Airborne protection for staff is associated with reduced hospital-acquired COVID-19 in English NHS Trusts

***Tom Lawton**, Bradford Teaching Hospitals NHS Foundation Trust**
***Matt Butler**, Cambridge University Hospitals NHS Foundation Trust*
***Christine Peters**, QEUH, NHS Greater Glasgow and Clyde*

*Corresponding author: tom.lawton@bthft.nhs.uk

Abstract

Introduction

Hospital-acquired infection with COVID-19 (HAI) has reduced from 14.3% to 4.2% over the last year, but substantial differences still exist between English NHS trusts.

Methods

We assessed rates of HAI, comparing trusts using airborne respiratory protection (RPE, eg FFP3 masks) for all staff, as a marker of measures to reduce airborne spread, against those using mostly droplet precautions (eg surgical masks).

Results/Discussion

RPE use was associated with a 33% reduction in HAI odds in the Delta wave, and 21% in the Alpha wave ($p<0.00001$). We recommend all hospitals make airborne mitigations a priority.

Introduction

Hospital-acquired infections (HAIs) are associated with poorer outcomes both for the individual and the wider health care system,[1,2] and hospital-acquired COVID-19 in the NHS has been a significant driver of the pandemic.[3] National reporting and investigation of other nosocomial infections have led to a significant reduction in rates,[4] but for COVID-19 there has been little central work to understand the large variation between trusts. Over the last 18 months there has been substantial development in the understanding of airborne transmission,[5] asymptomatic spread,[6] PPE use,[7] and regular testing for patients[8] and staff.[9] The improvements and variation still seen suggest that nosocomial spread of COVID-19 is not inevitable, but the question remains as to how best to reduce rates and keep them low.

Current NHS guidance states that COVID-19 can spread by the airborne route, but that outside a list of “aerosol generating procedures” (“AGPs”) only droplet precautions are required unless a local risk assessment suggests otherwise.[10] Some NHS trusts have nevertheless chosen to protect staff against airborne transmission by allowing the use of respiratory protective equipment (RPE, eg FFP3 masks) for all staff caring for patients with COVID-19. Our hypothesis is that this acceptance of airborne transmission, and the mitigation measures it entails, is associated with a reduction in the nosocomial transmission of COVID-19.

Methods

Hospital-acquired COVID-19 was calculated as “probable” or “definite” hospital-acquired infections from NHS England weekly COVID-19 statistics, defined as COVID-19 diagnoses made 8 or more days after hospital admission. The first available data was from 1st August 2020; data was separated into waves - “Alpha” from 1st August 2020 to 30th April 2021, and “Delta” from 1st May 2021 onwards. Data was downloaded from NHS England on 16th September 2021, and the last data point was 12th September 2021. The rate of hospital-acquired infection with COVID-19 (“HAI rate”) was calculated as a percentage of total COVID-19 cases for each trust. Hospital size was calculated from NHS England overnight bed data, as the average number of acute hospital beds open overnight from July to September 2020. Hospital COVID-19 pressure was calculated as the total number of COVID-19 patients treated per acute hospital bed.

RPE use was from a public dataset maintained by FreshAirNHS, compiled from news reports, public statements, and private communication. All trusts recorded as using RPE were contacted on 20th September 2021 to confirm their current practice, and an open call was made to other trusts who may have been missing from the dataset to come forward. A trust was considered to be using RPE for a wave if it was recorded as using RPE outside “AGP” areas at any point during the wave.

Data was analysed in R 4.0.4 (R Core Team). Significance testing used the exact 2x2 test for patient-level analysis, and Wilcoxon rank-sum test for trust-level analysis. Correlations were

calculated as Spearman's rank correlation coefficient. Data used in this analysis is publicly available and accompanies this article.

Results

Alpha wave (Aug '20-Apr '21) HAI rates	Delta wave (May '21-Sep '21) HAI rates
Trusts using RPE (n=14) *Mean* 11.9% *Median* 11.2% (8.4% to 14.4% IQR) **Trusts not using RPE (n=109)** *Mean* 14.7% *Median* 15.0% (10.4% to 18.2% IQR) **Reduction in HAI rates** *Absolute*: 3.0% (-0.3% to 6.3%) *p=0.0713*	**Trusts using RPE (n=16)** *Mean* 2.8% *Median* 2.6% (2.2% to 3.7% IQR) **Trusts not using RPE (n=107)** *Mean* 4.7% *Median* 4.0% (2.7% to 6.0% IQR) **Reduction in HAI rates** *Absolute*: 1.4% (0.3% to 2.7%) *p=0.0088*
Patient Level Overall proportion 14.3% **At trusts using RPE (n=31,163)** Proportion 11.8% **At trusts not using RPE (n=224,156)** Proportion 14.6% **Reduction in HAI proportion** *Absolute*: 2.7% (2.4% to 3.1%) *Relative odds*: 21.3% (18% to 24%) *p<0.00001*	**Patient Level** Overall proportion 4.2% **At trusts using RPE (n=8,746)** Proportion 3.0% **At trusts not using RPE (n=45,542)** Proportion 4.4% **Reduction in HAI proportion** *Absolute*: 1.4% (1.0% to 1.8%) *Relative odds*: 33.1% (24% to 42%) *p<0.00001*

Table 1 - HAI rates during Alpha and Delta waves

Results for trust-level and patient-level analyses are given in Table 1, and overall trust-level rates are shown in Figure 1. During the Alpha wave, we estimate that 6000 extra patients (5150 to 6800) at non-RPE trusts caught COVID-19 in hospital than if rates at trusts using RPE had been replicated across England.

In a comparison of HAI rate against hospital size, there was no significant correlation (Alpha: p=0.25, Delta: p=0.16). Comparing HAI rate against hospital COVID-19 pressure (Figure 2, Figure 3), there was a significant correlation (Alpha: p=0.03, Delta: p=0.002), however with limited predictive value (Linear regression - Alpha: R^2=0.05, Delta: R^2=0.05). The direction of the correlation indicated that hospitals with more COVID-19 had a lower HAI rate, probably because there were fewer patients without a COVID-19 diagnosis available to contract it. RPE

use was not associated with hospital COVID-19 pressure (Alpha: p=0.74, Delta: p=0.29). HAI rate was not correlated with the total number of COVID-19 cases (Alpha: p=0.76, Delta: p=0.21).

A time series analysis of HAI rates across all acute trusts (Figure 4) shows a large peak in December 2020 followed by improvement to June 2021. However in this present wave up to September 2021, rates are again increasing.

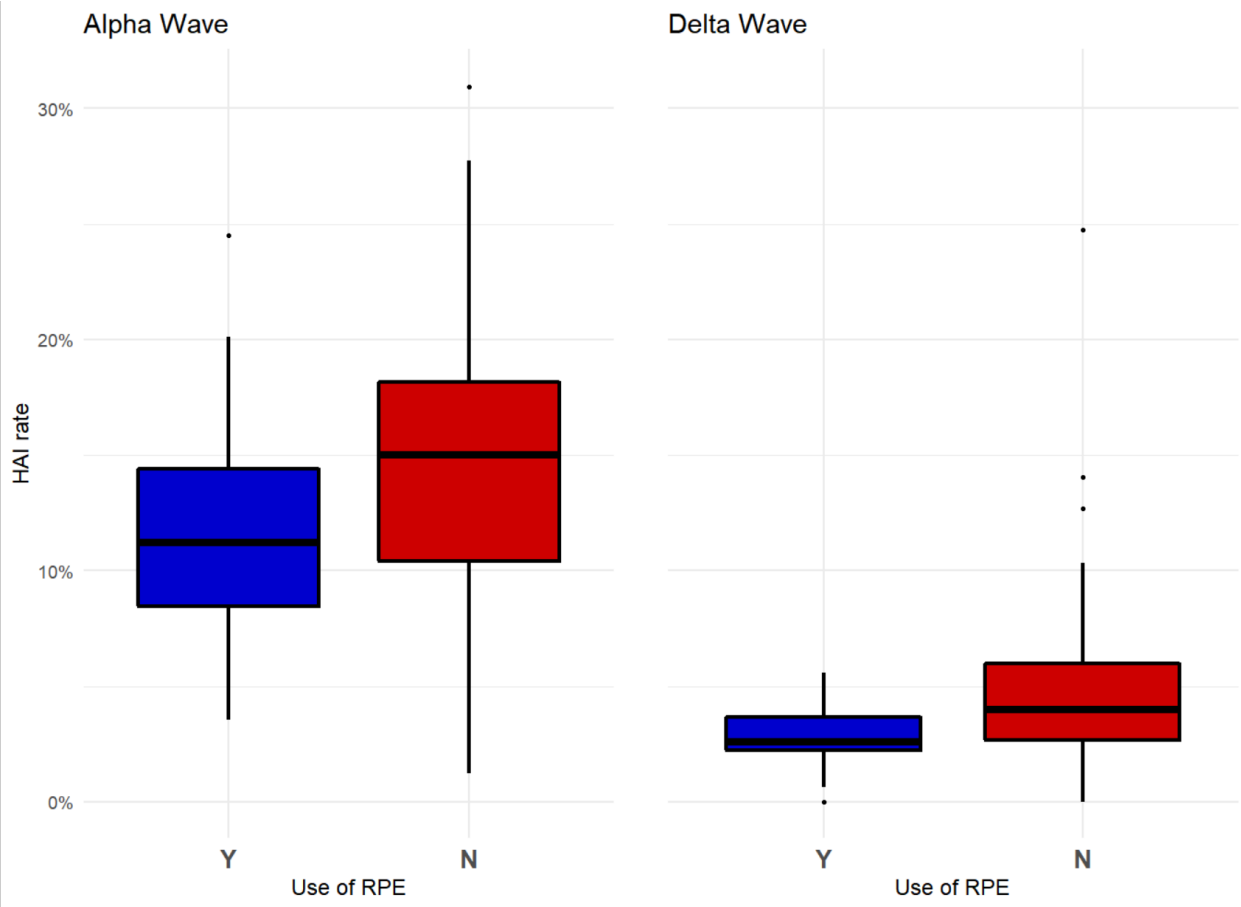

Figure 1 - Boxplot of HAI rates by NHS trust during Alpha and Delta waves

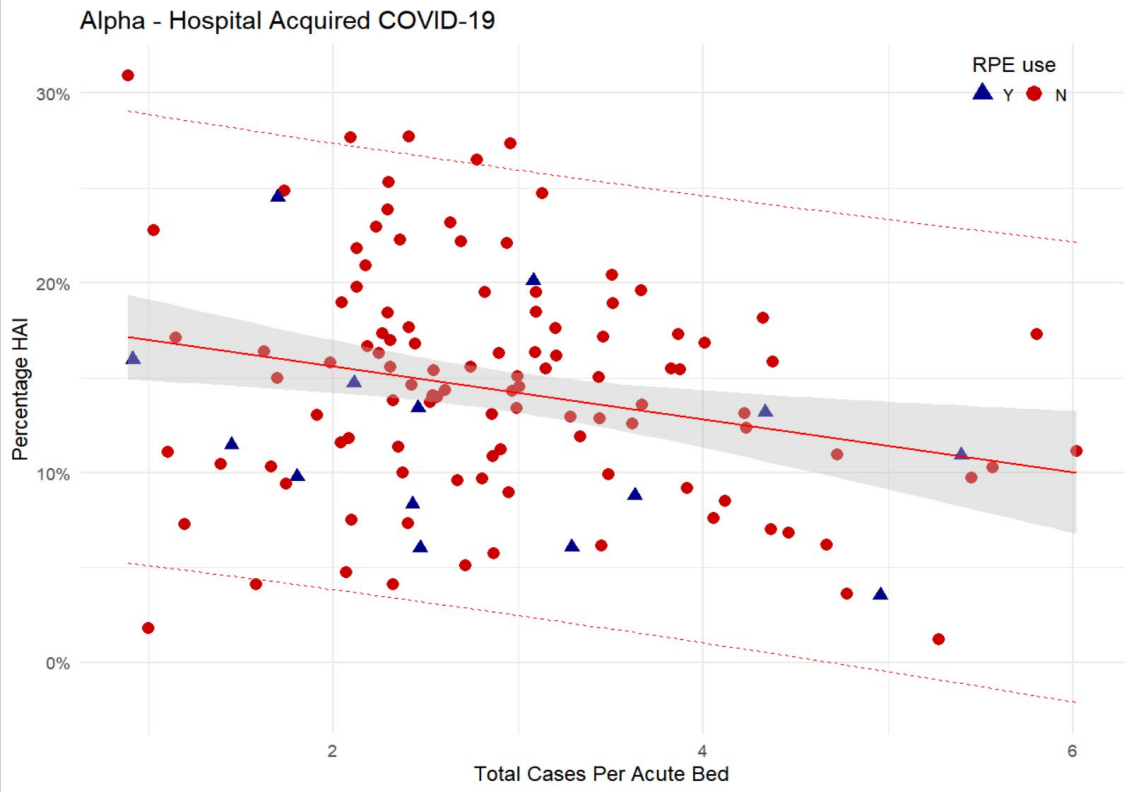

Figure 2 - HAI rates against trust COVID-19 pressure, Alpha wave

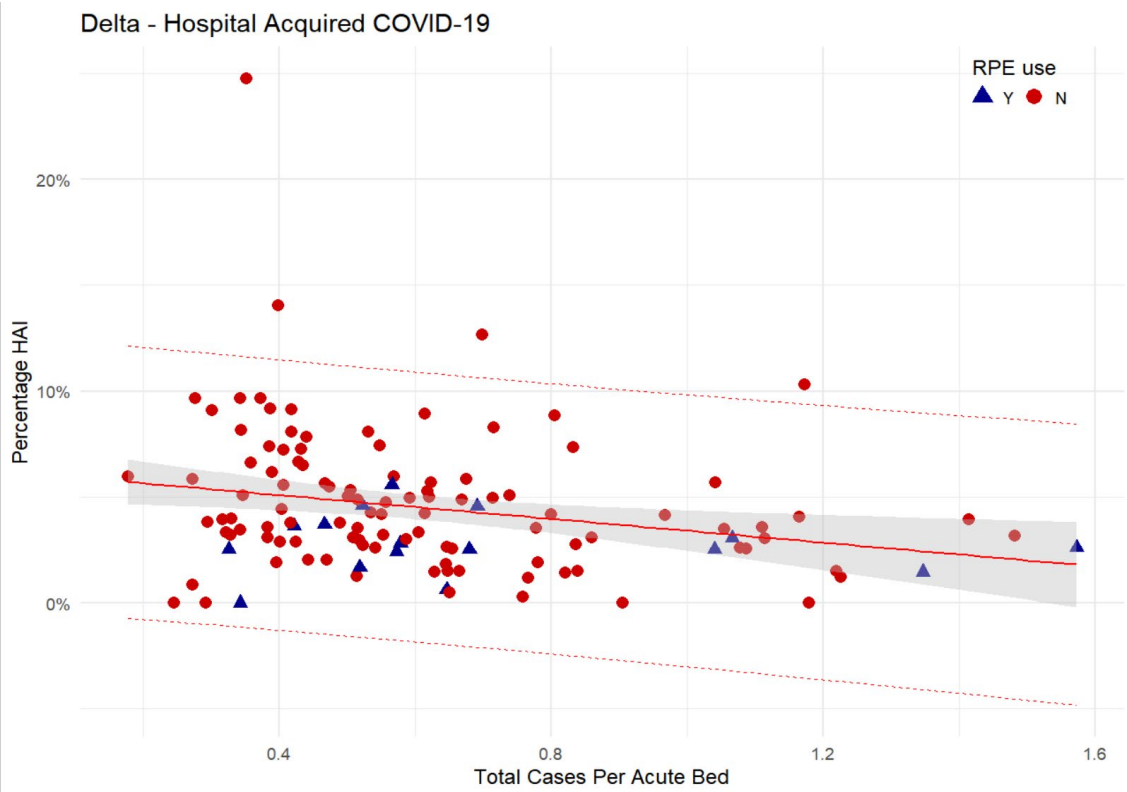

Figure 3 - HAI rates against trust COVID-19 pressure, Delta wave

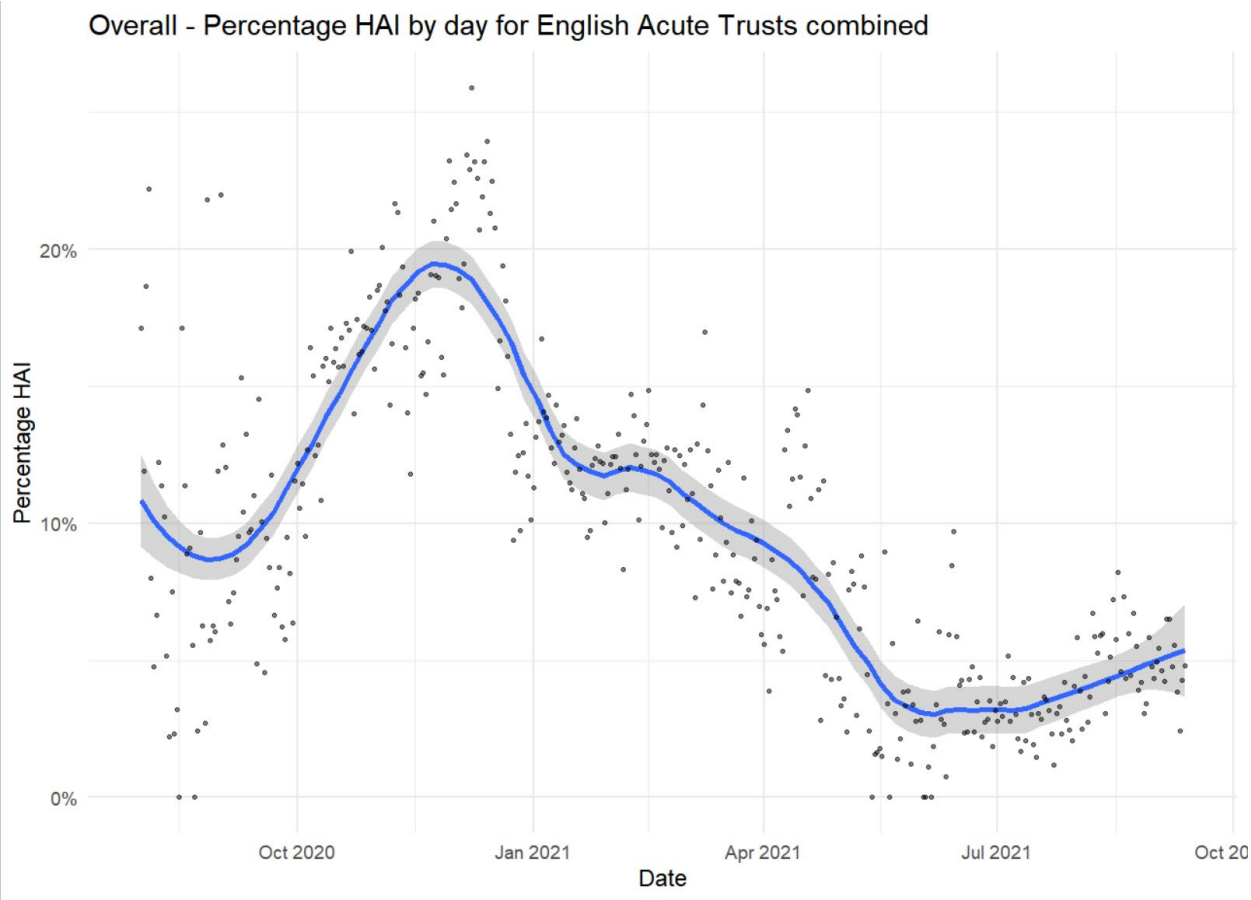

Figure 4 - Time series of HAI rates in English trusts combined by day

Discussion

RPE use for all COVID-19 facing staff by English NHS trusts is associated with a significant reduction in hospital-acquired COVID-19. Whilst we have used RPE use outside “AGPs” as a marker, we consider the results likely to be due to a multimodal series of interventions directed against airborne transmission in trusts which have prioritised action in this way. The reduction in HAI rates demonstrated is greater than would be expected directly from RPE use i.e. by preventing asymptomatically infected health care workers infecting patients, reported as 9%.[11] The data presented demonstrate that the measures associated with RPE implementation, likely involving improvements to ventilation and air filtration, are associated with a 21% and 33% relative reduction in odds of hospital-acquired COVID-19 for the Alpha and Delta waves respectively.

We have made efforts to have accurate data on RPE use; it is possible that we are unaware of some trusts using RPE officially or unofficially. This would tend to reduce the effect size so our results may underestimate the true impact. Our findings are in keeping with modelling suggesting that screening and effective PPE use are effective interventions to reduce nosocomial COVID-19 transmission.[12] Our finding that high trust COVID-19 pressure was associated with lower HAI rates is novel, but the effect size is relatively small and is potentially

because a high COVID-19 occupancy means there are few patients without COVID-19 able to catch it. It also suggests that community rates are not the main driver of hospital-acquired COVID-19 once considered as a percentage of cases. Our combined patient-level and trust-level analyses ensure that small hospitals having large outbreaks do not skew the analysis, but care must be taken in interpretation – the patient level numbers do not represent risk for a COVID-19 negative patient subsequently catching it in hospital, but the proportion of COVID-19 positive patients in hospital who probably caught it there.

The greater relative reduction in HAI rates seen with the Delta wave in trusts implementing RPE likely reflects the underlying hierarchy of controls being more effective from April 2021, coinciding with updates to national infection prevention and control guidance which emphasised their use.[10] In the later wave, trusts were seemingly better able to isolate cases through enhanced staff and patient testing, achieving reductions in HAI rates in all trusts irrespective of airborne mitigations. Once all trusts are appropriately implementing the hierarchy, this increased homogeneity would cause differences like airborne mitigations to have a larger relative effect on reducing nosocomial transmission.

The current rates of hospital-acquired COVID-19 could be still reduced as further mitigations directed against airborne transmission are rolled out. Whilst it is relatively quick to deploy FFP3 respirators outside of AGP areas, it is much slower to audit ventilation and deploy air filtration units, and even slower to upgrade hospital estates to include more side rooms including negative pressure isolation rooms. However it is important to recognise that even hospitals with majority side room provision have still seen nosocomial spread (personal communication, C Peters), The potential role of ventilation and air flows in these types of wards is in keeping with detailed investigations of quarantine hotel outbreaks in Australia.[13]

Recent data highlights that over 4% of hospital COVID-19 cases are still nosocomial, and by only including patients who became positive after more than 7 days this is likely to be an underestimate[14] particularly for Delta, where the peak of infectivity is earlier than previous lineages.[15] Also, patients who have acquired infection but are not yet shedding the virus by their last test before discharge will likewise not be counted. The time series data shows that COVID-19 HAI rates have been worsening since July 2021, lending an urgency to finding ways to further improve. SAGE advice from early 2021 suggests a range of ways to mitigate airborne transmission of COVID-19 in hospitals,[16] and more general advice has existed longer.[17] We recommend all hospitals to adopt appropriate airborne aerosol mitigations to protect staff and patients.

Acknowledgements

Data provided by NHS England under Open Government Licence v3.0

Conflicts of Interest

TL,MB are clinicians at NHS trusts which use RPE for all COVID-19 patients

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