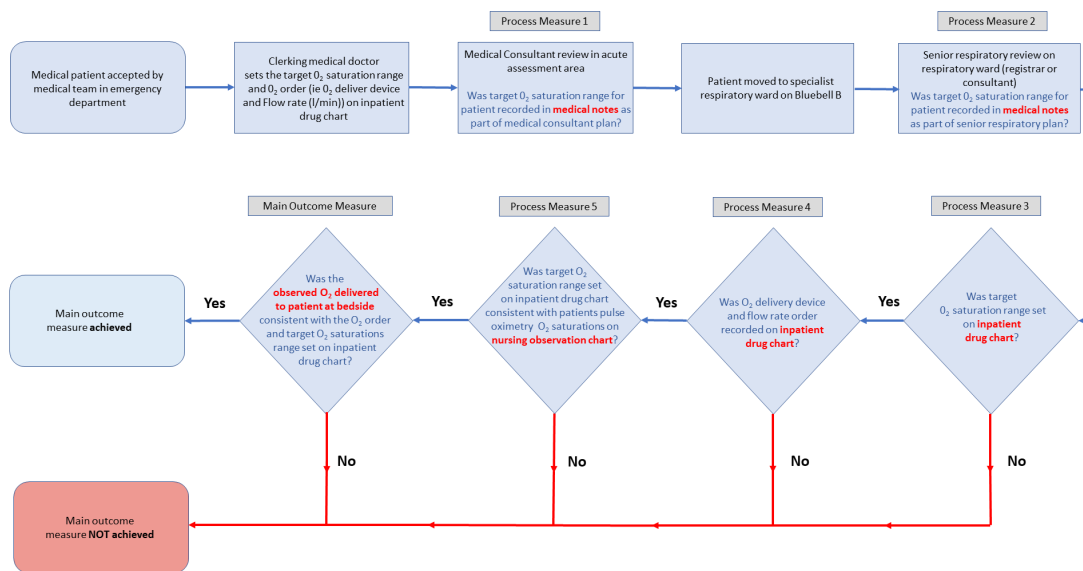


**Figure 1** Current oxygen prescription area on drug chart and National Early Warning Score (NEWS) nursing observation chart at Barking, Havering and Redbridge University Hospitals NHS Trust.

bedside . The nurse would then measure the respiratory rate, pulse oximetry saturations, mode of delivery and flow rate/fraction inspired oxygen and record this information on the nursing observation chart. The emergency admission process is summarised in figure 2.

We observed however that recording of target oxygen saturation range and oxygen orders remained low

even after a senior review on respiratory ward. We also noticed that oxygen was often being given by nurses in our ward without an oxygen order being in place. As part of a trainee-led quality improvement programme, our aim was to improve appropriate oxygen delivery to 90% of our patients in our 30-bedded Bluebell B respiratory ward within 3 months.



**Figure 2** Schematic process steps for oxygen prescribing quality improvement programme. The boxes in red are the emergent plan-do-study-act (PDSA) cycles that were implemented during the programme.

## BACKGROUND

Oxygen is a drug and should be given safely to patients like any other medication.<sup>2</sup> However, the degree of complexity for prescribing and delivery of oxygen to patients is often underestimated. Most tablet medications do not require titration against a physiological parameter or require a possible change of delivery device on the same day. Although improvements in oxygen orders have been seen over the last decade, the consistent approach to oxygen orders for inpatient drug charts has not been fully established. The lack of an oxygen order and administration of oxygen without a valid order are common targets for quality improvement initiatives.<sup>3</sup> Several factors have been highlighted as possible reasons for this apparent lack of compliance.<sup>4</sup> There is evidence for insufficient training and education,<sup>5</sup> a lack of familiarity of oxygen delivery devices,<sup>6</sup> difficulties in changing established behaviours towards oxygen therapy,<sup>7</sup> communication breakdowns between doctors and nurses,<sup>8</sup> and limited enthusiasm to change practice by senior clinical staff.<sup>9</sup> It is therefore not surprising to find that even with a complete oxygen order, this did not always result in improved oxygen delivery to the patient.<sup>10</sup>

Similar findings were found for poor or inappropriate recording of target oxygen saturations documented on drug charts.<sup>11</sup> British Thoracic Society guidance states that acutely unwell patients should achieve oxygen saturations between 94% and 98%. Those at risk of hypercapnic respiratory failure should receive restrictive oxygen aiming for saturations of 88%–92%.<sup>12</sup> If this is not adhered to, this may lead to patient harm from either prolonged hypoxaemia<sup>13</sup> or hyperoxia<sup>14</sup> in certain patient groups.

Our quality improvement programme therefore need to incorporate multidisciplinary interventions that include all steps from giving an oxygen order, setting of target oxygen saturation range, through to consistent delivery of oxygen to the patient (figure 2).

## MEASUREMENT

Fifteen patients were randomly selected for each of the 14 measurement cycles. Data were collected twice weekly by four trainee doctors during May 2017 and then once weekly from June to July 2017. Sources of information included the nursing observation chart, the inpatient drug chart, the inpatient medical records and direct observation of oxygen delivery device and flow rate at patient's bedside.

Our main outcome measure was whether 'the observed oxygen delivered to patient at bedside was consistent with the oxygen order and target oxygen saturations range given on the inpatient drug chart'. We identified five process measures that would help inform our main outcome measure. Key process measures 3 to 5 must be completed successfully as they relate directly to the aim (figure 2).

1. At medical consultant review, was target oxygen saturation range for patient recorded in medical notes as part of medical consultant plan?
2. At senior respiratory review on ward, was target oxygen saturation range for patient recorded in medical notes as part of senior respiratory plan?
3. Were target oxygen saturation ranges set on inpatient drug chart?
4. Was there a full oxygen order (device and flow rate) recorded on inpatient drug chart?
5. Was target oxygen saturation range set on inpatient drug chart consistent with patient's pulse oximetry oxygen saturations on nursing observation chart?

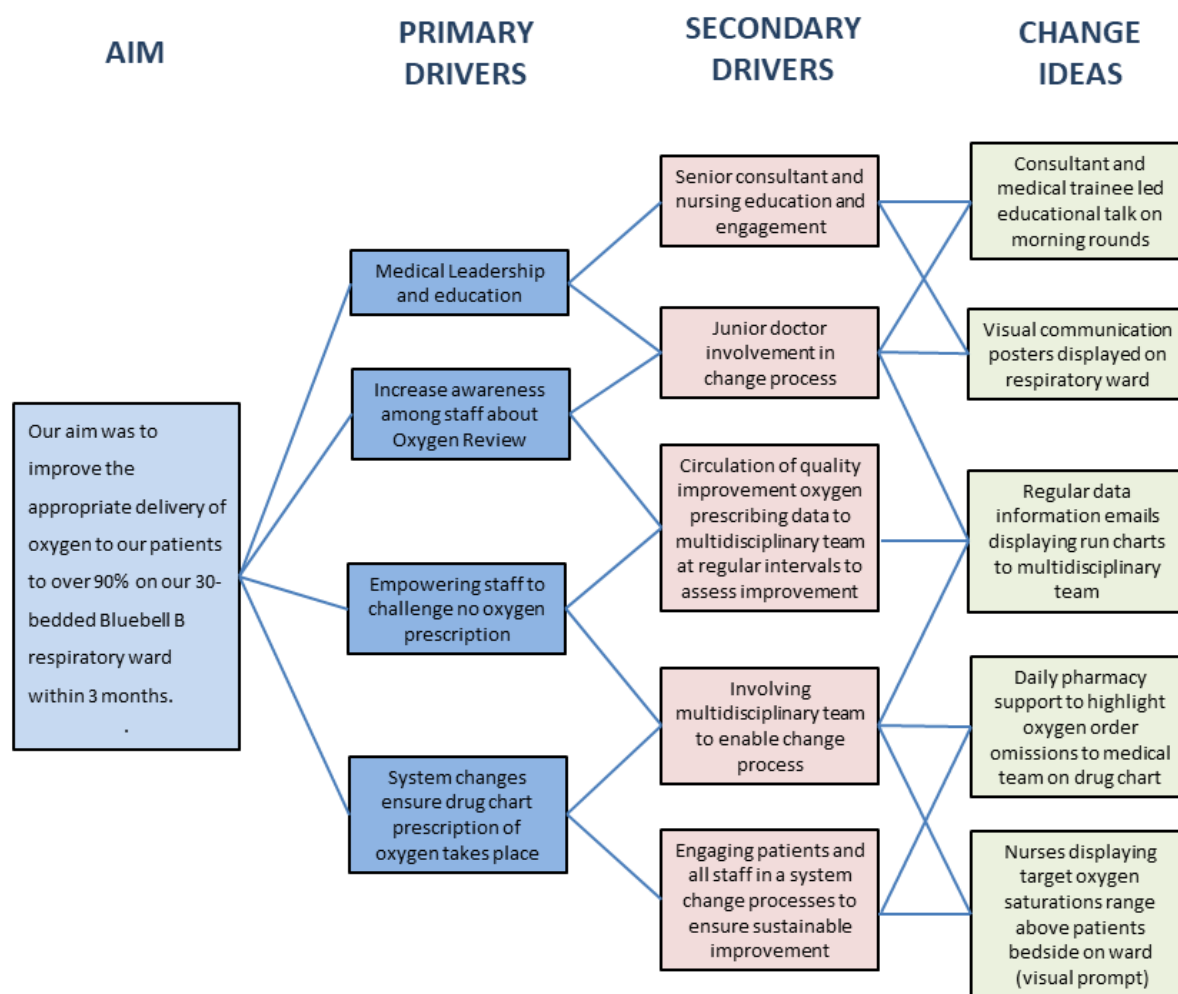
The balancing measure was continued written adherence to 48 hours antibiotic review by completion of the 48 hours review tick box.<sup>15</sup> This item is also located on inpatient drug chart and completed by doctors. We chose this balancing measure as we envisaged that a greater focus on oxygen orders by doctors may result in less completion of this element of inpatient drug chart.

To help interpret the outcomes, we collected additional information from inpatient medical records including the presenting diagnosis, past medical history of respiratory disease and whether an arterial blood gas was performed. The baseline measurements were calculated as the median value of the first six measurements (ie, measurement cycles 1–6) for outcome, process and balancing measures. The completion measurement was calculated from the median value of the last six measurements (ie, measurement cycles 9–14). Our goal was set as 90% completion and accuracy for all outcome and process measures. A goal of 10% or less omission rate of the antimicrobial tick box section of inpatient drug chart was set for achieving our balancing measure.

## DESIGN

The quality improvement programme was performed using the model of improvement methodology by using the 'Quality Improvement Essentials Toolkit' provided by the Institute for Healthcare Improvement.<sup>16</sup> The improvement team consisted of a respiratory consultant who was our mentor, four trainee medical doctors and two senior ward nurses.

The team conducted a series of interviews with the multidisciplinary staff on Bluebell B ward to understand more clearly the issues with oxygen prescribing and delivery. This also acted as an opportunity to communicate the project to our staff. Many nurses were not aware of the need for an oxygen order by doctors. They felt they could be guided by the target oxygen saturation range to deliver oxygen to the patient. Other nurses stated that oxygen orders by doctors on the inpatient drug chart were often incomplete. Either the delivery device, the flow or both elements were missing. These nurses also felt uneasy about delivering oxygen to a patient without an order but often did so in an emergency.



**Figure 3** Driver diagram to improve oxygen prescribing and recording of target saturations on acute respiratory wards.

Trainee doctors commented that the oxygen section of the inpatient drug chart was sometimes left incomplete on arrival to Bluebell B; this is despite senior medical review in the emergency department areas. Respiratory ward rounds were described as very busy and left limited time for review of oxygen therapy. Doctors also commented that nurses did not always wean oxygen to keep within the set oxygen target saturation range resulting in overoxygenation.

Following the interviews, we identified several key steps to safe oxygen delivery on our respiratory ward. These include the recording of target oxygen saturation range and presence of an oxygen order on inpatient drug chart and the correct bedside delivery of oxygen to the patient by our nursing staff. These key steps are summarised in [figure 2](#).

This helped identify potential points of intervention. Primary drivers of medical leadership and education, staff awareness, empowering staff to challenge non-prescribing of oxygen and instituting system changes, were formulated. Potential change ideas are summarised on our driver diagram ([figure 3](#)). Communication of improvement measures via email, daily pharmacy support

to reduce oxygen order omissions on drug chart and displaying oxygen saturation range at patient's bedside were emergent change ideas that developed during the quality improvement.

### STRATEGY

We undertook five plan-do-study-act (PDSA) interventions after studying each measurement cycle. There were regular fortnightly progress meetings by the improvement team throughout the project. These meetings were facilitated by our mentor. The meetings reviewed progress of the quality improvement programme, assessed effectiveness of PDSA interventions through evaluation of measurements and planned future interventions.

#### PDSA cycle 1: educational announcement at handover meeting to raise oxygen awareness (week 1)

The aim was to inform staff of the importance of an oxygen order on the inpatient drug chart before delivering oxygen to the patient. We also discussed the potential harmful effects of hypoxaemia and hyperoxia to encourage staff to record target oxygen saturation range

on the drug chart and encourage appropriate titration of oxygen to the patient at bedside. The discussion of the quality improvement programme took place at the 9:00 multidisciplinary team board round and was led by members of the improvement team. This intervention had negligible effect on any of our measures. This was likely to be because (1) Only a small proportion of the total ward staff were present at board round. (2) The focus of board rounds was to identify sick patients and formulate discharge plans, hence not the ideal environment for oxygen learning or communication. (3) Not enough time was set for the delivery of the communication. We did however raise some awareness of the quality improvement programme and gave a formal ‘start date’ to the ward teams.

### PDSA cycle 2: a visual prompt to remind staff (week 3)

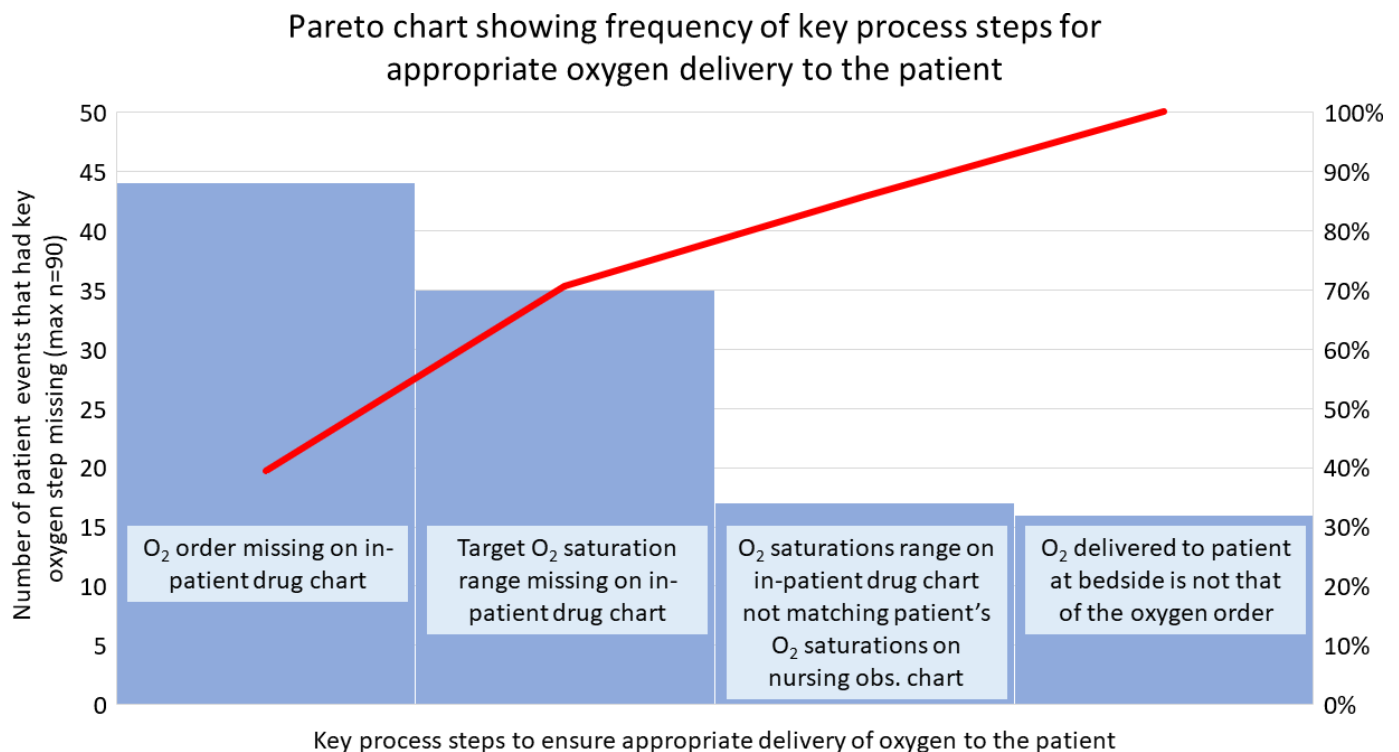
The aim was to provide a permanent visual reminder of the importance of an oxygen order and setting of target oxygen saturation range on drug chart. An A4 communication poster was developed and displayed at strategic points at the entrance of each patient bay. The message stated ‘Alert: Oxygen is a drug. Has it been prescribed correctly? Have target saturations been recorded? Please check oxygen has been prescribed on drug chart before giving to your patient. As you would with any other prescribed medication’. The effectiveness of this intervention was limited. Our posters were not laminated to hospital requirements and were removed to comply with infection control. The communication posters were transferred to more communal areas

away from patient bedsides where they had less impact. Although the posters were clear in their instruction, there was no information on the poster as to why it is important to give an oxygen order or why there was a need to stay within the oxygen target saturation range set. It was therefore unlikely to result in behavioural change among staff.

### PDSA cycle 3: email communications to ward teams discussing progress of oxygen quality improvement programme (week 4)

At this point we had performed six measurement cycles. Of the 90 case notes analysed, we discovered that over 80% of the issues regarding appropriate oxygen therapy were related to the following steps: (1) Lack of an oxygen order on drug chart. (2) Lack of target oxygen saturation range on drug chart. (3) Not matching target oxygen saturation ranges on drug chart to recorded patient oxygen saturations on nursing observation chart. This is shown on the Pareto chart (figure 4).

Our aim was to increase engagement with ward staff by regularly sharing our improvement data. A progress report email was created that displayed all five process measures in the form of a data table and embedded run charts. This was sent to ward consultants, senior nursing staff, ward managers, junior doctors and allied health professionals on five separate occasions. We found this intervention had a significant effect on our main outcome. Displaying the data and emphasising our 90% target aim allowed the ward teams to evaluate their progress. Specifically, staff members were able to engage with the key process



**Figure 4** Pareto chart highlighting frequency of missing key steps for the delivery of appropriate oxygen to the patient at bedside. Data are taken from the first six measurement cycles (n=90). The first three bars on graph account for 85% of the effect.

steps themselves and were more empowered to address the problems. For example, doctors on the improvement team observed that their consultants were increasingly asking if the oxygen component of the drug chart had been completed. Nurses were highlighting omissions in the oxygen prescribing section on their nursing rounds and with the medical staff. Doctors were also prescribing oxygen orders that allowed nursing staff greater flexibility for titrating oxygen (eg, nasal cannula with flow rate between 0 L/min to 4 L/min). Finally, senior staff members were observed giving short educational talks to their staff to promote safe oxygen practices.

#### **PDSA cycle 4: ward pharmacist to highlight oxygen omissions on drug chart (week 6)**

We had identified a lack of an oxygen order as a major step in the appropriate delivery of oxygen to the patient. Our aim was to involve our ward pharmacist to review each drug chart daily and highlight patients to the medical team where a valid oxygen order had not been completed. This was an attempt at a system change to improve the number of valid oxygen orders available to our nursing staff. Our ward pharmacists review all inpatient drug charts daily and therefore felt well placed to oversee this process. However, this intervention had limited additional effect. Although our pharmacy team recognised the importance of oxygen orders, they were unable to deliver consistently the drug chart oxygen review. This was primarily due to their already significant workload on our high turnover respiratory ward.

#### **PDSA cycle 5: target oxygen saturation ranges displayed above patients' bedside (week 8)**

The improvement team discussed interventions that could facilitate a system process change that encouraged interdependent team working. We had improved the documentation elements for oxygen therapy, but there were no interventions to improve oxygen delivery to the patient's bedside. Nurses currently had to find the inpatient drug chart each time to confirm the target oxygen saturation range and oxygen order. Our aim was to improve the titration of oxygen at the bedside. Ward nursing staff were empowered to scribe the target oxygen saturation range with a marker pen on the patients' information whiteboard at the bedside. The target oxygen saturation range was visible to all healthcare staff, patients and their families. This acted as a visual prompt.

This had a noticeable effect in sustaining our process measures and achieving our aim. The ward nurses in each bay were responsible for updating the patient whiteboard each morning. However, doctors and senior nurses also supported the updates on their daily ward rounds. Omissions of the target oxygen saturation range on the patient whiteboard instigated a check-back of the oxygen prescription area of drug chart and encouraged the following actions: (1) A new prescription of oxygen and target saturations if missing on drug chart with immediate transcription onto whiteboard. (2) Where an

oxygen prescription was already complete on drug chart, this was transcribed onto whiteboard. Finally, nurses on their patient observation rounds were immediately able to titrate the oxygen at the bedside to keep within the target oxygen saturation range stated.

## **RESULTS**

A total of 210 patient cases was reviewed throughout the quality improvement period. Of these, the most common respiratory conditions were chronic obstructive pulmonary disease (COPD) (n=68), pneumonia (n=42) and lung cancer (n=24). A sizeable number of records had patients admitted with no respiratory condition as their presenting complaint or their past medical history (n=48). Of the patient records 107/210 (51%) had an arterial blood gas performed at time of admission. Of which, 40/107 (37%) of arterial blood gases performed confirmed hypercapnia. Setting of oxygen target saturations by doctors on the 40 case records with confirmed hypercapnia was overall good (88%–92% n=25, 85%–88% n=3, 85%–90% n=7). Five patients had unsatisfactory recording of their target oxygen saturations, with one patient set at 94%–98% and for four patients the prescription was blank.

We completed 14 data measurement cycles during the quality improvement period. Fifteen randomly selected patients for each cycle had their oxygen therapy reviewed. Pulse oximetry oxygen saturations recorded on nursing observation chart was complete at 100% throughout the quality improvement period, this finding is consistent with national audits.<sup>1</sup>

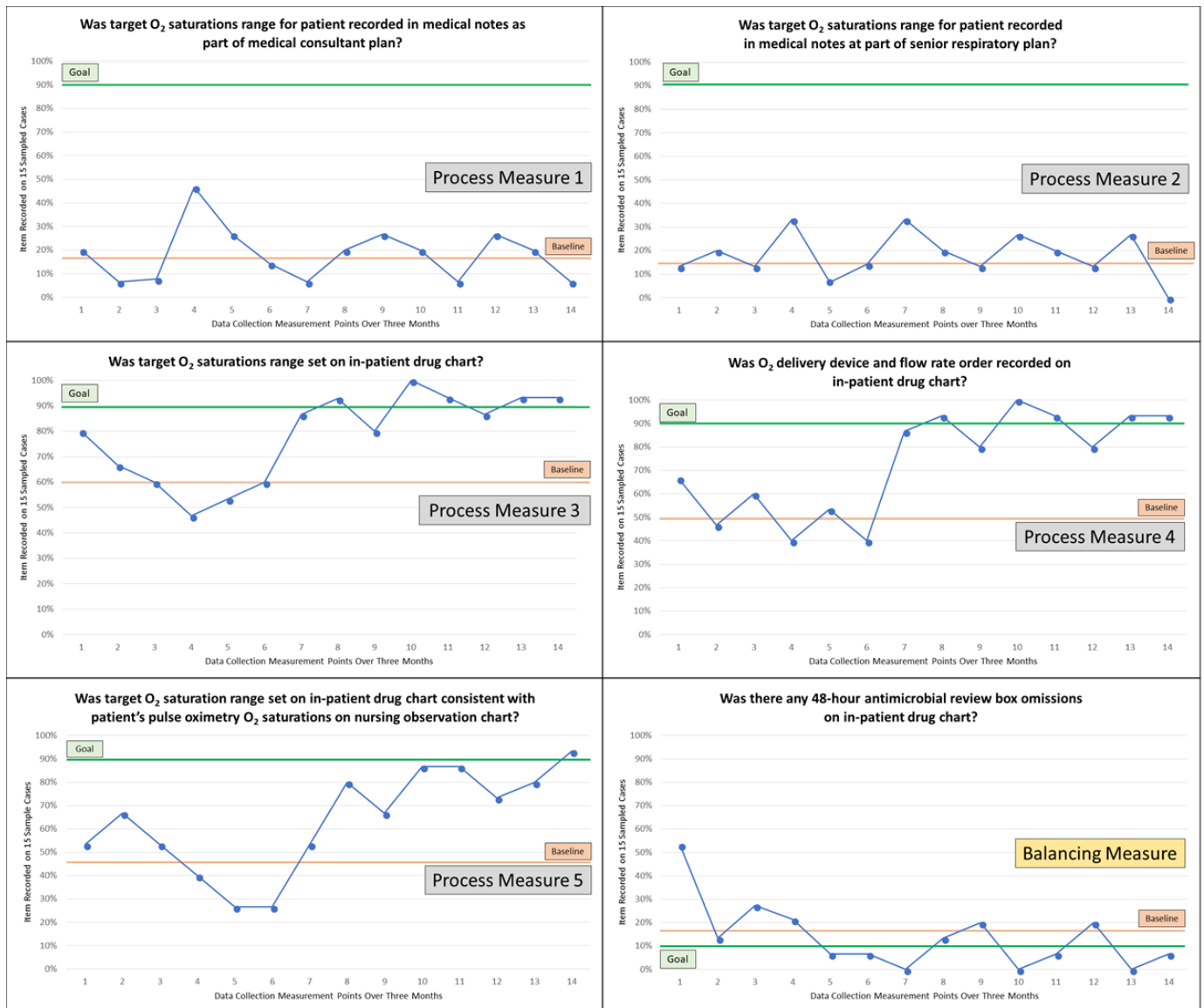
The process measures assessing recording of target oxygen saturation range in medical plan at senior medical review (baseline 17%, completion 20%) and senior review on respiratory ward (baseline 14%, completion 17%) did not show significant improvement. However, our key process measures all improved. Oxygen order on drug chart (baseline 50%, completion 93%), target oxygen saturation range recorded on drug chart (baseline 60%, completion 93%) and matching target oxygen saturation range on drug chart to oxygen saturations recorded on nursing observation chart (baseline 47%, completion 83%) are shown in [figure 5](#).

The main outcome measure: 'was the observed oxygen delivered to patient at bedside consistent with the oxygen order and target oxygen saturation range on inpatient drug chart' showed significant improvement (baseline 20%, completion 80%) ([figure 6](#)).

Our balancing measure, the review of antibiotics at 48 hours improved throughout the project with a reduction in the number of tick box omissions (baseline 17%, completion 7%).

## **LESSONS AND LIMITATIONS**

Our main aim of delivering appropriate oxygen to the patient at bedside that is consistent with the oxygen order and target oxygen saturation range set showed a

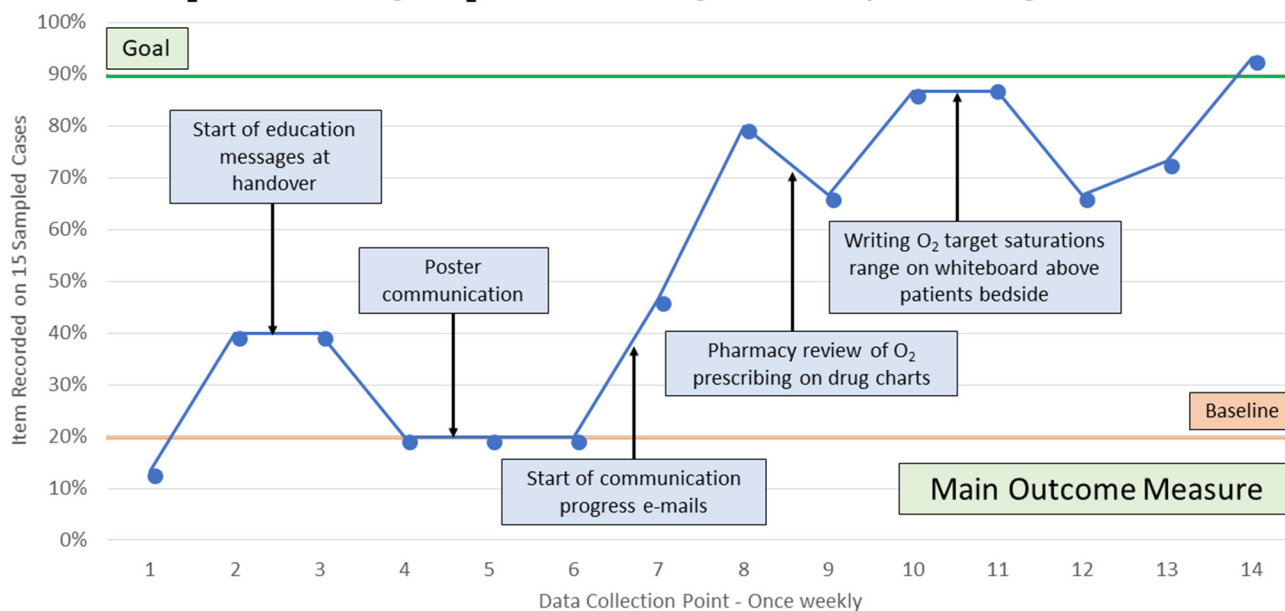


**Figure 5** Process and balancing measures for oxygen prescribing quality improvement programme over a 3-month period between 09 May 2017 to 28 July 2017. Data measurement points 1–6 were twice weekly. Data measurements 7–14 were once weekly. The baseline measurements are calculated from the median value of the first six measurements for each run chart.

substantial improvement. Although we did not quite reach our aim of 90%, this still represented a shift change in practice. All our key process measures showed significant improvement towards the end of the programme. However, recording of target oxygen saturation ranges in medical notes at medical consultant review and at first senior respiratory review did not show improvement. This may reflect that no specific interventions were targeted to improve these measures, such as a change in admission clerking pro forma or educational sessions in the acute medical unit. However, this did not impact on our main outcome measure, as the oxygen order and target oxygen saturation range are recorded on the drug chart. Our balancing measure of reducing omissions of the 48 hours antimicrobial review also improved, suggesting a positive effect and focus on completing other mandatory components of the drug chart.

We adhered to several key components of a quality improvement programme<sup>17</sup> using model of improvement methodology. The programme had a near-complete data set with 14 measurement cycles over 3 months. The outcome, process and balancing measures were selected using SMART criteria. All the measurements were easily available and were not arduous or time-consuming to collect on the ward. Prior to commencing our first PDSA, the improvement team met to identify potential change ideas after review of baseline measurements. The formulation of a process flow chart (figure 2) and driver diagram (figure 3) helped to identify potential PDSA interventions. The improvement meetings with mentor support enabled (1) Group discussions for evaluation of measurement. (2) Assessed impact of previous PDSA cycles. (3) Allowed discussion and consensus for future change ideas.

## Was the observed O<sub>2</sub> delivered to patient at bedside consistent with the O<sub>2</sub> order and target O<sub>2</sub> saturations range set on in-patient drug chart?



**Figure 6** Main outcome measure with annotation for each plan-do-study-act (PDSA) intervention.

The two most effective interventions were the improvement progress emails that informed and engaged our ward staff and secondly, displaying the target oxygen saturation range above the patient's bedside acting as a visual reminder to staff. Such strategies by the bedside have been successfully used in other studies to improve oxygen delivery compliance.<sup>18 19</sup>

Some limitations of our improvement programme were identified. ((1) We were unable to enact change within our emergency department or acute medical units. This was due to the improvement team and interventions being focused on one respiratory ward. Future oxygen improvement programmes will focus on oxygen delivery at the front end of our hospital. The development of an oxygen care bundle such as those used in COPD could be developed as part of this improvement.<sup>20</sup> (2) We were unable to facilitate our nurses to record and sign for ongoing oxygen therapy on the inpatient drug chart (figure 1A). Our nurses commented that there was duplication of effort, as this was already done on the nursing observation charts (figure 1B). We may remove this element of the inpatient drug chart and consider a single multidisciplinary oxygen chart.<sup>21</sup> (3) There is a potential risk of displaying a target oxygen saturation range at bedside from the previous patient at the time of a bed move. This risk is minimised as all patient data are immediately wiped clean from the patient's whiteboard at the time of move by our nursing staff. (4) Even though oxygen orders and setting target oxygen saturations were performed well in our quality improvement, we did not always see this translate to appropriate oxygen delivery to the patient.<sup>22</sup> We found occasional failures in setting of appropriate target oxygen saturation range in patients with type 2 respiratory failure by doctors, delay or failure

of oxygen weaning, and giving a delivery device different to that of the oxygen order by our nurses.

### CONCLUSION

Our data suggest that our key process measures were closely linked to the significant improvement achieved in delivering appropriate oxygen at the patient's bedside. Our PDSA interventions were easy to implement and engaged the multidisciplinary team. The PDSA intervention with the most positive effect on the outcome measure was sharing our progress data via email to ward staff and displaying target oxygen saturation range by the patient's bedside.

We showed that simple interventions can improve prescribing of oxygen and is consistent with other oxygen quality improvement studies.<sup>3 10 18</sup> We acknowledge that despite good oxygen prescribing practice, oxygen delivered to patients was not always that of the prescription or within the target range specified. This suggests that greater emphasis needs to be placed on nursing delivery of oxygen to patients.<sup>10</sup> This can be done through education, formalised ward-based oxygen protocols or nurse-led improvement initiatives.<sup>19</sup>

We showed a shift change improvement for our main outcome and three of our key process measures. Two spot audits at 2 months and 4 months post quality improvement phase showed compliance of oxygen target saturation ranges displayed at bedside at 82% and 88%, respectively, for Bluebell B ward. Sustainability of improvement is supported by our senior medical and nursing leadership on our ward. Oxygen delivery is now part of the ward induction pack for all junior doctors. We are also developing a multidisciplinary 1 hour teaching package for oxygen prescribing and delivery for our clinical ward staff. This will be presented quarterly at our respiratory educational meeting.



Our improvements need to be developed to ensure trust-wide good practice for oxygen therapy, beginning with patients arriving from the community via ambulance.<sup>14</sup> We will be updating our local trust oxygen policy using a template provided by the British Thoracic Society,<sup>23</sup> develop eLearning mandatory teaching modules for our clinical staff and scale our quality improvement programme with support of our trust improvement team.

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**Contributors** RR proposed the idea. AC and GY drafted the manuscript. All authors made critical revisions and approved the final manuscript. All authors contributed to the design and implementation of the proposal. GY, RR, BR and NS performed the data collection. All authors analysed the data. AC acted as mentor for the quality improvement programme.

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