

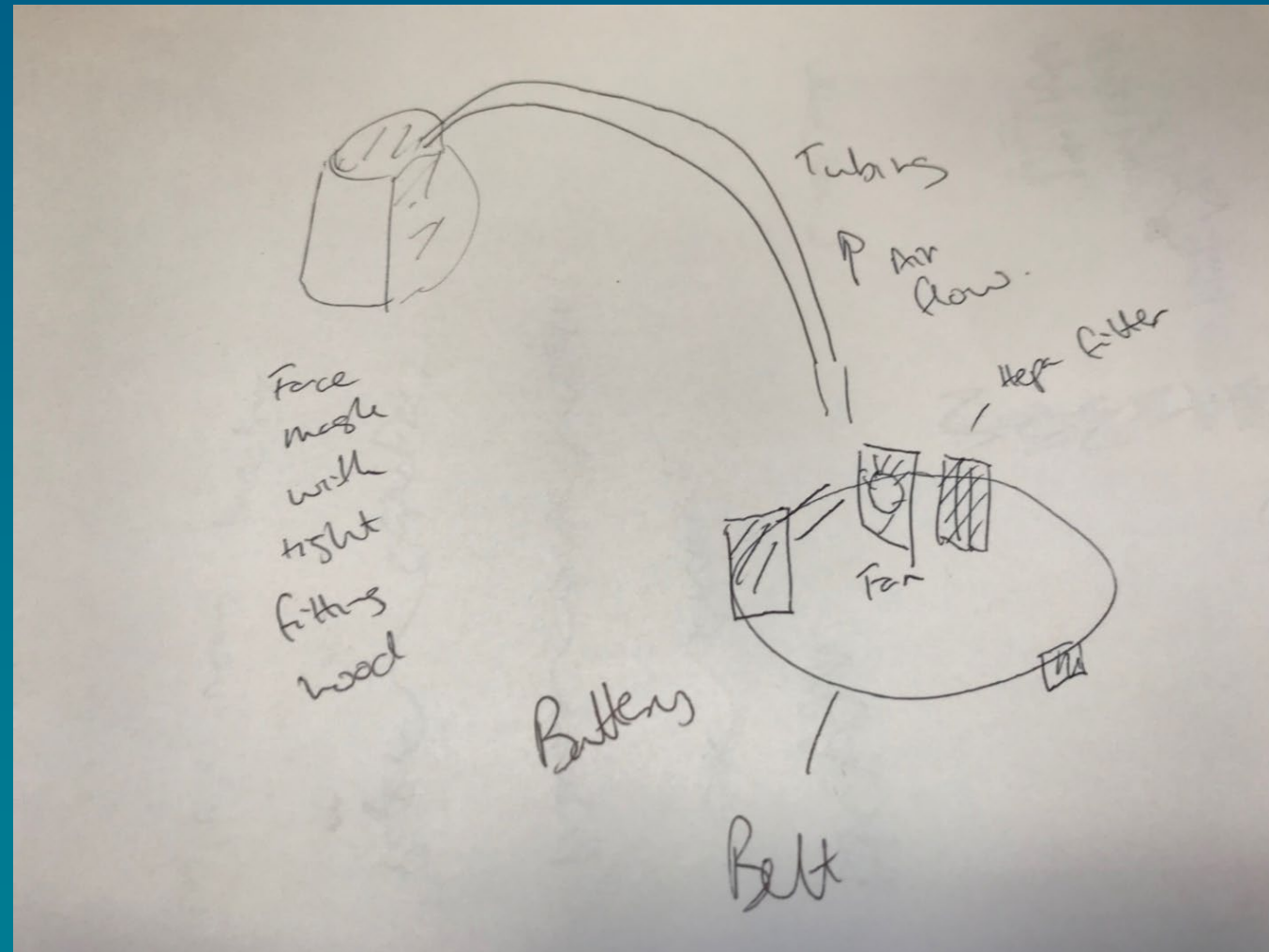
# Implementation and evaluation of widespread powered air purifying respirator use as an alternative PPE strategy during COVID-19

Paul Elkington

University of Southampton and University Hospitals Southampton

[p.elkington@soton.ac.uk](mailto:p.elkington@soton.ac.uk)

# The origins: perceived urgent need March 2021



# In house design and production of respirators



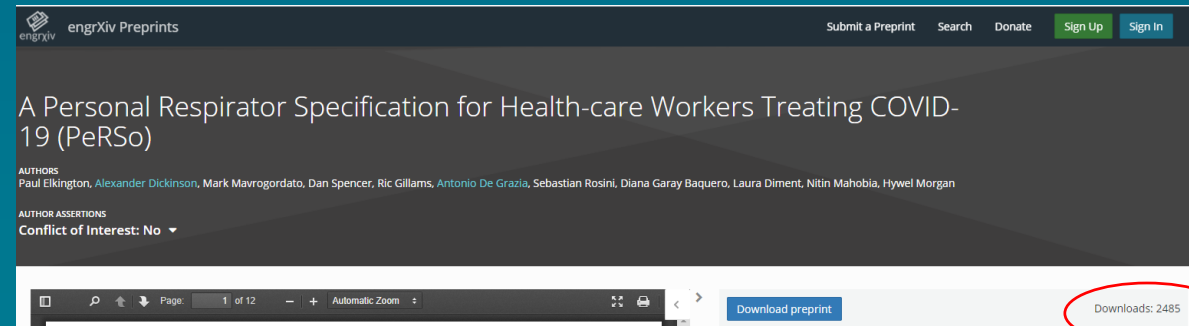
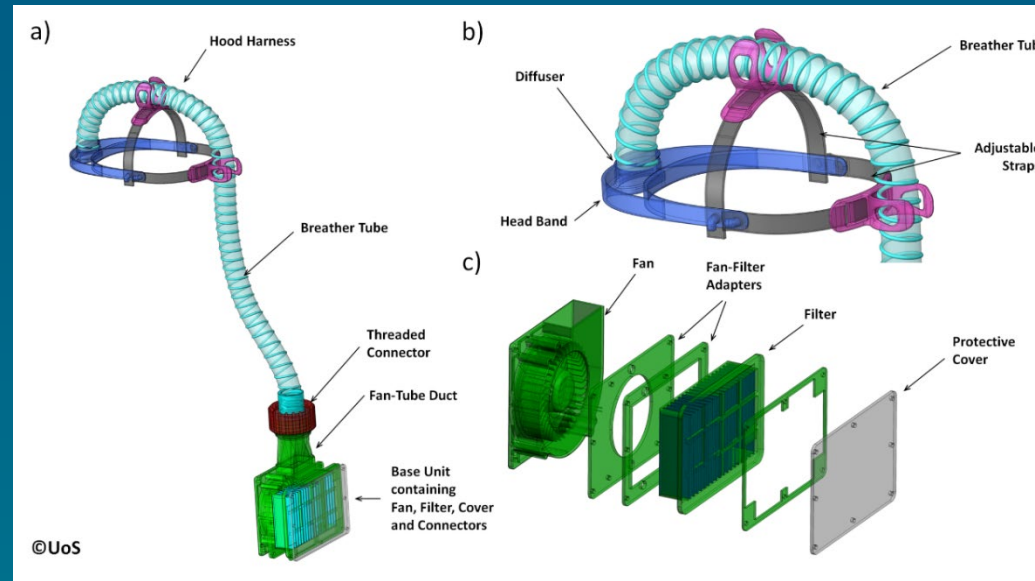
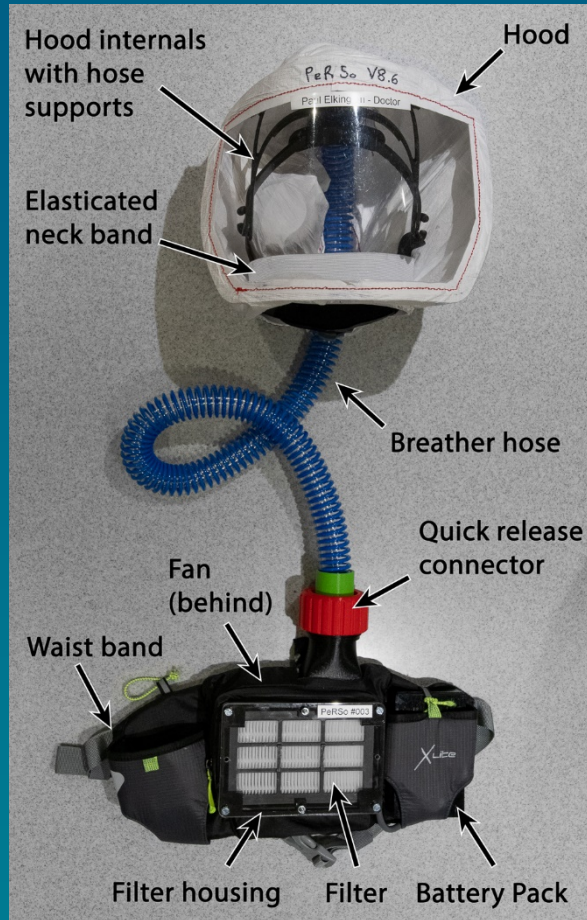
©UoS

Initial evaluation



3D printed connectors

# Early PeRSo prototype and open access design



Downloaded almost 2,500 times

<https://www.frontiersin.org/articles/10.3389/fmedt.2021.664259/full>



# Production version: INDO Lighting and wave 1 implementation



Lecture theatre 2

Deployed on COVID positive wards in place of surgical face mask

“I have felt sick with fear every day coming to work, now I feel safe”

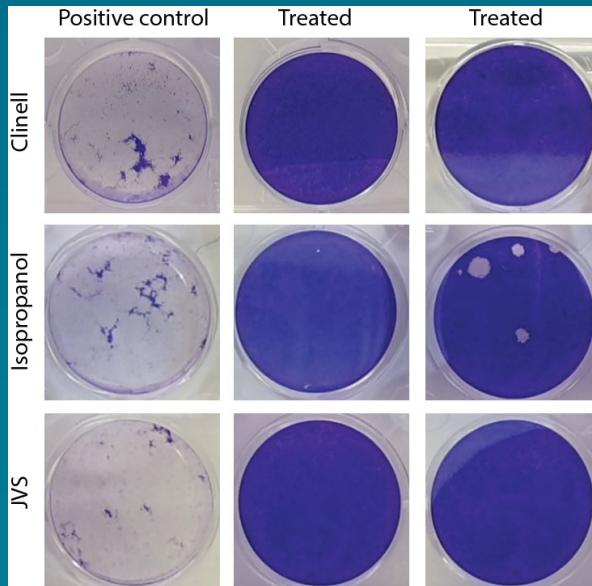
# Prospective feedback via online survey

- Significant findings vs droplet protection
  - more comfortable (p 0.011)
  - harder to doff (p < 0.001)
  - patients respond better (p 0.044)
  - wearer feels safer (p < 0.0001)
  - overall experience is better (p 0.006)
  
- 1,396 staff requested reissue for wave 2



# Regulatory hurdles for use in place of FFP3 masks

- PeRSo 3.0 approved 22<sup>nd</sup> September 2020
  - Previously certified PAPR with medical grade filter inserted
- PeRSo 1.0 approved 6<sup>th</sup> April 2021
  - Simple mass produced version made in UK



- Validation of efficacy of killing SARS-CoV-2
- Previously approved PAPRs did not have to go through same validations

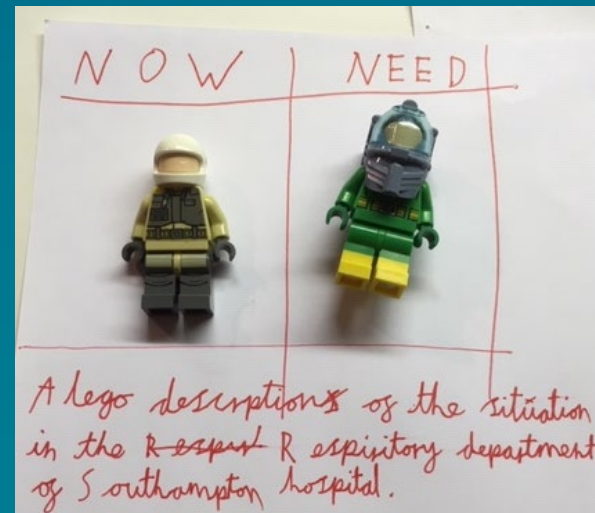
# Additional benefits of wide PeRSo use

- During second wave, 3,629 deployed across trust
- 5% of staff who fail fit testing could return to work
- Much more robust FFP3 supply as daily use minimised
- No failure during use, compared to 18% mask failure during CPR

 The American Journal of Emergency Medicine  
Volume 38, Issue 1, January 2020, Pages 12-17

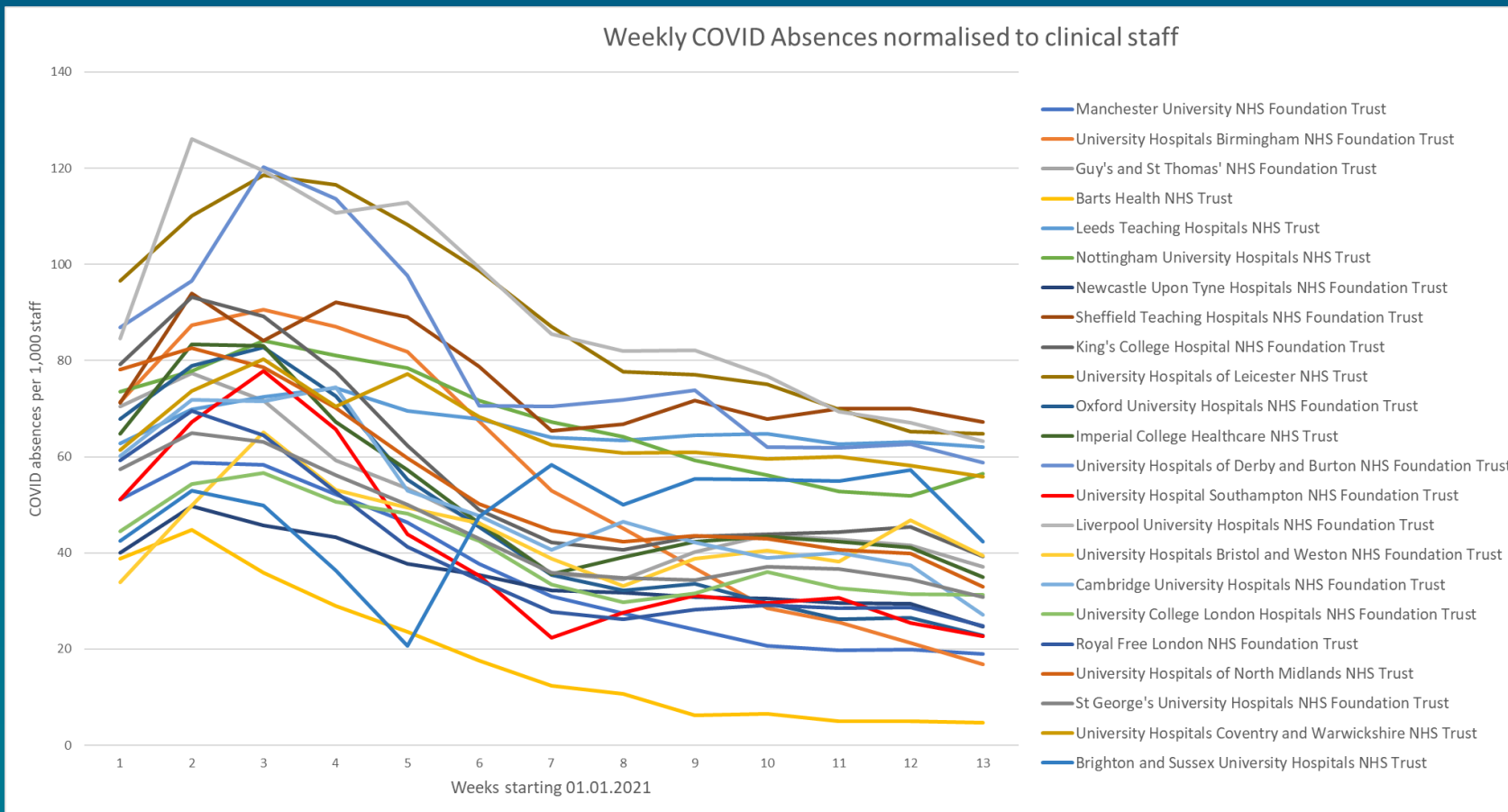
**N95 filtering facepiece respirators do not reliably afford respiratory protection during chest compression: A simulation study**

Sung Yeon Hwang MD <sup>a</sup>, Hee Yoon MD <sup>a</sup> , Aerin Yoon RN <sup>b</sup>, Taerim Kim MD <sup>a</sup>, Guntak Lee MD <sup>a</sup>, Kwang Yul Jung MD <sup>a</sup>, Joo Hyun Park MD <sup>a</sup>, Tae Gun Shin MD <sup>a</sup>, Won Chul Cha MD <sup>a</sup>, Min Seob Sim MD <sup>a</sup>, Seonwoo Kim PhD <sup>c</sup>





# COVID absences Jan – Mar 2021



2.5-fold lower staff absence at UHS during pandemic versus at worst performing Trust

# Advantages of inexhaustible high efficacy PPE



BBC: August 2020

## Aerosol emission from the respiratory tract: an analysis of relative risks from oxygen delivery systems

F Hamilton, F Gregson, D Arnold, S Sheikh, K Ward, J Brown, E Moran, C White, A Morley, AERATOR group, B Bzdek, J Reid, N Maskell, JW Dodd

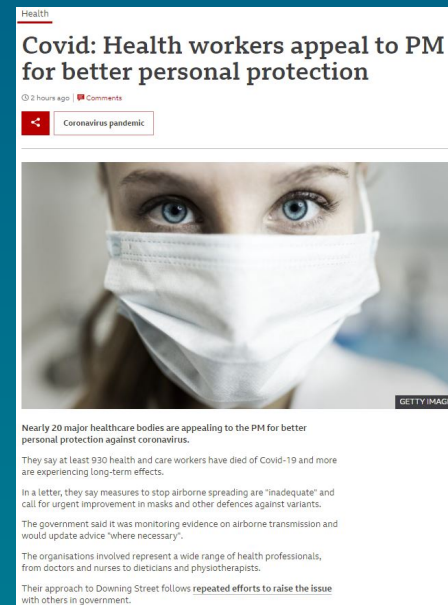
doi: <https://doi.org/10.1101/2021.01.29.21250552>

As a consequence, the risk of SARS-CoV-2 aerosolisation is likely to be high in all areas where patients with Covid-19 are coughing. Guidance on personal protective equipment policy should reflect these updated risks.

MedRxiv: 1<sup>st</sup> February 2021

## Healthcare workers 7 times as likely to have severe COVID-19 as other workers

BMJ: 8<sup>th</sup> December 2020



BBC: 19<sup>th</sup> January 2021

## Covid: Science advisers call for better PPE for healthcare workers

By David Shukman  
Science editor  
5 days ago

Coronavirus pandemic



Healthcare workers have welcomed a change in scientific advice on how to protect them from coronavirus.

A document by the government's scientific advisory group (Sage) says higher grade masks may be needed when caring for Covid patients.

BBC: 24<sup>th</sup> April 2021 SAGE advice

## Covid-19: Health staff in plea for better protection

David Shukman  
Science editor  
3 June | Comments

Coronavirus pandemic



BBC: 3<sup>rd</sup> June 2021

# Guidance for CDC and HSE support powered respirator use

My hospital uses powered air-purifying respirators (PAPRs). Will they protect me from SARS?

Yes. PAPRs use HEPA filters (high-efficiency particulate air filters), which are as efficient as P-100 filters and will protect against SARS. PAPRs provide a higher level of protection than disposable respirators.



<https://www.cdc.gov/niosh/npptl/topics/respirators/factsheets/respsars.html>



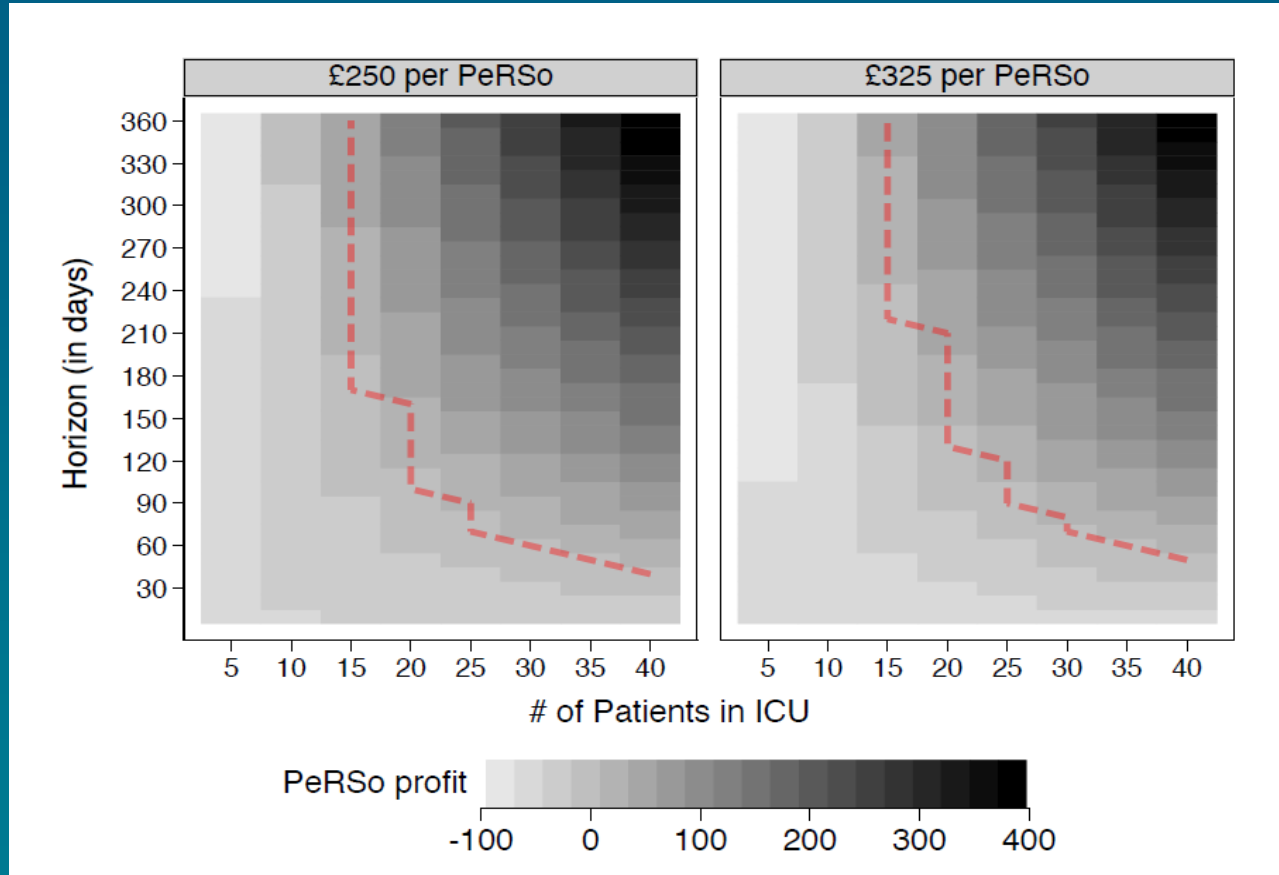
**Respiratory protective equipment at work**

65 For example, it is recommended that continuous wear time for tight-fitting (unpowered) RPE is less than an hour, after which the wearer should take a break. Otherwise, the RPE can become uncomfortable to wear, leading to loosening or removal of the mask in the work area. In these situations, where RPE is required to be worn continuously for long periods, powered respirators or airline BA, for example a loose-fitting facepiece such as a hood or helmet, are better options.

69 Other head-worn PPE can potentially interfere with RPE, preventing one or more of the components from working correctly (eg eye protection, ear protection and safety helmets – see Figure 6). Where possible, choose equipment where the different forms of protection required are combined (often referred to as integrated or combined PPE), eg eye, face, head and respiratory protection provided by a powered helmet respirator.

<https://www.hse.gov.uk/pubns/priced/hsg53.pdf>

# Economic modelling: cost saving after 8 – 12 weeks vs FFP3



UHS ITU during second wave

Red line = time to cost saving, based on an ITU with 180 staff, comparing disposable PPE with PerSo use and all ongoing costs



# Summary

- Widespread respirator deployment has been successful in a large NHS trust
  - Preferred by staff
  - Preferred by patients
  - Cost-saving after approximately 2 months
  - Environmentally sustainable
  - Communication is much better: we all lip read partially
  - Associate with low staff absence and low mortality
- We propose that personal respirators should become part of PPE strategy for the chronic phase of the pandemic

# Acknowledgements and conflicts of interest

- COI: Impact case study and potential research revenue share from INDO



**University of Southampton PeRSo team:** Hywel Morgan, Paul Elkington, Mark Mavrogordarto, Alex Dickinson, Dan Spencer, Ric Gillams, Antonio de Grazia, Sebastian Rosini, and Alex Mant

Service evaluation: Saul Faust, Ally Munro

Economists: Emmanouil Mentzakis, Corrado Giuliatti

Research and Innovation: Gareth Giles, Diana Galpin, Mark Spearing

**University Hospitals Southampton PeRSo team:** Nitin Mahobia, Trevor Smith, Peter Baker, Jacqui Prieto, Mohammed Dibas, Sarah Herbert, Matthew Hine, Joann Hall, Angie McClarren, Mike Davidson, Julie Brooks, Jane Fisher, David Griffiths, Matt Wheeler

**Indo Lighting:** Tom Baynham, Laurence Baynham, Simon Martin

**Many others:** Sophie Fletcher, Anastasios Lekkas, Wessex AHSN, McLaren Racing, Kemp Sails

# University Hospital Southampton Outcomes

## Together we have made a difference

What is becoming apparent is just what this collective effort has meant for us all. UHS is in top the 10% of trusts across the UK for low death rates in Covid-19 positive patients and nosocomial (hospital acquired) infection. A great achievement and testament to how you have worked individually and as teams over this period in order to protect the safety of each other and our patients. That of course does not diminish the difficulty of what we've all faced.



# Challenges to mass implementation

Stakeholder	Role and responsibilities
Director and nursing leads for infection prevention and control	Protocols for use, donning and doffing, assessment of usage areas
Medical and nursing director	Prioritising staff for roll-out; ensuring compliance with regulatory guidance
Communications	Updating all staff on deployment and prioritisation strategy of new PPE; news release to inform public
Logistics and estates	Deployment centres, storage areas, charging stations 7 day distribution needed in December / January
Education team	Training staff in use, cleaning, storage, return at end of contract
Procurement and Purchasing	Confirming contract and delivery schedule, liaising with design team for technical aspects of manufacture, replacement hoods, spare batteries, on site storage arrangements
Local industry	Production of units, shipping in parts, regulatory approvals
University	Initial concept and prototype evaluation; prospective analysis of deployment
End users: Doctors, nurses, healthcare assistants, research teams, phlebotomists, cleaning staff, porters	Compliance with training, storage, ongoing use, return when leaving post



# Wave 1 data further support widespread deployment


ARTICLES | VOLUME 5, ISSUE 9, E475-E483, SEPTEMBER 01, 2020

**Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study**

Long H Nguyen, MD \* • David A Drew, PhD \* • Mark S Graham, PhD \* • Amit D Joshi, PhD • Chuan-Guo Guo, MS • Wenjie Ma, ScD • et al. [Show all authors](#) • [Show footnotes](#)

*Lancet Public Health* 31<sup>st</sup> July 2020

At least a 3-fold increased risk of positive COVID-19 test

**SARS-CoV-2 seroprevalence and asymptomatic viral carriage in healthcare workers: a cross-sectional study** 

*Thorax* 11<sup>th</sup> Sept 2020

Seroprevalence was greatest among those working in housekeeping (34.5%), acute medicine (33.3%) and general internal medicine (30.3%), with lower rates observed in participants working in intensive care (14.8%).

**A prospective study of 3, 6, 9 and 12 month respiratory outcomes following COVID-19 related hospitalisation**

*Lancet Respiratory Medicine* 2021 *In press*

At 12 months after discharge, radiologic changes persisted in 24% of patients.