

Original citation:

Thorne, C. J., Lockey, A. S., Kimani, P. K., Bullock, I., Hampshire, S., Begum-Ali, S. and Perkins, Gavin D.. (2017) e-Learning in advanced life support - what factors influence assessment outcome? Resuscitation, 114 . pp. 83-91.

Permanent WRAP URL:

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Elsevier Editorial System(tm) for

Resuscitation

Manuscript Draft

Manuscript Number: RESUS-D-16-00615R1

Title: e-learning in Advanced Life Support - What factors influence assessment outcome?

Article Type: Original Article

Keywords: Advanced life support; Education; Assessment; elearning; ALS

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Abstract: Aim To establish variables which are associated with favourable Advanced Life Support (ALS) course assessment outcomes, maximising learning effect.

Method

Between 1 January 2013 and 30 June 2014, 8,218 individuals participated in a Resuscitation Council (UK) e-learning Advanced Life Support (e-ALS) course. Participants completed 5-8 hours of online e-learning prior to attending a one day face-to-face course. e-learning access data were collected through the Learning Management System (LMS). All participants were assessed by a multiple choice questionnaire (MCQ) before and after the face-to-face aspect alongside a practical cardiac arrest simulation (CAS-Test). Participant demographics and assessment outcomes were analysed.

Results

The mean post e-learning MCQ score was 83.7 (SD 7.3) and the mean postcourse MCQ score was 87.7 (SD 7.9). The first attempt CAS-Test pass rate was 84.6% and overall pass rate 96.6%. Participants with previous ALS experience, ILS experience, or who were a core member of the resuscitation team performed better in the post-course MCQ, CAS-Test and overall assessment. Median time spent on the e-learning was 5.2 hours (IQR 3.7-7.1). There was a large range in the degree of access to elearning content. Increased time spent accessing e-learning had no effect on the overall result (OR 0.98, P=0.367) on simulated learning outcome.

Conclusion

Clinical experience through core membership of cardiac arrest teams and previous ILS or ALS training were independent predictors of performance on the ALS course whilst time spent accessing e-learning materials did not affect course outcomes. This supports the blended approach to e-ALS which allows participants to tailor their e-learning experience to their specific needs.

*Manuscript Click here to view linked References

| Thorne CJ^{1,2}, Lockey AS^{2,3}, Kimani PK⁵, Bullock I^{2,4}, Hampshire S², Begum-Ali S², Perkins GD^{1,2,5} on behalf of Advanced Life Support Subcommittee of the Resuscitation Council (UK) | the |
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| 20 21 | |
| 22 | |
| 23 | |
| 24 Word Count: 3,063 | |
| 25 | |
| 26 Abstract Word Count: 257 | |
| 27 | |
| 28 Tables: 3 | |
| 29 | |
| 30 Figures: 331 | |
| 32 Supplementary material: 1 | |
| 33 | |
| 34 | |
| 35 | |
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45 ABSTRACT

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To establish variables which are associated with favourable Advanced Life Support (ALS) course assessment
 outcomes, maximising learning effect.

49

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Between 1 January 2013 and 30 June 2014, 8,218 individuals participated in a Resuscitation Council (UK) e-learning Advanced Life Support (e-ALS) course. Participants completed 5-8 hours of online e-learning prior to attending a one day face-to-face course. e-learning access data were collected through the Learning Management System (LMS). All participants were assessed by a multiple choice questionnaire (MCQ) before and after the face-to-face aspect alongside a practical cardiac arrest simulation (CAS-Test). Participant demographics and assessment outcomes were analysed.

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The mean post e-learning MCQ score was 83.7 (SD 7.3) and the mean post-course MCQ score was 87.7 (SD 7.9). The first attempt CAS-Test pass rate was 84.6% and overall pass rate 96.6%. Participants with previous ALS experience, ILS experience, or who were a core member of the resuscitation team performed better in the post-course MCQ, CAS-Test and overall assessment. Median time spent on the e-learning was 5.2 hours (IQR 3.7-7.1). There was a large range in the degree of access to e-learning content. Increased time spent accessing e-learning had no effect on the overall result (OR 0.98, P=0.367) on simulated learning outcome.

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67 Clinical experience through core membership of cardiac arrest teams and previous ILS or ALS training were 68 independent predictors of performance on the ALS course whilst time spent accessing e-learning materials did not 69 affect course outcomes. This supports the blended approach to e-ALS which allows participants to tailor their e-70 learning experience to their specific needs.

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74 INTRODUCTION

The Formula for Survival¹ identifies three factors that influence survival from cardiac arrest: high-quality research, 75 efficient education of patient caregivers and an effective chain of survival from the early recognition of cardiac arrest 76 through to post resuscitation care.² Advanced Life Support (ALS) courses, which address both the second and third 77 78 aspects of this formula, are used internationally to train healthcare personnel how to manage patients in cardiac arrest. Previous studies have linked participation on ALS courses to improved outcomes from cardiac arrest.³⁻⁵ 79 Courses use multimodal delivery methods to equip participants with background scientific knowledge, targeted 80 81 clinical skills and non-technical skill development. This blended learning approach is from course manuals, online e-82 learning material, didactic lectures, hands-on skill stations and formative assessment. In the United Kingdom (UK) and many other countries, successful completion of an ALS course (or similar) is required for healthcare 83 84 professionals who manage acutely unwell patients on a regular basis.

85

The Resuscitation Council (UK) has a 25 year history in delivering ALS courses.⁶ A total of 20,268 individuals 86 participated in an ALS course between January 2015 and December 2015.^{6,7} In 2011, a strategic decision was taken 87 to meet increasing demand, and to increase the flexibility of learning for participants. The Resuscitation Council (UK) 88 89 launched a novel e-learning ALS course (e-ALS), as an alternative to the conventional two day face-to-face (c-ALS) 90 course, valuing this key educational approach of blended learning. This constitutes 5-8 hours of pre-course online elearning, followed by a condensed, focussed one day face-to-face element. A multi-centre randomised control trial 91 (RCT) in 2012⁸ and a large observational study of 27,170 participants in 2015⁹ demonstrated almost identical 92 93 assessment outcomes for participants enrolled upon either c-ALS or e-ALS. The findings of these two studies consolidated the emerging role of the Resuscitation Council (UK) e-ALS course. Whilst outcome data were 94 95 comparable in the observational study,⁹ it did not assess the extent to which those participants enrolled on the e-ALS 96 course actually accessed the e-learning material, or its effect on assessment outcomes.

97

98 Previous studies investigating the utility of e-learning all display a common limitation, whereby participants often do 99 not fully access the e-learning material.^{10,11} Jensen et al. investigated e-learning as a means for retaining ALS 100 competency but found that only 57.5% of candidates accessed all of the stipulated modules.¹⁰ Similarly Perkins et al. 101 found that only 64% of candidates accessed pre-course e-learning via a CD prior to attending an ALS course.¹¹ This 102 limitation was acknowledged by the authors, who postulated that any true difference between the control and intervention groups may not have been detected because the intervention had not been implemented effectively. Secondly, it provides challenges for ALS course organisers to establish exactly what extent of e-learning has been undertaken by the participants prior to attending a face-to-face course. Whilst this allows personalisation of the learning experience, it also reduces the standardisation of content delivered to those on an ALS course. Consequently, it is unknown whether making e-learning non-compulsory adversely affects candidate outcome.

108 This study was designed to access the aforementioned observational study data set,⁹ analysing the extent to which 109 participants access pre-requisite e-learning material, establishing the effect on candidate ALS assessment outcome.

110 In doing this, study authors intend to highlight independent predictors of successful ALS course outcome.

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- 112

113 METHODS

114 Setting and Participants

ALS participants voluntarily enrolled on a one-day e-ALS course at one of 94 national training centres. Each candidate registered on the Resuscitation Council (UK) Learning Management System (LMS) prior to attending the course. Participants were from a wide range of healthcare professions and stages of training.

118

119 The e-ALS Course

The e-ALS course consists of 5-8 hours of e-learning content covering essential ALS topics. Each candidate is given access to the LMS 8 weeks prior to their course and is asked to complete the 12 electronic learning modules. Additionally, participants receive a physical copy of the ALS course manual at least four weeks before the course date. e-learning progress is monitored by the course centres. Participants are free to choose to personalise their learning experience – undertaking as little or as much of the e-learning preparation as they feel necessary although there are three compulsory modules: ALS in perspective; advanced life support algorithm; non-technical skills (progress data are not routinely collected on the LMS for this module as it was only introduced in 2013).

127 There are nine non-compulsory modules: causes and prevention of cardiac arrest; acute coronary syndromes; 128 monitoring, rhythm recognition and 12 lead ECG; bradycardia, pacing and drugs; tachycardia, cardioversion and 129 drugs; special circumstances; post resuscitation care; arterial blood gas analysis; and decisions relating to

130 resuscitation.

131

On completion of the e-learning, participants undertake a compulsory multiple choice questionnaire (MCQ), 132 although their results in this do not affect the participants' post-course outcome. After completing the one-day face 133 134 to face aspect, each candidate undertakes a post-course MCQ and a practical cardiac arrest management simulation test (CAS-Test). In order to achieve ALS competency participants need to pass both of these aspects. Participants are 135 permitted two attempts at the MCQ and three attempts at the CAS-Test. The pre and post-course MCQs comprise 30 136 different stem questions, with each having four true/false answers, creating a total of 120 questions. The pass mark 137 is 75%. The CAS-Test simulations are criterion based and are well validated.^{12,13} They assess participants' abilities in 138 patient assessment, formulating a treatment plan and leadership of the cardiac arrest team. Overall scores and 139 140 pass/fail data are recorded.

141

142 Statistical analysis

Demographic data were collected on the LMS. Anonymised data were transferred to Microsoft Excel (*Microsoft Corporation, Redmond, USA*) and analysed using SPSS 23 (*IBM, Armonk, USA*) and R statistical program Version 3.3.1.¹⁴ Categorical baseline characteristics were summarised using counts and percentages while continuous baseline characteristics were summarised using mean, median (IQR, interquartile range) and ranges. Independent ttests, one-way ANOVAs and linear regression models were utilised to determine differences between continuous variables. Logistic regression was used for dichotomous outcome variables.

149

A multivariable logistic regression model was fitted to assess which variables predict whether a trainee passes the 150 CAS-Test on the first attempt. Trainees attending the same course session tend to have similar outcomes⁸ and so the 151 multivariable logistic regression model included a random effects term for course session. A similar model was fitted 152 to assess which variables predict whether a trainee passes the overall test. Odds ratios (OR), 95% confidence 153 154 intervals and p-values from the multivariable random effects logistic regression models were reported. To assess which variables predict the MCQ score of a trainee in the first attempt, MCQ scores were analysed by fitting a linear 155 mixed model with a random effects term for course session. Mean difference in MCQ scores, 95% confidence 156 intervals and p-values from the linear missed model were reported. An analysis of standard residuals was carried out 157 and outliers removed. Co-linearity was assessed by independently entering each independent variable into a logistic 158 159 regression with the remaining variables entered as dependent variables. Collinearity diagnostics were calculated and 160 the variance inflation factor (VIF) in all instances was <1. In all models, missing data were excluded from the

161 complete case analysis by a listwise deletion. Statistical significance was set at P-values of <0.05.

162

163 **RESULTS**

164 **Demographics**

165 8,218 participants were enrolled on one of 450 e-ALS courses during the study period. Mean age was 32.0 years (SD

166 8.2). 15 participants started but failed to complete the course. 1.8% of the total participants had a degree of missing

167 data and these were excluded from the analysis. Any missing data occurred due to incomplete data entry by

168 participants or local course facilitators on the LMS. Stratified participant demographics are displayed below in table 1

169 in addition to time spent accessing the e-learning and corresponding pass rates.

| Table 1: Particip | ant de | mographics on the e-A | LS course and time s | pent on e-learni | ng |
|--------------------------|-------------|--------------------------------------|---|--|-----------------------------|
| Characteristics/outcomes | n, 6 (%) | Hours spent on compulsory modules | Hours spent on non-compulsory modules | Total hours spent on e- Learning | Overall pass rate (%) |
| | | Healthcare bac | kground | | |
| Doctor | 6236 | | | | 6095 |
| Range | (75.9) | 0-13.2 | 0-21.0 | 0-24.0 | (97.8) |
| Mean (SD) | | 1.1 (0.8) | 4.1 (2.5) | 5.3 (3.0) | |
| Median (IQR) | | 0.9 (0.7-1.4) | 3.8 (2.6-5.3) | 4.9 (3.4-6.7) | |
| Nurse | 1244 | | | | 1122 |
| Range | (15.1) | 0-8.9 | 0-17.2 | 0-24.0 | (90.9) |
| Mean (SD) | | 1.3 (0.9) | 5.4 (3.4) | 6.9 (3.9) | |
| Median (IQR) | | 1.1 (0.8-1.6) | 4.8 (3.4-6.6) | 6.2 (4.5-8.5) | |
| Medical student | 534 | | | | 525 (98.3) |
| Range | (6.5) | 0-4.7 | 0-16.0 | 0-17.6 | |
| Mean (SD) | | 1.1 (0.7) | 4.4 (2.2) | 5.6 (2.6) | |
| Median (IQR) | | 0.9 (0.7-1.3) | 4.1 (2.9-5.6) | 5.3 (4.0-6.9) | |
| Operating Department | 73 | | | | 67 (93.1) |
| Practitioner | (0.9) | | | | |
| Range | | 0-6.9 | 0-11.5 | 0.2-21.4 | |
| Mean (SD) | | 1.3 (1.1) | 5.3 (2.7) | 7.0 (3.7) | |
| Median (IQR) | | 1.0 (0.8-1.4) | 5.2 (3.5-7.2) | 6.4 (4.8-8.8) | |
| Ambulance staff/ | 40 | | | | 39 (97.5) |
| Paramedic | (0.5) | | | | |
| Range | | 0-6.4 | 0-18.7 | 0-22.7 | |
| Mean (SD) | | 1.3 (1.2) | 4.7 (3.1) | 6.5 (4.0) | |
| Median (IQR) | | 1.1 (0.7-1.9) | 4.8 (3.3-5.7) | 6.4 (4.4-8.0) | |
| Resuscitation Officer | 15 | | | | 15 (100.0) |
| Range | (0.2) | 0.6-3.0 | 4.3-9.5 | 5.1-10.4 | |
| Mean (SD) | | 1.3 (0.7) | 6.1 (1.5) | 7.5 (1.7) | |
| Median (IQR) | | 1.0 (0.8-2.1) | 6.1 (4.8-7.1) | 7.5 (5.7-9.2) | |
| Other | 74 | | | | 62 (84.9) |
| Range | (0.9) | 0-5.5 | 0-18.0 | 0-20.6 | |
| Mean (SD) | 1 | 1.4 (0.9) | 6.0 (3.4) | 7.8 (4.1) | |

| Not available 2 Stage of training Medical Student 537 537 526 Range (6.5) 0.4.7 0-16.0 0-17.6 (98.0) Mealin (IQR) 0.9 (0.7.1.3) 4.1 (2.9.5.6) 5.3 (4.0-6.9) 1624 Foundation Year 1 1650 0.7.0 0-21.0 0-21.7 1633 Range 0.7.0 0.21.0 0.2 (2.2) 4.9 (3.6-6.5) 1633 Foundation Year 2 1663 0.9 (0.7.1.3) 3.8 (2.7.5.2) 4.9 (3.6-6.6) 1633 Doctor (20.2) 0.9 (0.7.1.3) 3.9 (2.7.5.2) 5.0 (3.6-6.6) 1633 Junior Grade Doctor (9.9 (0.7.1.3) 3.9 (2.7.5.2) 5.0 (3.6-6.6) 1634 Junior Grade Doctor (9.7) .1 (0.8) 4.1 (2.3) 5.3 (2.8) 66.8 Median (IQR) 0.9 (0.7.1.3) 3.9 (2.7.5.2) 5.0 (3.6-6.6) 1434 Range 0.9.1 1.0 (0.7.1.5) 3.7 (2.6-5.4) 4.9 (3.5-7.0) Median (IQR) 1.0 (0.7.1.4) 3.5 (2.3.5) 5.1 | Median (IQR) | | 1.2 (0.9-1.5) | 4.8 (3.7-7.5) | 6.7 (5.0-9.7) | |
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| Median (IQR) D.9 (0.7-1.3) 3.8 (2.7-5.2) 4.9 (3.6-6.5) Foundation Year 2 1663 (20.2) (363) Range 0-10.0 0-18.4 0-20.8 Mean (SD) 1.1 (0.8) 4.1 (2.3) 5.3 (2.8) (98.6) Junior Grade Doctor 794 | Range | | 0-7.0 | 0-21.0 | 0-21.7 | |
| Foundation Year 2 1663 1639 Doctor (20.2) 98.6 Range 0-10.0 0-18.4 0-20.8 Mean (SD) 1.1 (0.8) 4.1 (2.3) 5.3 (2.8) Median (IQR) 0.9 (0.7-1.3) 3.9 (2.7-5.2) 5.0 (3.6-6.6) Junior Grade Doctor 794 768 768 KSTJ/STZ) (9.7) 8.7 (2.6-5.4) 4.9 (3.5-7.0) Median (IQR) 1.0 (0.7-1.5) 3.7 (2.6-5.4) 4.9 (3.5-7.0) Middle Grade Doctor* 1463 9.2 (2.5) 5.1 (2.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) Mean (SD) 1.1 (0.8) 3.9 (2.5) 5.1 (2.9) Mean (SD) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) Mean (SD) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) Junior Nurse (Band 7-9) 1002 886 886 Range (12.2) 0-8.9 0-17.2 0-23.1 (88.4) | Mean (SD) | | 1.1 (0.7) | 4.0 (2.2) | 5.2 (2.6) | |
| Doctor (20.2) (91.0.0) (91.8.4) (92.6) Range 0.10.0) 0.18.4 0.20.8 (91.6.6) Median (IQR) 0.9 (0.7.1.3) 3.9 (2.7.5.2) S.0 (3.6.6.6) (95.8) Junior Grade Doctor (94.10.8) 4.1 (2.3) S.3 (2.8) (95.8) Range 0.9 (0.7.1.3) 3.9 (2.7.5.2) S.0 (3.6.6.6) (95.8) Main (IQR) 1.0 (0.7.1.5) 3.7 (2.6-5.4) 4.9 (3.5-7.0) (95.8) Median (IQR) 1.0 (0.7.1.5) 3.7 (2.6-5.4) 4.9 (3.5-7.0) 1433 Range (17.8) 0.12 (0.8) 3.9 (2.5) 5.1 (2.9) 4.49 Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5.) 469 Range (12.8) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5.) 469 Mean (SD) 1.1 (0.8) 3.9 (2.5) 5.1 (2.9) 4.1 (2.7) 5.4 (3.4) 469 Mage (SD) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) 469 Mean (SD) 1.2 (0.8-9 | Median (IQR) | | 0.9 (0.7-1.3) | 3.8 (2.7-5.2) | 4.9 (3.6-6.5) | |
| Range 0-10.0 0-18.4 0-20.8 Mean (SD) 1.1 (0.8) 4.1 (2.3) 5.3 (2.8) Median (IQR) 0.9 (0.7-1.3) 3.9 (2.7-5.2) 5.0 (3.6-6.6) Junior Grade Doctor 794 (9.7) (9.7) Range 0-9.4 0-20.6 0-24.0 Median (IQR) 1.2 (0.8) 4.3 (2.7) 5.5 (3.3) Median (IQR) 1.0 (0.7-1.5) 3.7 (2.6-5.4) 4.9 (3.5-7.0) Middle Grade Doctor [#] 1465 1434 Range (17.8) 0-13.2 0-20.8 0-23.5 (97.5) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) 469 Range (10.8) 3.9 (2.5) 5.1 (2.9) 469 Mean (SD) 1.1 (0.8) 3.9 (2.5-5.3) 4.9 (3.5-6.7) 469 Range (5.9) 0-5.1 0-17.7 0-21.2 (96.1) Mean (SD) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) 469 Mean (SD) 1.0 (0.8-1.5) 3.7 (2.5-5.3) 4.9 (3.5-6.7) | Foundation Year 2 | 1663 | | | | 1639 |
| Mean (SD) 1.1 (0.8) 4.1 (2.3) 5.3 (2.8) Median (IQR) 0.9 (0.7-1.3) 3.9 (2.7-5.2) 5.0 (3.6-6.6) Junior Grade Doctor (ST1/ST2) 794 768 (ST1/ST2) (9.7) (9.6.8) 4.3 (2.7) 5.5 (3.3) Median (IQR) 1.0 (0.7-1.5) 3.7 (2.6-5.4) 4.9 (3.5-7.0) Middle Grade Doctor [#] 1465 14434 Range 1.1 (0.8) 3.9 (2.5) 5.1 (2.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5.) Median (IQR) 1.0 (0.8-1.5) 3.7 (2.5-5.3) 4.9 (3.3-7.1) Junior Nurse (Band 4-6) 1002 886 886 Range (12.2) 0-8.9 0-17.2 0-23.1 882 Median (IQR) 1.1 (0.8-1.6) 4.9 (3.5-6.7) 6.4 (4.7-8.7) 580 | Doctor | (20.2) | | | | (98.6) |
| Median (IQR) 0.9 (0.7-1.3) 3.9 (2.7-5.2) 5.0 (3.6-6.6) Junior Grade Doctor (ST1/ST2) (9.7) 768 768 Range 0.9.4 0.20.6 0.24.0 Median (IQR) 1.0 (0.7-1.5) 3.7 (2.6-5.4) 4.9 (3.5-7.0) Middle Grade Doctor" 1465 1.434 Range (17.8) 0-13.2 0-20.8 0-23.5 (97.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) 5.1 (2.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) 5.1 (2.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) 5.1 (2.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) 5.1 (2.9) Median (IQR) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) 469 Range (5.9) 0-5.1 0-17.7 0-21.2 9.6 Range (5.9) 0.5.1 0.7 (2.7) 5.4 (3.4) 5.3 (3.2) Median (IQR) 1.2 (0.9 5.0 (3.2) 7.1 (3.9) <td>Range</td> <td></td> <td>0-10.0</td> <td>0-18.4</td> <td>0-20.8</td> <td></td> | Range | | 0-10.0 | 0-18.4 | 0-20.8 | |
| Junior Grade Doctor 794 794 768 (ST1/ST2) (9.7) (9.7) (96.8 Mean (SD) 1.2 (0.8) 4.3 (2.7) 5.5 (3.3) Median (IQR) 1.0 (0.7-1.5) 3.7 (2.6-5.4) 4.9 (3.5-7.0) Middle Grade Doctor# 1465 1434 Range (17.8) 0-13.2 0-20.8 0-23.5 (97.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) Senior Grade Doctor* 488 Range (17.8) 0-13.2 0-20.8 0-23.5 (97.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) Senior Grade Doctor* 488 Range (15.9) 0-5.1 0-17.7 0-21.2 (96.1 Junior Nurse (Band 4-6) 1002 886 886 886 Range (12.2) 0-8.9 0-17.2 0-23.1 (88.4) Mean (SD) 1.3 (0.9) 5.0 (3.2) 7.1 (3.9) 378 Maange (12.2) 0-8.9 0-15.4 0-24.0 (95.5 <tr< td=""><td>Mean (SD)</td><td></td><td>1.1 (0.8)</td><td>4.1 (2.3)</td><td>5.3 (2.8)</td><td></td></tr<> | Mean (SD) | | 1.1 (0.8) | 4.1 (2.3) | 5.3 (2.8) | |
| (ST1/ST2) (9.7) (9.7) (9.7) (9.6.8) Range 0-9.4 0-20.6 0-24.0 (96.8) Median (IQR) 1.2 (0.8) 4.3 (2.7) 5.5 (3.3) (96.8) Middle Grade Doctor [#] 1465 1434 (9.7) (9.7) Middle Grade Doctor [#] 1465 1434 (9.7) (9.7) Mean (SD) 1.1 (0.8) 3.9 (2.5) 5.1 (2.9) (97.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) (96.8) Senior Grade Doctor ⁵ 488 | Median (IQR) | | 0.9 (0.7-1.3) | 3.9 (2.7-5.2) | 5.0 (3.6-6.6) | |
| Range 0-9.4 0-20.6 0-24.0 Mean (SD) 1.2 (0.8) 4.3 (2.7) 5.5 (3.3) Median (IQR) 1.0 (0.7-1.5) 3.7 (2.6-5.4) 4.9 (3.5-7.0) Middle Grade Doctor" 1465 1434 Range (17.8) 0-13.2 0-20.8 0-23.5 (97.5) Mean (SD) 1.1 (0.8) 3.9 (2.5) 5.1 (2.9) (469 Range (5.9) 0-5.1 0-17.7 0-21.2 (96.1) Mean (SD) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) (96.1) Median (IQR) 1.0 (0.8-1.5) 3.7 (2.5-5.3) 4.9 (3.3-7.1) 886 Mean (SD) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) (88.4) Mean (SD) 1.2 (0.9 0.17.2 0-23.1 (88.4) Mean (SD) 1.1 (0.8-1.6) 4.9 (3.5-6.7) 6.4 (4.7-8.7) 9 Senior Nurse (Band 7-9) 395 395 378 378 Range (4.8) 0-6.8 0-15.4 0-24.0 (95.5) <t< td=""><td>Junior Grade Doctor</td><td>794</td><td></td><td></td><td></td><td>768</td></t<> | Junior Grade Doctor | 794 | | | | 768 |
| Mean (SD) 1.2 (0.8) 4.3 (2.7) 5.5 (3.3) Median (IQR) 1.0 (0.7-1.5) 3.7 (2.6-5.4) 4.9 (3.5-7.0) Middle Grade Doctor [#] 1465 1434 Range (17.8) 0-13.2 0-20.8 0-23.5 (97.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) 469 Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) 469 Senior Grade Doctor ⁵ 488 6 469 Range (5.9) 0-5.1 0-17.7 0-21.2 (96.1) Mean (SD) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) 886 Range (10.2) 0.9 017.2 0-23.1 (88.4) Mean (SD) 1.3 (0.9) 5.0 (3.2) 7.1 (3.9) 896 Median (IQR) 1.1 (0.8-1.6) 4.9 (3.5-6.7) 6.4 (4.7-8.7) 378 Range (4.8) 0-6.8 0-15.4 0-24.0 (95.5) Median (IQR) 1.1 (0.8-1.6) 4.5 (3.1-6.5) 5.9 (4.2-8.1 | (ST1/ST2) | (9.7) | | | | (96.8) |
| Median (IQR) 1.0 (0.7-1.5) 3.7 (2.6-5.4) 4.9 (3.5-7.0) Middle Grade Doctor" 1465 1434 Range (17.8) 0-13.2 0-20.8 0-23.5 (97.5) Mean (SD) 1.1 (0.8) 3.9 (2.5) 5.1 (2.9) 47 (3.2 (3.5)) 4.7 (3.2 (5.5)) 4.7 (3.2 (5.5)) Senior Grade Doctor ⁵ 488 | Range | | 0-9.4 | 0-20.6 | 0-24.0 | |
| Middle Grade Doctor" 1465 1434 Range (17.8) 0-13.2 0-20.8 0-23.5 (97.9) Mean (SD) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) 469 Range (5.9) 0-5.1 0-17.7 0-21.2 (96.1) Median (IQR) 1.0 (0.8-1.5) 3.7 (2.5-5.3) 4.9 (3.3-7.1) 486 Mean (SD) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) 486 Median (IQR) 1.0 (0.8-1.5) 3.7 (2.5-5.3) 4.9 (3.3-7.1) 486 Junior Nurse (Band 4-6) 1002 886 886 886 Range (12.2) 0-8.9 0-17.2 0-23.1 (88.4 Mean (SD) 1.1 (0.8-1.6) 4.9 (3.5-6.7) 6.4 (4.7-8.7) 5 Senior Nurse (Band 7-9) 395 7 378 8 Mean (SD) 1.1 (0.8-1.6) 4.5 (3.1-6.5) 5.9 (4.2-8.1) 76 Other 223 0-18.7 0-22.7 (90.2) Range (2.7) 0-8.3 | Mean (SD) | | 1.2 (0.8) | 4.3 (2.7) | 5.5 (3.3) | |
| Range (17.8) 0-13.2 0-20.8 0-23.5 (97.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) 469 Senior Grade Doctor ⁵ 488 469 469 Range (5.9) 0-5.1 0-17.7 0-21.2 (96.1) Median (IQR) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) 54 488 Median (IQR) 1.0 (0.8-1.5) 3.7 (2.5-5.3) 4.9 (3.3-7.1) 886 Range (12.2) 0-8.9 0-17.2 0-23.1 (88.4) Median (IQR) 1.1 (0.8-1.6) 4.9 (3.5-6.7) 6.4 (4.7-8.7) 586 Senior Nurse (Band 7-9) 395 395 378 378 Range (4.8) 0-6.8 0-15.4 0-24.0 (95.5) Mean (SD) 1.3 (0.9) 5.0 (3.2) 6.6 (3.8) 59 Median (IQR) 1.1 (0.8-1.6) 4.5 (3.1-6.5) 5.9 (4.2-8.1) 0202 Other 223 0-18.7 0-22.7 (90.2) Range <td>Median (IQR)</td> <td></td> <td>1.0 (0.7-1.5)</td> <td>3.7 (2.6-5.4)</td> <td>4.9 (3.5-7.0)</td> <td></td> | Median (IQR) | | 1.0 (0.7-1.5) | 3.7 (2.6-5.4) | 4.9 (3.5-7.0) | |
| Mean (SD) 1.1 (0.8) 3.9 (2.5) 5.1 (2.9) Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) Senior Grade Doctor ⁵ 488 469 Range (5.9) 0-5.1 0-17.7 0-21.2 (96.1) Mean (SD) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) 886 Median (IQR) 1.0 (0.8-1.5) 3.7 (2.5-5.3) 4.9 (3.3-7.1) 886 Junior Nurse (Band 4-6) 1002 886 886 886 Range (12.2) 0-8.9 0-17.2 0-23.1 (88.4) Mean (SD) 1.3 (0.9) 5.0 (3.2) 7.1 (3.9) 886 Range (4.8) 0-6.8 0-15.4 0-24.0 (95.5) Mean (SD) 1.3 (0.9) 5.0 (3.2) 6.6 (3.8) 96 Mean (SD) 1.3 (0.9) 5.0 (3.2) 6.6 (3.8) 96 Range (4.8) 0-6.8 0-15.4 0-24.0 (95.5) Median (IQR) 1.1 (0.8-1.6) 4.5 (3.1-6.5) 5.9 (4.2.8.1) | Middle Grade Doctor [#] | 1465 | | | | 1434 |
| Median (IQR) 0.9 (0.7-1.4) 3.5 (2.3-5.0) 4.7 (3.2-6.5) Senior Grade Doctor ⁵ 488 469 Range (5.9) 0-5.1 0-17.7 0-21.2 (96.1) Mean (SD) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) 886 Median (IQR) 1.0 (0.8-1.5) 3.7 (2.5-5.3) 4.9 (3.3-7.1) 886 Junior Nurse (Band 4-6) 1002 0-17.2 0-23.1 (88.4) Mean (SD) 1.3 (0.9) 5.0 (3.2) 7.1 (3.9) 886 Mean (SD) 1.1 (0.8-1.6) 4.9 (3.5-6.7) 6.4 (4.7-8.7) 718 Senior Nurse (Band 7-9) 395 . 378 378 Range (4.8) 0-6.8 0-15.4 0-24.0 (95.5) Median (IQR) 1.1 (0.8-1.6) 4.5 (3.1-6.5) 5.9 (4.2-8.1) 202 Other 223 Median (IQR) 1.2 (0.9-1.9) 5.3 (3.5-7.7) 6.9 (4.9-9.5) . No 4615 . </td <td>Range</td> <td>(17.8)</td> <td>0-13.2</td> <td>0-20.8</td> <td>0-23.5</td> <td>(97.9)</td> | Range | (17.8) | 0-13.2 | 0-20.8 | 0-23.5 | (97.9) |
| Senior Grade Doctor ⁵ 488 469 Range (5.9) 0-5.1 0-17.7 0-21.2 (96.1) Median (IQR) 1.0 (0.8-1.5) 3.7 (2.5-5.3) 4.9 (3.3-7.1) 886 Range (12.2) 0-8.9 0-17.2 0-23.1 (88.4) Mean (SD) 1.3 (0.9) 5.0 (3.2) 7.1 (3.9) 1.4 (0.8-1.6) 4.9 (3.5-6.7) 6.4 (4.7-8.7) Senior Nurse (Band 7-9) 395 7.1 (3.9) 1.1 (0.8-1.6) 4.9 (3.5-6.7) 6.4 (4.7-8.7) 5.8 Senior Nurse (Band 7-9) 395 378 378 378 Range (4.8) 0-6.8 0-15.4 0-24.0 (95.5) Mean (SD) 1.3 (0.9) 5.0 (3.2) 6.6 (3.8) 1.1 (0.8-1.6) 4.5 (3.1-6.5) 5.9 (4.2-8.1) 202 Other 223 223 202 202.7 (90.2 202.7 (90.2 Median (IQR) 1.2 (0.9-1.9) 5.3 (3.5-7.7) 6.9 (4.9-9.5) 1.6 (1.2) 5.9 (3.3) 7.6 (4.2) 1.2 (0.8 | Mean (SD) | | 1.1 (0.8) | 3.9 (2.5) | 5.1 (2.9) | |
| Range (5.9) 0-5.1 0-17.7 0-21.2 (96.1) Median (IQR) 1.2 (0.9) 4.1 (2.7) 5.4 (3.4) 10 Junior Nurse (Band 4-6) 1002 3.7 (2.5-5.3) 4.9 (3.3-7.1) 886 Range (12.2) 0-8.9 0-17.2 0-23.1 (88.4) Mean (SD) 1.3 (0.9) 5.0 (3.2) 7.1 (3.9) 878 Median (IQR) 1.1 (0.8-1.6) 4.9 (3.5-6.7) 6.4 (4.7-8.7) 878 Senior Nurse (Band 7-9) 395 378 378 378 Range (4.8) 0-6.8 0-15.4 0-24.0 (95.5) Mean (SD) 1.3 (0.9) 5.0 (3.2) 6.6 (3.8) 91 Median (IQR) 1.1 (0.8-1.6) 4.5 (3.1-6.5) 5.9 (4.2-8.1) 90.2 Mean (SD) 1.6 (1.2) 5.9 (3.3) 7.6 (4.2) 90.2 Range (2.7) 0-8.3 0-18.7 0-22.7 (90.2 Mean (SD) 1.2 (0.9-1.9) 5.3 (3.5-7.7) 6.9 (4.9-9.5) 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2 | Median (IQR) | | 0.9 (0.7-1.4) | 3.5 (2.3-5.0) | 4.7 (3.2-6.5) | |
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| Yes 3593 3515 Range (43.8) 0-13.2 0-21.0 0-24.0 (98.0) Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) 1.0 (0.7-1.4) 3.8 (2.5-5.3) 5.3 (3.9-7.2) | | | | | | |
| Range(43.8)0-13.20-21.00-24.0(98.0)Mean (SD)1.2 (0.8)4.1 (2.6)5.4 (3.2)Median (IQR)1.0 (0.7-1.4)3.8 (2.5-5.3)5.3 (3.9-7.2) | Median (IQR) | | 1.0 (0.7-1.4) | 4.1 (3.9-7.2) | 5.3 (3.8-7.2) | |
| Mean (SD)1.2 (0.8)4.1 (2.6)5.4 (3.2)Median (IQR)1.0 (0.7-1.4)3.8 (2.5-5.3)5.3 (3.9-7.2) | Yes | 3593 | | | | 3515 |
| Median (IQR) 1.0 (0.7-1.4) 3.8 (2.5-5.3) 5.3 (3.9-7.2) | - | . , | | | | (98.0) |
| | | | | | | |
| Not available 10 | Median (IQR) | | 1.0 (0.7-1.4) | 3.8 (2.5-5.3) | 5.3 (3.9-7.2) | |
| | Not available | 10 | | | | |
| Previous ILS experience* | | | Previous ILS ex | perience* | | |

| No | 2704 | | | | 2624 |
|---------------|--------|----------------|----------------------|---------------|---------|
| Range | (32.9) | 0-8.3 | 0-21.0 | 0-24.0 | (95.5) |
| Mean (SD) | | 1.2 (0.9) | 4.5 (2.8) | 5.8 (3.4) | |
| Median (IQR) | | 1.0 (0.8-1.5) | 4.1 (2.7-5.8) | 5.3 (3.7-7.4) | |
| Yes | 5466 | | | | 5302 |
| Range | (67.1) | 0-13.2 | 0-20.9 | 0-24.0 | (97.2) |
| Mean (SD) | | 1.1 (0.8) | 4.3 (2.6) | 5.5 (3.1) | |
| Median (IQR) | | 1.0 (0.7-1.4) | 4.2 (2.9-5.7) | 5.4 (3.8-7.3) | |
| Not available | 48 | | | | |
| | | Core member of | f resuscitation team | | |
| No | 4373 | | | | 4173 |
| Range | (53.8) | 0-9.4 | 0-21.0 | 0-23.5 | (95.7) |
| Mean (SD) | | 1.2 (0.8) | 4.5 (2.7) | 5.8 (3.2) | |
| Median (IQR) | | 1.0 (0.8-1.5) | 4.2 (2.9-5.7) | 5.4 (3.9-7.3) | |
| Yes | 3759 | | | | 3668 |
| Range | (46.2) | 0-13.2 | 0-21.0 | 0-24.0 | (97.7) |
| Mean (SD) | | 1.1 (0.8) | 4.1 (2.6) | 4.9 (3.1) | |
| Median (IQR) | | 0.9 (0.7-1.4) | 3.8 (2.6-5.3) | 4.9 (3.5-6.8) | |
| Not available | 86 | | | | |
| Total | 8218 | | | | 7926 |
| Range | | 0-13.2 | 0-21.0 | 0-24.0 | (96.6%) |
| Mean (SD) | | 1.2 (2.8) | 4.3 (2.7) | 5.6 (3.2) | |
| Median (IQR) | | 1.0 (0.74-1.4) | 4.0 (2.7-5.5) | 5.2 (3.7-7.1) | |

*Immediate Life Support

[#]ST3+, middle grade equivalent

^{\$} Consultant or associate specialist

170

171 Assessment outcomes

172 Assessment outcome data are displayed in Table 2. 99.1% of participants completed the post e-learning MCQ, with a

mean score of 83.7 (SD 7.3). The mean post-course MCQ score was 87.7 (SD 7.9). Resuscitation officers had the

174 highest mean score in the post-course MCQ (90.5, SD 5.5), with operating department practitioners (ODP) the lowest

175 (79.2, SD 17.0). Those participants who had previous ALS experience or were a core member of the resuscitation

team performed better in the post-course MCQ (P<0.001, P<0.001 respectively), as did the more senior doctors and

177 nurses. Participants with previous ILS experience performed worse in the post-course MCQ (P<0.001).

| Table 2: Univariate predictors of assessment outcomes | | | | | | | | | | |
|---|-----------------------|-----------------------------------|---------------------|--------------------------|---------------------------|-------------|-------------------------------|---------------------------|-------------|--|
| Independent variables | e-learning | Mean post- course MCQ score | P-value | CAS- Test pass (%) | Odds ratio (95% CI) | P- value | Overall course pass (%) | Odds ratio (95% CI) | P- value | |
| | Healthcare profession | | | | | | | | | |
| Doctor (comparision) | 84.7 | 88.7 | | 5352 (86.0) | | | 6095 (97.8) | | | |
| Nurse | 79.7 | 80.0 | <0.001 ^f | 1005 (81.3) | 0.71 (0.60- 0.83) | <0.001 | 1122 (90.9) | 0.22 (0.17- 0.29) | <0.001 | |
| Medical student | 83.4 | 86.5 | | 425 | 0.64 | <0.001 | 525 (98.3) | 1.31 | 0.435 | |

| | | | l | (| 10 - 1 | | | 10.00 | |
|--|------|--------|---------------------|----------------|-------------------------|--------|----------------|-------------------------|--------|
| | | | | (79.6) | (0.51- 0.79) | | | (0.66- 2.59) | |
| Operating Department Practitioner | 73.0 | 79.2 | | 51 (70.8) | 0.40 (0.24- 0.66) | <0.001 | 67 (93.1) | 0.30 (0.12- 0.76) | 0.011 |
| Ambulance staff/ Paramedic | 81.4 | 85.4 | | 37 (92.5) | 2.00 (0.62- 6.62) | 0.247 | 39 (97.5) | 0.88 (0.12- 6.43) | 0.897 |
| Resuscitation Officer | 86.6 | 90.5 | | 13 (86.7) | 1.06 (0.24- 4.69) | 0.941 | 15 (100.0) | 3.6x10 ⁶ | <0.001 |
| Other | 79.9 | 83.6 | | 46 (66.7) | 0.33 (0.20- 0.54) | <0.001 | 62 (84.9) | 0.12 (0.06- 0.24) | <0.001 |
| | | | Stage of trai | ning | | | | | |
| Medical Student | 83.3 | 86.4 | | 426 (79.5) | 0.72 (0.56- 0.92) | 0.010 | 526 (98.0) | 0.70 (0.34- 1.44) | 0.332 |
| Foundation Year 1 Doctor | 83.0 | 86.6 | | 1394 (84.7) | 1.03 (0.85- 1.24) | 0.754 | 1624 (98.4) | 0.92 (0.52- 1.60) | 0.754 |
| Foundation Year 2 Doctor (comparision) | 83.2 | 87.7 | | 1401 (84.3) | | | 1639 (98.6) | | |
| Junior Grade Doctor (ST1/ST2) | 85.2 | 89.1 | | 667 (85.6) | 1.11 (0.87- 1.40) | 0.406 | 768 (96.8) | 0.45 (0.26- 0.79) | 0.006 |
| Middle Grade Doctor [#] | 87.0 | 91.1 | <0.001 [£] | 1322 (90.4) | 1.75 (1.40- 2.17) | <0.001 | 1434 (97.9) | 0.70 (0.41- 1.20) | 0.197 |
| Senior Grade Doctor ^{\$} | 87.9 | 92.0 | | 425 (87.3) | 1.28 (0.95- 1.72) | 0.107 | 469 (96.1) | 0.40 (0.22- 0.76) | 0.005 |
| Junior Nurse (Band 4-6) | 78.8 | 82.8 | | 777 (78.3) | 0.67 (0.55- 0.82) | <0.001 | 886 (88.4) | 0.12 (0.08- 0.19) | <0.001 |
| Senior Nurse (Band 7-9) | 81.4 | 86.6 | | 346 (87.8) | 1.34 (0.97- 1.87) | 0.080 | 378 (95.5) | 0.31 (0.17- 0.57) | <0.001 |
| Other | 82.6 | 86.6 | | 163 (74.1) | 0.53 (0.38- 0.74) | <0.001 | 202 (90.2) | 0.14 (0.08- 0.26) | <0.001 |
| | | Previo | us life support co | urse exp | erience | | | | |
| Previous ALS experience | 85.5 | 89.7 | <0.001 [#] | 3204 (89.3) | 1.97 (1.73- | <0.001 | 3515 (98.0) | 2.27 (1.73- | <0.001 |
| No previous ALS experience | 82.3 | 86.1 | | 3727 (81.0) | 2.24) | | 4411 (95.6) | 2.98) | |
| Previous ILS experience | 83.2 | 87.4 | <0.001# | 4666 (85.6) | 1.24 (1.09- | 0.001 | 5302 (97.2) | 1.64 (1.29- | <0.001 |
| No previous ILS experience | 84.5 | 88.3 | | 2265 (82.7) | 1.40) | | 2624 (95.5) | 2.09) | |
| Core member of | 84.4 | 88.8 | <0.001 [#] | 3305 | 1.67 | <0.001 | 3668 | 1.91 | <0.001 |

| resuscitation team | | | | | (88.0) | (1.48- | | (97.7) | (1.48- | |
|---|------|------|---------------------------------|--------|----------------|-------------------------|--------|----------------|-------------------------|--------|
| Not a core member of resuscitation team | 83.0 | 86.6 | | | 3540 (81.4) | 1.90) | | 4173 (95.7) | 2.47) | |
| Age (years) | | | -0.33 ([-0.52]- [-0.11])* | 0.003 | | 0.98 (0.97- 0.98) | <0.001 | | 0.93 (0.93- 0.94) | <0.001 |
| Time spent on e-Learning (hours) | | | -0.24 ([-0.30]- [-0.19])* | <0.001 | | 0.93 (0.91- 0.94) | <0.001 | | 0.90 (0.87- 0.93) | <0.001 |

[#]Independent samples t-test

[£] One way ANOVA

*Linear regression to predict post course MCQ score (B value with 95% confidence intervals)

[#]ST3+, registrar equivalent

^{\$} Consultant or associate specialist

178

179 The first attempt pass rate for CAS-Test was 84.6%. Univariate analysis found that paramedic and resuscitation officer pass rates were similar to physicians whilst nurses, medical students and those in the 'other' category had 180 lower pass rates. Those participants with previous ALS experience were 1.97 times more likely to pass the CAS-Test 181 assessment on the first attempt (OR 1.97 (95% CI 1.73-2.24), P<0.001) compared to those with no previous ALS 182 experience. Those who were core members of the resuscitation team were 1.67 times more likely to pass the CAS-183 184 Test scenario, compared with those who were not core members (95% Cl 1.48-1.90), P<0.001). Middle grade doctors were 1.75 times more likely to pass the CAS-Test compared to Foundation Year 2 doctors. (95% CI 1.40-2.17, 185 P<0.001). 186

187

The overall course pass rate was 96.6%. Resuscitation officers demonstrated the highest pass rate at 100%. Junior nurses had the lowest pass rate of 88.4%. When compared to doctors in the univariate analysis; nurses (OR 0.22, 95% CI 0.17-0.29, P<0.001), ODPs (OR 0.30, 95% CI 0.12-0.76, P=0.011) and participants from the 'other' category (OR 0.12, 95% CI 0.06-0.24, P<0.001) had significantly lower overall pass rates. Participants were more likely to pass if they had previously undertaken ALS training (OR 2.27, 95% CI 1.73-2.98, P<0.001), ILS training (OR 1.64, 95% CI 1.29-2.09, P<0.001) or were a core member of the resuscitation team (OR 1.91, 95% CI 1.48-2.47, P<0.001).

194

The significant independent variables from the univariate analyses were assessed for co-linearity. Grade of training was removed due to co-linearity with healthcare background. The remaining independent variables were entered into multivariate analyses. Figures 1-3 present the findings from the multivariate analyses, with full data in supplementary material. Previous ILS and ALS experience and being a core member of a resuscitation team were 199 independent predictors of CAS-Test performance, post course MCQ score and overall success rates. Increasing age

200 was associated with worse post course MCQ score, CAS-Test outcome and overall result.

201

202 Time spent accessing e-learning

203 Median time spent on the e-learning was 5.2 hours (IQR 3.7-7.1). Resuscitation officers spent the longest time (median 7.5 hours, IQR 5.7-9.2). Doctors spent the least amount of time (median 4.9 hours, IQR 3.4-6.7). In general, 204 those doctors with more clinical experience spent less time accessing the e-learning material. This is demonstrated 205 206 below in table 3 where middle grade doctors spend the least time on every module. In the univariate analysis, increased hours spent accessing e-learning was a statistically significant predictor of failing the post-course MCQ (B=-207 0.24, 95% CI [-0.30]-[-0.19], P<0.001), the CAS-Test assessment (OR 0.93, 95% CI 0.91-0.94, P<0.001) and the overall 208 209 course (OR 0.90, 95% CI 0.87-0.93, P<0.001). When all other co-variates were controlled for in the multivariate regression, time spent accessing e-learning remained a significant predictor of CAS-Test failure (OR 0.96, 95% CI 210 211 0.95-0.98, P<0.001) but was not a significant predictor of overall course failure (OR 0.98, 95% CI 0.95-1.02, P=0.367).

| | ALS in perspective | ALS algorithm | Causes and Prevention of Cardiac Arrest | y Syndromes | Post Resuscitation Care | Monitoring, Rhythm Recognition and 12-lead ECG | pu | ardia, Pacing and Drugs | Special Circumstances | Decisions Relating to Resuscitation | l Gas Analysis |
|-----------------------------------|--------------------|---------------|--|-------------|-------------------------|---|------|-------------------------|-----------------------|--|----------------|
| | G | rade/h | ealthca | re prof | ession | | | | | | |
| Foundation year doctor | 9.2 | 44.0 | 17.0 | 27.1 | 22.5 | 34.3 | 32.3 | 15.7 | 25.1 | 8.0 | 14.5 |
| Junior grade doctor (ST1/ST2) | 9.8 | 45.3 | 17.7 | 26.6 | 22.7 | 32.5 | 30.4 | 14.6 | 24.6 | 8.9 | 15.3 |
| Middle grade doctor | 9.5 | 43.8 | 17.0 | 26.4 | 21.8 | 30.7 | 27.8 | 13.6 | 22.8 | 8.0 | 12.4 |
| Senior grade doctor | 10.1 | 48.0 | 17.8 | 25.8 | 21.4 | 33.5 | 31.6 | 14.2 | 26.1 | 9.0 | 15.4 |
| Junior nurse | 11.0 | 51.0 | 21.4 | 31.1 | 24.9 | 53.5 | 39.6 | 19.9 | 32.7 | 10.3 | 25.1 |
| Senior nurse | 10.6 | 50.1 | 19.7 | 29.9 | 24.8 | 46.9 | 38.2 | 17.6 | 31.0 | 9.7 | 22.4 |
| Paramedic | 10.5 | 42.9 | 19.4 | 29.7 | 25.2 | 42.4 | 36.4 | 17.6 | 28.9 | 10.2 | 19.8 |
| Operating department practitioner | 10.6 | 49.5 | 22.6 | 29.5 | 24.8 | 57.8 | 43.8 | 20.3 | 33.0 | 12.1 | 28.6 |
| Resuscitation officer | 13.3 | 41.7 | 20.0 | 40.0 | 25.9 | 83.8 | 42.2 | 25.6 | 41.4 | 11.4 | 29.9 |
| Medical student | 9.3 | 45.0 | 17.8 | 28.1 | 24.1 | 38.5 | 35.8 | 16.5 | 28.7 | 9.3 | 15.6 |
| Specialty background | | | | | | | | | | | |
| Anaesthetics | 9.7 | 45.5 | 17.9 | 27.5 | 23.0 | 36.2 | 32.9 | 16.0 | 26.1 | 8.6 | 16.0 |
| Cardiology | 10.0 | 44.6 | 17.9 | 25.7 | 21.7 | 33.1 | 33.9 | 15.4 | 31.8 | 9.0 | 19.1 |
| Surgery | 9.3 | 45.0 | 17.9 | 28.0 | 23.0 | 35.9 | 33.7 | 15.5 | 25.5 | 8.1 | 15.5 |
| Medicine | 9.3 | 44.2 | 17.2 | 26.5 | 22.4 | 33.0 | 30.9 | 14.8 | 25.3 | 8.1 | 14.3 |

Table 3: Duration spent on individual ALS modules stratified by grade, profession and specialty background (minutes)

| Emergency | 10.0 | 45.2 | 18.2 | 27.6 | 23.4 | 38.3 | 32.6 | 16.4 | 25.6 | 9.1 | 18.3 |
|---------------|------|------|------|------|------|------|------|------|------|-----|------|
| Critical Care | 11.1 | 52.1 | 20.8 | 30.7 | 23.8 | 46.1 | 38.2 | 18.9 | 32.0 | 9.8 | 18.5 |

212

Table 3 demonstrates the homogeneity between time spent on individual e-learning modules when stratified by specialty. Those from a critical care background spent slightly more time on modules compared to others, but this is likely due to the high proportion of nurses participating in the e-ALS course from this specialty (357/487, 73.3%).

216

217 DISCUSSION

This study has shown that previous experience in life support courses and being a core member of the resuscitation team predicts a favourable outcome on an e-ALS course. It also identifies the extent to which different candidate groups access the e-learning material and highlights particular modules that may be more challenging. Time spent accessing e-learning material was not related to course outcome; this was thought to be because participants who utilise these skills on a daily basis are already familiar with the material and thus require less time to re-familiarise themselves.

There are increasing pressures to minimise time spent on courses for both participants and faculty and to improve outcomes. It has been postulated that pre-course preparation could lead to either better outcomes or a reduced amount of face-to-face time needed on the course. This could in theory lead to equivalent or better participant outcomes with less resources (time off work for faculty/participants, venue hire etc.). There is very little evidence relating specifically to pre-learning for advanced life support courses, so this study goes some way towards filling that void.

Perkins et al.¹¹ looked at one example of pre-course preparation. This open label, multicentre RCT was a study of 572 participants on Resuscitation Council (UK) ALS courses. The control group received the course manual four weeks before the course. The intervention group received the course manual and also a CD with an interactive e-learning simulation programme. Although there were no significant differences in the primary outcome (performance during a standard cardiac arrest simulation), user evaluations were favourable. The results however cannot necessarily be generalised to all other types of pre-course learning or pre-course learning for other populations/course groups.

A multi-centre RCT demonstrated equivalence in outcome when comparing e-ALS and c-ALS learning methods and was significantly less costly to deliver.⁸ The findings of this were corroborated by a large observational study of 27,170 participants which demonstrated almost identical assessment outcomes for participants enrolled on either a
 c-ALS or e-ALS course.⁹ These studies were a comparison of a standard life support course against specific pre-course
 e-learning associated with a shorter duration hybrid life support course.

The topic of pre-course learning was addressed during the 2015 ILCOR international consensus on science process. It was felt that a specific recommendation for or against pre-course preparation in ALS courses was too speculative due to the lack of evidence in the literature.¹⁵ These findings were balanced with a statement highlighting the considerable ambiguity in the definition of "pre-course learning" and the difficulty in comparing single interventions like a pre-course CD¹¹ with an intervention followed by a hybrid version of the face-to-face element.^{8,9}

With regard to the findings from this study, we found some unexpected and interesting results. The most surprising 246 247 result was that time spent accessing prerequisite e-learning material was actually associated with worse assessment 248 and overall course outcome in the univariate regression. On further analysis however, this is explained by the fact that those with greater clinical experience spent less time accessing the e-learning but paradoxically performed 249 250 better in the course assessments. This demonstrates the educational notion that when learning can be based on previous experience; it will normally lead to improved outcomes. This is demonstrated in the multivariate regression 251 where time spent on e-learning was no longer a significant predictor of overall course outcome. Increased age was 252 253 associated with significantly poorer assessment outcomes. Whilst there is a paucity of evidence for the literature regarding the effect of age on ALS outcomes, this pattern has been found in BLS studies and has been attributed to 254 skill decline over time^{16,17} and psychological factors where younger participants are more motivated to learn.¹⁸ It has 255 256 been found that those working in a high risk area for area for cardiac arrest were more motivated to learn life support skills.¹⁹ 257

258

Participants with greater experience in managing critically unwell patients (paramedics, middle grade doctors, previous ALS/ILS experience, core member of the resuscitation team) performed substantially better in the CAS-Test and overall result. This should not come as a surprise, but is a useful insight for course organisers when identifying participants at the start of a course who do not fall into these groups and may benefit from additional support.

263

The e-learning package allows participants to dictate their own level of access dependent upon their prior knowledge, experience and specialty background. They can access material at an appropriate time for them and dedicate a greater amount of time to their weaker knowledge areas. The need for this degree of flexibility is demonstrated by the vastly different durations spent accessing the online content. This is exemplified in table 3 which highlights that certain candidate groups (junior nurses and operating department practitioners) spent twice as long on the 'Monitoring, rhythm recognition and 12-lead ECG' module compared to middle grade doctors, perhaps because they do not routinely utilise such skills on a daily basis. The flexibility that the e-ALS course creates is just one reason amongst many why participant satisfaction is greater on e-learning courses than compared to traditional didactic courses.^{20,21}

273

274 Limitations and Further Research

The main limitation of this exploratory study is its observational nature. This means that the authors are only able to suggest causality when determining whether independent variables influence assessment outcome. A specifically designed RCT would be needed to establish a cause-effect relationship on assessment outcome.

278

Time is not necessarily an accurate marker of whether participants have truly engaged with the material and as this 279 study has shown, it is significantly confounded by clinical experience (ie if participants are already well versed in ECG 280 interpretation they will spend less time on this module). Furthermore, different individuals possess a spectrum of 281 learning abilities with some participants learning faster than others. A proportion of participants may have chosen to 282 preferentially utilise the course manual as opposed to the e-learning package and others may leave the e-learning 283 running whilst not at the computer, providing a falsely elevated time spent accessing the material. There remains a 284 285 need for more specific markers for determining whether participants have truly engaged with the e-learning material. 286

287

A final limitation is that it does not determine whether accessing e-learning actually affects patient outcome from cardiac arrest. Whilst this should be the overriding aim behind all resuscitation-related research, such studies are very difficult to achieve. The authors believe however, that by critically appraising course outcome data and continuously improving the delivery methods of resuscitation courses this will ultimately improve the care of the critically unwell patient.

293

294 Conclusion

| 295 | Clinical experience through core membership of cardiac arrest teams and previous ILS or ALS training were |
|-----|--|
| 296 | independent predictors of performance on the e-ALS course whilst time spent accessing e-learning materials did not |
| 297 | affect course outcomes. The large variation in time spent accessing e-learning reflects the diverse nature of |
| 298 | participants on our e-ALS courses and the spectra of learning needs that they possess. This supports the blended |
| 299 | approach to e-ALS which allows participants to tailor their e-learning experience to their specific needs. |

300

301 CONFLICTS OF INTEREST

302 CJT is a Trainee Representative for the ALS Subcommittee for the Resuscitation Council (UK). ASL is Honorary 303 Secretary of the Resuscitation Council (UK) and a member of the European Resuscitation Council ALS Course 304 Committee. IB is an Educator for the Resuscitation Council (UK). SH is Director of Course Development and Training 305 for the Resuscitation Council (UK). SB-A is Project and Development Manager for the Resuscitation Council (UK). GDP 306 is Chair of the ALS Subcommittee for the Resuscitation Council (UK) and member of the European Resuscitation 307 Council ALS Course Committee.

308

309 FUNDING

310 GDP is supported by the National Institute for Health Research (Senior Investigator) and Intensive Care Foundation 311 (Director of Research).

312

313 ACKNOWLEDGEMENTS

314 The authors would like to acknowledge the ALS instructors and candidates who have participated in an e-ALS course

over the duration of this study. They also acknowledge the ongoing work of the ALS subcommittee of the

Resuscitation Council (UK) to oversee the hundreds of ALS courses that take place each year.

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| 372 | LEGENDS TO FIGURES |
|-------------------|--|
| 373 | Table 1: Participant demographics on the e-ALS course and time spent on e-learning |
| 374 | Table 2: Univariate predictors of assessment outcomes |
| 375 376 | Table 3: Duration spent on individual ALS modules stratified by grade, profession and specialty background |
| 377 | Figure 1: Multivariate analysis demonstrating factors that influence CAS-Test outcome |
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| | Mean | Mean | Mean | P-value | CAS- | Test | Odds | P- | Ove | rall | Odds | P- |
|-------------|----------|--------|------------|---------|------|------|----------|-------|--------|--------|----------|-------|
| | post e- | post- | difference | | res | ult | ratio of | value | course | result | ratio of | value |
| | learning | course | (95% CI) | | | | CAS- | | | | course | |
| Independent | MCQ | MCQ | | | | | Test | | | | Pass | |
| variables | score | score | | | | | Pass | | | | (95% CI) | |
| | | | | | Pass | Fail | (95% | | Pass | Fail | | |
| | | | | | (%) | (%) | CI) | | (%) | (%) | | |

| | | | | Health | icare p | 101622 | | | | | | |
|---|------|------|---------------------------------|--------|----------------|---------------|--------------------------|-------|----------------|--------------|---------------------------|--------|
| Doctor (comparison) | 84.7 | 88.7 | | | 5352 (86.0) | 871 (14.0) | | | 6095 (97.8) | 137 (2.2) | | |
| Nurse | 79.7 | 80.0 | -4.35 ([- 4.85]-[- 3.85]) | <0.001 | 1005 (81.3) | 231 (18.7) | 0.92 (0.76- 1.10) | 0.356 | 1122 (90.9) | 113 (9.1) | 0.27 (0.20- 0.37) | <0.001 |
| Medical student | 83.4 | 86.5 | -0.43 ([- 1.31]-0.45) | 0.334 | 425 (79.6) | 109 (20.4) | 0.87 (0.63- 1.20) | 0.390 | 525 (98.3) | 9 (1.7) | 2.16 (0.96- 4.48) | 0.063 |
| Operating Department Practitioner | 73.0 | 79.2 | -9.41 ([-11.13]-[- 7.69]) | <0.001 | 51 (70.8) | 21 (29.2) | 0.44 (0.25- 0.78) | 0.005 | 67 (93.1) | 5 (6.9) | 0.36 (0.13- 1.01) | 0.052 |
| Ambulance staff/ Paramedic | 81.4 | 85.4 | -2.42 ([- 4.71-[0.12]) | 0.039 | 37 (92.5) | 3 (7.5) | 3.75 (1.10- 12.85) | 0.035 | 39 (97.5) | 1 (2.5) | 2.34 (0.27- 20.54) | 0.444 |
| Resuscitation Officer | 86.6 | 90.5 | 0.98 ([- 3.18]-5.14) | 0.644 | 13 (86.7) | 2 (13.3) | 0.79 (0.17- 3.73) | 0.769 | 15 (100.0) | 0 (0) | 78518 (0- infinity) | 0.986 |
| Other | 79.9 | 83.6 | -4.27 ([- 6.00]-[- 2.53]) | <0.001 | 46 (66.7) | 23 (32.4) | 0.47 (0.27- 0.81) | 0.007 | 59 (84.3) | 11 (15.7) | 0.19 (0.09 - 0.42) | <0.001 |

Previous life support experience

| Previous ALS experience | 85.5 | 89.7 | 3.83 (3.44 – | <0.001 | 3204 (89.3) | | 2.61 | <0.001 | 3515 (98.0) | 72 (2.0) | 5.13 | <0.001 |
|--|------|------|--------------|--------|----------------|---------------|-----------------|--------|----------------|--------------|-----------------|--------|
| No previous ALS experience | 82.3 | 86.1 | 4.21) | <0.001 | 3727 (81.0) | 877 (19.0) | 、 3.07) | <0.001 | 4411 (95.6) | 205 (4.4) | (3.66- 7.19) | <0.001 |
| Previous ILS experience | 83.2 | 87.4 | -0.27 ([- | 0.172 | 4666 (85.6) | | 1.19 | 0.024 | 5302 (97.2) | 153 (2.8) | 2.18 | -0.001 |
| No previous ILS experience | 84.5 | 88.3 | 0.66]-0.12) | 0.172 | 2265 (82.7) | 473 (17.3) | (1.02- 1.39) | 0.024 | 2624 (95.5) | 124 (4.5) | (1.61- 2.95) | <0.001 |
| Core member of resuscitation team | 84.4 | 88.8 | 1.28 (0.94- | <0.001 | 3305 (88.0) | 451 (12.0) | | <0.001 | . , | 87 (2.3) | 1.47 (1.10- | 0.009 |
| Not a core member of resuscitation | 83.0 | 86.6 | 1.62) | | 3540 (81.4) | | 1.59) | | 4173 (95.7) | 189 (4.3) | 1.98) | |

| team | | | | | | | | | |
|--|--|---------------------------------|--------|--|-------------------------|--------|--|-------------------------|--------|
| Age (years) | | -0.06 ([- 0.09]-[- 0.04]) | <0.001 | | 0.96 (0.95- 0.97) | <0.001 | | 0.93 (0.92- 0.94) | <0.001 |
| Time spent on e-Learning (hours) | | -0.05 ([- 0.11]-0.00) | 0.047 | | 0.96 (0.95- 0.98) | <0.001 | | 0.98 (0.95- 1.02) | 0.367 |

[#]ST3+, middle grade equivalent ^{\$} Consultant or associate specialist

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*Manuscript redline version Click here to view linked References

e-learning in Advanced Life Support – What factors influence assessment outcome?

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Word Count: 3,063

Abstract Word Count: 257

Tables: 3

Figures: 3

Supplementary material: 1 Word Count: 2,985

Abstract Word Count: 254

Tables: 31

Figures: 34

Supplementary material: 12

ABSTRACT

Aim

To establish variables which are associated with favourable Advanced Life Support (ALS) course assessment outcomes, maximising learning effect.

Method

Between 1 January 2013 and 30 June 2014, 8,218 candidates-individuals participated in a Resuscitation Council (UK) e-learning Advanced Life Support (e-ALS) course. Candidates Participants were asked to completed 5-8 hours of online e-learning prior to attending <u>athe</u> one day modified face-to-face course. The extent to which they accessed this material was ascertained online <u>e-learning access data were collected</u> through the Learning Management System (LMS). All candidates <u>participants</u> were assessed by <u>a pre and post course MCQa multiple choice</u> <u>questionnaire (MCQ) before and after the face to face aspect alongside and</u> a practical cardiac arrest simulation (CAS-Test). Candidate Participant demographics and assessment outcomes were analysed.

Results

The mean pre-coursepost e-learning MCQ score was 83.7 (SD 7.3) and the mean post-course MCQ score was 87.7 (SD 7.9). The <u>first attempt</u> CAS-Test pass rate was 84.6% and overall pass rate 96.6%. <u>CandidatesParticipants</u> who had-with previous ALS course experience, ILS course experience, or who were a core member of the resuscitation team performed better in the post-course MCQ, CAS-Test and overall assessment. Median time spent on the e-learning was 5.2 hours (IQR 3.7-7.1). There was a large range in the degree of access to e-learning content. Increased time spent accessing e-learning had no effect on the overall result (OR 0.989, P=0.367435) on simulated learning outcome.

Conclusion

<u>Clinical experience through core membership of cardiac arrest teams and previous ILS or ALS training were</u> <u>independent predictors of performance on the ALS course whilst time spent accessing e-learning materials did not</u> <u>affect course outcomes</u>. This supports the blended approach to e-ALS which allows participants to tailor their e-<u>learning experience to their specific needs</u>.

Regular clinical experience in managing critically unwell patients is the most discriminating factor for<u>a more</u> significant predictor of ALS assessment outcome as opposed to<u>than time spent on</u> pre-course e-learning. Candidates have a spectrum of learning needs and it is imperative that they have the opportunity to shape their e-learning around prior knowledge and experience.

INTRODUCTION

The Formula for Survival¹ proposes-<u>identifies</u> three <u>critical</u> factors that influence survival from cardiac arrest: highquality research, efficient education of patient caregivers and <u>a slickan effective</u> chain of survival <u>from the early</u> <u>recognition of cardiac arrest through to post resuscitation care</u>.² Advanced Life Support (ALS) courses, which address both the second and third aspects of this formula, are used internationally to train healthcare personnel how to manage patients in cardiac arrest. Previous studies have linked candidate participation on ALS courses to improved patient-outcomes from cardiac arrest.³⁻⁵ Courses use multimodal delivery methods to equip candidates <u>participants</u> with background scientific knowledge, targeted clinical skills and non-technical skill development. This blended learning approach is from course manuals, online e-learning material, didactic lectures, hands-on skill stations and formative assessment. In the United Kingdom (UK) and many other countries, successful completion of an ALS course (or similar) is essential required for healthcare professionals who manage acutely unwell patients on a regular basis.

The Resuscitation Council (UK) has a 25 year history in delivering ALS courses₂⁶-and year on year sees increasing demand for such courses. A total of 20,268 candidates individuals participated in an ALS course between January 2015 and December 2015.^{6,7} In 2011, a strategic decision was taken to meet increasing demand, and to increase the

flexibility of learning for candidatesparticipants. The Resuscitation Council (UK) launched a novel e-learning ALS course (e-ALS), as an alternative to the conventional two day face-to-face (c-ALS) course, valuing this key educational approach of blended learning. This constitutes 5-8 hours of online e-learning that is undertaken pre-course, followed by attendance for a condensed, focussed one day face-to-face element. A multi-centre randomised control trial in 2012⁸ and a large observational study of 27,170 candidatesparticipants in 2015⁹ demonstrated almost identical assessment outcomes for candidatesparticipants enrolled upon either c-ALS or e-ALS. The findings of these two studies consolidated the emerging role of the Resuscitation Council (UK) e-ALS course. Whilst outcome data were comparable in the observational study,⁹ it did not assess the extent to which those candidatesparticipants enrolled on the e-ALS course actually accessed the e-learning material, or its effect on assessment outcomes.

Previous studies investigating the utility of e-learning; <u>all display a common limitation, whereby participants often do</u> <u>not fully access the e-learning material</u>.^{10,11} <u>Jensen et al.</u> investigated e-learning as a means for retaining ALS competency <u>but found that only 57.5% of candidates accessed all of the stipulated modules</u>.¹⁰ <u>Similarly Perkins et al. found that</u> <u>only 64% of candidates accessed pre-course e-learning via a CD prior to attending an ALS course</u>.¹¹ <u>This has several</u> <u>adverse-outcomes</u>; firstly it increases the likelihood of a type II error,<u>This limitation was acknowledged by the</u> <u>authors, who postulated that any true difference between the control and intervention groups</u> <u>-whereby any</u> <u>difference between the groups is not identified may not have been detected</u> because the intervention ha<u>d</u>s not been implemented effectively. Secondly, it provides challenges for ALS course organisers to establish exactly what extent of e-learning has been undertaken by the <u>candidatesparticipants</u> prior to attending a face-to-face course. Whilst in theory this allows personalisation of the learning experience, it also potentially reduces the standardisation of content delivered to those on an ALS course. Consequently, it is currently unknown whether making e-learning noncompulsory adversely affects candidate outcome.

This study was designed to access the aforementioned observational study data set,⁹ analysing the extent to which candidatesparticipants access pre-requisite e-learning material, establishing the effect on candidate outcome in their subsequent ALS assessments. In doing this, study authors intend to highlight independent predictors of successful ALS course outcome.

METHODS

Setting and Participants

ALS <u>candidatesparticipants</u> voluntarily enrolled on a one-day e-ALS course at one of 94 national training centres. Each candidate <u>was required to registerregistered</u> on the Resuscitation Council (UK) Learning Management System (LMS) prior to attending the course. <u>CandidatesParticipants</u> were from a wide range of healthcare professions and stages of training.

The e-ALS Course

The e-ALS course consists of 5-8 hours of e-learning content covering essential ALS topics. Each candidate <u>is given</u> access to the LMS 8 weeks prior to their course and is asked to complete the 12 electronic learning modules. Additionally, Candidatesparticipants receive the physical copy of the ALS course manual a minimum of at least four weeks before the course date. Progress on the e-learning contente-learning progress is monitored by the course centres and this information is available to the faculty at the start of the course. CandidatesParticipants are free to choose to personalise their learning experience – undertaking as little or as much of the e-learning progress they feel necessary although there are three compulsory modules: ALS in perspective; advanced life support algorithm; non-technical skills (progress data <u>areis</u> not routinely collected on the LMS for this module as it was only introduced in 2013).

In addition to the three compulsory modules listed above, the There are nine non-compulsory modules are: causes and prevention of cardiac arrest; acute coronary syndromes; monitoring, rhythm recognition and 12 lead ECG; bradycardia, pacing and drugs; tachycardia, cardioversion and drugs; special circumstances; post resuscitation care; arterial blood gas analysis; and decisions relating to resuscitation.

On completion of the e-learning-package, candidatesparticipants undertake a compulsory pre-course-multiple choice guestionnaire (MCQ), although their results in this are formative and do not affect the candidatesparticipants' postcourse outcome. After completing the one-day face to face aspect, each candidate is subject toundertakes a compulsory-post-course MCQ and a practical cardiac arrest management simulation test (CAS-Test). In order to achieve ALS competency candidatesparticipants need to pass both the post-course MCQ and the CAS-Test.of these aspects. CandidatesParticipants are permitted two attempts at the MCQ and three attempts at the CAS-Test. The pre and post-course MCQs comprise 30 different stem questions, with each having four true/false answers, creating a total of 120 questions to answer. The pass mark is 75%. The CAS-Test simulations are criterion based and are well validated.^{12,13} They assess candidatesparticipants' abilities in patient assessment, formulating a treatment plan and leadership of the cardiac arrest team. Overall scores and pass/fail data are recorded.

Statistical analysis

Demographic data <u>were</u>is collected for each participant at the time of registration on the LMS. Anonymised data <u>we</u>are transferred to Microsoft Excel (*Microsoft Corporation, Redmond, USA*) and subject to statistical analysis <u>usinganalysed using</u> SPSS 23 (*IBM, Armonk, USA*) and <u>R statistical program Version 3.3.1</u>.¹⁴ <u>Categorical baseline</u> <u>characteristics were summarised using counts and percentages while continuous baseline characteristics - spent on e-</u><u>learning were summarised using median and interquartile range (IQR)</u>.

A multivariable logistic regression model was fitted to assess which variables predict whether a trainee passes the CAS-Test on the first attempt. Trainees attending the same course session tend to have similar outcomes⁸ and so the multivariable logistic regression model included a random effects term for course session. A similar model was fitted to assess which variables predict whether a trainee passes the overall test. Odds ratios (OR), 95% confidence intervals and p-values from the multivariable random effects logistic regression models were reported. To assess which variables predict the MCQ score of a trainee in the first attempt, MCQ scores were analysed by fitting a linear mixed model with a random effects term for course session. Mean difference in MCQ scores, 95% confidence intervals and p-values from the linear missed model were reported. An analysis of standard residuals was carried out and outliers removed. Descriptive statistics were calculated. Independent t-tests, one-way ANOVAs and linear regression models were utilised to determine differences between continuous variables, and logistic regression was used for the dichotomous variables. Significant predictors of assessment outcome were entered into a multivariate logistic regression model and reported as odds ratios (OR) and 95% confidence intervals. All independent variables were assessed for co-linearity before running the models. Co-linearity was assessed by independently entering each independent variable into a logistic regression with the remaining variables entered as dependent variables. Collinearity diagnostics were calculated and the variance inflation factor (VIF) in all instances was <1. In all models, Mmissing data were excluded from the complete case analysis by a listwise deletion. Statistical significance was set at P-values of <0.05.

RESULTS

450 e-ALS courses took place between 1st January 2013 and 30th June 2014 at 94 different ALS centres across the

UK.

Demographics

8,218 participants were enrolled on one of 450 e-ALS courses during the study period.8,218 candidates undertook an e-ALS course during the study period. Mean age was 32.0 years (SD 8.2). 15 candidatesparticipants started but failed to complete the course. 1.8% of the total candidatesparticipants had a degree of missing data and this wasthese were excluded from the analysis. Any missing data occurred due to incomplete data entry by candidatesparticipants or local course facilitators on the LMS. Stratified participant demographics are displayed below in table 1 in addition to time spent accessing the e-learning and corresponding pass rates.

| Table 1: Participant demographics on the e-ALS course and time spent on e-learning | | | | | | | | | |
|--|------------------|--------------------------------------|---|---|-----------------------------|--|--|--|--|
| <u>Characteristics/outcomes</u> | <u>n,</u> (%) | Hours spent on compulsory modules | Hours spent on non-compulsory modules | <u>Total hours</u> spent on e- Learning | Overall pass rate (%) | | | | |
| Healthcare background | | | | | | | | | |

| Doctor | <u>6236</u> | | | | <u>6095</u> |
|---------------------|--------------|----------------------|----------------------|----------------------|---------------|
| Range | (75.9) | <u>0-13.2</u> | <u>0-21.0</u> | <u>0-24.0</u> | <u>(97.8)</u> |
| Mean (SD) | | <u>1.1 (0.8)</u> | <u>4.1 (2.5)</u> | <u>5.3 (3.0)</u> | |
| <u>Median (IQR)</u> | | <u>0.9 (0.7-1.4)</u> | <u>3.8 (2.6-5.3)</u> | <u>4.9 (3.4-6.7)</u> | |
| <u>Nurse</u> | 1244 | | | | <u>1122</u> |
| Range | (15.1) | <u>0-8.9</u> | <u>0-17.2</u> | 0-24.0 | <u>(90.9)</u> |
| Mean (SD) | | <u>1.3 (0.9)</u> | <u>5.4 (3.4)</u> | <u>6.9 (3.9)</u> | |
| Median (IQR) | | <u>1.1 (0.8-1.6)</u> | <u>4.8 (3.4-6.6)</u> | <u>6.2 (4.5-8.5)</u> | |
| Medical student | 534 | | | | 525 (98.3) |
| Range | <u>(6.5)</u> | 0-4.7 | <u>0-16.0</u> | <u>0-17.6</u> | |
| <u>Mean (SD)</u> | | <u>1.1 (0.7)</u> | <u>4.4 (2.2)</u> | <u>5.6 (2.6)</u> | |
| <u>Median (IQR)</u> | | <u>0.9 (0.7-1.3)</u> | <u>4.1 (2.9-5.6)</u> | <u>5.3 (4.0-6.9)</u> | |

| Operating Department | 72 | Γ | | T | 67 (02 1) |
|---|---------------------|-----------------------------------|--------------------------------|--------------------------------|----------------------|
| Operating Department | <u>73</u> (0.9) | | | | <u>67 (93.1)</u> |
| Practitioner | <u>(0.9)</u> | | | | |
| Range | | <u>0-6.9</u> | <u>0-11.5</u> | 0.2-21.4 | |
| Mean (SD) | | <u>1.3 (1.1)</u> | <u>5.3 (2.7)</u> | <u>7.0 (3.7)</u> | |
| <u>Median (IQR)</u> | | <u>1.0 (0.8-1.4)</u> | <u>5.2 (3.5-7.2)</u> | <u>6.4 (4.8-8.8)</u> | |
| Ambulance staff/ | <u>40</u> | | | | <u>39 (97.5)</u> |
| <u>Paramedic</u> | <u>(0.5)</u> | | | | |
| <u>Range</u> | | <u>0-6.4</u> | <u>0-18.7</u> | <u>0-22.7</u> | |
| <u>Mean (SD)</u> | | <u>1.3 (1.2)</u> | 4.7 (3.1) | <u>6.5 (4.0)</u> | |
| <u>Median (IQR)</u> | | <u>1.1 (0.7-1.9)</u> | <u>4.8 (3.3-5.7)</u> | <u>6.4 (4.4-8.0)</u> | |
| Resuscitation Officer | 15 | | | | 15 (100.0) |
| Range | (0.2) | 0.6-3.0 | 4.3-9.5 | 5.1-10.4 | |
| Mean (SD) | | 1.3 (0.7) | 6.1 (1.5) | 7.5 (1.7) | |
| Median (IQR) | | 1.0 (0.8-2.1) | 6.1 (4.8-7.1) | 7.5 (5.7-9.2) | |
| Other | 74 | | <u></u> | | 62 (84.9) |
| | | <u>0-5.5</u> | 0-18.0 | 0-20.6 | 02 (04.9) |
| <u>Range</u> Mean (SD) | 10.9] | <u>0-5.5</u> 1.4 (0.9) | <u>6.0 (3.4)</u> | <u>0-20.6</u> 7.8 (4.1) | |
| | 1 | | | | |
| Median (IQR) | - | <u>1.2 (0.9-1.5)</u> | <u>4.8 (3.7-7.5)</u> | <u>6.7 (5.0-9.7)</u> | |
| <u>Not available</u> | <u>2</u> | | | | |
| | | Stage of tra | aining | 1 | |
| Medical Student | <u>537</u> | | | | <u>526</u> |
| <u>Range</u> | <u>(6.5)</u> | <u>0-4.7</u> | <u>0-16.0</u> | <u>0-17.6</u> | <u>(98.0)</u> |
| <u>Mean (SD)</u> | | <u>1.1 (0.7)</u> | <u>4.4 (2.2)</u> | <u>5.6 (2.6)</u> | |
| Median (IQR) | | <u>0.9 (0.7-1.3)</u> | 4.1 (2.9-5.6) | <u>5.3 (4.0-6.9)</u> | |
| Foundation Year 1 | 1650 | | | | 1624 |
| Doctor | (20.1 | | | | (98.4) |
| Range | | 0-7.0 | 0-21.0 | 0-21.7 | · · · · |
| Mean (SD) | | 1.1 (0.7) | 4.0 (2.2) | 5.2 (2.6) | |
| Median (IQR) | | <u>0.9 (0.7-1.3)</u> | <u>3.8 (2.7-5.2)</u> | 4.9 (3.6-6.5) | |
| Foundation Year 2 | 1663 | 0.5 (0.7 1.5) | 5.6 (2.7 5.2) | 4.5 (5.6 6.5) | 1639 |
| | (20.2) | | | | (98.6) |
| Doctor | (20.2 | | 0.40.4 | 0.00.0 | (98.0) |
| Range | | <u>0-10.0</u> | <u>0-18.4</u> | <u>0-20.8</u> | |
| Mean (SD) | | <u>1.1 (0.8)</u> | <u>4.1 (2.3)</u> | <u>5.3 (2.8)</u> | |
| <u>Median (IQR)</u> | | <u>0.9 (0.7-1.3)</u> | <u>3.9 (2.7-5.2)</u> | <u>5.0 (3.6-6.6)</u> | |
| Junior Grade Doctor | <u>794</u> | | | | <u>768</u> |
| <u>(ST1/ST2)</u> | <u>(9.7)</u> | | | | <u>(96.8)</u> |
| Range | | <u>0-9.4</u> | <u>0-20.6</u> | <u>0-24.0</u> | |
| <u>Mean (SD)</u> | | <u>1.2 (0.8)</u> | 4.3 (2.7) | <u>5.5 (3.3)</u> | |
| Median (IQR) | | <u>1.0 (0.7-1.5)</u> | <u>3.7 (2.6-5.4)</u> | 4.9 (3.5-7.0) | |
| Middle Grade Doctor [#] | 1465 | | | | 1434 |
| Range | (17.8 | <u>0-13.2</u> | 0-20.8 | 0-23.5 | (97.9) |
| Mean (SD) | | 1.1 (0.8) | 3.9 (2.5) | 5.1 <u>(2.9)</u> | · |
| Median (IQR) | | 0.9 (0.7-1.4) | 3.5 (2.3-5.0) | 4.7 (3.2-6.5) | |
| Senior Grade Doctor ^{\$} | 488 | <u>0.0 (0.7 1.17</u> | <u>515 (115 515)</u> | | 4 <u>69</u> |
| Range | | <u>0-5.1</u> | <u>0-17.7</u> | 0-21.2 | <u>469</u> (96.1) |
| <u>Mean (SD)</u> | (3.3) | <u>0-5.1</u> 1. <u>2 (0.9)</u> | <u>0-17.7</u> 4.1 (2.7) | <u>0-21.2</u> 5.4 (3.4) | (50.1) |
| | | | | | |
| Median (IQR) | 4000 | <u>1.0 (0.8-1.5)</u> | <u>3.7 (2.5-5.3)</u> | <u>4.9 (3.3-7.1)</u> | 000 |
| Junior Nurse (Band 4-6) | 1002 | | 0.47.0 | | <u>886</u> |
| Range | <u>(12.2</u> | <u>0-8.9</u> | <u>0-17.2</u> | <u>0-23.1</u> | <u>(88.4)</u> |
| | 1 | <u>1.3 (0.9)</u> | <u>5.0 (3.2)</u> | <u>7.1 (3.9)</u> | |
| <u>Mean (SD)</u> | | | | In | 1 |
| <u>Mean (SD)</u> Median (IQR) | | <u>1.1 (0.8-1.6)</u> | <u>4.9 (3.5-6.7)</u> | <u>6.4 (4.7-8.7)</u> | |
| | <u>395</u> | <u>1.1 (0.8-1.6)</u> | <u>4.9 (3.5-6.7)</u> | <u>6.4 (4.7-8.7)</u> | <u>378</u> |
| Median (IQR) | <u>395</u> (4.8) | <u>1.1 (0.8-1.6)</u> 0-6.8 | <u>4.9 (3.5-6.7)</u> 0-15.4 | <u>6.4 (4.7-8.7)</u> 0-24.0 | <u>378</u> (95.5) |
| Median (IQR) Senior Nurse (Band 7-9) | | | | | |

| Other 223 Image 0-18.7 0-22.7 90.2 Range 1.6 (1.2) 5.9 (3.3) 7.6 (4.2) 90.2 Median (IQR) 1.2 (0.9-1.9) 5.3 (3.5-7.7) 6.9 (4.9-9.5) 1 Not available 1 Image 1.2 (0.9-1.9) 5.3 (3.5-7.7) 6.9 (4.9-9.5) 1 Not available 1 Image Image Image Image 1 Not available 1 Image |
|--|
| Mean (SD) Median (IQR) 1.6 (1.2) 1.2 (0.9-1.9) 5.9 (3.3) 5.3 (3.5-7.7) 7.6 (4.2) 6.9 (4.9-9.5) Not available 1 Image 6.9 (4.9-9.5) Image No 4615 (56.2) Image 1.2 (0.8) Image 4411 (95.6) Median (IQR) 4615 (56.2) Image 0-21.0 0-24.0 0-24.0 (95.6) 4411 (95.6) Mean (SD) 1.2 (0.8) 4.5 (2.7) 5.8 (3.2) 1mage 4413 (95.6) Yes 3593 Range 1.0 (0.7-1.4) 4.1 (3.9-7.2) 5.3 (3.8-7.2) 1mage Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) 1mage 3515 (98.0) Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) 1mage 3515 (98.0) Median (IQR) 1.0 (0.7-1.4) 3.8 (2.5-5.3) 5.3 (3.9-7.2) 1mage Not available 10 1mage 1mage 1mage 1mage |
| Median (IQR) 1.2 (0.9-1.9) 5.3 (3.5-7.7) 6.9 (4.9-9.5) Not available 1 Not available 1 Not available 1 Not available 1 Previous ALS experience <th< td=""></th<> |
| Not available 1 Image Image 4615 Image 4411 Range (56.2) 0-10.0 0-21.0 0-24.0 (95.6) Mean (SD) 1.2 (0.8) 4.5 (2.7) 5.8 (3.2) (95.6) Median (IQR) 1.0 (0.7-1.4) 4.1 (3.9-7.2) 5.3 (3.8-7.2) (98.0) Yes 3593 0-21.0 0-24.0 (98.0) Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) (98.0) Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) (98.0) Mean (SD) 1.0 (0.7-1.4) 3.8 (2.5-5.3) 5.3 (3.9-7.2) (98.0) Median (IQR) 1.0 (0.7-1.4) 3.8 (2.5-5.3) 5.3 (3.9-7.2) (98.0) |
| Previous ALS experience No 4615 4411 Range (56.2) 0-10.0 0-21.0 0-24.0 (95.6) Mean (SD) 1.2 (0.8) 4.5 (2.7) 5.8 (3.2) 5.3 (3.8-7.2) 5.3 (3.8-7.2) Median (IQR) 3593 0-13.2 0-21.0 0-24.0 (98.0) Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) 3515 Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) 4.1 (3.9-7.2) Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) 4.1 (3.9-7.2) Median (IQR) 1.0 (0.7-1.4) 3.8 (2.5-5.3) 5.3 (3.9-7.2) 4.1 (3.9-7.2) Not available 10 4.1 (2.6) 5.4 (3.2) 4.1 (3.9-7.2) 4.1 (3.9-7.2) |
| No 4615 4411 Range (56.2) 0-10.0 0-21.0 0-24.0 (95.6) Mean (SD) 1.2 (0.8) 4.5 (2.7) 5.8 (3.2) (95.6) Median (IQR) 1.0 (0.7-1.4) 4.1 (3.9-7.2) 5.3 (3.8-7.2) (98.0) Yes 3593 0-21.0 0-24.0 (98.0) Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) Median (IQR) 1.0 (0.7-1.4) 3.8 (2.5-5.3) 5.3 (3.9-7.2) Not available 10 0 0 0 |
| Range (56.2) 0-10.0 0-21.0 0-24.0 (95.6) Mean (SD) 1.2 (0.8) 4.5 (2.7) 5.8 (3.2) 1.0 (0.7-1.4) 5.3 (3.8-7.2) 1.0 (0.7-1.4) 5.3 (3.8-7.2) 1.0 (0.7-1.4) |
| Range (56.2) 0-10.0 0-21.0 0-24.0 (95.6) Mean (SD) 1.2 (0.8) 4.5 (2.7) 5.8 (3.2) 1.0 (0.7-1.4) 5.3 (3.8-7.2) 1.0 (0.7-1.4) 5.3 (3.8-7.2) 1.0 (0.7-1.4) |
| Mean (SD) Median (IQR) 1.2 (0.8) 1.0 (0.7-1.4) 4.5 (2.7) 4.1 (3.9-7.2) 5.8 (3.2) 5.3 (3.8-7.2) Yes 3593 |
| Yes 3593 3515 Range (43.8) 0-13.2 0-21.0 0-24.0 (98.0) Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) (98.0) Median (IQR) 1.0 (0.7-1.4) 3.8 (2.5-5.3) 5.3 (3.9-7.2) (10) |
| Range (43.8) 0-13.2 0-21.0 0-24.0 (98.0) Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) 10 |
| Mean (SD) 1.2 (0.8) 4.1 (2.6) 5.4 (3.2) Median (IQR) 1.0 (0.7-1.4) 3.8 (2.5-5.3) 5.3 (3.9-7.2) Not available 10 10 10 |
| Median (IQR) 1.0 (0.7-1.4) 3.8 (2.5-5.3) 5.3 (3.9-7.2) Not available 10 |
| Median (IQR) 1.0 (0.7-1.4) 3.8 (2.5-5.3) 5.3 (3.9-7.2) Not available 10 |
| |
| |
| Previous ILS experience* |
| <u>No</u> <u>2704</u> <u>2624</u> |
| Range (32.9)0-8.3 0-21.0 0-24.0 (95.5) |
| Mean (SD) 1.2 (0.9) 4.5 (2.8) 5.8 (3.4) |
| Median (IQR) <u>1.0 (0.8-1.5)</u> <u>4.1 (2.7-5.8)</u> <u>5.3 (3.7-7.4)</u> |
| Yes 5466 5302 |
| Range (67.1)0-13.2 0-20.9 0-24.0 (97.2) |
| Mean (SD) 1.1 (0.8) 4.3 (2.6) 5.5 (3.1) |
| Median (IQR) <u>1.0 (0.7-1.4)</u> <u>4.2 (2.9-5.7)</u> <u>5.4 (3.8-7.3)</u> |
| Not available 48 |
| Core member of resuscitation team |
| <u>No</u> 4373 4173 |
| Range (53.8)0-9.4 0-21.0 0-23.5 (95.7) |
| Mean (SD) 1.2 (0.8) 4.5 (2.7) 5.8 (3.2) |
| Median (IQR) <u>1.0 (0.8-1.5)</u> <u>4.2 (2.9-5.7)</u> <u>5.4 (3.9-7.3)</u> |
| <u>Yes 3759</u> <u>3668</u> |
| Range (46.2)0-13.2 0-21.0 0-24.0 (97.7) |
| Mean (SD) 1.1 (0.8) 4.1 (2.6) 4.9 (3.1) |
| Median (IQR) 0.9 (0.7-1.4) 3.8 (2.6-5.3) 4.9 (3.5-6.8) |
| Not available 86 |
| Total 8218 7926 |
| Range 0-13.2 0-21.0 0-24.0 (96.6%) |
| Mean (SD) 1.2 (2.8) 4.3 (2.7) 5.6 (3.2) |
| Median (IQR) <u>1.0 (0.74-1.4)</u> <u>4.0 (2.7-5.5)</u> <u>5.2 (3.7-7.1)</u> |

*Immediate Life Support *ST3+, middle grade equivalent * Consultant or associate specialist

| Tal | Table 1: Participant demographics on the e ALS course and time spent on e learning | | | | | | | | | | |
|--------------------------|--|--|--|--|--|--------------------------------------|--|--|--|--|--|
| Healthcare background | Total (%) | Median hours spent on compulsory modules (IQR) | Median hours spent on non-compulsory modules (IQR) | Median total hours spent on e-Learning (IQR) | Median completed modules (max 11) | Overall pass rate (%) | | | | | |
| Doctor | 6236 (75.9) | 0.9 (0.7-1.4) | 3.8 (2.6-5.3) | 4 .9 (3.4-6.7) | 11 | 6095 (97.8) | | | | | |

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| Nurse | 12 44 | 1.1 | 4.8 | 6.2 | 11 | 1122 |
|--------------------------|--|--|--|--|---------------|--------------------------------------|
| | (15.1) | (0.8-1.6) | (3.4-6.6) | (4.5-8.5) | | (90.9) |
| Medical student | 534 | 0.9 | 4.1 | 5.3 | 11 | 525 (98.3) |
| medical Student | (6.5) | (0.7-1.3) | (2.9-5.6) | (4.0-6.9) | | 525 (50.5) |
| Operating | 73 | 1.0 | 5.2 | 6.4 | 11 | |
| Department | 73 (0.9) | (0.8-1.4) | (3.5-7.2) | 0.4 (4.8-8.8) | | 67 (93.1) |
| Practitioner | (0.9) | | | (4.0-0.0) | | |
| Ambulance staff/ | 40 | 1.1 | 4.8 | 6.4 | 11 | 39 (97.5) |
| Paramedic | (0.5) | (0.7-1.9) | (3.3-5.7) | (4.4-8.0) | | 39 (97.3) |
| Resuscitation | 15 | 1.0 | 6.1 | 7.5 | 11 | 15 (100.0) |
| Officer | (0.2) | (0.8-2.1) | (4.8-7.1) | (5.7-9.2) | | 13 (100.0) |
| Other | 74 | 1.2 | 4.8 | 6.7 | 11 | (2)(24,0) |
| Uther | (0.9) | (0.9-1.5) | (3.7-7.5) | (5.0-9.7) | | 62 (84.9) |
| Not available | 2 | | | | | |
| | | | Stage of training | | | • |
| | 537 | 0.9 | <u>4,1</u> | , <u>5.3</u> | 11 | 526 |
| Medical Student | (6.5) | (0.7-1.3) | (2.9-5.6) | (4.0-6.9) | | (98.0) |
| Foundation Year 1 | 1650 | 0.9 | 3.8 | 4.9 | 11 | 1624 |
| Doctor | $\frac{1000}{(20.1)}$ | (0.7-1.3) | (2.7-5.2) | (3.6-6.5) | | (98.4) |
| Foundation Year 2 | 1663 | 0.9 | 3.9 | <u>5.0</u> | 11 | 1639 |
| Doctor | $\frac{1000}{(20.2)}$ | (0.7-1.3) | (2.7-5.2) | (3.6-6.6) | | (98.6) |
| Junior Grade | 794 | 1.0 | <u>3.7</u> | 4 <u>.9</u> | 11 | 768 |
| Doctor (ST1/ST2) | (9.7) | (0.7-1.5) | (2.6-5.4) | (3.5-7.0) | | (96.8) |
| Middle Grade | 1465 | 0.9 | 3.5 | 4.7 | 11 | 1434 |
| Doctor [#] | (17.8) | (0.7-1.4) | (2.3-5.0) | (3.2-6.5) | 11 | (97.9) |
| Senior Grade | 488 | 1.0 | <u>3.7</u> | 4 <u>9</u> | 11 | 4 69 |
| Doctor ^{\$} | (5.9) | (0.8-1.5) | (2.5-5.3) | (3.3-7.1) | | (96.1) |
| Junior Nurse | 1002 | (0.0 1.0) 1.1 | 4 <u>.9</u> | 6.4 | 11 | 886 |
| (Band 4 6) | $\frac{1002}{(12.2)}$ | (0.8-1.6) | (3.5-6.7) | (4.7-8.7) | 11 | (88.4) |
| Senior Nurse | 395 | (0.0 1.0) 1.1 | 4.5 | <u>5.9</u> | 11 | 378 |
| (Band 7-9) | (4.8) | (0.8-1.6) | (3.1-6.5) | (4.2-8.1) | | (95.5) |
| | 223 | 1.2 | 5.3 | 6.9 | 11 | 202 |
| Other | (2.7) | 1.2 (0.9-1.9) | (3.5-7.7) | (4.9-9.5) | | (<u>90.2)</u> |
| Not available | 1 | (0.0 1.0) | (3.37.77) | (1.5 5.5) | | (30.2) |
| | - | | Previous ALS experi | ence | I | 1 |
| | 4615 | 1.0 | 4.1 | 5,3 | 11 | 4402 |
| Never | 4015 (56.2) | 1.0 (0.7 1.4) | 4.1 (2.9 5.7) | 3.3 (3.8 7.2) | 11 | (95.4) |
| | 209 | 1.0 | 4 <u>.2</u> | (3.87.2) 5.4 | 11 | 205 |
| 0-6-months | 205 (2.5) | 1.0 (0.7-1.4) | 4.2 (2.4-6.0) | 3.4 (3.5-7.5) | ** | 203 (98.1) |
| | 220 | 0.9 | 4.0 | 5.1 | 11 | 216 |
| 7-12 months | (2.7) | 0.7-1.4) | 4.0 (2.5-5.4) | 3.6-6.9) | | (<u>98.2)</u> |
| | (2.7) <u>119</u> | 1.0 | 4.3 | <u>5.5</u> | 11 | (30.2) 116 |
| 18-24 months | (<u>1.4</u>) | 1.0 (0.7 1.5) | 4.5 (<u>3.2 5.7)</u> | (4.2 7.1) | | 110 (97.5) |
| | 1157 | 0.9 | 3.5 | (4.2 7.1) 4.6 | 11 | (37.3) 1140 |
| 2-4 years | $\frac{1137}{(14.1)}$ | 0.3 (0.7-1.4) | 3.3 (2.4-5.1) | 4.0 (3.2-6.6) | ** | 1140 (98.5) |
| | (14.1) 1888 | (0.7-1.4) 1.0 | 3,9 | (3.2-0.0) 5.0 | 11 | (98.3) 1838 |
| > 4 years | ++++++++++++++++++++++++++++++++++++++ | 1.0 (07-1.4) | 3.9 (2.5 5.4) | 5.0 (3.4-6.9) | ** | 1838 (97.7) |
| Not available | (25.0) 10 | | (2.5 5.4) | (3.+ 0.3) | | (777) |
| not available | 10 | | Directions II Community | | I | |
| | 2701 | 4.0 | Previous ILS experi | | | |
| Never | 2704 | 1.0 | 4.1 | 5.3 | 11 | 2577 |
| | (32.9) | (0.8-1.5) | (2.7-5.8) | (3.7-7.4) | | (95.3) |
| 0 6 months | 1010 | 1.0 | 4.2 | 5.4 | 11 | 970 |

| | (12.4) | (0.7-1.4) | (2.9-5.7) | (3.8-7.3) | | (96.0) |
|----------------------|--------------------------------------|---|---|--|---------------|---------------------------------------|
| 7-12 months | 1766 (21.5) | 0.9 (0.7-1.4) | 3.9 (2.7-5.3) | 5.1 (3.7-6.7) | 11 | 1714 (97.1) |
| 18-24 months | 1126 (13.7) | 0.9 (0.7-1.4) | 4.0 (2.9 5.4) | 5.2 (3.8 6.8) | 11 | 1126 (97.7) |
| 2-4 years | 505 (6.1) | 1.0 (0.8-1.5) | 4 .3 (2.9-6.0) | 5.4 (3.8-7.5) | 11 | 4 75 (94.1) |
| > 4 years | 1059 (12.9) | 0.9 (0.7-1.3) | 3.5 (2.4-5.0) | 4.7 (3.3-6.4) | 11 | 1043 (98.5) |
| Not available | 4 8 | | | | | |
| Total | 8218 | 1.0 (0.74-1.4) | 4 .0 (2.7-5.5) | 5.2 (3.7-7.1) | 11 | 7926 (96.6%) |

*Immediate Life Support

[#]ST3+, middle grade equivalent

Second State Second State Specialist

Assessment outcomes

Full assessment outcome data are displayed in <u>Supplementary MaterialTable 21</u>. 99.1% of <u>candidatesparticipants</u> completed the <u>pre-coursepost e-learning</u> MCQ. The mean pre-course MCQ, with a mean score <u>was-of</u> 83.7 (SD 7.3). and <u>tT</u>he mean post-course MCQ score was 87.7 (SD 7.9). Resuscitation officers had the highest mean score in the post-course MCQ (90.5, SD 5.5), with operating department practitioners (ODP) the lowest (79.2, SD 17.0). Those <u>candidatesparticipants</u> who had previous ALS course experience or were a core member of the resuscitation team on a day-to-day basis performed better in the post-course MCQ (P<0.001, P<0.001 respectively), as did the more senior doctors and nurses. <u>CandidatesParticipants</u> who had previous ILS course experience <u>actually</u>-performed<u>minimally</u> worse in the post-course MCQ (P<0.001).

| | | Table 2: I | Univariate predic | tors of assessment | t outcor | nes | | | |
|---|---|---|------------------------------|---------------------|---------------------------------------|--------------------|-------------------------------|----------------------------------|--------------------|
| <u>Independent</u> <u>variables</u> | <u>Mean</u> post e- learning <u>MCQ</u> score | Mean post- course MCQ score | <u>P-value</u> | CAS-Test pass (%) | Odds ratio (95% <u>CI)</u> | <u>P-</u> value | Overall course pass (%) | <u>Odds</u> ratio (95% CI) | <u>P-</u> value |
| | | | <u>Healthcar</u> | <u>e profession</u> | | | | | |
| <u>Doctor</u> (comparision) | <u>84.7</u> | <u>88.7</u> | | <u>5352 (86.0)</u> | | | <u>6095</u> (97.8) | | |
| <u>Nurse</u> | <u>79.7</u> | <u>80.0</u> | | <u>1005 (81.3)</u> | <u>0.71</u> (0.60- <u>0.83)</u> | <u><0.001</u> | <u>1122</u> (90.9) | <u>0.22</u> (0.17- 0.29) | <0.001 |
| <u>Medical student</u> | <u>83.4</u> | <u>86.5</u> | <u><0.001[£]</u> | <u>425 (79.6)</u> | <u>0.64</u> (0.51- <u>0.79)</u> | <u><0.001</u> | <u>525</u> (98.3) | <u>1.31</u> (0.66- 2.59) | <u>0.435</u> |
| Operating Department Practitioner | <u>73.0</u> | <u>79.2</u> | | <u>51</u> (70.8) | <u>0.40</u> (0.24- <u>0.66)</u> | <u><0.001</u> | <u>67 (93.1)</u> | <u>0.30</u> (0.12- | <u>0.011</u> |

| | | | | | | | | <u>0.76)</u> | | | | |
|---|-------------|-------------|-------------------------------|-----------------------|---------------------------------------|------------------|-----------------------|---|------------------|--|--|--|
| Ambulance staff/ Paramedic | <u>81.4</u> | <u>85.4</u> | | <u>37</u> (92.5) | <u>2.00</u> (0.62- <u>6.62)</u> | <u>0.247</u> | <u>39 (97.5)</u> | <u>0.88</u> (0.12- <u>6.43)</u> | <u>0.897</u> | | | |
| <u>Resuscitation</u> <u>Officer</u> | <u>86.6</u> | <u>90.5</u> | | <u>13</u> (86.7) | <u>1.06</u> (0.24- <u>4.69)</u> | <u>0.941</u> | <u>15</u> (100.0) | <u>3.6x10⁶</u> | <u><0.001</u> | | | |
| <u>Other</u> | <u>79.9</u> | <u>83.6</u> | | <u>46</u> (66.7) | <u>0.33</u> (0.20- 0.54) | <u><0.001</u> | <u>62 (84.9)</u> | <u>0.12</u> (0.06- <u>0.24)</u> | <u><0.001</u> | | | |
| Stage of training | | | | | | | | | | | | |
| Medical Student | <u>83.3</u> | <u>86.4</u> | <u><0.001[£]</u> | <u>426</u> (79.5) | <u>0.72</u> (0.56- 0.92) | <u>0.010</u> | <u>526</u> (98.0) | <u>0.70</u> (0.34- <u>1.44)</u> | <u>0.332</u> | | | |
| Foundation Year 1 Doctor | <u>83.0</u> | <u>86.6</u> | | <u>1394</u> (84.7) | <u>1.03</u> (0.85- <u>1.24)</u> | <u>0.754</u> | <u>1624</u> (98.4) | <u>0.92</u> (0.52- <u>1.60)</u> | <u>0.754</u> | | | |
| Foundation Year 2 Doctor (comparision) | <u>83.2</u> | <u>87.7</u> | | <u>1401</u> (84.3) | | | <u>1639</u> (98.6) | | | | | |
| Junior Grade Doctor (ST1/ST2) | <u>85.2</u> | <u>89.1</u> | | <u>667</u> (85.6) | <u>1.11</u> (0.87- <u>1.40)</u> | <u>0.406</u> | <u>768</u> (96.8) | <u>0.45</u> (0.26- <u>0.79)</u> | <u>0.006</u> | | | |
| <u>Middle Grade</u> Doctor [#] | <u>87.0</u> | <u>91.1</u> | | <u>1322</u> (90.4) | <u>1.75</u> (1.40- <u>2.17)</u> | <u><0.001</u> | <u>1434</u> (97.9) | <u>0.70</u> (0.41- <u>1.20)</u> | <u>0.197</u> | | | |
| <u>Senior Grade</u> Doctor ^{\$} | <u>87.9</u> | <u>92.0</u> | | <u>425</u> (87.3) | <u>1.28</u> (0.95- <u>1.72)</u> | <u>0.107</u> | <u>469</u> (96.1) | <u>0.40</u> (0.22- <u>0.76)</u> | <u>0.005</u> | | | |
| <u>Junior Nurse</u> (Band 4-6) | <u>78.8</u> | <u>82.8</u> | | <u>777 (78.3)</u> | <u>0.67</u> (0.55- 0.82) | <u><0.001</u> | <u>886</u> (88.4) | <u>0.12</u> (0.08- 0.19) | <u><0.001</u> | | | |
| <u>Senior Nurse</u> (Band 7-9) | <u>81.4</u> | <u>86.6</u> | | <u>346</u> (87.8) | <u>1.34</u> (0.97- <u>1.87)</u> | <u>0.080</u> | <u>378</u> (95.5) | <u>0.31</u> (0.17- <u>0.57)</u> | <u><0.001</u> | | | |
| <u>Other</u> | <u>82.6</u> | <u>86.6</u> | | <u>163</u> (74.1) | <u>0.53</u> (0.38- <u>0.74)</u> | <u><0.001</u> | <u>202</u> (90.2) | <u>0.14</u> (0.08- <u>0.26)</u> | <u><0.001</u> | | | |
| | | <u>P</u> | revious life suppo | ort course experie | <u>nce</u> | | | | | | | |
| <u>Previous ALS</u> <u>experience</u> No previous ALS | <u>85.5</u> | <u>89.7</u> | <u><0.001</u> [#] | <u>3204 (89.3)</u> | <u>1.97</u> (1.73- | <0.001 | <u>3515</u> (98.0) | <u>2.27</u> (1.73- 2.98) | <u><0.001</u> | | | |
| experience | <u>82.3</u> | <u>86.1</u> | | <u>3727 (81.0)</u> | <u>2.24)</u> | | <u>4411</u> (95.6) | | | | | |
| Previous ILS experience | <u>83.2</u> | <u>87.4</u> | <u><0.001</u> # | <u>4666</u> (85.6) | <u>1.24</u> (1.09- 0 | 0.001 | <u>5302</u> (97.2) | <u>1.64</u> (<u>1.29-</u> <u>2.09)</u> | <u><0.001</u> | | | |
| No previous ILS experience | <u>84.5</u> | <u>88.3</u> | | <u>2265 (82.7)</u> | <u>1.40)</u> | | <u>2624</u> (95.5) | | | | | |
| Core member of resuscitation team | <u>84.4</u> | <u>88.8</u> | <u><0.001</u> # | <u>3305</u> (88.0) | <u>1.67</u> (1.48- | <0.001 | <u>3668</u> (97.7) | <u>1.91</u> (1.48- | <0.001 | | | |
| <u>Not a core</u> <u>member of</u> <u>resuscitation</u> | <u>83.0</u> | <u>86.6</u> | | <u>3540</u> (81.4) | <u>1.90)</u> | | <u>4173</u> (95.7) | <u>2.47)</u> | | | | |

| team |] | Γ | | | | |
|----------------------------------|---|--------------|---------------------------------------|------------------|---------------------------------------|------------------|
| <u>Age (years)</u> | <u>-0.33</u> ([-0.52]- [-0.11])* | <u>).003</u> | <u>0.98</u> (0.97- <u>0.98)</u> | <u><0.001</u> | <u>0.93</u> (0.93- <u>0.94)</u> | <u><0.001</u> |
| Time spent on e-Learning (hours) | <u>-0.24</u> ([-0.30]- <([-0.19])* | <u>0.001</u> | <u>0.93</u> (0.91- <u>0.94)</u> | <u><0.001</u> | <u>0.90</u> (0.87- <u>0.93)</u> | <u><0.001</u> |

*Independent samples t-test

[±] One way ANOVA

*Linear regression to predict post course MCQ score (B value with 95% confidence intervals)

<u>*#ST3+, registrar equivalent*</u>

^{\$} Consultant or associate specialist

The overall first attempt pass rate for CAS-Test was 84.6%. Univariate analysis found that paramedic and resuscitation officer pass rates were similar to physicians whilst nurses, medical students and those in the 'other' category had lower pass rates. Those candidatesparticipants with previous ALS experience were twice-1.97 times moreas likely to pass the CAS-Test assessment on the first attempt (OR 1.97 (95% CI 1.73-2.24), P<0.001) compared to those with no previous ALS experience. Those who were a-core members of the resuscitation team were also significantly1.67 times more likely to pass the CAS-Test scenario, compared with those who were not core members (OR 1.67 (95% CI 1.48-1.90), P<0.001) or as were mMiddle grade doctors were 1.75 times more likely to pass the CAS-Test compared to Foundation Year 2 doctors. (OR 1.75, [95% CI 1.40-2.17, P<0.001).

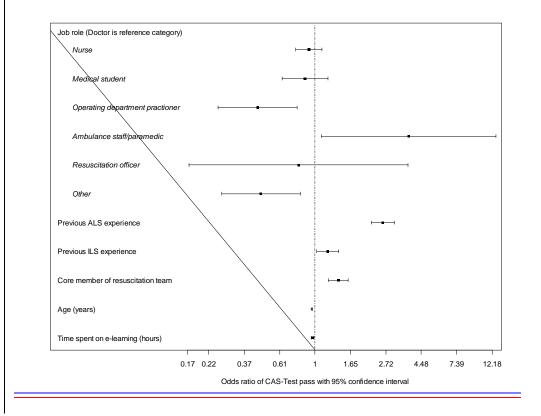
In terms of overall e-ALS course results the<u>The overall course</u> pass rate was 96.6%. Resuscitation officers demonstrated the highest pass rate at 100%. Junior nurses had the lowest pass rate of 88.4%. When compared to doctors in the univariate analysis; nurses (OR 0.22, 95% CI 0.17-0.29, P<0.001), ODPs (OR 0.30, 95% CI 0.12-0.76, P=0.011) and <u>candidatesparticipants</u> from the 'other' category (OR 0.12, 95% CI 0.06-0.24, P<0.001) had significantly lower overall pass rates. <u>CandidatesParticipants</u> were more likely to pass if they had previously undertaken ALS training (OR 2.27, 95% CI 1.73-2.98, P<0.001), ILS training (OR 1.64, 95% CI 1.29-2.09, P<0.001) or were a core member of the resuscitation team (OR 1.91, 95% CI 1.48-2.47, P<0.001).

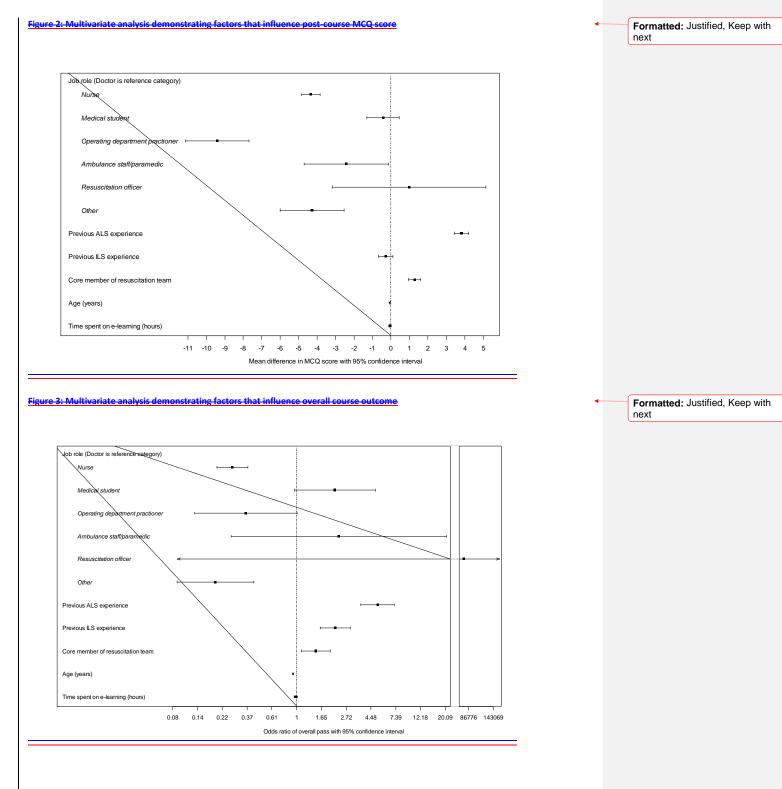
The significant independent variables from the univariate analyses were assessed for co-linearity. Grade of training was removed due to co-linearity with healthcare background. The remaining independent variables were entered

into multivariate analyses. Figure 1 and figure 2Figures 1-3 presents the findings from the multivariate analyses, with full data in supplementary material. The full outcome data from the analyses can be accessed in Supplementary Material 2. Previous ILS and ALS experience and being a core member of a resuscitation team were independent predictors of CAS-Test performance, post course MCQ score and overall success rates. Increasing age was associated with worse post course MCQ score, CAS-Test outcome and overall result.

Figure 1: Multivariate analysis demonstrating factors that influence CAS-Test outcome

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Time spent accessing e-learning

Median time spent on the e-learning was 5.2 hours (IQR 3.7-7.1) and the median number of modules completed was 11 (only 11/12 modules had access data recorded). Resuscitation officers spent the longest time on the e-learning package (median 7.5 hours, IQR 5.7-9.2). Doctors spent the least amount of time accessing the content (median 4.9 hours, IQR 3.4-6.7). In general, those doctors with more clinical experience spent less time accessing the e-learning material. This is demonstrated below in figure-table_3 where middle grade doctors spend the least time on every module. In the univariate analysis, increased hours spent accessing e-learning was a statistically significant predictor of failing the post-course MCQ (B=-0.24, 95% CI [-0.30]-[-0.19], P<0.001), the CAS-Test assessment (OR 0.93, 95% CI 0.91-0.94, P<0.001) and the overall course (OR 0.90, 95% CI 0.87-0.93, P<0.001). When all other co-variates were controlled for in the multivariate regression, time spent accessing e-learning remained a significant predictor of CAS-Test failure (OR 0.96, 95% CI 0.95-0.98, P<0.001) but was not a significant predictor of overall course failure (OR 0.989, 95% CI 0.9<u>5</u>6-1.02, P=0.<u>367435</u>).

| | ALS in perspective | ALS algorithm | <u>Causes and Prevention of</u> <u>Cardiac Arrest</u> | Acute Coronary Syndromes | Post Resuscitation Care | <u>Monitoring, Rhythm</u> <u>Recognition and 12-lead</u> | <u>Tachycardia, Cardioversion</u> and Drugs | <u>Bradycardia, Pacing and</u> <u>Drugs</u> | <u>Special Circumstances</u> | <u>Decisions Relating to</u> <u>Resuscitation</u> | Arterial Blood Gas Analysis |
|-----------------------------------|--------------------|---------------|--|--------------------------|-------------------------|---|--|--|------------------------------|--|-----------------------------|
| | <u>Gr</u> | ade/he | althca | re prof | <u>ession</u> | | | | | - | |
| Foundation year doctor | <u>9.2</u> | <u>44.0</u> | <u>17.0</u> | <u>27.1</u> | <u>22.5</u> | <u>34.3</u> | <u>32.3</u> | <u>15.7</u> | <u>25.1</u> | <u>8.0</u> | <u>14.5</u> |
| Junior grade doctor (ST1/ST2) | <u>9.8</u> | <u>45.3</u> | <u>17.7</u> | <u>26.6</u> | <u>22.7</u> | <u>32.5</u> | <u>30.4</u> | <u>14.6</u> | <u>24.6</u> | <u>8.9</u> | <u>15.3</u> |
| Middle grade doctor | <u>9.5</u> | <u>43.8</u> | <u>17.0</u> | <u>26.4</u> | <u>21.8</u> | <u>30.7</u> | <u>27.8</u> | <u>13.6</u> | <u>22.8</u> | <u>8.0</u> | <u>12.4</u> |
| Senior grade doctor | <u>10.1</u> | <u>48.0</u> | <u>17.8</u> | <u>25.8</u> | <u>21.4</u> | <u>33.5</u> | <u>31.6</u> | <u>14.2</u> | <u>26.1</u> | <u>9.0</u> | <u>15.4</u> |
| Junior nurse | <u>11.0</u> | <u>51.0</u> | <u>21.4</u> | <u>31.1</u> | <u>24.9</u> | <u>53.5</u> | <u>39.6</u> | <u>19.9</u> | <u>32.7</u> | <u>10.3</u> | <u>25.1</u> |
| Senior nurse | <u>10.6</u> | <u>50.1</u> | <u>19.7</u> | <u>29.9</u> | <u>24.8</u> | <u>46.9</u> | <u>38.2</u> | <u>17.6</u> | <u>31.0</u> | <u>9.7</u> | <u>22.4</u> |
| Paramedic | <u>10.5</u> | <u>42.9</u> | <u>19.4</u> | <u>29.7</u> | <u>25.2</u> | <u>42.4</u> | <u>36.4</u> | <u>17.6</u> | <u>28.9</u> | <u>10.2</u> | <u>19.8</u> |
| Operating department practitioner | <u>10.6</u> | <u>49.5</u> | <u>22.6</u> | <u>29.5</u> | <u>24.8</u> | <u>57.8</u> | <u>43.8</u> | <u>20.3</u> | <u>33.0</u> | <u>12.1</u> | <u>28.6</u> |
| Resuscitation officer | <u>13.3</u> | <u>41.7</u> | <u>20.0</u> | <u>40.0</u> | <u>25.9</u> | <u>83.8</u> | <u>42.2</u> | <u>25.6</u> | <u>41.4</u> | <u>11.4</u> | <u>29.9</u> |
| Medical student | <u>9.3</u> | <u>45.0</u> | <u>17.8</u> | <u>28.1</u> | <u>24.1</u> | <u>38.5</u> | <u>35.8</u> | <u>16.5</u> | <u>28.7</u> | <u>9.3</u> | <u>15.6</u> |
| | | <u>Speci</u> | alty ba | ckgrou | nd | | | | | | |
| Anaesthetics | <u>9.7</u> | <u>45.5</u> | <u>17.9</u> | <u>27.5</u> | <u>23.0</u> | <u>36.2</u> | <u>32.9</u> | <u>16.0</u> | <u>26.1</u> | <u>8.6</u> | <u>16.0</u> |
| Cardiology | <u>10.0</u> | <u>44.6</u> | <u>17.9</u> | <u>25.7</u> | <u>21.7</u> | <u>33.1</u> | <u>33.9</u> | <u>15.4</u> | <u>31.8</u> | <u>9.0</u> | <u>19.1</u> |
| Surgery | <u>9.3</u> | <u>45.0</u> | <u>17.9</u> | 28.0 | <u>23.0</u> | <u>35.9</u> | <u>33.7</u> | <u>15.5</u> | <u>25.5</u> | <u>8.1</u> | <u>15.5</u> |
| Medicine | <u>9.3</u> | <u>44.2</u> | <u>17.2</u> | <u>26.5</u> | <u>22.4</u> | <u>33.0</u> | <u>30.9</u> | <u>14.8</u> | <u>25.3</u> | <u>8.1</u> | <u>14.3</u> |
| Emergency | <u>10.0</u> | <u>45.2</u> | <u>18.2</u> | <u>27.6</u> | <u>23.4</u> | <u>38.3</u> | <u>32.6</u> | <u>16.4</u> | <u>25.6</u> | <u>9.1</u> | <u>18.3</u> |
| Critical Care | <u>11.1</u> | <u>52.1</u> | <u>20.8</u> | <u>30.7</u> | <u>23.8</u> | <u>46.1</u> | <u>38.2</u> | <u>18.9</u> | <u>32.0</u> | <u>9.8</u> | <u>18.5</u> |

Table 3: Duration spent on individual ALS modules stratified by grade, profession and specialty background

Figure <u>Table 34</u> demonstrates the homogeneity between times spent on individual e-learning modules when stratified by speciality. Those from a critical care background spent slightly more time on modules compared to others, but this is likely due to the high proportion of nurses participating in the e-ALS course from this specialty (357/487, 73.3%).

DISCUSSION

This study has shown that previous experience in life support courses and being a core member of the resuscitation team predicts a favourable outcome on an e-ALS course. It also identifies the extent to which different candidate groups access the e-learning material and highlights particular modules that may be more challenging. Time spent accessing e-learning material was not related to course outcome; <u>largelythis was thought to be</u> because candidatesparticipants who utilise these skills on a daily basis are already familiar with the material and thus require less time to re-familiarise themselves.

There are increasing pressures to minimise time spent on courses for both participants and faculty and to improve outcomes. It has been postulated that pre-course preparation could lead to either better outcomes or a reduced amount of face-to-face time needed on the course. This could in theory lead to equivalent or better participant outcomes with less resources (time off work for faculty/participants, venue hire etc.). There is very little evidence relating specifically to pre-learning for advanced life support courses, so this study goes some way towards filling that void.

Perkins et al.¹¹ looked at one example of pre-course preparation. This open label, multicentre randomised controlled trial was a study of 572 participants on Resuscitation Council (UK) ALS courses. The control group received the course manual four weeks before the course. The intervention group received the course manual and also a CD with an interactive e-learning simulation programme. Although there were no significant differences in the primary outcome (performance during a standard cardiac arrest simulation), user evaluations were favourable. The results however cannot necessarily be generalised to all other types of pre-course learning or pre-course learning for other populations/course groups.

A multi-centre randomised controlled trial demonstrated equivalence in outcome when comparing e-ALS and c-ALS learning methods and was significantly cheaper-less costly to deliver.⁸ The findings of this were corroborated by a

large observational study of 27,170 candidates<u>participants</u> which demonstrated almost identical assessment outcomes for candidates<u>participants</u> enrolled on either a c-ALS or e-ALS course.⁹ These studies were a comparison of a standard life support course against specific pre-course e-learning associated with a shorter duration hybrid life support course.

The topic of pre-course learning was addressed during the 2015 ILCOR international consensus on science process. It was felt that a specific recommendation for or against pre-course preparation in ALS courses was too speculative due to the lack of evidence in the literature.¹⁵ These findings were balanced with a statement highlighting the considerable ambiguity in the definition of "Pre-course learning" and the difficulty in comparing single interventions like a pre-course CD¹¹ with an intervention followed by a hybrid version of the face-to-face element.^{8,9}

With regard to the findings from this study, we found some unexpected and interesting results. The most surprising result was that time spent accessing prerequisite e-learning material was actually associated with worse assessment and overall course outcome in the univariate regression. On further analysis however, this is explained by the fact that those with greater clinical experience spent less time accessing the e-learning but paradoxically performed better in the course assessments. This intuitively underpinsdemonstrates the educational position of notion that when learning can be based on previous experience; it will normally lead to improved outcomes. This is demonstrated in the multivariate regression where time spent on e-learning was no longer a significant predictor of overall course outcome. Whilst the influence of both time and age onIncreased age was associated with significantly poorer assessment outcomes. Whilst there is a paucity of evidence for the literature regarding the effect of age on ALS outcomes, this pattern has been found in BLS studies and has been attributed to skill decline over time^{16,17} and psychological factors where younger participants are more motivated to learn.¹⁸ It has been found that those working in a high risk area for area for cardiac arrest were more motivated to learn life support skills.¹⁹ assessment outcomes were statistically significant, this is largely due to the large sample size and is unlikely to be of any clinical significance.

Candidates<u>Participants</u> presenting with greater clinical experience in managing critically unwell patients (paramedics, middle grade doctors, those with previous ALS/ILS experience, and those who are a core member of the resuscitation team) performed substantially better in the CAS-Test and overall result. This should not come as a

surprise, but is a useful insight for course organisers when identifying candidatesparticipants at the start of a course who do not fall into these groups and may benefit from additional support.

The e-learning package allows candidatesparticipants to dictate their own level of access dependent upon their prior knowledge, experience and specialty background. They are able tocan access material at a time that isat an appropriate time forte them and spend-dedicate a greater amount of time on-to their weaker knowledge areas. In essence, this is no different to providing candidates with a course manual where they may not read some chapters as the topics are familiar to them. The need for this degree of flexibility is demonstrated by the vastly different durations spent accessing the online content. This need is exemplified in table 3figure 3 which highlights that certain candidate groups (in this instance-junior nurses and operating department practitioners) spent twice as long on the 'Monitoring, rhythm recognition and 12-lead ECG' module compared to middle grade doctors, perhaps because they do not routinely utilise such skills on a daily basis. The flexibility that the e-ALS course creates is just one reason amongst many why participant satisfaction is greater on e-learning courses than compared to traditional didactic courses.^{20,21}

Limitations and Further Research

The main limitation of this exploratory study is its observational nature. This means that the authors are only able to suggest causality when determining whether independent variables influence assessment outcome. Whilst aA specifically designed randomised controlled trial would perhaps <u>be needed todefinitively</u> establish a cause-effect relationship on assessment outcome, such a trial would not be pragmatic given that half of the candidates would have to sacrifice preparatory e-learning to facilitate such a trial.

Time is not necessarily an accurate marker of whether candidatesparticipants have truly engaged with the material and as this study has shown, it is significantly confounded by clinical experience (ie if candidatesparticipants are already well versed in ECG interpretation they will spend less time on this module). Furthermore, different individuals possess a spectrum of learning abilities with some candidatesparticipants learning faster than others. A proportion of candidatesparticipants may have chosen to preferentially utilise the course manual as opposed to the e-learning package and others may leave the e-learning running whilst not at the computer, providing a falsely elevated time spent accessing the material. The authors have circumvented this to some extent by presenting the descriptive statistics using non-parametric methods to reduce the influence of outliers on the results. Nevertheless, <u>+</u>There remains a need for more specific markers for determining whether candidatesparticipants have truly engaged with the e-learning material.

A final limitation to this study-is that it does not determine whether accessing e-learning actually affects patient outcome from cardiac arrest. Whilst this should be the overriding aim behind all resuscitation-related research, such studies are very difficult to achieve. The authors believe however, that by critically appraising course outcome data and continuously improving the delivery methods of resuscitation courses this will ultimately improve the care of the critically unwell patient.

Conclusion

Our study has demonstrated that clinical experience through core membership of cardiac arrest teams and previous ILS or ALS training were independent predictors of performance on the ALS course. The large variation in time spent accessing e-learning reflects the diverse nature of candidates<u>participants</u> who participate on our e-ALS courses and the spectra of learning needs that they possess. It reinforces for course organisers that these modules should be optional rather than compulsory and identifies certain aspects of our course that candidates<u>participants</u> designate more attention to and may need more support with.

Clinical experience through core membership of cardiac arrest teams and previous ILS or ALS training were independent predictors of performance on the e-ALS course whilst time spent accessing e-learning materials did not affect course outcomes. The large variation in time spent accessing e-learning reflects the diverse nature of participants on our e-ALS courses and the spectra of learning needs that they possess. This supports the blended approach to e-ALS which allows participants to tailor their e-learning experience to their specific needs.

CONFLICTS OF INTEREST

CJT is a Trainee Representative for the ALS Subcommittee for the Resuscitation Council (UK). ASL is Honorary Secretary of the Resuscitation Council (UK) and a member of the European Resuscitation Council ALS Course Committee. IB is an Educator for the Resuscitation Council (UK). SH is Director of Course Development and Training for the Resuscitation Council (UK). SB-A is Project and Development Manager for the Resuscitation Council (UK). GDP is Chair of the ALS Subcommittee for the Resuscitation Council (UK) and member of the European Resuscitation Council ALS Course Committee.

FUNDING

GDP is supported by the National Institute for Health Research (Senior Investigator) and Intensive Care Foundation (Director of Research).

ACKNOWLEDGEMENTS

The authors would like to acknowledge the ALS instructors and candidates who have participated in an e-ALS course over the duration of this study. They also acknowledge the ongoing work of the ALS subcommittee of the Resuscitation Council (UK) to oversee the hundreds of ALS courses that take place each year. They would also like to acknowledge Dr Peter Kimani for his statistical advice regarding the project.

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LEGENDS TO FIGURES

Table 1: Participant demographics on the e-ALS course and time spent on e-learning

Figure 1: Multivariate regression of independent variables that predict CAS-Test outcome

Figure 2: Multivariate regression of independent variables that predict overall course outcome

Figure 13: Time spent on e-learning modules stratified by grade and profession

Figure 24: Time spent on e-learning modules stratified by specialty

Supplementary material 1<u>Table 2</u>: Univariate predictors of assessment outcomes

Supplementary material 2Table 3: Multivariate predictors of assessment outcomes

| Independent variables | Mean pre- course MCQ score | Mean post- course MCQ score | P-value | CAS-Test pass (%) | Odds ratio (95% CI) | P_ value | Overall course pass (%) | Odds ratio (95% Cl) | ₽. valu |
|--|--|---|----------------------|-------------------------------------|---|------------------|--|---|-----------------------|
| | | | Healthc | are profession | | | | | |
| Doctor | 84.7 | 88.7 | | 5352 (86.0) | | | 6095 (97.8) | | |
| Nurse | 79.7 | 80.0 | < 0.001 € | 1005 (81.3) | 0.71 (0.60- 0.83) | <0.001 | 1122 (90.9) | 0.22 (0.17- 0.29) | <0.00 |
| Medical student | 83. 4 | 86.5 | | 425 (79.6) | 0.64 (0.51- 0.79) | <0.001 | 525 (98.3) | 1.31 (0.66- 2.59) | 0.43 |
| Operating Department Practitioner | 73.0 | 79.2 | | 51 (70.8) | 0.40 (0.24- 0.66) | < <u>0.001</u> | 67 (93.1) | 0.30 (0.12- 0.76) | 0.01 |
| Ambulance staff/ Paramedic | 81.4 | 85.4 | | 37 (92.5) | 2.00 (0.62- 6.62) | 0.247 | 39 (97.5) | 0.88 (0.12- 6.43) | 0.89 |
| Resuscitation Officer | 86.6 | 90.5 | | 13 (86.7) | 1.06 (0.24- 4 .69) | 0.941 | 15 (100.0) | 3.6x10⁶ | <0.00 |
| Other | 79.9 | 83.6 | | 4 6 (66.7) | 0.33 (0.20- 0 .54) | <0.001 | 62 (84.9) | 0.12 (0.06- 0.24) | <0.00 |

| Medical Student | 83.3 | 86.4 | | | 4 26 (79.5) | 0.72 (0.56 0.92) | 0.010 | 526 (98.0) | 0.70 (0.34- 1.44) | 0.332 | | |
|--|-----------------|-------------------|--|----------------------|--------------------------------------|--|--------------------------------------|---------------------------------------|--|--------------------------------------|--|------------------|
| Foundation Year 1 Doctor | 83.0 | 86.6 | <0.001[€] | | 1394 (84.7) | 1.03 (0.85- 1.24) | 0.754 | 1624 (98.4) | 0.92 (0.52- 1.60) | 0.754 | | |
| Foundation Year 2 Doctor | <u>83.2</u> | 87.7 | | | | | 1401 (84.3) | | | 1639 (98.6) | | |
| Junior Grade Doctor (ST1/ST2) | 85.2 | 89.1 | | | | | 667 (85.6) | 1.11 (0.87- 1.40) | 0.406 | 768 (96.8) | 0.45 (0.26- 0.79) | 0.006 |
| Middle Grade Doctor[#] | 87.0 | 91.1 | | | 1322 (90.4) | 1.75 (1.40- 2.17) | <0.001 | 1434 (97.9) | 0.70 (0.41- 1.20) | 0.197 | | |
| Senior Grade Doctor^{\$} | 87.9 | 92.0 | | | 4 25 (87.3) | 1.28 (0.95- 1.72) | 0.107 | 4 69 (96.1) | 0.40 (0.22- 0.76) | 0.005 | | |
| Junior Nurse (Band 4-6) | 78.8 | 82.8 | | | 777 (78.3) | 0.67 (0.55 0.82) | <0.001 | 886 (88.4) | 0.12 (0.08- 0.19) | <0.001 | | |
| Senior Nurse (Band 7-9) | 81.4 | 86.6 | | | 346 (87.8) | 1.34 (0.97- 1.87) | 0.080 | 378 (95.5) | 0.31 (0.17- 0.57) | < 0.001 | | |
| Other | 82.6 | 86.6 | | | 163 (74.1) | 0.53 (0.38- 0.74) | <0.001 | 202 (90.2) | 0.14 (0.08- 0.26) | <0.001 | | |
| | | | Previous li | fe supp | ort course experi | ience | | | | | | |
| Previous ALS experience | 85.5 | 89.7 | - <0.00 | | 3204 (89.3) | 1.97 | <0.001 | 3515 (98.0) | 2.27 (1.73 | <0.001 | | |
| No previous ALS experience | 82.3 | 86.1 | | , 1 | 3727 (81.0) | 2.24) | \$0.001 | 4411 (95.6) | 2.98) | .0.001 | | |
| Previous ILS experience | 83.2 | 87.4 | <0.00 | 11# | 4666 (85.6) | 1.24 (1.09- | 0.001 | 5302 (97.2) | 1.64 (1.29- | <0.001 | | |
| No previous ILS experience | 84.5 | 88.3 | | | 2265 (82.7) | 1.40) | | 2624 (95.5) | 2.09) | | | |
| Core member of resuscitation team | 84.4 | 88.8 | | | 3305 (88.0) | 1.67 | | 3668 (97.7) | 1.91 | | | |
| Not a core member of resuscitation team | 83.0 | 86.6 | <0.001 [#] | | 3540 (81.4) | (1.48- 1.90) | <0.001 | 4 173 (95.7) | (1.48- 2.47) | <0.001 | | |
| Age (years) | | | - 0.33 ([-0.52]- [-0.11])* | 0.003 | | 0.98) | <0.001 | | 0.93 (0.93- 0.94) | <0.001 | | |
| Time spent on e Lo | | hours) | -0.24 ([0.30]- [0.19])* | <0.001 | | 0.93 (0.91 0.94) | <0.001 | | 0.90 (0.87– 0.93) | <0.001 | | |

[#]Independent samples t-test

-One way ANOVA

*Linear regression to predict post course MCQ score (B value with 95% confidence intervals) *ST3+, registrar equivalent

*-Consultant or associate specialist

| Supplementary | Supplementary material 1: Multivariate predictors of assessment outcomes | | | | | | | | | | | | | | | |
|--|--|---|---------------------------------|---------------|---------------------------------|---------------|--------------------------|------------|----------------|--------------|---------------------------|-------------|-----------------------|--|--|-------------|
| Independent variables | Mean post e- learning MCQ score | Mean post- course MCQ score | Mean difference (95% CI) | P-value | CAS-Test result Pass Fail | | result | | result | | Odds | P- value | Ove course Pass | | Odds ratio of course Pass (95% CI) | P- value |
| | | | | Llaalth | (%) | (%) | CI) | | (%) | (%) | | | | | | |
| Doctor | | | | Healtr | care p 5352 | 871 | lon | | 6095 | 137 | | | | | | |
| <u>(comparison)</u> | 84.7 | 88.7 | | | | 871 (14.0) | | | (97.8) | (2.2) | | | | | | |
| Nurse | 79.7 | 80.0 | -4.35 ([- 4.85]-[- 3.85]) | <0.001 | 1005 (81.3) | - | 0.92 (0.76- 1.10) | 0.356 | 1122 (90.9) | 113 (9.1) | 0.27 (0.20- 0.37) | <0.001 | | | | |
| Medical student | 83.4 | 86.5 | -0.43 ([- 1.31]-0.45) | 0.334 | 425 (79.6) | 109 (20.4) | 0.87 (0.63- 1.20) | 0.390 | 525 (98.3) | 9 (1.7) | 2.16 (0.96- 4.48) | 0.063 | | | | |
| Operating Department Practitioner | 73.0 | 79.2 | -9.41 ([-11.13]-[- 7.69]) | <0.001 | 51 (70.8) | 21 (29.2) | 0.44 (0.25- 0.78) | 0.005 | 67 (93.1) | 5 (6.9) | 0.36 (0.13- 1.01) | 0.052 | | | | |
| Ambulance staff/ Paramedic | 81.4 | 85.4 | -2.42 ([- 4.71-[0.12]) | 0.039 | 37 (92.5) | 3 (7.5) | 3.75 (1.10- 12.85) | 0.035 | 39 (97.5) | 1 (2.5) | 2.34 (0.27- 20.54) | 0.444 | | | | |
| Resuscitation Officer | 86.6 | 90.5 | 0.98 ([- 3.18]-5.14) | 0.644 | 13 (86.7) | 2 (13.3) | 0.79 (0.17- 3.73) | 0.769 | 15 (100.0) | 0 (0) | 78518 (0- infinity) | 0.986 | | | | |
| Other | 79.9 | 83.6 | -4.27 ([- 6.00]-[- 2.53]) | <0.001 | 46 (66.7) | 23 (32.4) | 0.47 (0.27- 0.81) | 0.007 | 59 (84.3) | 11 (15.7) | 0.19 (0.09 - 0.42) | <0.001 | | | | |
| | | | | Previous lif | | ort ex | perience | 2 | | 1 | | | | | | |
| Previous ALS experience | 85.5 | 89.7 | 3.83 (3.44 – | -0.001 | 3204 (89.3) | 383 (10.7) | 2.61 | -0.001 | 3515 (98.0) | 72 (2.0) | 5.13 | -0.001 | | | | |
| No previous ALS experience | 82.3 | 86.1 | 4.21) | <0.001 | 3727 (81.0) | 877 (19.0) | (2.22- 3.07) | <0.001 | 4411 (95.6) | 205 (4.4) | (3.66- 7.19) | <0.001 | | | | |
| Previous ILS experience | 83.2 | 87.4 | -0.27 ([- | 0.172 | 4666 (85.6) | | 1.19 | 0.024 | 5302 (97.2) | 153 (2.8) | 2.18 | -0.001 | | | | |
| No previous ILS experience | 84.5 | 88.3 | 0.66]-0.12) | 0.172 | 2265 (82.7) | 473 | (1.02- 1.39) | 0.024 | 2624 (95.5) | 124 (4.5) | (1.61- 2.95) | <0.001 | | | | |
| Core member of resuscitation team | 84.4 | 88.8 | 1.28 (0.94- | <0.001 | 3305 (88.0) | | 1.39 | <0.001 | 3668 (97.7) | 87 (2.3) | 1.47 | 0.009 | | | | |
| Not a core member of resuscitation team | 83.0 | 86.6 | 1.62) | \0.001 | 3540 (81.4) | | 1.59) | VUU | 4173 (95.7) | 189 (4.3) | (1.10- 1.98) | 0.009 | | | | |
| Age (years) | | | -0.06 ([- | <0.001 | | | 0.96 | <0.001 | | | 0.93 | <0.001 | | | | |

| | 0.09]-[- 0.04]) | | (0.95- 0.97) | | (0.92 0.94 | |
|-----------------------------|--------------------|-------|-----------------|---------------|---------------|---|
| Time spent on e-Learning | -0.05 ([- | 0.047 | 0.96 (0.95- | <0.001 | 0.98 (0.95 | 7 |
| (hours) | 0.11]-0.00) | 0.047 | 0.98) | \0.001 | 1.02 | ' |

[#] ST3+, middle grade equivalent ^{\$} Consultant or associate specialist

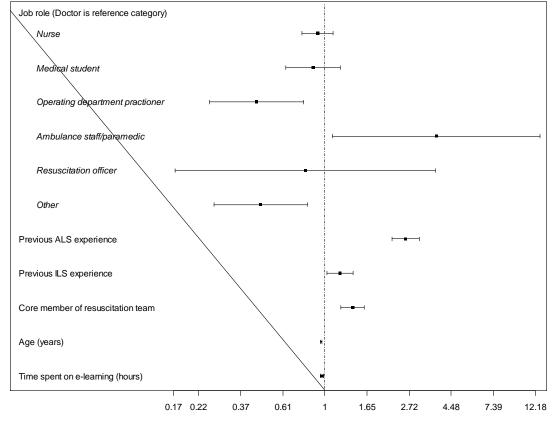


Figure 1: Multivariate analysis demonstrating factors that influence CAS-Test outcome

Odds ratio of CAS-Test pass with 95% confidence interval

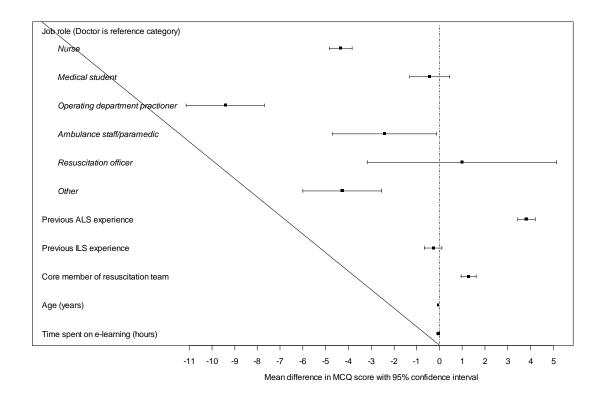
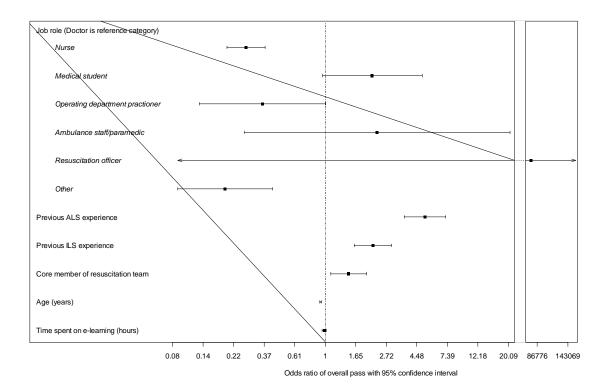


Figure 1: Multivariate analysis demonstrating factors that influence post-course MCQ score

Figure 1: Multivariate analysis demonstrating factors that influence overall course outcome



CONFLICTS OF INTEREST

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FUNDING

GDP is supported by the National Institute for Health Research (Senior Investigator) and Intensive Care Foundation (Director of Research).