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Simulation and education

The nationwide impact of COVID-19 on life support courses. A retrospective evaluation by Resuscitation Council UK

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Abstract

Aim: To determine the impact of the COVID-19 pandemic on Resuscitation Council UK Advanced Life Support (ALS) and Immediate Life Support (ILS) course numbers and outcomes.

Methods: We conducted a before-after study using course data from the Resuscitation Council UK Learning Management System between January 2018 and December 2021, using 23 March 2020 as the cut-off between pre- and post-pandemic periods. Demographics and outcomes were analysed using chi-squared tests and regression models.

Results: There were 90,265 ALS participants (51,464 pre-; 38,801 post-) and 368,140 ILS participants (225,628 pre-; 142,512 post-). There was a sharp decline in participants on ALS/ILS courses due to COVID-19. ALS participant numbers rebounded to exceed pre-pandemic levels, whereas ILS numbers recovered to a lesser degree with increased uptake of e-learning versions. Mean ALS course participants reduced from 20.0 to 14.8 post-pandemic ($P < 0.001$).

Post-pandemic there were small but statistically significant decreases in ALS Cardiac Arrest Simulation Test pass rates (from 82.1 % to 80.1 % (OR = 0.90, 95 % CI = 0.86–0.94, $P < 0.001$)), ALS MCQ score (from 86.6 % to 86.0 % (mean difference = -0.35, 95 % CI −0.44 to −0.26, $P < 0.001$)), and overall ALS course results (from 95.2 %to 94.7 %, OR = 0.92, CI = 0.85–0.99, P = 0.023). ILS course outcomes were similar post-pandemic (from 99.4 % to 99.4 %, P = 0.037).

Conclusion: COVID-19 caused a sharp decline in the number of participants on ALS/ILS courses and an accelerated uptake of e-learning versions, with the average ALS course size reducing significantly. The small reduction in performance on ALS courses requires further research to clarify the contributing factors.

Keywords: Advanced life support, Immediate life support, Education, Covid-19, E-learning, Assessment

Introduction

In March 2020, hospitals across the United Kingdom (UK) were inundated with a surge of patients with COVID-19[1]. The first wave in particular led to widespread workforce redistribution within the National Health Service (NHS). Healthcare professionals found themselves redeployed on surge rotas with patient-facing roles to accommodate the influx of patients with COVID-19[2,3].

This rapid restructuring of healthcare staffing had some significant implications. Medical education was largely put on hold during this period to focus on patient care[4]. This included life support courses, such as Advanced Life Support (ALS) and Immediate Life Support (ILS) which are often core competencies that must be maintained by healthcare workers in acute settings. Both ALS and ILS teach participants key skills in the prevention, recognition and treatment of cardiac arrest, and in peri-arrest care. Participation on such courses has been shown to be associated with improved cardiac arrest survival[5]. The importance of maintaining training through these life-saving courses was particularly important given the modification to treatment algorithms as a result of COVID-19[6,7], coupled with the increased incidence of in-hospital cardiac arrest that occurred during the first wave[8].

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https://doi.org/10.1016/j.resplu.2023.100366

COVID-19 has had a profound impact upon individual life support certification for healthcare professionals. It has also caused organisational ramifications for NHS hospitals and Resuscitation Council UK itself who have had to ensure that courses are delivered in a COVID-safe manner in the context of rapidly evolving government guidelines. To date, there have been no studies investigating the impact of the pandemic on ALS or ILS training. This observational study aims to characterise the impact that the COVID-19 pandemic has had on life support course delivery and outcomes in the UK as COVID-19 transitions from a pandemic to an endemic disease. The results of this study will guide future course delivery and allow evidence-based recommendations to be provided to course centres.

Methods

Settings and participants

The Resuscitation Council UK ALS course[9] teaches the recognition and management of a deteriorating patient; technical and non-technical skills in emergency situations and leadership in cardiac arrest scenarios. It contains a combination of pre-course e-learning material, workshops, skill stations, lectures and simulation. Currently there are three versions of the ALS course, each with their own unique structure to deliver the learning objectives. The two-day ALS course provides face-to-face training supplemented with pre-course e-learning materials. The electronic ALS (e-ALS) consists of an additional pre-course e-learning package followed by one day of face-to-face training. Finally, there is a one-day face to face recertification course for participants who have formerly completed ALS training.

The Resuscitation Council UK ILS course[10] is aimed at all healthcare professionals with a focus on recognising the deteriorating patient, assessment and immediate cardiopulmonary resuscitation. The structure follows skills stations, lectures, and simulations, with options of one day face-to-face or half day blended e-ILS and recertification courses. Completion of the pre-course e-learning package is compulsory for e-ILS and recertification courses.

Participants enrolled on ALS and ILS courses between 1 January 2018 and 31 December 2021 were included.

Assessment methods

Upon completion of the face-to-face aspect of the ALS course, participants are assessed by a post-course multiple choice questionnaire (MCQ) and a practical cardiac arrest simulation test (CAS-Test). In order to achieve ALS provider status, participants must pass both sections. Participants are allowed two MCQ attempts and three CAS-Test attempts. The MCQs comprise 30 stem questions, each having four true/false answers, totalling 120 questions. The pass mark is 75 % with no negative marking. The CAS-Test scenarios are criterion-based and well validated[11,12]. We analysed participant results for their first CAS-Test and MCQ.

Assessment of ILS proficiency is through continuous assessment focusing on the demonstration of competency in basic life support skills, clinical assessment and initial resuscitation of the acutely ill patient in practical cardiac arrest simulations. The outcome is a binary pass or fail. [10].

Data collection

At course registration participants self-complete demographic data, with course outcome data inputted by course centres. We extracted demographics and outcome data from the Resuscitation Council UK learning management system (LMS). Demographic data were less detailed for ILS than ALS due to different structures in the registration process. Pre/post-pandemic cut-off date was the UK national lockdown on 23 March 2020.

Statistical analysis

Categorical characteristics of the pre-pandemic and post-pandemic cohorts were summarised using counts and percentages. Mean and median were reported to give averages for continuous characteristics whilst standard deviation, quartiles, minimum and maximum values were reported to give variability. SPSS was used for this descriptive analysis.

To compare pre-pandemic and post-pandemic ALS test outcomes, we fitted models that included potential confounders (see appendix for variables based on previous research[13,14]). A known predictor variable (pre-course MCQ score) was not analysed as these results were corrupted. To account for similarity of outcomes from the same testing centre, we included random effects terms for the centre by using random effects logistic regression models for CAS-Test and overall result and a linear mixed model for MCQ score. Due to concerns about the impact of missing data, complete case analysis and analysis after multiple imputation using chained equations were performed. The imputation model included the assessment outcomes, course centre, all potential confounders and whether a participant achieved instructor potential and 25 datasets were generated. The imputation results were considered the primary analysis and were obtained by combining estimates from the 25 datasets using the Rubin's rules[15]. The R statistical program[16] was used for imputation (MICE package[17]) and fitting random effects models. P-values of < 0.05 were considered significant.

Chi-squared tests were used to compare ILS pass rates pre-pandemic and post-pandemic. An adjusted model was not fitted because minimal demographic data were collected and pre/post-pandemic pass rates were high and similar.

Ethics

Formal ethical approval was not required as data were the property of Resuscitation Council UK and all participant information was fully anonymised.

Results

Between January 2018 and December 2021 there were 90,265 (51,464 pre-; 38,801 post-) ALS participants across 5,298 (2,655 pre-; 2,643 post-) courses and 368,140 (225,628 pre-; 142,512 post-) ILS participants across 39,100 (23,300 pre-; 15,800 post-) courses.

ALS Pre-pandemic cohort and post-pandemic cohort characteristics

Pre-pandemic, 43.7 % of participants took e-ALS compared to 72.1 % post-pandemic (Table 1). There was also a marked difference in proportions of participants that were core members of cardiac arrest teams (43.0 % pre-pandemic versus 49.5 % post-pandemic). For other characteristics, there were no marked differences between pre-pandemic and post-pandemic cohorts. Most characteristics had missing values (Table 1). Missingness for whether a participant was a core member of the cardiac arrest team

Table 1 – Summary of characteristics for pre-pandemic and post-pandemic cohorts.

Characteristic	Pre-pandemic (n = 51464)	Post-pandemic (n = 38801)
Note: Denominator for percentages of missing cases is the cohort total whilst denominator for the other percentages excludes missing cases		
Course type, n (%)		
Two day ALS	26,206 (50.9)	9182 (23.7)
e-ALS	22,479 (43.7)	27,965 (72.1)
ALS recertification	2779 (5.4)	1654 (4.3)
Age, years		
Mean (SD)	33.2 (8.6)	33.0 (8.3)
Median (LQ, UQ)	30 (26, 38)	31 (27, 37)
Minimum – maximum	20 – 74	20 – 75
Missing cases (%)	***395 (0.8)***	***440 (1.1)***
Core member of a CA team, n (%)		
No	26,681 (57.0)	12,929 (50.5)
Yes	20,163 (43.0)	12,695 (49.5)
Missing cases	***4620 (9.0)***	***13,177 (34.0)***
Ethnicity, n (%)		
Afro Caribbean/Black	3654 (7.5)	3134 (8.6)
Asian	11,832 (24.4)	9941 (27.2)
Mixed	1467 (3.0)	1164 (3.2)
White	28,940 (59.7)	20,279 (55.4)
Other	2570 (5.3)	2061 (5.6)
Missing cases	***3001 (5.8)***	***2222 (5.7)***
Place of work, n (%)		
NHS hospital	45,803 (90.3)	34,425 (90.2)
Private sector	2147 (4.2)	1434 (3.8)
Ambulance service	523 (1.0)	494 (1.3)
Community	716 (1.4)	698 (1.8)
Other	1555 (3.1)	1121 (2.9)
Missing cases	***720 (1.4)***	***629 (1.6)***
Job title, n (%)		
Doctor	37,705 (74.3)	28,199 (73.9)
Nurse	9679 (19.1)	6953 (18.2)
Paramedic	668 (1.3)	531 (1.4)
Operating Department Practitioner	541 (1.1)	364 (1.0)
Resuscitation Officer	164 (0.3)	114 (0.3)
Student	941 (1.9)	584 (1.5)
Other	1017 (2.0)	703 (1.8)
Advanced clinical practitioner	27 (0.1)	713 (1.9)
Missing cases	***722 (1.4)***	***640 (1.6)***
Job grade (seniority), n (%)		
Foundation year 1*	9768 (19.3)	7684 (20.3)
Foundation year 2	8810 (17.4)	7057 (18.6)
Junior grades$	7672 (15.2)	5272 (13.9)
Middle grades	13,023 (25.7)	9575 (25.3)
Senior grades	2781 (5.5)	1805 (4.8)
Other	8577 (16.9)	6517 (17.2)
Missing cases	***833 (1.6)***	***891 (2.3)***

* Foundation year 1 and 2 are doctors immediately post medical school graduation

$ Grade seniority includes all job titles

was high (34 % post-pandemic) whilst for other characteristics it ranged from 0.8 % to 5.8 %. The percentage of complete cases was 75.2 % with most missing due to being a member of cardiac arrest team.

There was a sharp decline in the number of ALS and ILS courses in the second quarter of 2020. There was a simultaneous decrease in the number of participants undertaking both ALS and ILS courses (Fig. 1). Overall ALS participant numbers rebounded in 2021 to exceed pre-pandemic levels. The total number of participants on ILS courses in 2021 remained lower than pre-pandemic levels.

Between 2018 and early 2020 the relative proportion of participants on the e-ALS course increased to become the most popular ALS course. The abrupt decline in participant numbers in the second quarter of 2020 was followed by a sharp increase in the number of e-ALS participants compared to the two-day course (Fig. 1a). There has been a similar increase in the share of participants on the e-ILS course compared to the traditional ILS course (Fig. 1b).

The mean number of participants on individual ALS courses was significantly less post-pandemic (14.8, SD 1.4) compared to pre-

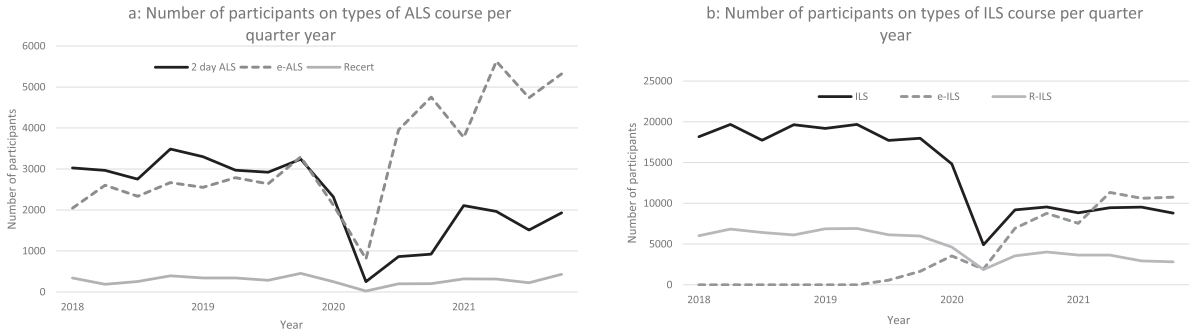

Fig. 1 – Number of ALS and ILS participants per quarter year.

pandemic (20.0, SD 0.7, P < 0.001). Participant: faculty ratio on ALS courses was 1.6:1 from 2018-19, reducing to 1.4:1 in 2020, before increasing to 1.5:1 in 2021.

ALS participant course success

The CAS-Test pass rate was slightly lower post-pandemic (80.1 % versus 82.1 %). Based on imputation results, the odds of passing the CAS-Test post-pandemic were 90 % the odds of passing pre-pandemic (adjusted OR = 0.90, 95 % CI = 0.86–0.94, P < 0.001) (Fig. 2, Appendix Table A2).

There were also small changes in knowledge test results. The mean MCQ score post-pandemic was less than mean MCQ score pre-pandemic (mean (SD) 86.6 % (6.8) versus 86.0 % (6.8), adjusted mean difference = -0.35, 95 % CI −0.44 to −0.26, P < 0.001) (Fig. 3, Appendix Table A3). Overall pass rate was lower post-pandemic (94.7 % versus 95.2 %, adjusted OR = 0.92, CI = 0.85–0.99, P = 0.023) (Appendix Fig. A1 and Table A4). The difference was not significant based on complete cases analysis (OR = 0.96, 95 % CI 0.83–1.11, P = 0.570).

ILS participant course success

There were similar ILS course pass rates between the pre-pandemic (224,291/225,628, 99.4 %) and post-pandemic periods (141,589/142,512, 99.4 %, P = 0.037). Results stratified according to professional background and type of ILS course are seen in Appendix Table 1.

Table 2 demonstrates annual ALS CAS-Test outcomes stratified by course type. There is a clear reduction in first attempt pass rate in 2020, which is sustained throughout the latter stages of the pandemic in 2021. This is more marked in the two-day course than the e-ALS course. There was not such a clear pattern in the ALS recertification course.

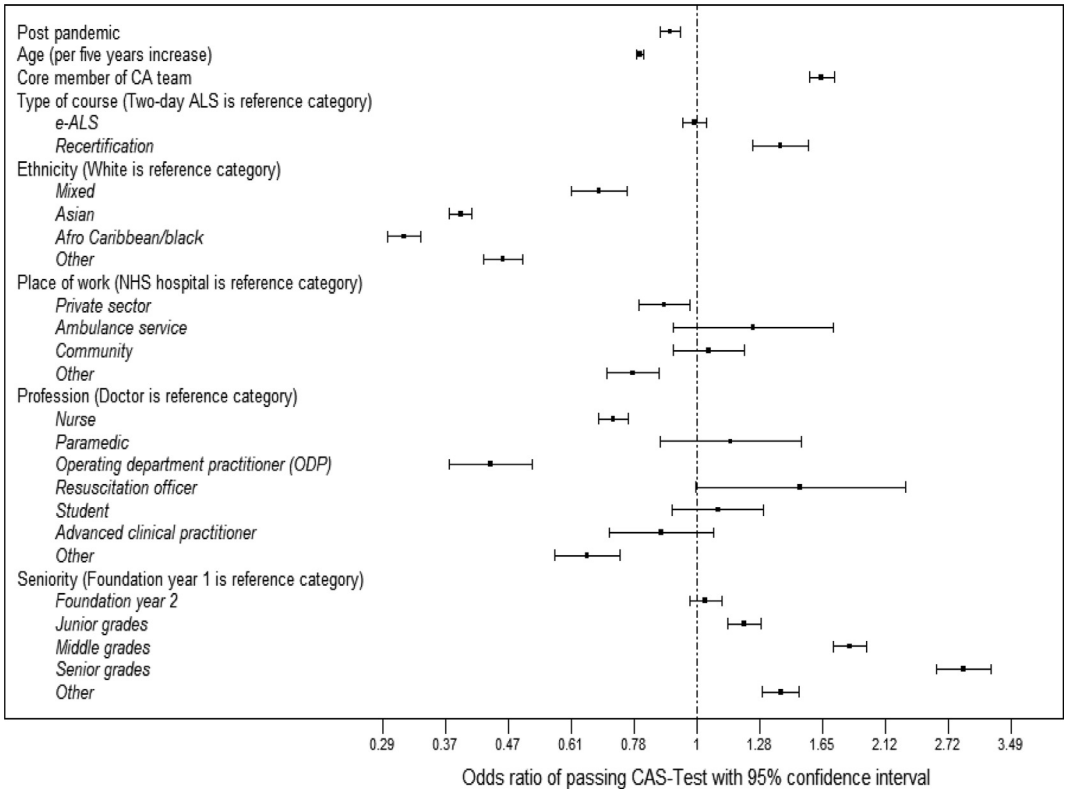

Fig. 2 – Summary of odds ratios comparing CAS Test pass rates from the random effects models fitted after multiple imputation.

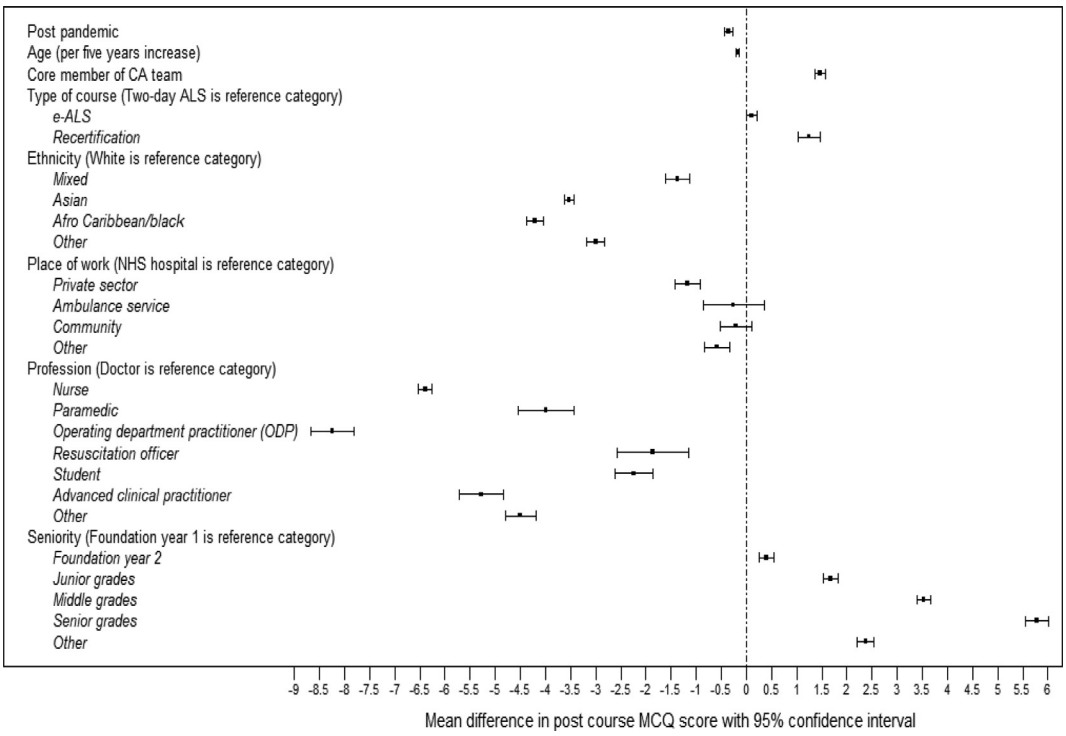

Fig. 3 – Summary of mean differences comparing MCQ scores from the random effects models fitted after multiple imputation.

Discussion

In this observational study that analysed data from 90,265 ALS participants across 5,298 courses and 368,140 ILS participants across 39,100 courses, we observed important changes in course delivery and outcomes. In particular, we observed that COVID-19 caused a sharp decline in the number of ALS/ILS courses and participants being trained in the second quarter of 2020. There were three likely reasons for this; firstly, workforce redistribution led to medical educators and resuscitation officers returning to patient-facing roles so that organising courses was problematic. Secondly, there were challenges recruiting faculty for life support courses due to recurrent national lockdowns and a reluctance to travel for such courses. Thirdly social distancing, and mandatory self-isolation led to short notice dropouts of both participants and faculty. Collectively these partially explain the reduction in participant: faculty ratio, meaning that relatively more faculty were needed for each course.

With ALS provider accreditation lasting four years and healthcare professionals needing to maintain proficiency as part of their job, this led to lapses in accreditation. This created a high demand for courses as medical education was restarted after the first national lockdown ended in the third quarter of 2020. Course centres rose to the challenge of tackling the backlog of participants with 2021 breaking the record of both the number of courses run annually, and also the number of participants trained. This statistic is particularly impressive given that the average course size has reduced by 29 %, primarily due to social distancing measures. Decreased average course numbers will have far reaching ramifications such as increased administrative burden, increased cost for hiring facilities due to more room bookings needed to train a smaller number of participants, and increased susceptibility to cancellation from COVID-19 related faculty absence.

Course outcomes were similar to previously published work by Resuscitation Council UK, as were the factors associated with course success (increasing seniority, being a core member of the cardiac arrest team, attending the recertification course) and course failure (increasing age, private sector place of work, non-white ethnicity, nursing & ODP background)[13,14,18]. Whilst controlling for the aforementioned variables there has still been a small but statistically significant reduction in post-pandemic ALS performance in all assessment modalities. This included a 2 % fall in CAS-Test success; this is a test of leadership, decision making and both technical and non-technical skills. It is unlikely that the decline in performance is explained by reduced clinical exposure to cardiac arrests during this period, as research demonstrates that the incidence of in-hospital cardiac arrest increased during the pandemic[8,19]. There was no material decline in ILS outcomes which is likely due to the baseline high pass rate and continuous rather than summative assessment.

This decline in ALS performance may therefore be attributable to educational changes as a result of COVID-19. The educational experience was reshaped with social distancing measures and mask wearing, meaning that it is more difficult for instructors to teach non-technical skills but also more challenging for participants to learn them. There is a plethora of evidence of the negative effects of mask wearing including a reduced ability to understand acoustic messages[20], difficulty interpreting emotions and attributing trust[21]. These are crucial components in the process of learning non-technical skills[22,23] and consequently mask-wearing gives participants a clear handicap for non-verbal communication[24].

Previous research by the authors identified that junior doctors often were some of the best performers on the ALS course[13]. CAS-Test pass rates in 2013–2014 were 84.7 % for FY1s and 84.4 % for FY2s, using identical assessment criteria[13]. In our study, post-pandemic performance for FY1s was 81.2 % and 78.8 % for

Table 2 – Annual ALS CAS-Test outcomes stratified by course type.

Year	2018	2019	2020	2021	Total
Two-day ALS					
Pass	9639	9807	3336	5426	47,626
Fail	2233	2333	873	1759	11,280
Total	11,872	12,140	4209	7185	58,906
Pass rate (%)	**81.1**	**80.8**	**79.3**	**75.5**	**80.9**
e-ALS					
Pass	7795	9126	9020	15,270	55,052
Fail	1576	1927	2242	3523	11,708
Total	9371	11,053	11,262	18,793	66,760
Pass rate (%)	**83.2**	**82.6**	**80.1**	**81.3**	**82.5**
ALS recertification					
Pass	1029	1230	562	1096	6488
Fail	112	172	90	143	862
Total	1141	1402	652	1239	7350
Pass rate (%)	**90.2**	**87.7**	**86.2**	**88.5**	**88.3**

FY2s. The poor performance in the FY2 group is of particular interest as these are the cohort of doctors who graduated early from medical school and started working as FY1s in the midst of the pandemic[25]. This may be a reflection of the negative impact that COVID-19 has had upon their clinical training with research showing that final year medical students felt underprepared for clinical examinations[26,27]. There is a plethora of evidence showing the negative effect that the COVID-19 pandemic has had on outcomes in medical schools[28–30], and also post-graduate exams[31].

The negative impact of COVID-19 on healthcare professional training has been profound, and a worldwide phenomenon. For example; simulation based rapid response training almost halved in the United States (US)[32], trainee surgeons have had reduced surgical operating time and redeployment to intensive care units caused negative psychological effects[33], and European trainees in obstetrics and gynaecology felt their training goals were unachievable and were concerned about the impact on patient care[34]. There is a paucity of research on the impact of COVID-19 on standardised healthcare courses, including life support. A small preliminary study from the US found that Advanced Trauma Life Support (ATLS) course outcomes were better on a new hybrid e-learning course post-pandemic compared to a face-to-face course pre-pandemic[35]. A large observational study of emergency medical service refresher courses also found that COVID-19 caused a post-pandemic surge in course numbers and an almost total transition towards e-learning courses, but it did not investigate course outcomes directly[36]. The declining performance that we have identified on our ALS course is likely representative of the system-wide effect of COVID-19 on medical education, rather than anything specific to the ALS course.

The differential impact on outcomes on the three types of ALS course, shown in Table 2 is interesting. The biggest decline in performance was noticed on the two-day course with CAS-Test pass rates falling from between 81.0 % in 2018 to 75.5 % in 2021. The drop in e-ALS CAS-Test outcomes was less dramatic from 83.2 % in 2018 to 81.3 % in 2021. Once other predictors were accounted for in the multivariate analysis only the recertification course was a positive predictor of passing the assessment. The most likely explanation is that the majority of participants on the two-day course were relatively junior healthcare professionals, undertaking an ALS course for the first time. This is in comparison to the e-ALS course, which many participants use as a form of recertification, despite them already having an ALS qualification[13,18].

Perhaps the most noticeable effect of COVID-19 has been the acceleration towards e-learning courses and away from the more traditional face-to face versions. Both e-ALS and e-ILS courses are hybrid courses, so a proportion of the course is undertaken online prior to attendance for a condensed face-to-face aspect. One of the distinct advantages that e-learning courses have in the post-covid era is the reduction in face-to-face time to minimise the spread of COVID-19. This means that person-person contacts are reduced and participants, faculty and facilities are only required for one day. Ultimately this has meant that course centres have been able to run more courses to accommodate the high demand. This transition towards e-learning as a result of the pandemic has not been limited to life support courses, but has become commonplace in undergraduate medical education[37,38], post-graduate education[39] and has been taken further and used for online objective structured clinical examinations (OSCEs)[40]. In the field of life support this uptake of e-learning is likely a benefit; pre-course preparation is flexible around participants schedules, gives cost and efficiency savings to course centres and ALS course outcomes are similar[13,18,41]. It is however important to remember that e-learning courses do not suit every type of learner and there still remains a need for the traditional ALS and ILS courses. This is supported by previous work that found participant satisfaction was lower on e-ALS courses, perhaps due to the time-pressure on the face-to-face element of this course[14].

Limitations and further research

There is potential for residual confounding in the multivariate analysis. Known predictor variables such as pre-course MCQ score were not analysed as these results were corrupted. There may be an unseen effect due to missing data but the authors have addressed this by multiple imputation. Due to the absence of detailed demographic data in the ILS cohort we were unable to perform the same adjusted outcome analysis as ALS.

We opted for a before-after study to enable an adjusted analysis of course outcomes, however this does mean that epoch-related outcome changes were not statistically analysed although they can be visualised in Figs. 1-2 and Table 2.

As this is purely a retrospective observational study, it is not possible to ascertain causality for certain changes in course numbers and results. It is instead, hypothesis-generating and future research should seek to identify the reasons for the decline in ALS performance since the COVID-19 pandemic.

Conclusion

COVID-19 caused a transient, but sharp decline in the number of participants on ALS/ILS courses in 2020. The small decline in ALS outcomes likely represents the more widespread system effect of COVID-19 on healthcare training, although this requires further research. In the post-covid era, e-learning versions of life support courses have an increasing role by balancing the need to train healthcare staff efficiently whilst maintaining social distancing. Our findings provide useful information for other international resuscitation organisations to compare if similar changes have been observed globally.

Conflicts of Interest

CJT has a voluntary role for Resuscitation Council UK and an editorial board member for Resuscitation Plus. SH, IHB, ABC, and SBA are paid employees of Resuscitation Council UK. JY has a voluntary role at Resuscitation Council UK. KC has a voluntary role at Resuscitation Council UK and is associate editor of Resuscitation Plus. AL is President of Resuscitation Council UK, a board member for Resuscitation Plus and guest editor for the education special edition. GDP has a voluntary role at Resuscitation Council UK, is editor-in-chief for Resuscitation Plus and an editor for Resuscitation. JS has a voluntary role at Resuscitation Council UK and is an editor for Resuscitation and an editorial board member for Resuscitation Plus.

CRediT authorship contribution statement

C.J. Thorne: Conceptualization, Methodology, Visualization, Writing – original draft. **P.K. Kimani:** Software, Formal analysis, Data curation, Writing – original draft. **S. Hampshire:** Conceptualization, Project administration, Visualization, Writing – review & editing. **I. Hamilton-Bower:** Conceptualization, Project administration, Visualization, Writing – review & editing. **S. Begum-Ali:** Data curation, Resources. **A. Benson-Clarke:** Conceptualization, Project administration, Data curation, Visualization. **K. Couper:** Conceptualization, Methodology, Writing – review & editing. **J. Yeung:** Conceptualization, Methodology, Writing – review & editing. **A. Lockey:** Conceptualization, Methodology, Writing – review & editing. **G.D. Perkins:** Conceptualization, Methodology, Writing – review & editing, Supervision. **J. Soar:** Conceptualization, Methodology, Writing – review & editing, Supervision.

Acknowledgements

The authors wish to thank members of Resuscitation Council UK who co-ordinate the ILS and ALS courses and the course directors and instructors who deliver life support courses nationwide. Funding was through a small in-house grant from Resuscitation Council UK for the statistical analysis undertaken by Dr PK Kimani from the University of Warwick.

Appendix A

See Fig. A1 and Tables A1-A4.

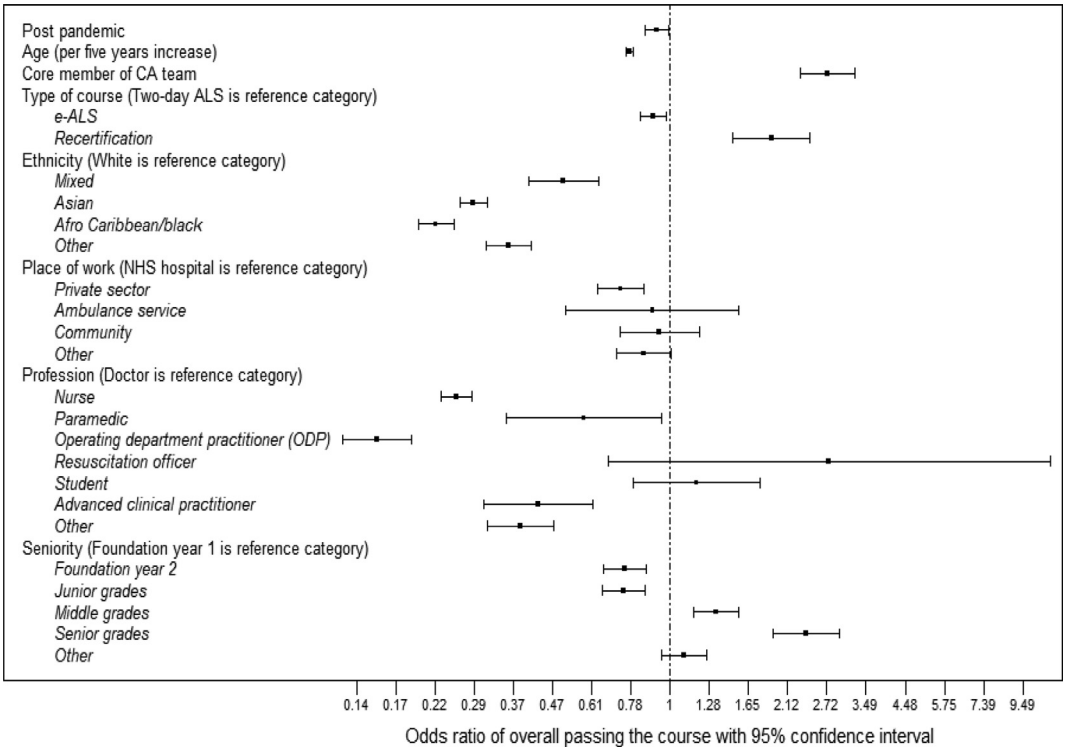

Fig. A1 – Summary of odds ratios comparing overall pass rates from the random effects models fitted after multiple imputation.

Table A1 – ILS course demographics and results.

	Pre-pandemic			Post-pandemic			
	Pass	Fail	Pass rate (%)	Pass	Fail	Pass rate (%)	P-value
Professional background							
Air Stewards	53	0	100	0	0	n/a	n/a
Paramedics	928	0	100	441	9	98.0	<0.001
Cardiac technicians	3345	18	99.5	1880	8	99.6	0.581
Dental Nurses	4181	7	99.8	2311	9	99.6	0.085
Dentists	3068	0	100	2440	9	99.6	<0.001
Community doctors	2221	9	99.6	3796	2	99.9	0.002
Hospital doctors	13,744	67	99.5	10,325	37	99.6	0.132
Fire service technicians	14	0	100	2	0	100	0.596
Healthcare assistants	1392	33	97.7	826	17	98.0	0.064
Medical students	16,127	39	99.8	9170	5	99.9	<0.001
Midwives	2110	5	99.8	960	2	99.8	0.878
Community nurses	12,789	97	99.2	8466	93	98.9	0.011
Hospital nurses	138,142	938	99.3	84,488	552	99.4	0.474
Nursing students	1954	12	99.4	820	16	98.1	0.001
Occupational therapists	181	4	97.8	127	0	100	0.010
Operating department practitioners	5649	19	99.7	3123	6	99.8	0.226
Other	12,990	70	99.5	9289	131	98.6	<0.001
Physiotherapists	1250	1	99.9	619	2	99.7	0.218
Police officers	175	0	100	134	0	100	n/a
Prison officers	122	0	100	112	4	96.6	0.039
Radiographers	3783	18	99.5	2206	21	99.1	0.028
Resuscitation officers	73	0	100	54	0	100	n/a
Type of ILS course							
1 day ILS	163,066	1109	99.3	60,566	557	99.1	<0.001
eILS	5681	23	99.6	58,225	256	99.6	0.705
Recertification ILS	55,544	205	99.6	22,798	110	99.5	0.023
Grand Total	224,291	1337	99.4	141,589	923	99.4	0.037

Table A2 – Multivariable analysis results (CAS-Test).

Characteristic	Odds ratio (95 % confidence interval), p-value	
	Complete case analysis	After multiple imputation
Post-pandemic (Reference is pre-pandemic)	0.96 (0.91, 1.01), 0.135	0.90 (0.86, 0.94), <0.001
Age (per five years increase)	0.80 (0.79, 0.82), <0.001	0.80 (0.79, 0.81), <0.001
Core member of CA team (reference is not)	1.51 (1.44, 1.58), <0.001	1.64 (1.56, 1.72), <0.001
Course type (Reference is Two day ALS)		
e-ALS	0.99 (0.93, 1.05), 0.711	0.99 (0.94, 1.04), 0.690
ALS recertification	1.45 (1.27, 1.65), <0.001	1.39 (1.25, 1.56), <0.001
Ethnicity (White is reference category)		
Mixed	0.74 (0.65, 0.85), <0.001	0.68 (0.61, 0.76), <0.001
Asian	0.41 (0.39, 0.44), <0.001	0.39 (0.37, 0.41), <0.001
Afro Caribbean/Black	0.34 (0.31, 0.36), <0.001	0.31 (0.29, 0.33), <0.001
Other	0.50 (0.45, 0.54), <0.001	0.46 (0.43, 0.50), <0.001
Place of work (Reference is NHS hospital)		
Private sector	0.88 (0.78, 0.99), 0.037	0.88 (0.79, 0.97), 0.011
Ambulance service	1.30 (0.89, 1.89), 0.177	1.25 (0.91, 1.72), 0.170
Community	1.13 (0.95, 1.34), 0.158	1.05 (0.91, 1.21), 0.513
Other	0.75 (0.67, 0.85), <0.001	0.77 (0.70, 0.86), <0.001
Job title (Reference is Doctor)		
Nurse	0.84 (0.78, 0.91), <0.001	0.72 (0.67, 0.76), <0.001
Paramedic	1.15 (0.83, 1.59), 0.412	1.14 (0.86, 1.51), 0.355
Operating Department Practitioner	0.56 (0.46, 0.69), <0.001	0.44 (0.37, 0.52), <0.001
Resuscitation Officer	1.68 (1.01, 2.80), 0.045	1.51 (0.99, 2.29), 0.054
Student	1.12 (0.90, 1.38), 0.306	1.09 (0.91, 1.30), 0.371
Advanced clinical practitioner	0.95 (0.74, 1.22), 0.683	0.87 (0.70, 1.07), 0.175

Table A2 (continued)

Characteristic	Odds ratio (95 % confidence interval), p-value	
	Complete case analysis	After multiple imputation
Other	0.78 (0.66, 0.91), 0.002	0.65 (0.57, 0.73), <0.001
Seniority (Reference is Foundation year 1)		
Foundation year 2	1.03 (0.96, 1.12), 0.383	1.03 (0.97, 1.10), 0.317
Junior grades	1.21 (1.12, 1.31), <0.001	1.21 (1.13, 1.29), <0.001
Middle grades	1.77 (1.63, 1.92), <0.001	1.84 (1.72, 1.97), <0.001
Senior grades	2.68 (2.35, 3.05), <0.001	2.88 (2.59, 3.22), <0.001
Other	1.26 (1.15, 1.37), <0.001	1.39 (1.30, 1.50), <0.001
Adjusted R-Squared	0.0547	0.0741[†]

[†] Median from analysis 25 imputed dataset

Table A3 – Multivariable analysis results (MCQ score).

Characteristic	Difference (95 % confidence interval), p-value	
	Complete case analysis	After multiple imputation
Post-pandemic (Reference is pre-pandemic)	−0.19 (-0.29, −0.10), <0.001	−0.35 (-0.44, −0.26), <0.001
Age (per five years increase)	−0.11 (-0.14, −0.07), <0.001	−0.18 (-0.21, −0.14), <0.001
Core member of CA team (reference is not)	1.08 (0.99, 1.16), <0.001	1.46 (1.36, 1.57), <0.001
Course type (Reference is Two day ALS)		
e-ALS	0.08 (-0.03, 0.19), 0.138	0.10 (0.00, 0.21), 0.057
ALS recertification	1.06 (0.84, 1.28), <0.001	1.25 (1.03, 1.47), <0.001
Ethnicity (White is reference category)		
Mixed	−1.21 (-1.44, −0.98), <0.001	−1.37 (-1.60, −1.14), <0.001
Asian	−3.26 (-3.36, −3.16), <0.001	−3.53 (-3.63, −3.42), <0.001
Afro Caribbean/Black	−3.91 (-4.08, −3.74), <0.001	−4.21 (-4.38, −4.05), <0.001
Other	−2.74 (-2.92, −2.56), <0.001	−3.00 (-3.18, −2.82), <0.001
Place of work (Reference is NHS hospital)		
Private sector	−1.10 (-1.37, −0.84), <0.001	−1.17 (-1.42, −0.91), <0.001
Ambulance service	−0.32 (-0.93, 0.29), 0.302	−0.26 (-0.86, 0.35), 0.410
Community	−0.11 (-0.43, 0.20), 0.478	−0.21 (-0.52, 0.11), 0.204
Other	−0.57 (-0.82, −0.32), <0.001	−0.59 (-0.84, −0.34), <0.001
Job title (Reference is Doctor)		
Nurse	−5.52 (-5.66, −5.39), <0.001	−6.39 (-6.52, −6.26), <0.001
Paramedic	−3.69 (-4.24, −3.13), <0.001	−3.99 (-4.54, −3.43), <0.001
Operating Department Practitioner	−7.05 (-7.49, −6.61), <0.001	−8.24 (-8.66, −7.82), <0.001
Resuscitation Officer	−2.02 (-2.74, −1.31), <0.001	−1.87 (-2.57, −1.16), <0.001
Student	−2.36 (-2.74, −1.99), <0.001	−2.22 (-2.60, −1.85), <0.001
Advanced clinical practitioner	−4.94 (-5.38, −4.50), <0.001	−5.28 (-5.72, −4.84), <0.001
Other	−4.10 (-4.41, −3.79), <0.001	−4.50 (-4.80, −4.20), <0.001
Seniority (Reference is Foundation year 1)		
Foundation year 2	0.31 (0.16, 0.45), <0.001	0.40 (0.26, 0.54), <0.001
Junior grades	1.71 (1.56, 1.86), <0.001	1.67 (1.52, 1.82), <0.001
Middle grades	3.35 (3.20, 3.49), <0.001	3.53 (3.38, 3.68), <0.001
Senior grades	5.22 (4.98, 5.46), <0.001	5.78 (5.55, 6.01), <0.001
Other	2.11 (1.94, 2.28), <0.001	2.38 (2.21, 2.54), <0.001
Adjusted R-Squared	0.2041	0.2134[†]

[†] Median from analysis 25 imputed datasets.

Table A4 – Multivariable analysis results (Overall result).

Characteristic	Odds ratio (95 % confidence interval), p-value	
	Complete case analysis	After multiple imputation
Post-pandemic (Reference is pre-pandemic)	0.96 (0.83, 1.11), 0.567	0.92 (0.85, 0.99), 0.023
Age (per five years increase)	0.73 (0.71, 0.76), <0.001	0.77 (0.76, 0.79), <0.001
Core member of CA team (reference is not)	2.66 (2.29, 3.09), <0.001	2.73 (2.29, 3.26), <0.001
Course type (Reference is Two day ALS)		
e-ALS	0.94 (0.81, 1.09), 0.417	0.90 (0.83, 0.97), 0.010
ALS recertification	1.83 (1.17, 2.87), 0.008	1.91 (1.49, 2.44), <0.001
Ethnicity (White is reference category)		
Mixed	0.71 (0.43, 1.20), 0.202	0.51 (0.41, 0.63), <0.001
Asian	0.25 (0.21, 0.30), <0.001	0.29 (0.26, 0.31), <0.001
Afro Caribbean/Black	0.18 (0.15, 0.22), <0.001	0.22 (0.20, 0.25), <0.001
Other	0.35 (0.27, 0.46), <0.001	0.36 (0.31, 0.41), <0.001
Place of work (Reference is NHS hospital)		
Private sector	0.70 (0.55, 0.90), 0.005	0.73 (0.63, 0.85), <0.001
Ambulance service	0.94 (0.35, 2.53), 0.909	0.89 (0.52, 1.55), 0.692
Community	0.97 (0.62, 1.53), 0.910	0.93 (0.73, 1.20), 0.595
Other	0.65 (0.49, 0.87), 0.003	0.84 (0.71, 1.00), 0.055
Job title (Reference is Doctor)		
Nurse	0.35 (0.29, 0.42), <0.001	0.26 (0.23, 0.28), <0.001
Paramedic	0.45 (0.20, 1.04), 0.062	0.58 (0.35, 0.95), 0.030
Operating Department Practitioner	0.17 (0.12, 0.25), <0.001	0.15 (0.12, 0.19), <0.001
Resuscitation Officer	1.61 (0.22, 11.94), 0.643	2.76 (0.67, 11.28), 0.158
Student	1.57 (0.69, 3.54), 0.279	1.19 (0.79, 1.78), 0.411
Advanced clinical practitioner	0.37 (0.21, 0.65), 0.001	0.43 (0.30, 0.61), <0.001
Other	0.37 (0.25, 0.54), <0.001	0.39 (0.31, 0.48), <0.001
Seniority (Reference is Foundation year 1)		
Foundation year 2	0.53 (0.41, 0.70), <0.001	0.75 (0.65, 0.86), <0.001
Junior grades	0.58 (0.44, 0.76), <0.001	0.74 (0.65, 0.85), <0.001
Middle grades	1.14 (0.86, 1.52), 0.362	1.34 (1.16, 1.55), <0.001
Senior grades	1.85 (1.24, 2.75), 0.003	2.39 (1.93, 2.95), <0.001
Other	0.84 (0.63, 1.12), 0.239	1.09 (0.95, 1.26), 0.222
Adjusted R-Squared	0.0307	0.0701[†]

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