British Thoracic Society
BTS National Audit Report: Adult NIV Audit 2019
National Audit Period: 1 February – 31 March 2019
Dr Michael Davies

Number of participating institutions and records submitted:
Part 1: 3502 records from 158 hospitals
Part 2 (Organisation): 101 hospitals (86 trusts)

Introduction

This was the largest audit to date with 3502 patient submissions, growing from 2693 patient submissions in the previous audit in 2013. Compared to previous data, the 2019 audit found increased areas of good practice; results were consistent with substantial improvements in processes of care and patient outcomes.

National Improvement Objectives:

1. Improve patient selection for NIV, evidenced by reducing the proportion of patients who start NIV in the absence of a clearly documented evidence-based indication (current audit = 13%: target <10%)
2. Increase the proportion of patients who start NIV within 60 minutes of the blood gas that defines its need (current 50%: target >60%)
3. Increase the proportion of NIV services that have a named nursing lead and/or physiotherapy lead with time allocated to provide service leadership (current 69%: target >90%)

Timeframe: to be achieved by 2022/23

Key Findings

1. Compared to the last audit, an increased proportion of patients treated with acute non-invasive ventilation (NIV) had COPD, the indication with the strongest evidence. We saw a decreased proportion of patients who were treated with NIV despite no clearly documented indication. This suggests improved patient selection in line with the evidence base for NIV.
2. 50% of patients treated with NIV started NIV treatment within 60 minutes of the blood gas that defined the need for NIV. Clinician responses indicate a reduced perception of treatment delay in comparison to prior audits.
3. Acute NIV was successful in resolving respiratory acidaemia for 76% of patients treated, in comparison to 69% in the last audit (2013).
4. Inpatient mortality was 26%. It has reduced from 34% in 2013 and represents the first time that mortality has improved since the first BTS audit in 2010.

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5. Only 74% of organisations reported that they have sufficient capacity to deliver the routine acute NIV service.
6. Only 52% of organisations had a nursing lead and 34% had a physiotherapy lead for their acute NIV service.

Evidence Base

The standards for this audit were derived from the British Thoracic Society/Intensive Care Society (BTS/ICS) Guideline for the ventilatory management of acute hypercapnic respiratory failure (2016)[1]; the BTS Quality Standards for Acute Non-Invasive Ventilation (2018)[2]; and the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) Report 'Inspiring Change: A review of the quality of care provided to patients received acute non-invasive ventilation' (2017)[3].

Background

Acute NIV can be a lifesaving treatment for selected patients. However, successive audits showed a worsening trend in outcomes with high mortality rates and significant institutional variation.

In response to this, a number of national documents and reports may have influenced clinical practice since the last audit. These include the BTS/ICS guidelines for the ventilatory management of acute hypercapnic respiratory failure in adults (2016)[1], the National Asthma and Chronic Obstructive Pulmonary Disease Audit Programme (NACAP) and publication of the national COPD audit (2017/8)[5], NCEPOD's Inspiring Change study (2017)[3], the BTS Quality Standards for acute NIV (2018)[2], and the BTS NIV Quality Improvement toolkit (2018)[4].

Methodology

Instructions and data collection questionnaires were made available on the BTS audit website before the start of the audit. Data entry was via the secure online BTS audit tool. We asked all UK organisations to enter data for patients treated with acute NIV during the audit period 1 February to 31 March 2019, with the final deadline for data entry being 31 July 2019. Organisations were asked to enter all eligible cases, or if this was not possible e.g. due to large numbers, then care should be taken to avoid bias, e.g. by entering consecutive cases.

Results

This has been the largest audit to date. 159 hospitals took part in the audit and 3502 records were submitted. The median number of patient submissions has increased from 18.2 per hospital to 22.2.

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The median (interquartile range) age for patients treated with acute NIV was 72 (64-80) years and comprised 56% females. Table 1 below shows demographic data alongside the 2013 audit for comparison.

	2013	2019
Patient submissions	2693	3502
Participating hospitals	148	159
Age (median, years)	72	72
Gender (% female)	58	56
Diagnosis (%)		
COPD	62	67
Obesity-related respiratory failure	8	8
Acute Cardiogenic Pulmonary Oedema	8	7
Neuromuscular / Chest-wall disorders	4	3
Other	16	13
No data	2	2
Prior performance status (%)		
Unrestricted	7	7
Strenuous activity limited	9	10
Limited activity but self-caring	36	34
Limited activity limited self-care	34	32
Confined to bed/chair	9	10
No data	5	7
Previous acute NIV (%)		
Yes	25	31
No	60	48
No data	15	21
Consolidation present on CXR (%)		
Yes	40	36
No	56	61
No data	5	3
Pre-NIV blood gas results (median, kPa)		
pH	7.24	7.26
$PaCO_2$	10.2	9.3
PaO_2	9.7	8.1

Table 1. Demographic data

Use of NIV for patients with acute hypercapnic COPD has increased by 5% as a proportion of all patients treated and use for 'other' indications has reduced by 3%. A smaller proportion of patients in the current audit had evidence of consolidation on their initial chest X-Ray (36% vs. 40%). Taken together, these findings suggest a trend towards improved patient selection. Compared to the previous audit, there were no differences in age, gender, or prior performance status.

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Initial management

The NCEPOD Report and the BTS Quality Standard recommend that patients who meet evidence-based criteria for acute NIV should start NIV within 60 minutes of the blood gas result associated with the clinical decision to provide NIV[2,3]. We found that this was achieved for 51% of patients. However, on review of records clinicians indicated that only 17% of patients experienced a delay in treatment (compared with 27% of cases in the NCEPOD study). Reasons for treatment delay in order of magnitude were: not recognising the need for NIV > awaiting patient transfer > delay in blood gas measurements > lack of beds > lack of equipment.

The BTS Quality Standard also recommends that NIV should commence within 2 hours of admission if presenting with acute hypercapnic respiratory failure via ED.[2] This was reinforced by the findings of the National Asthma and Chronic Obstructive Pulmonary Disease Audit Programme (NACAP). NACAP assessed the management of patients admitted with obstructive lung disease (COPD and asthma) between September 2017 and September 2018. It found that NIV was commenced within two hours of admission for only 21% of patients treated with acute NIV[5]. In light of these findings, we added this measure to the 2019 audit. Door to mask times were available for 2896 patients (83% of whole cohort). For these patients, NIV was started within 2 hours of admission for 708 patients (24% of the total cohort with data available).

We recognise that 'door to mask' time has less validity for patients who develop Acute Hypercapnic Respiratory Failure (AHRF) later in their admission. Therefore, we assessed NIV start times for a sub-group of patients who started NIV within 24 hours of admission to gain further insight into the typical admission pathway. Data were available for 1950 patients. Incremental totals for 'door to mask' times are shown in Table 2;

'Door to mask' time (hours)	number	% of 24-hr total
0-2	708	36
0-4	1119	57
0-6	1361	70
0-12	1700	87
0-24	1950	100

Table 2. Admission to NIV start (sub-group of patients starting NIV within 24 hours)

Attainment of other selected aspects of initial NIV management against the BTS Quality Standard are shown in Table 3;

Measures within BTS Quality Standard[2]	**2019 (% achieved)**
All patients should have a documented escalation plan before starting treatment with acute NIV.	83
Patients who meet evidence-based criteria for acute NIV should start NIV within 60 min of the blood gas result associated with the clinical decision to provide NIV	51
Clinical progress should be reviewed by a healthcare professional with appropriate training and competence within 4 hours of starting NIV	49
All patients treated with acute NIV should have blood gas analysis performed within 2 hours of starting acute NIV.	62
Failure of these blood gas measurements to improve should trigger specialist healthcare professional review within 30 min.	43

Table 3. Process measure outcomes

In previous audits, there has been a progressive reduction in pre-NIV pH values, from 7.30 in 2010 to 7.24 in 2013. This year, the median pre-NIV pH was 7.26.

83% of patients had a documented escalation plan before starting treatment with acute NIV, an increase from 74% in the 2013 audit.

Over the first 24 hours, NIV was used for 16 (± 7.8) hours. The average initial $PaCO_2$ was 9.3 kPa prior to NIV, and fell by 1.1 kPa at 1-2 hours post NIV. Pressure support mode was used for 83% of cases, pressure control for 14%, with no documentation or other modes used for the remaining 3% of patients. Average settings reached after 2 hours of NIV were IPAP 18 cmH_2O, EPAP 5 cmH_2O.

Patient outcomes

NIV was successful in resolving AHRF for 76% of patients (66% in 2013). 21% of patients experienced treatment failure and did not proceed to intubation. A further 3% of patients failed NIV, but proceeded to intubation. Median length of stay was 9 days (Table 4).

Inpatient mortality was 26% (from 34% in the 2013 audit and 35% in NCEPOD's study). This is the first audit cycle in which we have reported a reduction in inpatient mortality.

Some improvement in overall mortality may be attributed to improved patient selection (higher proportion of patients with COPD, who as a group experience lower mortality rates than the overall average).

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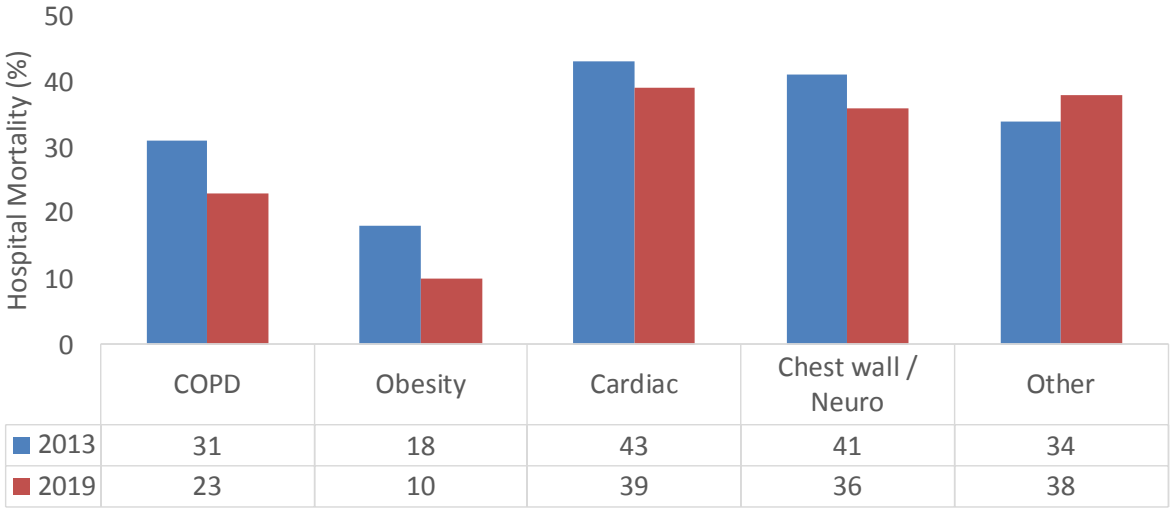
The data also suggest an improvement in the general process of NIV treatment. The higher pH at the start of NIV treatment may suggest a more timely application of NIV, though could represent selecting a milder patient group. Mortality outcomes were lower for each diagnostic category, and most notably for patients with COPD and obesity-related respiratory failure (Figure 1).



	COPD	Obesity	Cardiac	Chest wall / Neuro	Other
2013	31	18	43	41	34
2019	23	10	39	36	38

Figure 1. Hospital mortality according to diagnostic group (2013 vs. 2019)

In 2019, we also saw an improvement in hospital survival across most pre-NIV pH ranges, with a greater effect for pH ranges typically associated with ward-based NIV use (Figure 2);

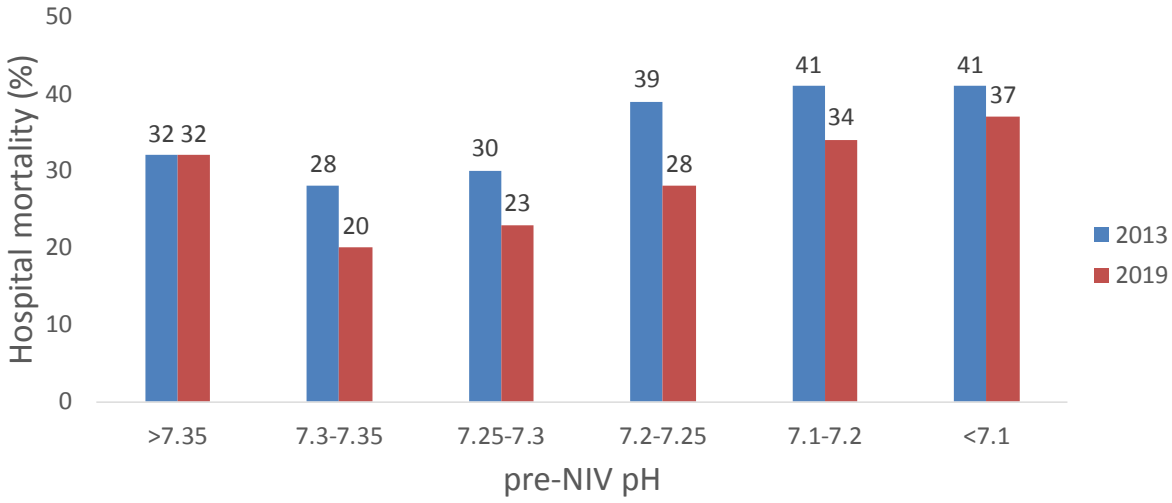


Figure 2. Relationship between pre-NIV pH and hospital mortality (2013 vs. 2019)

As for prior audits and studies, hospital mortality was higher in those with radiological consolidation than in those without (32% vs. 22%), though both values were lower this year compared to the last audit period in 2013 (43% vs. 28% respectively).

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	2013	2019
Median hours of NIV in first 24 hours	15	16
NIV outcome (%)		
Success	66	76
Failure	27	21
Failure but proceeded to intubation	3	3
No data	1	0
Length of stay (median days)	9	9
Outcome of admission (%)		
Death	34	26
Discharged from hospital off NIV	52	56
Discharged on home NIV (or transferred to home NIV centre)	10	14
Other / No data	3	3

Table 4. NIV outcomes

We assessed the impact of the timing of NIV on patient outcomes. As in prior analyses, there was a clear signal that starting NIV at a later stage in hospital admission is associated with a lower likelihood of success. Figure 3 shows the hospital mortality for the 2019 audit cohort with respect to the timing of starting NIV (post admission). It is important to note that starting NIV more than 24 hours after admission is unlikely to represent a treatment delay; rather it is more likely to reflect late clinical deterioration despite initial medical therapy. In the current audit, more than 80% of patients started NIV within 24 hours (0-1 calendar days) of admission. Only 5% of patients started NIV at day 5 or later.

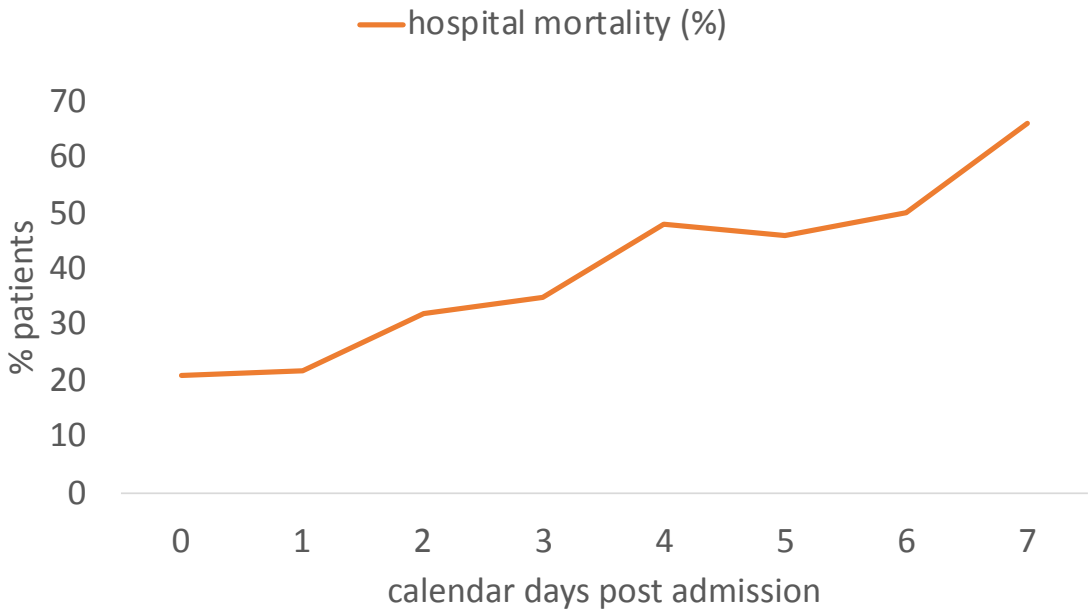

Figure 3. Relationship between hospital mortality and timing of NIV initiation (days post-admission)

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We further reviewed the outcome of patients who started NIV within 12 hours of admission. Hospital mortality was similar across each hour interval with no clear trend. However, there was a progressive increase in pre-NIV pH values over the first six hours of admission (median pH rising from 7.22 if NIV started at 0-1 hour post-admission to 7.29 at 5-6 hours post-admission). This suggests that patients treated earlier also present with greater physiological derangement. We plan to conduct a more detailed analysis of these findings.

Organisational data

For individual organisations, local operational policies should define the arrangements for NIV delivery, including designated clinical areas, equipment, staffing, and staff competencies. In the 2019 audit, we found:

93% of organisations have designated NIV area(s) in their institution. If designated, the relative frequency was as follows: Respiratory ward (99%), critical care unit (97%), emergency department (92%), high dependency unit (86%), acute medical unit (53%), and respiratory high care area (40%). Figure 4 shows the pattern of initial and subsequent location of NIV treatment, showing that the most common patient pathway is to start NIV within the ED and then continue treatment in a respiratory ward;

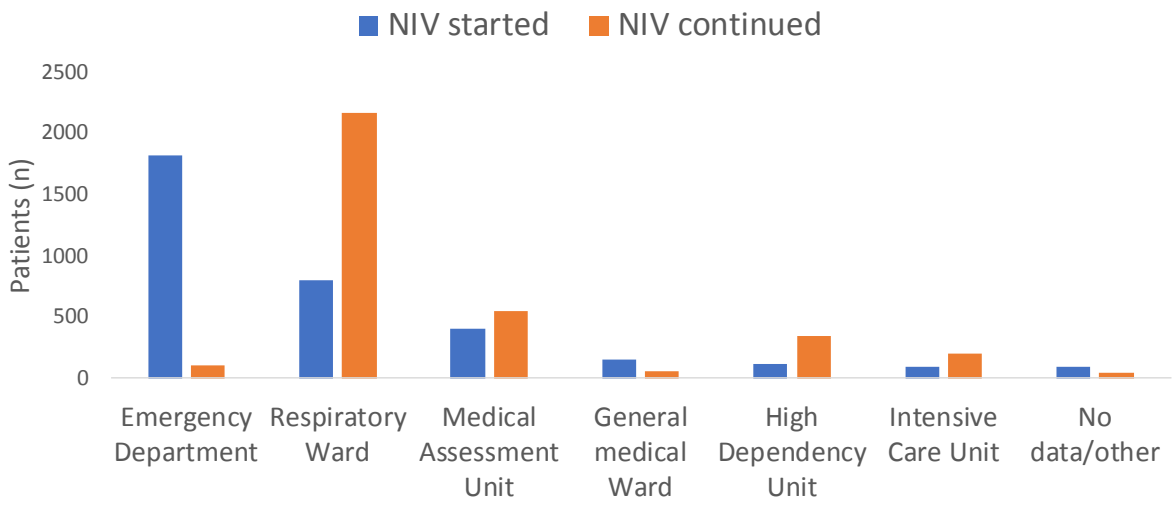

Figure 4. Initial and subsequent location of NIV treatment

We reviewed the outcomes for patients who started NIV in a respiratory ward (n=807). Of these, 494 (61%) of patients started treatment in an NIV-designated area and 313 (39%) of patients started NIV in a ward area that had not been designated for NIV. Inpatient mortality was 40% for patients who started NIV in a non-designated NIV respiratory ward area (n=313), compared to 29% for those who started NIV in a designated respiratory ward area (n=494).

89% of organisations had a clinical lead for the acute NIV service, though only 39% of clinical leads had time allocated within their job plan to provide service leadership. Despite practical delivery being led by nursing staff and/or physiotherapy in almost all trusts, only 52% of organisations had a nursing lead and 34% had a physiotherapy lead for NIV. There was some cross-over here, with 14% of organisations having both nursing and physiotherapy leads. However, 31% of organisations reported having neither a nursing nor physiotherapy lead for service.

84% of units had provision for continuous pulse oximetry monitoring during the first 24 hours of acute NIV and 86% of units had provision for point of care blood gas analysis within or adjacent to all designated NIV areas.

NIV guidelines recommended a staffing ratio of one nurse to two NIV patients during the first 24 hours of treatment[1,2]. The Intensive Care Society's 2009 document, 'Levels of Critical Care for Adult Patients,' recommended level 2 as the environment to deliver treatment with NIV[1]. In the 2019 audit, we found that 46% of units were routinely staffed at 1:4 – 1:8 and lacked routine provide 1:2 staffing when clinically indicated.

26% of organisations reported that they did not have sufficient capacity to deliver the routine acute NIV service. Insufficient staffing and beds were the most frequently cited reasons. Despite national guidance to the contrary, 46% of units could not provide 1:2 nursing staffing when needed for more acute patients. There was significant variability in NIV training, with only a small minority of consultants who have on-call responsibility for the acute NIV service documented to have up to date training.

Whilst 94% of organisations provided a training programme for staff with responsibility to start or continue treatment with NIV, there was variability in its completeness and maintenance. Only 69% kept a register of NIV-trained staff and only 56% conducted formal training updates for permanent staff. If there was a register of trained staff, then only 19% of consultants with on-call responsibility for the acute NIV service were included within this register. Induction programmes for rotating medical staff included NIV training in only 43% of organisations.

Conclusions

The 2019 BTS acute NIV audit was the largest to date and provides a rich dataset. To our knowledge it provides the largest global dataset to explore patient outcomes and processes of care. We are very grateful to those who contributed to data entry on 3502 patients from 158 institutions. We present key findings within this report though hope to analyse the data further to gain a greater understanding of the factors associated with successful outcomes.

The patient cohort appears similar to prior audits in terms of age, gender, and prior performance status. Other demographic data, including diagnostic grouping, pre-NIV pH, and consolidation status, suggest improved patient selection for NIV compared to previous audits.

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Organisational data also suggests improvements towards NCEPOD and BTS recommendations. Whilst there are still areas of concern, a higher proportion of units have a clinical lead with time in their job plan to lead the service. However, there is significant variation in training, especially within differing groups of staff; whilst 94% of organisations have a training programme, only 19% of NIV-service consultants were included in the training register. We also found that NIV was frequently delivered in non-designated respiratory ward areas; inpatient mortality for such patients appeared worse than for those treated in NIV-designated areas.

Acute NIV services require effective multidisciplinary leadership and the 2019 audit results highlight that this remains an area for improvement. Most services had a medical lead, though only 39% of medical consultant leads had time allocated within their job plan. This was a key recommendation of the NCEPOD report, which had found 34% had time allocated. The 2019 audit also shows that only 52% of organisations had a nursing lead and 34% had a physiotherapy lead. Only 14% of organisations have a medical, nursing and physiotherapy lead, despite the multidisciplinary nature of successful NIV. 31% of organisations reported having neither a nursing nor physiotherapy lead for service. Whilst likely that some services will have nursing leadership within a standard ward structure, we conclude that the explicit recognition of nursing and AHP leadership should be an objective for national improvement.

Nevertheless, overall outcome data are encouraging. We show an improvement in NIV success rates and hospital survival for the first time, compared to the worsening trend in outcomes in successive audits seen previously. Whilst this is the first BTS audit since 2013, NCEPOD's study had collected patient outcome data during the same time window as the BTS audits. Data obtained by NCEPOD in 2015 and reported in 2017 had shown that overall inpatient mortality had reached 35%[3]. The 2019 audit shows overall inpatient mortality at 26%. Whilst recognising the pragmatic nature of data collection, we find improvements in patient selection and in the delivery of treatment.

The timing of NIV is an increasing focus, with delays in care potentially associated with worsening outcome. We will explore this in more detail using the current dataset, though this initial analysis shows that patients who are treated within 60 minutes of ED arrival also demonstrate a greater degree of physiological derangement. It seems likely that there is a degree of natural triage, with sicker patients treated more promptly with NIV. Whilst many patients did not start treatment within two hours of arrival, clinicians reviewing individual notes rarely felt that there had been a clinically significant delay in starting NIV. Consistent with previous findings across a number of studies and audits, starting acute NIV later (>48 hours) into hospital admission is typically less successful than for those patients who present with AHRF on admission. Of course, this is more likely to relate to patient-related factors as opposed to any difference in the delivery of NIV. Importantly, these data may inform treatment discussions with patients, but should not preclude a trial of NIV on an individual basis.

Alongside this audit we note that there has been an increase in abstract submissions to the BTS Winter Meeting with a specific focus on Quality Improvement in NIV over the past few

years. These coincide with NCEPOD's Inspiring Change report and the subsequent publication of BTS Quality Standards for acute NIV and the Quality Improvement toolkit. We hope that all may have contributed the stimulus and tools to improve care locally. We hope that the positive findings of this audit will encourage further quality improvement work to reduce organisational variation and improve the care of all patients treated with acute NIV.

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