RESEARCH

Impact of COVID-19 on UK stress echocardiography practice: insights from the EVAREST sites

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Abstract

Introduction: Healthcare delivery is being transformed by COVID-19 to reduce transmission risk but continued delivery of routine clinical tests is essential. Stress echocardiography is one of the most widely used cardiac tests in the NHS. We assessed the impact of the first (W_1) and second (W_2) waves of the pandemic on the ability to deliver stress echocardiography.
Methods: Clinical echocardiography teams in 31 NHS hospitals participating in the EVAREST study were asked to complete a survey on the structure and delivery of stress echocardiography as well as its impact on patients and staff in July and November 2020. Results were compared to stress echocardiography activity in the same centre during January 2020.
Results: 24 completed the survey in July, and 19 NHS hospitals completed the survey in November. A 55% reduction in the number of studies performed was reported in W_1, recovering to exceed pre-COVID rates in W_2. The major change was in the mode of stress delivery. 70% of sites stopped their exercise stress service in W_1, compared to 19% in W_2. In those still using exercise during W_1, 50% were wearing FFP3/N95 masks, falling to 38% in W_2. There was also significant variability in patient screening practices with 7 different pre-screening questionnaires used in W_1 and 6 in W_2.
Conclusion: Stress echocardiography delivery restarted effectively after COVID-19 with adaptations to reduce transmission that means activity has been able to continue, and exceed, pre-COVID-19 levels during the second wave. Further standardization of protocols for patient screening and PPE may help further improve consistency of practice within the United Kingdom.

Key Words

- stress echocardiography
- COVID-19
- coronary artery disease
- ischaemic heart disease
- survey
- national health services

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https://doi.org/10.1530/ERP-20-0043

Introduction

The coronavirus (COVID-19) pandemic is placing unprecedented strain on healthcare services across the world (1), with the UK's National Health Service (NHS) experiencing greatest challenge in 70 years of its existence (2). The disease has spread rapidly across the United Kingdom (3) with now over 125,000 COVID-19-related deaths recorded in the country (3). The NHS activity restarted (4) following the first wave of COVID-19 infections but with new regulations to minimize patient's contact with the healthcare professionals and to reduce risk of transmission via aerosol generating procedures (5, 6, 7, 8). Stress echocardiography is one of the most widely used tests to assess cardiac function and to determine whether a patient has evidence of coronary ischaemia (9, 10, 11). Therefore, continued delivery of stress echocardiography is essential to provide effective healthcare within the NHS. We studied whether COVID-19 and its associated healthcare regulations had impacted the ability to deliver stress echocardiography in the NHS.

Methods

The 'Impact of COVID-19 on UK Stress Echocardiography Services' survey was sent to the research teams from the 31 NHS hospitals participating in the EVAREST study (ClinicalTrials.gov ID: NCT03674255) in both July and November 2020. The EVAREST study is a UK-wide prospective stress echocardiography study that aims to evaluate real world performance, accuracy and cost of stress echocardiography and has been running since 2011. The existing network of the UK hospitals, set up as a part of the EVAREST study, provided the infrastructure to distribute the survey and collect results from hospitals across the UK. Survey results could be compared to historical data from the same centres based on the data collected by the EVAREST study as well as comparing the results between the two waves of COVID-19. The survey was developed as a consensus document in collaboration with the British Society of Echocardiography (BSE) and contained questions focussing on the impact of COVID-19 on stress echocardiography practice, patients and the NHS staff (Supplementary data, see section on supplementary materials given at the end of this article). The survey was deployed electronically to 31 NHS sites via Google Forms (Google LLC., Mountain View, California, United States). Responses from the sites were collated after 10 days.

Statistical analysis

Hospital characteristics and reported data from the NHS sites were reported using standard approaches.

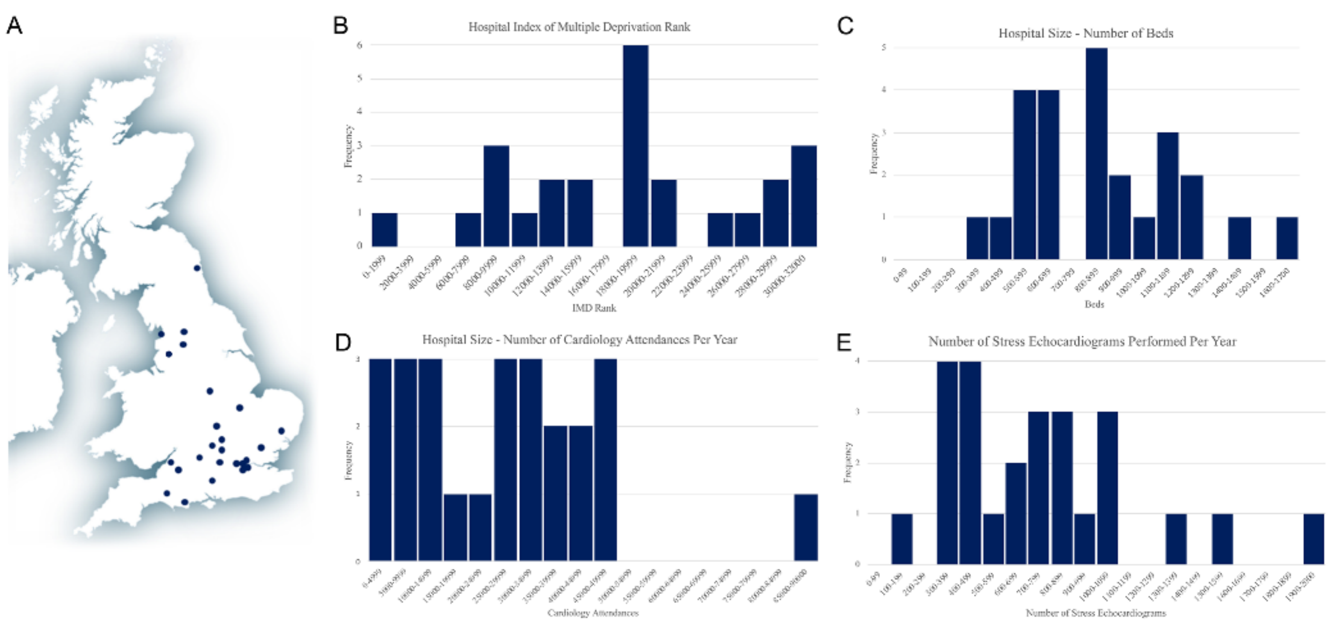

Figure 1
(A) Location of the 26 NHS hospital sites surveyed. (B) Range of IMD ranks for each hospital, demonstrating the wide range of socio-economic backgrounds represented (the lower the ranking, the greater the level of socio-economic deprivation). (C) Hospital size as measured by number of beds. (D) Hospital cardiology department size, as measured by number of cardiology attendances per year. (E) Volume of stress echocardiograms performed at each hospital per year. Two of the 24 hospitals who responded to the survey (Broomfield Hospital and Basildon Hospital) are grouped under the same trust name, therefore each graph represents data from 25 NHS trusts.

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To calculate the significance level of the difference in estimated numbers of stress echocardiography studies performed before and during the two waves of the pandemic, a paired two-tailed distribution *t*-test was used with a significance level of $P < 0.05$ (Microsoft Excel Version 16.39, Microsoft Corporation).

Results

Participating sites

A total of 24 NHS hospitals (77%) responded to the survey in July, immediately after the peak of the first wave (W_1) and 19 hospitals (61%) in November in the middle of the second wave (W_2). Seventeen hospitals responded to both the surveys. Data on the geographical spread, index of multiple deprivation, the number of hospital beds, the number of cardiology attendances and self-reported numbers of stress echocardiograms performed per annum at each site are presented in Fig. 1.

Stress echo practice

Figure 2A illustrates that stress echocardiography was being performed at 21 sites (87.5%) with three having stopped their service entirely in W_1. During W_2, stress echocardiography was being performed at all 19 sites (100%), with eight sites (42%) reporting that their stress echocardiography service was now unaffected by COVID-19. The number of sessions being performed at sites was reduced during W_1 (range 1–11 sessions per week) compared to pre-COVID-19 (range 1–20), recovering back to a range of 1–20 sessions per week reported by sites during W_2. Figure 2D shows a reduction in the number of patients seen in each stress echocardiography session,

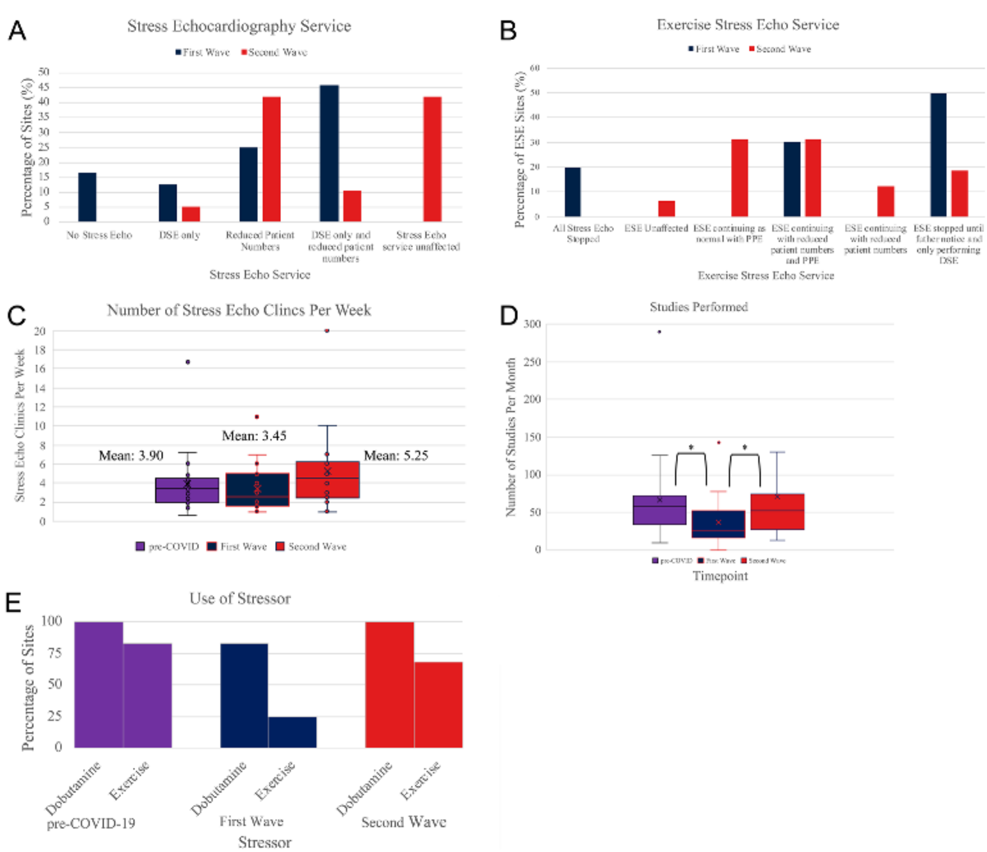

Figure 2
(A) Reported general stress echocardiography service at sites during the first wave ($n = 24$) and second wave ($n = 19$). (B) Reported exercise stress echocardiography service. Percentage reported as proportion of sites who performed ESE before COVID-19 ($n = 20$ W_1, $n = 16$ W_2). (C) The number of stress echocardiography sessions performed at the sites pre-COVID ($n = 25$), during the first wave ($n = 20$) and second wave ($n = 18$ – one site did not report). The number of sessions per week, pre-COVID, has been estimated using the reported annual number of studies, assuming four patients per session. (D) The reported number of patients seen in each stress echocardiography session, as reported in a sub-set of sites ($n = 7$). (E) The number of sites performing dobutamine and exercise stress echocardiography before COVID-19 ($n = 24$) and during the first ($n = 24$) and second ($n = 19$) waves.

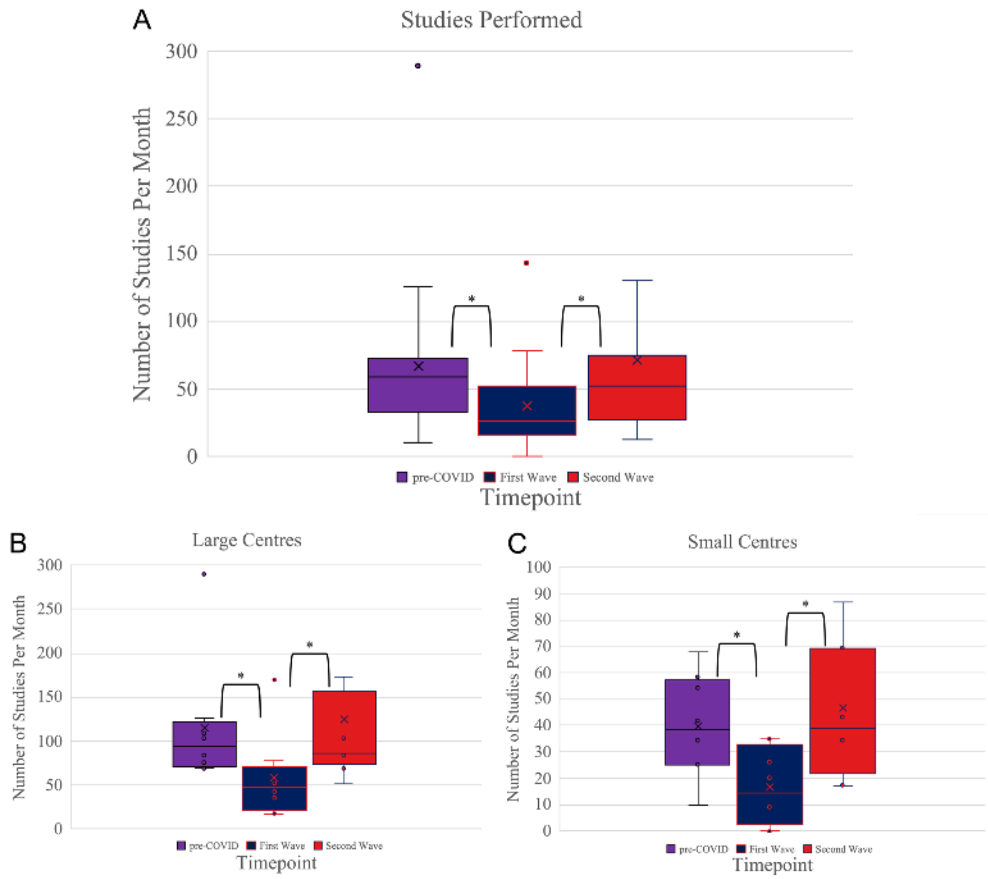

Figure 3
(A) The estimated number of stress echocardiography studies performed at each hospital site pre-COVID-19 (*n* = 16), during the first (*n* = 16) and second (*n* =16) waves. Pre-COVID-19 numbers are self-reported data previously collected as a part of the EVAREST study. Current COVID-19 numbers are an estimation based on the reported number of stress echocardiography sessions being performed weekly at each site, assuming four patients per session pre-COVID and three patients per session in W_1 and W_2, as reported in Fig. 2C. *n* number reduced as only sites who responded to both surveys (W_1 and W_2) and indicated number of sessions per week can be compared. (B) The estimated number of stress echocardiography studies performed at high volume centres (>800 stress echo studies per annum, *n* = 8) pre-COVID, during W_1 and during W_2. (C) The estimated number of stress echocardiography studies performed at lower volume centres (≤800 stress echo studies per annum, *n* = 8) pre-COVID, during W_1 and during W_2. W_1 – first wave, W_2 – second wave.

from 4 ± 0 pre-COVID to 2.7 ± 0.4 during W_1 and 2.9 ± 0.3 during W_2.

Using data from sites that indicated their numbers of stress echo sessions during both W_1 and W_2, Fig. 3 shows an overall 55% reduction in the estimated number of studies performed per month compared to pre-COVID-19 rates (78 ± 65 per month pre-COVID-19 vs 35 ± 32 per month during W_1, $P < 0.05$). The estimated number of studies performed during W_2 increased to more than reported during W_1 (71 ± 79 per month during W_2 vs 35 ± 32 per month during W_1, $P < 0.05$). The estimated number of studies performed during W_2 was not significantly different to pre-COVID-19 rates (71 ± 79 per month during W_2 vs 78 ± 65 per month pre-COVID-19, $P > 0.05$).

Figure 3B shows that in higher volume sites, the estimated number of studies per week fell from 116 studies per week pre-COVID to 58 per week in W_1 (50% fall, $P < 0.05$). This recovered to 125 per week in W_2 (108% of pre-COVID levels). In smaller sites (Fig. 3B), studies per week fell from 40 studies per week pre-COVID to 17 per week in W_1 (42% of pre-COVID levels, $P < 0.05$). This recovered to 47 per week in W_2 (118% of pre-COVID levels).

Figure 2B shows that of the 20 sites that reported use of exercise stressor pre-COVID-19, 14 sites (70%) had stopped their exercise stress echocardiography (ESE) service either due to ceasation of all stress echocardiography (four sites – 20%) or had replaced it with a dobutamine stress only service (ten sites – 50%) during W_1. The six sites (30%)

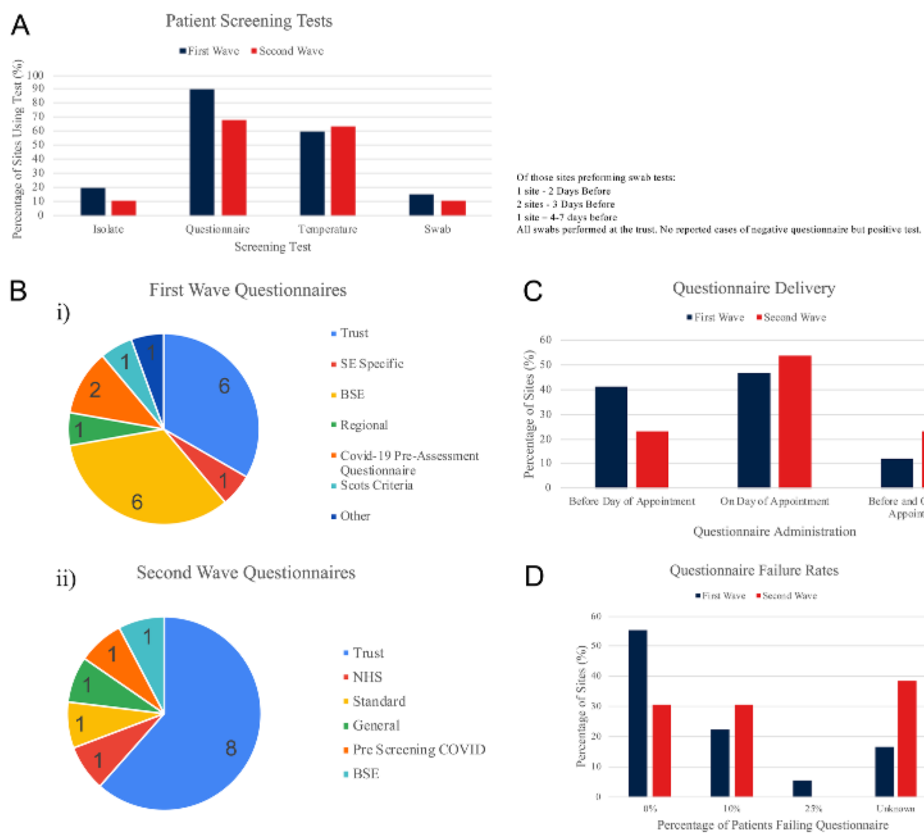

Figure 4

(A) The COVID-19 screening tests currently performed by the NHS sites performing stress echo during the first wave (*n* = 20) and second wave (*n* = 19). (B) Pie chart illustrating the different questionnaires used by the NHS sites during the first wave (i – *n* = 18) and second wave (ii – *n* = 13). (C) The point in the patient's pathway during which the questionnaire is administered at sites during the first wave (*n* = 18) and second wave (*n* = 13). (D) Percentages of patients failing the COVID-19 screening questionnaire during the first wave (*n* = 18) and second wave (*n* = 13).

continuing their exercise stress service during W_1 reported reduced the number of patients and a requirement to wear Level 2 PPE (fluid repellent disposable gown, respirator mask, gloves, eye protection).

Of the 16 sites who responded during W_2 and performed exercise stress pre-COVID-19, three sites (19%) had stopped their ESE service during W_2. Of the 13 sites still performing ESE during W_2, six sites (46%) reported that their ESE service was operating at a normal pre-COVID-19 rate.

Impact on patients and personal protective equipment

Figure 4A illustrates the screening procedures used at the sites across the two waves. Sixty per cent of sites performed temperature checks during W_1 and 63% did so during W_2. During W_1, two sites performed COVID-19 swab tests between 2 and 3 days prior to the appointment, with one site performing swab test after the stress echo. The two sites performing swabs in W_2 did so 72 h and 4–7 days pre-appointment, respectively. Twenty per cent of sites asked patients to self-isolate during W_1, with two sites requiring 7 days and two 14 days. During W_2, two sites (11%) required patients to self-isolate for 3 days (at one site) or 4 days (at the other) after their swab test, prior to their appointment.

Figures 4B, C and D provide more detail on the use of screening questionnaires at sites. Eighteen sites (90%) asked patients to complete a health questionnaire during W_1, while 13 (68%) sites used questionnaires during W_2. Seven different questionnaires were used by sites during W_1, with most sites using either trust-derived (six sites – 33%) and BSE (six sites – 33%) questionnaires. Six different questionnaires were used during W_2, with the majority of sites using trust-derived questionnaires (eight sites – 62%). The questionnaires were administered pre-appointment (41% in W_1, 23% in W_2), at the appointment (47% in W_1, 54% in W_2) and both pre-appointment and on the day (12% in W_1, 23% in W_2). Twenty-five per cent

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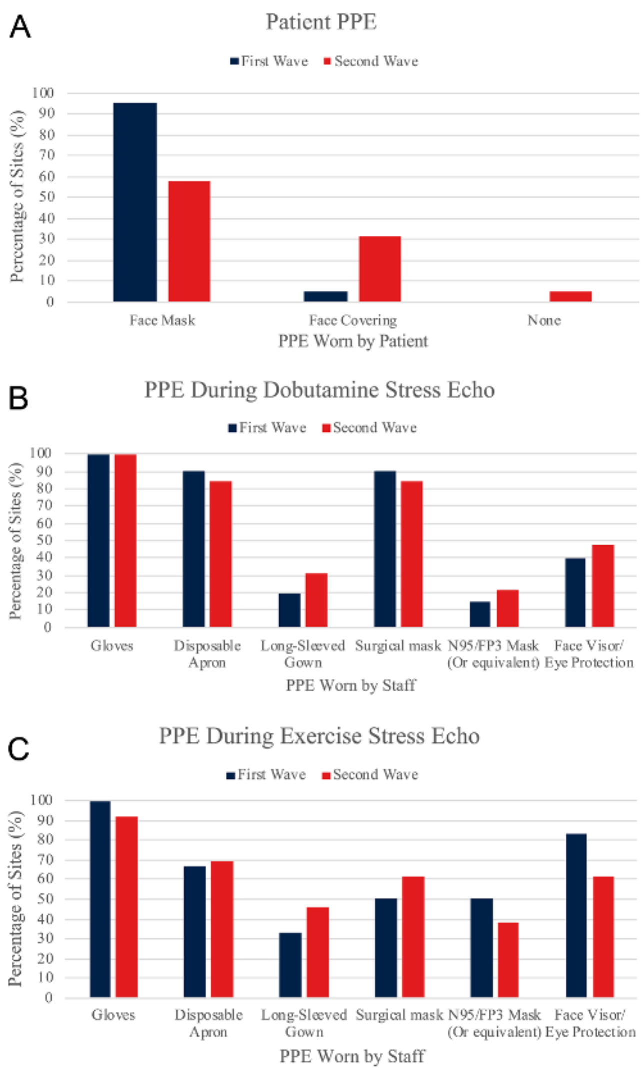

Figure 5
(A) The PPE required for patients to wear during stress echo at sites during the first wave (n = 20) and second wave (n = 19). (B) The percentage of sites requiring staff to wear each item of personal protective equipment during dobutamine stress echo in the first wave (n = 20) and second wave (n = 19). (C) The percentage of the sites performing exercise stress echocardiography requiring staff to wear each item of personal protective equipment during the procedure in the first wave (n = 6) and second wave (n = 13).

of patients had not proceeded to stress echo based on the questionnaire at one site during the first wave. No sites reported this incidence rate during the second wave. Ten per cent of patients did not proceed at 22% of sites in W_1 and 31% of sites during W_2. The remainder reported the questionnaire had not identified any patients. No cases of patients passing the questionnaire with a positive swab test were reported across both waves at all sites.

All sites, with the exception of one site during W_2, performing stress echocardiography reported that every patient is required to wear a face mask/covering for the procedure (Fig. 5A). For dobutamine stress echocardiography, surgical masks were worn by staff in 90% of sites during W_1 and 84% during W_2. Fifty per cent and 62% of sites reported use of surgical masks for exercise echocardiography during W_1 and W_2, respectively. The other sites required FFP3/N95 masks.

Staff and ongoing impact

During W_1, 42% of sites were reviewing their stress echo practice weekly, falling to 5% of sites reviewing practice weekly during W_2 (Fig. 6A). During W_1, the majority of sites (54.2%) reported that none of their staff were unable to perform stress echocardiography due to COVID-19. This number fell to 37% during W_2, with 11% of sites reporting 25–50% of their staff were affected (compared to 0% during W_1) (Fig. 7A). The effects of COVID-19 on resting echocardiography are also reported in Fig. 7B.

Discussion

This study shows stress echocardiography practice had restarted within a few months of the peak infection rate in

Figure 6
(A) The frequency with which the NHS sites reviewed the changes made to stress echocardiography practice at their site during the first wave (n = 24) and second wave (n = 19). (B) Duration of which the NHS sites anticipated the special measures put in place at their site, due to the COVID-19 pandemic, to continue for as collected during the first wave (n = 24) and second wave (n = 19).

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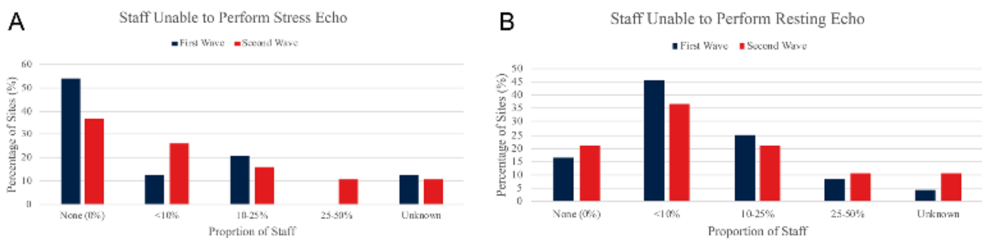

C **First Wave**

DSE	None	<10%	10-25%
Surgical Mask	10	3	3
Level 2 Mask	3	0	0
ESE	None	<10%	10-25%
Surgical Mask	2	N/A	0
Level 2 Mask	3	N/A	1

D **Second Wave**

DSE	None	<10%	10-25%	25-50%
Surgical Mask	7	3	3	1
Level 2 Mask	1	2	0	1
ESE	None	<10%	10-25%	25-50%
Surgical Mask	2	2	1	1
Level 2 Mask	2	2	1	0

Figure 7
(A) The number of staff who were unable to perform stress echocardiography at the NHS sites due to COVID-19 during the first wave (n = 24) and second wave (n = 19). (B) The number of staff who were unable to perform resting echocardiography at theNHS sites due to COVID-19 during the first wave (n = 24) and second wave (n = 19). (C) The association between the level of PPE used and staff absence rates for the sites performing dobutamine and exercise stress echocardiography during the first wave. (D) The association between the level of PPE used and staff absence rates for the sites performing dobutamine and exercise stress echocardiography during the second wave.

the majority of hospitals during the first wave of COVID-19 hospital admissions, albeit at a reduced rate. During the second wave of COVID-19, stress echocardiography practice has been able to operate at a level not significantly different from pre-COVID-19 rates. The impact of the first wave and subsequent recovery in W_2 was not different between high and low volume centres.

The reduction in capacity during W_1 is likely to have generated a significant backlog of patients and although our findings suggest a return to similar levels of activity in W_2, this will not have been sufficient to clear this backlog. The reduction in capacity during W_1 may have been mitigated by use of clinical triage to identify potentially inappropriate requests or suggest transfer to alternative imaging tests. However, the return to normal activity in W_2 would suggest that any rationing or redistribution of care was only required for a short period. This is supported by our observation using data from the EVAREST study that rates of positive stress studies were very similar during November 2020 to January 2021 (14%) as before the onset of the COVID pandemic (18%).

The major change in practice during W_1 was a shift from exercise to dobutamine being used as the stressor. By W_2 most exercise stress services have restarted. The number of patients seen per session was reduced during both waves, likely to allow for aerosol dispersion and cleaning. The slight increase in the number of stress echo clinics per week during the second wave likely reflects a compensation to maintain patient numbers when there is an average reduction in number of patients per list. However, a significant heterogeneity in use of PPE and patient preparation prior to stress echocardiography is evident in both the waves.

The major variation between sites was the selection of screening tests for risk of COVID-19 in individual patients. Current BSE guidance recommends varying degrees of screening, from a COVID symptom questionnaire for DSE and TOE patients up to asking patinets to self-isolate for 2 weeks followed by a negative swab test 72/48 h before their exercise stress echo. The guidance suggests that the intensity of screening should be adjusted according to the current local prevalence of COVID positive cases (12).

Variation also exists in the use of PPE with only 38% of sites still performing exercise stress during W_2 using Level 2 personal protective equipment. Departmental policies on use of PPE did not appear to have any significant association with staff absence rate. There is a paucity of data with regard to the aerosol generating potential of exercise stress echocardiography. British Society of Echocardiography guidance states that the consensus opinion amongst stress echo experts in the United Kingdom is that exercise stress echocardiography may be considered an aerosol generating procedure (12). There is, therefore, a need for more investigation into whether exercise stress echocardiography has an increased risk of infection and, until evidence to the contrary, current BSE guidance has remained unchanged. It is possible that the wider use of faster testing and even vaccination passports,

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as the vaccination programme continues to expand, could be integrated into stress echocardiography practice to reduce transmission.

It is important to note that the results for W_1 presented in this paper were collected in July, several weeks after the first peak of the COVID-19 pandemic in the United Kingdom, when stress echocardiography practice may have been more adversely affected by staff redeployment and infection rates. Additionally, the numbers of studies performed per month during the two waves are estimated, based on the reported number of sessions per week. Hard data on the number of studies would provide a more robust evaluation of the effect of the pandemic on the number of studies performed.

In summary, while the number of studies performed did fall during the first wave of infections, there has been no long lasting impact on ability to deliver stress echocardiography within the NHS during the COVID-19 pandemic. During the second wave, most services were operating at normal rates and services had fully adapted to take account of requirements to reduce the risk of exposure through use of alternative stressors and PPE. Significant heterogeneity in screening tests and personal protective equipment used may require standardized national guidance to ensure consistency but local flexibility of service design may explain the apparent resilience of the cardiology centres to deliver stress echocardiography during a pandemic.

Supplementary materials

This is linked to the online version of the paper at https://doi.org/10.1530/ERP-20-0043.

Declaration of interest

P L is a shareholder and non-executive director of Ultromics, which develops AI echocardiography software, has previously consulted for Intelligent Ultrasound and has held research grants from the ultrasound contrast company Lantheus Medical Imaging. P L is an inventor on patents in the field of echocardiography.

Funding

NIHR HEE Healthcare Science Research Fellowship (NIHR-HCS-P13-04-001); Cardiovascular Clinical Research Facility, University of Oxford; Ultromics Ltd.; Lantheus Medical Imaging Inc.; NIHR Oxford Biomedical Research Centre, University of Oxford.

Author contribution statement

All authors were responsible for the design of the EVAREST COVID-19 impact survey. A M, C D and W W disseminated the survey and collated results. C D performed data analysis. C D, D A and P L drafted the manuscript. The final version was reviewed by all authors and investigators.

References

1 Gates B. Responding to Covid-19 – a once-in-a-century pandemic? *New England Journal of Medicine* 2020 **382** 1677–1679. (https://doi.org/10.1056/NEJMp2003762)

2 Hunter DJ. Covid-19 and the stiff upper lip – the pandemic response in the United Kingdom. *New England Journal of Medicine* 2020 **382** e31. (https://doi.org/10.1056/NEJMp2005755)

3 Public Health England. Coronavirus (COVID-19) in the UK, 2020. (available at: https://coronavirus.data.gov.uk/). Accessed on 24 July 2020.

4 NHS England. Operating framework for urgent and planned services in hospital settings during covid-19, 2020. (available at: https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/05/Operating-framework-for-urgent-and-planned-services-within-hospitals.pdf). Accessed on 24 July 2020.

5 NHS England. Novel coronavirus (COVID-19) standard operating procedure: community health services, 2020. (available at: https://www.england.nhs.uk/coronavirus/publication/novel-coronavirus-covid-19-standard-operating-procedure-community-health-services/). Accessed on 24 July 2020.

6 Clerkin KJ, Fried JA, Raikhelkar J, Sayer G, Griffin JM, Masoumi A, Jain SS, Burkhoff D, Kumaraiah D, Rabbani L, *et al.* Coronavirus disease 2019 (COVID-19) and cardiovascular disease. *Circulation* 2020 **141** 1648–1655. (https://doi.org/10.1161/CIRCULATIONAHA.120.046941)

7 Public Health England. Recommended PPE for primary, outpatient, community and social care by setting, NHS and independent sector, 2020. (available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/878750/T2_poster_Recommended_PPE_for_primary__outpatient__community_and_social_care_by_setting.pdf). Accessed on 4 August 2020.

8 NHS Scotland. Assessing the evidence base for medical procedures which create a higher risk of respiratory infection transmission from patient to healthcare worker, 2020. (available at: https://hpspubsrepo.blob.core.windows.net/hps-website/nss/3055/documents/1_agp-sbar.pdf). Accessed on 4 August 2020.

9 Bhattacharyya S, Chehab O, Khattar R, Lloyd G, Senior R & British Society of Echocardiography. Stress echocardiography in clinical practice: a United Kingdom National Health Service Survey on behalf of the British Society of Echocardiography. *European Heart Journal Cardiovascular Imaging* 2014 **15** 158–163. (https://doi.org/10.1093/ehjci/jet082)

10 Asher A, Ghelani R, Thornton G, Rathod K, Jones D, Wragg A & Timmis A. UK perspective on the changing landscape of noninvasive cardiac testing. *Open Heart* 2019 **6** e001186. (https://doi.org/10.1136/openhrt-2019-001186)

11 British Heart Foundation. BHF heart and circulatory diseases in UK statistics – Jul 2020 factsheet, 2020. (available at: https://www.bhf.org.uk/what-we-do/our-research/heart-statistics). Accessed 24 July 2020.

12 British Society of Echocardiography. Restoration of a stress echocardiography service during the COVID-19 pandemic, 2020. (available at: https://www.bsecho.org/Public/Education/Post-COVID-clinical-guidance/Stress-echo/Public/Education/PC-stressecho.aspx). Accessed on 3 September 2020.

Received in final form 1 February 2021
Accepted 11 March 2021
Accepted Manuscript published online 19 March 2021