original article

Advanced trauma life support training outcomes in Saudi Arabia: a four-year multicenter analysis of influential characteristics and factors (2019-2023)

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BACKGROUND: The prevalence of trauma necessitates effective training for healthcare providers in Saudi Arabia. The Advanced Trauma Life Support (ATLS) program is pivotal, yet localized success rate data are lacking.

OBJECTIVES: Determine the failure rate and identify factors influencing ATLS course success rates among physicianss in Saudi Arabia.

DESIGN: A retrospective cohort.

SETTING: Two major accredited ATLS training centers in Riyadh.

PATIENTS AND METHODS: Participants who completed ATLS training at the Trauma Courses Office at the Ministry of National Guard Health Affairs from January 2019 to December 2020, and at the Clinical Skills and Simulation Center at King Saud University Medical City from December 2020 through January 2023. Particpitants were grouped as interns and all physicians other than interns, for the purpose of analysis.

MAIN OUTCOME MEASURES: Success and failure rates were the primary outcomes, with failure identified as a score of less than 75% or below standard performance in the practical session.

SAMPLE SIZE: 603

RESULTS: The overall failure rate for the ATLS courses was 36.6%. Analysis revealed age, pre-test scores, and attendance at a refresher course as significant predictors of success. Specifically, general practitioners and OMFS specialists had a higher odds of failing, while general surgeons and trauma-related specialties consultants were more likely to succeed.

CONCLUSION: ATLS course failure is notably high, with specific specialties and levels demonstrating increased risk. Results indicate a need for tailored pre-course preparation and an extension of the course duration for less experienced participants to improve proficiency, especially for at-risk groups.

LIMITATIONS: Retrospective design and other variables, such as emotional status, level of instructors, and level of motivation.

CONFLICT OF INTEREST: None.

Trauma continues to pose a significant healthcare challenge worldwide. It is the second leading cause of death, accounting for 22.6% of years of potential life lost in Saudi Arabia.[1] Consequently, training physicians in trauma management has become essential for improving outcomes related to trauma.[2] Developed by the American College of Surgeons in 1978, the Advanced Trauma Life Support (ATLS) course has evolved into the most widely used training course for the initial evaluation, stabilization, and management of injured patients.[3] With over a million clinicians trained in the past three decades, the ATLS course has become a common language for physicians in trauma management and is now taught in more than 60 countries.[4] Although ATLS is not the only contributor to patient survival, it is a leading factor in enhancing the management of patients with trauma.[5] Implementation of ATLS protocols has demonstrated a reduction in mortality within the first 60 minutes after arrival (the "golden hour") at the hospital, emergency room.[6] Applicants to the ATLS course are diverse in their backgrounds, medical specialties, native languages, academic backgrounds, trauma experience, and cultural preferences. This diversity raises questions regarding how these factors influence the outcome.[2-4] To the best of our knowledge, no other studies have described the characteristics and outcomes of ATLS in Saudi Arabia, with only a few addressing this in the Middle East.[4] This study aimed to identify the rate of failure and factors that influence the success rate of ATLS courses in Saudi Arabia.

PATIENTS AND METHODS

This retrospective cohort study, approved by the Institutional Review Board of Health Sciences Colleges Research on Human Subjects at King Saud University - College of Medicine (Approval No. E-22-7116), included 603 participants from ATLS courses. These courses were held at the Trauma Courses Office at the Ministry of National Guard Health Affairs and the Clinical Skills and Simulation Center at King Saud University Medical City, under the American College of Surgeons Committee of Trauma Affairs between January 2019 and December 2020 and the Clinical Skills and Simulation Center at King Saud University Medical City in Riyadh from December 2020 to January 2023. Data were retrospectively collected through a registry, capturing participant demographics and practice details to medical specialties and assessment outcomes such as pre-test scores, initial assessment results, and post-test scores. All participants were reviewed back to confirm missing data, opinions on course duration, and whether they used the provided textbook to prepare for the course. Specifically, for interns, we confirmed whether they undertook an elective rotation in a trauma-related specialty, with a response rate of 66.7% For this subset of data. Trauma-related specialties encompass general surgery, emergency medicine, orthopedic surgery, vascular surgery, and neurosurgery. For this study, failure was defined as a score of less than 75 percent on the written test or below the standard performance in the practical session.

For statistical analysis, we compared characteristics between participants who successfully completed the ATLS course and those who did not. Continuous variables were examined using median and interquartile ranges due to the non-normal distribution and presence of outliers, while categorical variables were analyzed using Chi-square or Fisher's exact tests as deemed appropriate. The Mann-Whitney U test was utilized to compare medians for continuous variables when the assumption of normality was not met, as indicated by the Shapiro-Wilk test. Data visualization was conducted using the statistical software R with the R Studio integrated development environment (version 2023.09.1 + 494), employing the Tidyverse dplyr and ggplot2 packages. A linear regression was applied to identify predictors of course completion. Binary logistic regression analysis was used for categorical outcomes, and multivariate regression analysis was conducted to adjust for potential confounders and determine the independent effects of the predictors on the likelihood of successfully completing the ATLS course.

RESULTS

The overall failure rate for participants in the ATLS course was 36.6%. **Table 1** presents participant demographics, test scores, and educational resources in relation to outcome. Males constituted 65.5% of the total participants, with a slightly lower percentage of failures (64.8% vs. 70.8%) and (35.2% vs 29.2%) compared to females, though this was not statistically significant (P=.06). Among participants older than 45 years, the failure rate was 2.7% compared to a 4.7% pass rate, which was not significantly different (P=.161). Focusing on test scores, the median (IQR) post-test score for all participants was 75 (17.5). Those who failed had a median (IQR) post-test score of 60 (10), significantly lower than the median score of 80 (10) for those who passed (P<.001). Pre-test scores showed a median (IQR) of 85 (17.5) for all participants, with no significant difference between those who failed (median: 85, IQR: 22.5) and those who passed (median: 87.5, IQR: 15) (P=.059). However, there was a significant association between

Table 1. Outcomes of advanced trauma life support (ATLS) course participants: demographics, test scores, and educational resources.

Parameter/Category	Total (n=603)	Failed n=221 (36.6)	Passed n=382 (63.3)	*P* value
Gender				
Male	407 (67.5)	215 (64.8)	192 (70.8)	.06
Female	196 (32.5)	117 (35.2)	79 (29.2)	
Age (years)				
Median (IQR)	29 (8)	28 (8)	30 (9)	**<.01**
>45	24 (4)	6 (2.7)	18 (4.7)	.161
Post-test				
Median (IQR)	75 (17.5)	60 (10)	80 (10)	**<.001**
Pre-test				
Median (IQR)	85 (17.5)	85 (22.5)	87.5 (15)	.059
Failed pre-test	147 (24.4)	63 (28.9)	84 (13.9)	**.045**
Edition				
9th edition	442 (73.3)	137 (62)	305 (79.8)	**<.01**
10th edition	161 (26.7)	84 (38)	77 (20.2)	
Level				
Intern	258 (42.8)	111 (50.2)	147 (38.5)	**.003**
Intern with trauma related elective rotation	136 (22.6)	51 (23.1)	85 (22.3)	.445
General Practitioner	49 (8.1)	23 (10.4)	26 (6.8)	.081
General Practitioner working in trauma related specialties	24 (4.1)	10 (4.5)	14 (3.7)	.375
General Practitioner working in non-trauma related specialties	25 (4.1)	13 (5.9)	12 (3.1)	.08
Resident	75 (12.6)	30 (13.6)	45 (12)	.335
Resident of trauma related specialties	52 (8.6)	13 (5.8)	39 (10.2)	.045
Resident of non-trauma related specialties	23 (3.8)	17 (7.7)	6 (1.6)	**<.001**
Junior Resident	52 (8.6)	24 (10.9)	28 (7.6)	.113
Junior Resident of trauma related specialties	35 (5.8)	10 (4.5)	25 (6.5)	.201
Junior Resident of non-trauma related specialties	17 (2.8)	14 (6.3)	3 (0.8)	**<.001**
Senior Resident	23 (3.8)	17 (4.5)	6 (2.7)	.199
Senior Resident of trauma related specialties	17 (2.8)	14 (6.33)	3 (0.8)	.077
Senior Resident of non-trauma-related specialties	6 (1)	3 (1.4)	3 (0.8)	.386
Registrar	109 (18.4)	35 (16.3)	74 (19.6)	.118

Table 1 (cont.). Outcomes of advanced trauma life support (ATLS) course participants: demographics, test scores, and educational resources.

Parameter/Category	Total (n=603)	Failed n=221 (36.6)	Passed n=382 (63.3)	*P* value
Registrar of trauma related specialties	88 (14.6)	26 (11.8)	62 (16.2)	.083
Registrar of non-trauma related specialties	21 (3.5)	9 (4.1)	12 (3.1)	.35
Fellows	9 (1.5)	3 (1.4)	6 (1.6)	.567
Fellow with trauma related specialty	5 (0.8)	1 (0.5)	4 (1)	.396
Fellow with no trauma related specialty	4 (0.7)	2 (0.9)	2 (0.5)	.466
Consultants	100 (16.6)	18 (8.1)	82 (21.1)	**<.001**
Consultants with trauma related specialty	60 (10)	4 (1.8)	56 (14.7)	**<.001**
Consultants with no trauma related specialty	40 (6.6)	14 (6.3)	26 (6.8)	.484
Participant related feedback questions				
Used ATLS manual for studying	365 (60.5)	145 (65.6)	220 (57.6)	**.031**
Comment on course duration: short	94 (15.6)	46 (20.8)	48 (12.6)	**.005**

Data are median (interquartile range) for continuous data and number (percentage) for categorical data. IQR=interquartile range; Failed and passed percentages are based on the column totals, except for the overall failure rate, which is calculated from the total number. The Pearson Chi-Square and the Fisher Exact Test were used to find the significance level of categorical variables, and the Mann-whitney U Test for continuous variables.

failing the pre-test and failure in the ATLS course overall (*P*=.045). In examining the levels of participants, 50.2% of interns failed the course, representing a significantly larger proportion of failures compared to their successes of 38.5% (*P*=.003). Among residents, 6.3% of those who failed were junior residents in non-trauma-related specialties, a higher rate than the 0.8% of successful participants from the same group (*P*<.001). Participant responses revealed a statistically significant association between not using the ATLS manual for studying and failing the course; 65.6% of those who failed did not use the manual, compared to 57.6% of those who passed (*P*=.031). There was also a notable difference in failure rates between editions of the ATLS manual; participants using the 9th edition had a success rate of 79.8%, whereas those using the 10th edition had a lower success rate of 20.2%, which was statistically significant (*P*<.01). For interns excluded from the total physicians taking the ATLS course, the failure rate was 31.8% (**Table 2**). When examining the nature of the practice, there was no significant difference in pass rates between those practicing in rural versus other settings (*P*=.464). A higher median (IQR) post-test was noticed in those who practice in urban settings (**Figure 1**). Specialization appeared to be a significant factor in course outcomes. Notably, general surgeons had a significantly higher pass rate (27.2% passed vs. 13.6% failed, *P*=.001), indicating a strong association between general surgery practice and success in the ATLS course (**Figure 2**) where both the pre-test and post-test medians and IQR exceeded the passing score of 75. Conversely, oral maxillofacial surgeons (OMFS) had a higher failure rate, with 10.9% of those who failed belonging to this specialty compared to only 2.1% who passed (*P*=.001) with a difference between median and IQR between the two boxplots representing pre-test and post-test scores (**Figure 2**). The median (IQR) for the age of all physician participants was 35 years (10), with those who failed being slightly younger at a median (IQR) age of 33.5 years (8.75) versus those who passed at a median (IQR) age of 35 years (8, *P*=.026). The median (IQR) post-test score for all participants was 75 (IQR: 17.5). Physicians who failed had a median (IQR) post-test score of 61.25 (IQR: 7.5), significantly lower than those who passed, who had a median post-test score of 80 (IQR: 10) (*P*<.001). The pre-test scores were

Table 2. Comparison of ATLS course outcomes by gender, age, practice nature, and specialization across all physicians other than interns.

Parameter/Category	Total (n=345)	Failed n=110 (31.8)	Passed n=235 (68.1)	*P* value
Total	345 (100)	110 (31.9)	235 (68.1)	
Gender				
Male	250 (72.5)	79 (71.8)	171 (72.8)	.393
Female	95 (27.5)	31 (28.2)	64 (27.2)	
Age (year)				
Median (IQR)	35 (10)	33.5 (8.75)	35 (8)	**.026**
>45 (yrs)	24 (7)	6 (5.5)	18 (7.7)	.307
Post-test				
Median (IQR)	75 (17.5)	61.25 (7.5)	80 (10)	**<.001**
Pre-test				
Median (IQR)	87.5 (15)	85 (17.5)	87.5 (12.5)	.14
Failed Pre-test	79 (22.9)	30 (27.3)	49 (20.9)	.177
Nature of practice				
Rural	152 (44.1)	50 (45.5)	102 (43.4)	.464
Specialties				
Emergency Medicine	110 (31.9)	29 (26.4)	81 (34.5)	.08
General Surgery	79 (22.9)	15 (13.6)	64 (27.2)	**<.001**
Orthopedics	33 (9.6)	10 (9.1)	23 (9.8)	.43
Pediatrics	30 (8.7)	12 (10.9)	18 (7.7)	.212
General practice	21 (6.1)	9 (8.2)	12 (5.1)	.57
Intensive Care Unit	21 (6.1)	7 (6.4)	14 (6)	.527
Oral Maxillofacial Surgery	17 (4.9)	12 (10.9)	5 (2.1)	**<.001**
Neurosurgery	9 (2.6)	1 (0.9)	8 (3.4)	.161
Pediatric Surgery	4 (1.2)	1 (0.9)	3 (1.3)	.618
Internal Medicine	3 (0.9)	1 (0.9)	2 (0.9)	.685
Family Medicine	3 (0.9)	3 (2.7)	0 (0)	**.032**
Anesthesia	3 (0.9)	1 (0.9)	2 (0.9)	.685
Ear, Nose, Throat	3 (0.9)	3 (2.7)	0 (0)	**.032**
Plastic Surgery	2 (0.6)	1 (0.9)	1 (0.4)	.537
Ophthalmology	2 (0.6)	2 (1.8)	0 (0)	.101
Cardiothoracic Surgery	2 (0.6)	1 (0.9)	1 (0.4)	.537
Obstetrics and Gynecology	1 (0.3)	1 (0.9)	0 (0)	.32
Vascular Surgery	1 (0.3)	0 (0)	1 (0.4)	.68
Urology	1 (0.3)	1 (0.9)	0 (0)	.32
Trauma-related specialties	232 (67.2)	55 (50)	177 (75.3)	**.000004**
Non-trauma specialties	113 (32.8)	55 (50)	58 (24.7)	**.000004**
Refresher course	94 (27.2)	20 (18.2)	74 (31.5)	**.006**

Total percentages are calculated based on the total number of physicians in each category. Failed and passed percentages are based on the column totals, except for the overall failure rate calculated from the total number. The Pearson Chi-Square and the Fisher Exact Test were used to find the significance level of categorical variables, and the Mann-Whitney U test for continuous variables. Trauma-related specialties included general surgery, emergency medicine, orthopedic surgery, vascular surgery and neurosurgery. IQR: interquartile range.

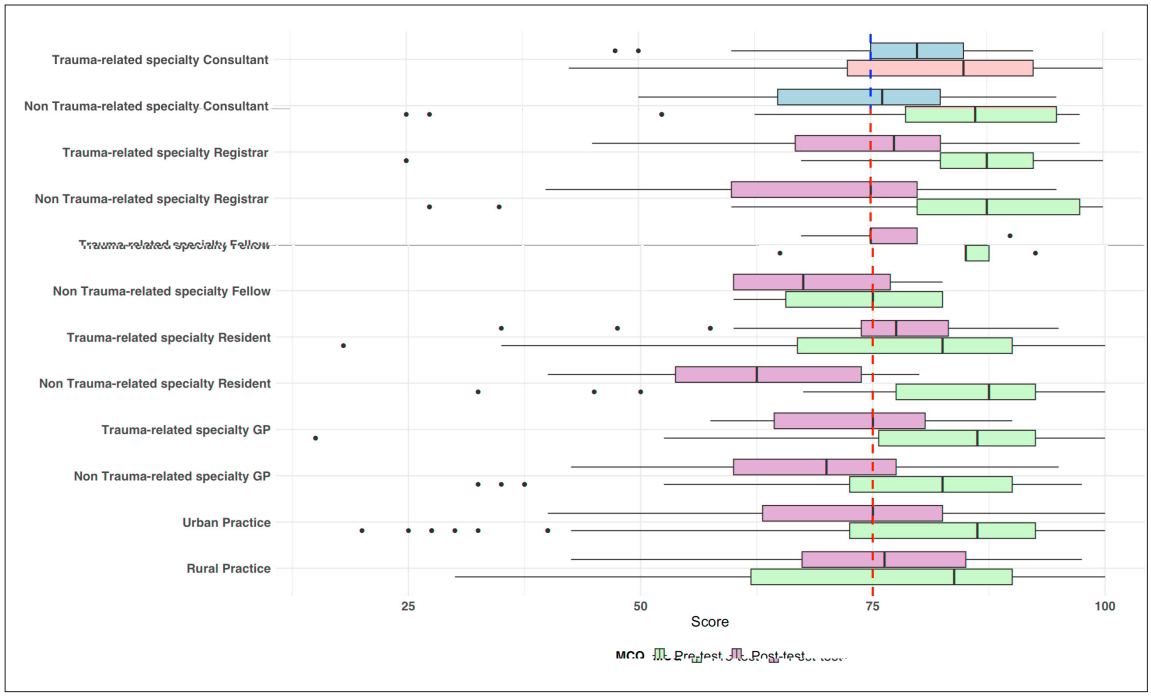

Figure 1. Pre- and post-test marks on the ATLS multiple choice question exams across across levels and nature of practice.

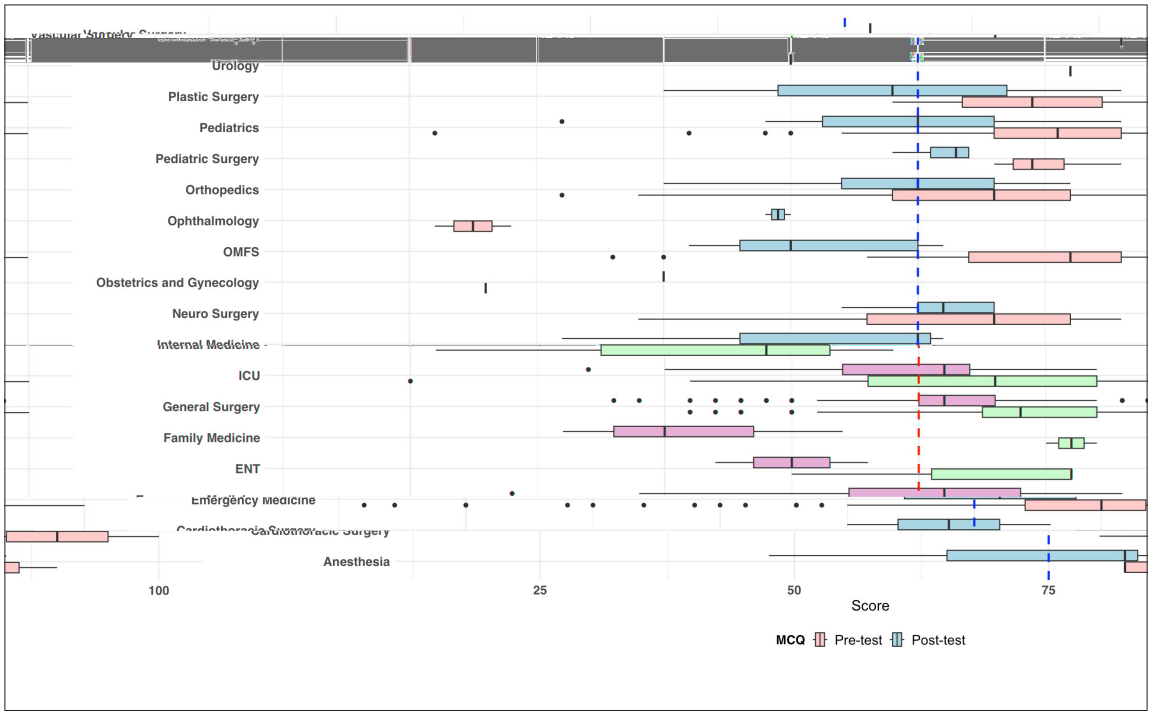

Figure 2. Pre- and post-test marks on the ATLS multiple choice question exams across different specialties.

Table 3. Association of elective in trauma-related specialty with ATLS course outcomes among interns among physicians.

Parameter/Category	Total (n=258)	Failed n=111 (43%)	Passed n=147 (57%)	*P* value
Total	258 (100%)	111 (43%)	147 (57%)	
Gender				
Male	157 (60.9%)	66 (59.5%)	91 (61.9%)	.393
Female	101 (39.1%)	45 (40.5%)	56 (38.1%)	
Age (year)	27 (2)	25 (2)	27 (2.25)	.179
Post-test score	75 (17.5)	60 (10)	80 (10)	**<.001**
Pre-test score	85 (21.87)	85 (23.75)	85 (17.5)	.25
Failed pre-test	68 (100%)	33 (29.7%)	35 (23.8%)	.177
Elective in trauma-related specialty	135 (52.3%)	51 (45.9%)	84 (57.1%)	**.049**

Data are median (interquartile range) for continuous data and number (percentage) for categorical data.The total percentage reflects the proportion of interns in the entire group. The median age and interquartile ranges are given for both failed and passed groups. 'Elective in trauma-related specialty' refers to whether interns had completed an elective in specialties such as general surgery, orthopedics, emergency medicine, or neurosurgery. Failed and Passed percentages are based on the column totals, except for the overall failure rate calculated from the total number. Pearson Chi-Square and Fisher's Exact Test were used to find the significance level of categorical variables, and for continuous variables, we used the Mann-Whitney U test).

not significantly different between the groups (*P*=0.14). When looking at the distinction between trauma-related specialties and non-trauma specialties, physicians in trauma-related fields had a significantly higher pass rate (75.3% vs. 24.7%, *P*=.000004). Further breakdown of trauma related practice to participtants level is presented in **Figure 1**. The refresher course also had a positive impact, with 31.5% of those who passed having taken it, compared to 18.2% who failed (*P*=.006). In the subset of interns, the failure rate for the ATLS course was 43%. The gender distribution among interns who failed and passed did not show a significant difference, with males constituting 59.5% of those who failed and 61.9% of those who passed (*P*=.393). The median (IQR) age for all intern participants was 27 years (2), with no significant age difference between those who failed (median: 25 years, IQR: 2) and those who passed (median: 27 years, IQR:2.25) (*P*=.179). Notably, undertaking an elective in a trauma-related specialty was significantly associated with passing the ATLS course among interns. Of those who passed, 57.1% had completed an elective in a trauma-related specialty, compared to 45.9% of those who failed (*P*=.049) (**Table 3**) (**Figure 3**).

Comparative analysis of pre-test and post-test scores across various participant categories revealed notable changes in median (IQR) scores before and after the course (**Table 4**), with significant differences observed across categories such as gender, age, and professional level. The overall median reduction in scores from pre-test to post-test across all participants was -10 points (*P*<.01). Participants older than 45 years experienced a median change of -12.5 points (*P*=.02), which is slightly more than the overall reduction. Participants aged 25-45 years showed a median change of -10 points (*P*=.03), aligning with the overall trend.

When comparing different levels, there were clear differences between those in trauma-related specialties and those in non-trauma-related specialties. Residents in non-trauma-related specialties exhibited a substantial decrease in scores, with a median change of -25 points (*P*=.001), whereas residents in trauma-related specialties experienced a much smaller median change of -5 points (P=.149) Consultants also showed a marked difference based on their specialty. Consultants in non-trauma-related specialties had a median reduction of -10 points (*P*<.01), which contrasts with a more modest reduction of -5 points (P=.045) observed in consultants in trauma-related specialties. The variation in median scores across different specialties is illustrated in **Figure 4**. OMFS participants, with a moderate count, experienced a substantial median change of -27.5 points (*P*<.001). Although family medicine participants saw the largest reduction with a median change of -40 points (*P*=.081), the number of participants in this category was small, rendering the result statistically insignificant.

A linear regression analysis was conducted to find predictors of success in the ATLS course among physicians, excluding interns (**Table 5**). The model identified three variables that were significantly predictive of success: age, pre-test scores, and attendance in the course

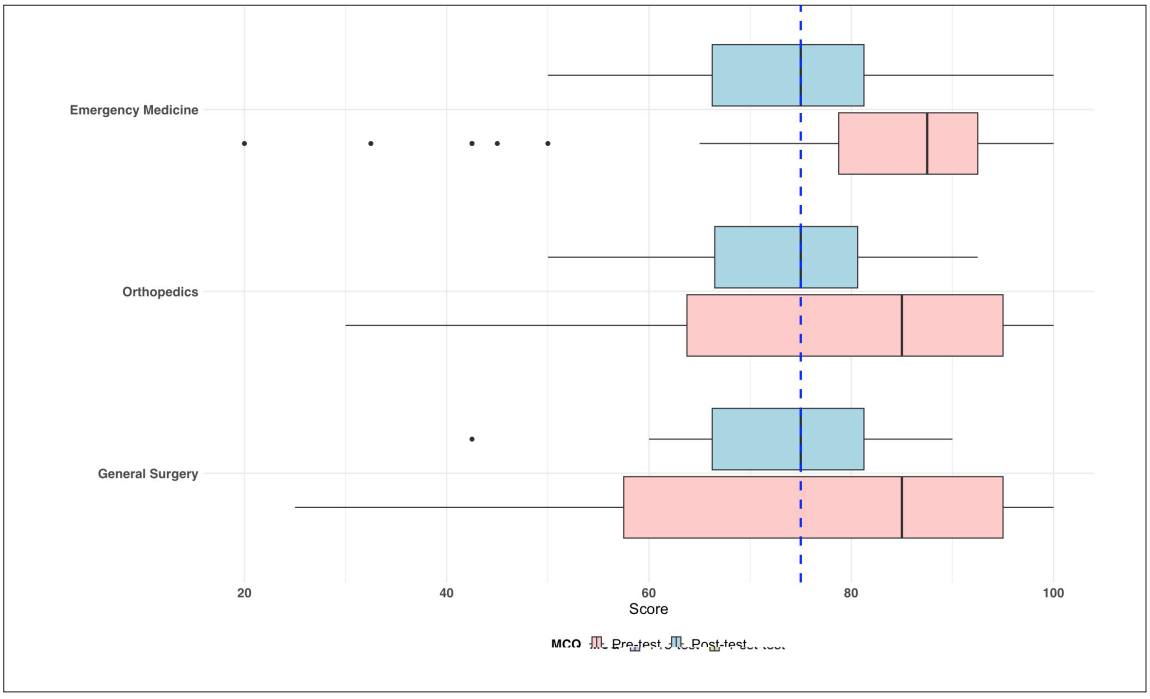

Figure 3. A box plot graph displays the distribution of scores for the ATLS multiple choice question (MCQ) exams among interns taking a summer elective in three specialties (trauma-related). The boxes represent pre-test scores, indicating the interns' knowledge before taking the ATLS course. The boxes illustrate post-test scores, reflecting the knowledge after the course completion. The central line in each box denotes the median score, while the edges of the box indicate the interquartile range (25th to 75th percentile). Outliers are represented by individual dots outside the boxes. The dashed vertical line indicates the threshold for a passing score on the exam.

Table 4. Compartive analysis of pre-test and post-test across overall participtants parameters.

Parameter/ Category	Total n (%)	Pre-Test Score Median (IQR)	Post-Test Score Median (IQR)	Change Median (IQR)	Difference of the change in parameter median from the total median change	*p*
Total	603 (100%)	85 (17.5)	75 (17.5)	-10 (0)	0	**<.001**
Gender						
Male	407 (67.4%)	87.5 (17.5)	75 (17.5)	-7.5 (0)	2.5	**<.01**
Female	196 (32.5%)	85 (17.5)	75 (20)	-10 (2.5)	0	**<.01**
Age (year)						
<25	20 (3.31%)	82.5 (31.25)	63.75 (17.5)	-18.75 (-13.75)	-8.75	**<.01**
25-45	559 (92.7%)	85 (17.5)	75 (17.5)	-10 (0)	0	**<.01**
>45	24 (4%)	90 (10.625)	77.5 (10.625)	-12.5 (0)	-2.5	**<.01**
Level						
Intern	258 (42.8%)	85 (21.875)	75 (17.5)	-10 (-4.375)	0	**<.01**

Table 4 (cont.). Compartive analysis of pre-test and post-test across overall participtants parameters.

Parameter/ Category	Total n (%)	Pre-Test Score Median (IQR)	Post-Test Score Median (IQR)	Change Median (IQR)	Difference of the change in parameter median from the total median change	*p*
Intern with elective in trauma related specialities[a]	136 (52.7%)	85 (20)	75 (15)	-10 (-5)	0	**<.01**
General Practitioner	49 (8.1%)	85 (17.5)	75 (17.5)	-12.5 (0)	-2.5	**<.01**
General Practitioner working in trauma related specialties	24 (4.1%)	86.25 (16.875)	75 (16.25)	-11.25 (-0.625)	-1.25	**<.01**
General Practitioner working in non-trauma related specialties	25 (4.1%)	82.5 (17.5)	70 (17.5)	-12.5 (0)	-2.5	.0722
Resident	75 (12.6%)	83.75 (21.25)	75 (18.125)	-8.75 (-3.125)	1.25	**<.01**
Resident of trauma related specialties	52 (8.6%)	82.5 (23.125)	77.5 (9.375)	-5 (-13.75)	5	.1497
Resident of non-trauma related specialties	23 (3.8%)	87.5 (15)	62.5 (20)	-25 (5)	-15	**<.01**
Registrar	109 (18.4%)	87.5 (10)	77.5 (17.5)	-10 (7.5)	0	**<.01**
Registrar of trauma related specialties	88 (14.6%)	87.5 (10)	77.5 (15.625)	-10 (5.625)	0	**<.01**
Registrar of non-trauma related specialties	21 (3.5%)	87.5 (17.5)	75 (20)	-12.5 (2.5)	-2.5	**<.01**
Fellows	9 (1.5%)	82.5 (17.5)	75 (12.5)	-7.5 (-5)	2.5	.2662
Fellow with trauma related specialty	5 (0.8%)	85 (2.5)	75 (5)	-10 (2.5)	0	.4005
Fellow with no trauma related specialty	4 (0.7%)	75 (16.875)	67.5 (16.875)	-16.875 (-7.5)	-6.875	.6489
Consultants	100 (16.6%)	85 (18.125)	77.5 (10)	-7.5 (-8.125)	2.5	**<.01**
Consultants with trauma related specialty	60 (10%)	85 (20)	80 (10)	-5 (-10)	5	**.0102**
Consultants with no trauma related specialty	40 (6.6%)	86.25 (16.25)	76.25 (17.5)	-10 (1.25)	0	**<.01**
Physicians other than interns	345 (57.2%)	87.5 (15)	75 (17.5)	-12.5 (2.5)	-2.5	**<.01**

Table 4 (cont.). Compartive analysis of pre-test and post-test across overall participtants parameters.

Parameter/ Category	Total n (%)	Pre-Test Score Median (IQR)	Post-Test Score Median (IQR)	Change Median (IQR)	Difference of the change in parameter median from the total median change	*p*
Medical Specialities						
Emergency Medicine[a]	110 (31.9%)	87.5 (11.875)	77.5 (16.875)	-10 (5)	0	**<.01**
General Surgery[a]	79 (22.9%)	85 (12.5)	77.5 (7.5)	-7.5 (-5)	2.5	**<.01**
Orthopedics[a]	33 (9.6%)	82.5 (17.5)	75 (16.875)	-7.5 (-0.625)	2.5	**.013**
Pediatrics[a]	30 (8.7%)	88.75 (12.5)	75 (16.875)	-13.75 (4.375)	-3.75	
General practice[a]	21 (6.1%)	81.25 (16.875)	75 (19.375)	-6.25 (2.5)	3.75	.18
Intensive Care Unit[a]	21 (6.1%)	82.5 (22.5)	77.5 (12.5)	-5 (-10)	5	.058
Oral Maxillofacial Surgery[a]	17 (4.9%)	90 (15)	62.5 (17.5)	-27.5 (2.5)	-17.5	**<.01**
Neurosurgery[a]	9 (2.6%)	82.5 (20)	77.5 (7.5)	-5 (-12.5)	5	.423
Pediatric Surgery[a]	4 (1.2%)	86.25 (5)	78.75 (3.75)	-7.5 (-1.25)	2.5	**.029**
Internal Medicine[a]	3 (0.9%)	60 (22.5)	75 (18.75)	15 (-3.75)	25	.383
Family Medicine[a]	3 (0.9%)	90 (2.5)	50 (13.75)	-40 (11.25)	-30	.081
Anesthesia[a]	3 (0.9%)	82.5 (3.75)	82.5 (18.75)	0 (15)	10	.643
Ear, Nose, Throat[a]	3 (0.9%)	90 (13.75)	62.5 (7.5)	-27.5 (-6.25)	-17.5	.261
Plastic Surgery[a]	2 (0.6%)	86.25 (13.75)	72.5 (22.5)	-13.75 (8.75)	-3.75	.699
Ophthalmology[a]	2 (0.6%)	31.25 (3.75)	61.25 (1.25)	30 (-2.5)	40	.245
Cardiothoracic Surgery[a]	2 (0.6%)	90 (10)	72.5 (10)	-17.5 (0)	-7.5	.699
Obstetrics and Gynecology[a]	1 (0.3%)	32.5 (0)	50 (0)	17.5 (0)	27.5	.999
Vascular Surgery[a]	1 (0.3%)	95 (0)	77.5 (0)	-17.5 (0)	-7.5	.999
Urology[a]	1 (0.3%)	90 (0)	62.5 (0)	-27.5 (0)	-17.5	.999
Takers of the course as a refresher course[a]	98 (28.4%)	87.5 (12.5)	77.5 (10)	-10 (-2.5)	0	**<.01**

The total percentage reflects the proportion of each category within the overall group. The median scores and interquartile ranges are provided for both pre-test and post-test assessments across various participant categories. 'Elective in trauma-related specialty' refers to whether interns had completed an elective in specialties such as general surgery, orthopedics, emergency medicine, or neurosurgery. Trauma-related specialties included general surgery, emergency medicine (ER), orthopedic surgery, vascular surgery, and neurosurgery. The changes observed between pre-test and post-test scores are calculated as the difference between the post-test and pre-test medians. The significance level for each category was determined using the Mann-Whitney U test. [a]Percentage reported from all physicians excluding interns (n=345).

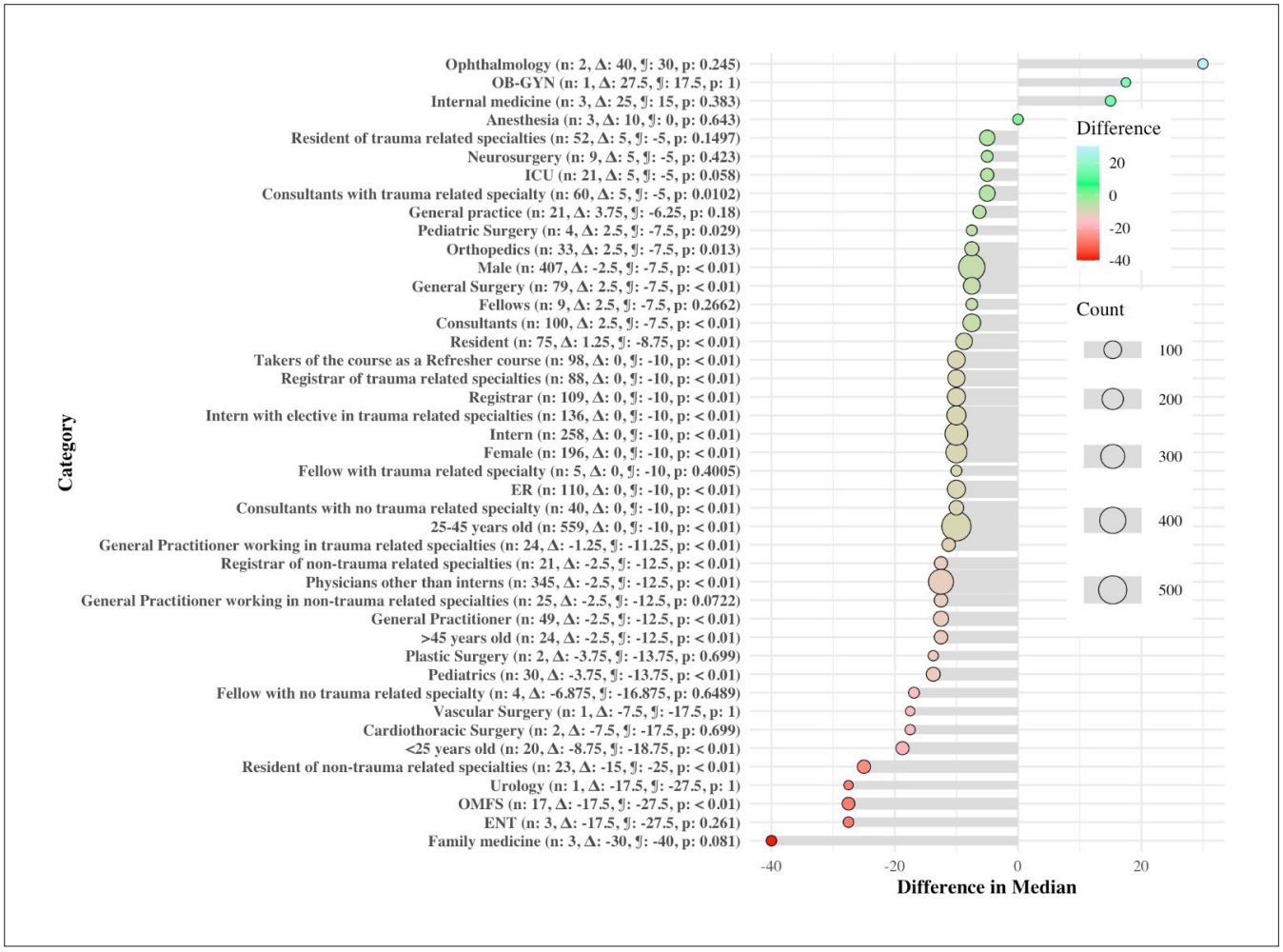

Figure 4. Difference in median (post-test - pre-test) by category. Circle size: Represents the count of participants in each category. Color Gradient: Indicates the difference in median scores from pre-test to post-test. Categories: Listed on the left, corresponding to each specialty and professional level. Δ: Represents the change in median scores relative to the overall median score change across all categories. ¶: Represents the specific difference between pre-test and post-test median scores for each category.

as a refresher course. For each additional year of age, the likelihood of success in the course increased by a factor of 2.2 (95% CI [0.78, 3.65], SE=0.73246, t=3.030, *P*<.01). Pre-test scores were also indicative of success; each additional point on the pre-test was associated with an increased probability of success by 0.13 (95% CI [0.03, 0.24], SE=.05348, t=2.437, *P*<.05). The most substantial predictor was the attendance of a refresher course. Physicians who attended the course as a refresher course were 4.8 times more likely to succeed in the ATLS course (95% CI [1.69,7.49], SE=1.59404, t=3.018, *P*<.01). **Table 6** displays the results from univariate and multivariate logistic regression models predicting the likelihood of success in the ATLS course among physicians, excluding interns. The univariate analysis identified that participation in a refresher course predicted an increased likelihood of success (OR=2.07, 95% CI [1.18-3.611, *P*=.016). Conversely, general practitioners (GPs) and OMFS were less likely to succeed, with odds ratios of 0.47 (95% CI [0.25-0.871, *P*=.0162) and 0.18 (95% CI [.06-0.52], *P*=.0015), respectively. General surgeons had a higher likelihood of success (OR=2.37, 95% CI [1.28-4.39], *P*=.006), and consultants of trauma-related specialties showed the highest odds of success (OR= 8.29, 95% CI [2.92-23.51, *P*=.0001). In the multivariate analysis, which controlled for confounding variables, attending a refresher course remained a significant predictor of success (OR=2.17, 95% CI [1.09-4.321, *P*=.0276). The odds for general surgeons increased to an OR of 3.26 (95% CI [1.10-9.66], *P*=.0331), while the

Table 5. Linear regression analysis of predictors of success in the ATLS course among physicians.

	r^2 (95% CI)	Standard error	t	*P*
Age (year)	2.2 (0.78-3.65)	0.73246	3.030	**<.01**
Pre-test	0.13 (0.03-0.24)	0.05348	2.437	**<.05**
Refresher course	4.8 (1.69-7.49)	1.59404	3.018	**<.01**

The refresher course variable indicates whether the physician attended this course as a refresher course. The table reports the magnitude of the association between each predictor and the likelihood of success in the ATLS course, with p-values detailing the statistical significance.

Table 6. Univariate and multivariate analysis predicting success in the ATLS course.

Predictor	Univariate		Multivariate	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Refresher course	2.07 (1.18-3.61)	.016	2.17 (1.09-4.32)	.0276
GP	0.47 (0.25-0.87)	.0162		
OMFS	0.18 (0.06-0.52)	.0015		
GS	2.37 (1.28-4.39)	.006	3.26 (1.10-9.66)	.0331
Consultant of trauma-related specialty	8.29 (2.92-23.5)	.0001	6.98 (1.45-33.61)	.0153

Note. OR=odds ratio; CI = confidence interval; GP=general practitioner; OMFS=oral maxillofacial surgery; GS = general surgery. Univariate analyses explore the individual effect of each predictor, while multivariate analyses control for other factors. *P* values denote the significance of each predictor's association with the likelihood of success in the course. Model fit was assessed during the analysis using: deviance, AIC, and McFadden's R^2. These were used to refine the model but are not included in the table for brevity.

solid predictive value for consultants of trauma-related specialties persisted (OR=6.98, 95% CI [1.45-33.611, *P*=.0153).

DISCUSSION

In a region characterized by a youthful population and elevated rates of traffic accidents, the imperative for providing top-tier advanced trauma education has never been more pronounced. One of the major components of an effective trauma system is developing a protocol-driven system.[7] Embracing the trauma care tenets devised by the American College of Surgeons Committee on Trauma has yielded positive outcomes in reducing mortality.[6] Serving as the standard in imparting knowledge to healthcare practitioners at every tier within Saudi Arabia and worldwide, the ATLS course plays an instrumental role.[6,8] This study stands as a pioneering effort in SA, comprising a robust cohort of 603 participants, aligning closely with reported figures in the literature. When compared to Abu-Zidan et al in the United Arab Emirates with 1041 participants and Mobily et al 2015 study in the United States involving 744 participants.[2,4] Compared to previously reported literature, this study offers an enhanced understanding of ATLS course dynamics in regions where English is not the primary language and where intern participants are large n=258 (42.8%). The fact that interns use this course to indicate interest in matching programs of trauma-related specialties clarifies the noticeable preponderance of intern participants in our study. Physicians from rural practice backgrounds represented a considerable amount, 44.1% of all interns excluded participtants. This high number of rural practitioners mandates tailored stations focusing on more critical aspects where rural practitioners had the most exposure. We recommend intensifying the course components for this part of the study population, as it is evident that this can enhance outcomes.[9] ATLS certification has evolved into a compulsory standardized mandate for Saudi Arabian hospitals.[10] The official entity responsible for conferring accreditation certificates to both governmental and private healthcare establishments within Saudi Arabia is The Saudi Central Board for Accreditation of Healthcare Institutions (CBAHI).[11] CBAHI underscores the critical importance of incorporating substantial trauma training across nursing, surgical, and non-surgical services to provide all-encompassing trauma care. This includes the acquisition of certifications such as ATLS, Advanced Trauma Care for Nurses (ATCN), or their equivalents.[10]

The failure rate in our study was 36.6%, which is substantially higher than the rates reported by Mobily et al (10.5%) and Abu-Zidan et al (15.8%).[2,4] A notable 50.2%

of those who failed in our cohort were interns, whereas the failure rate after excluding interns from all participtants stood at 31.8%. The predictors of ATLS course failure differ across various studies and populations. Meanwhile, Mobily et al identified English as a second language as a contributing factor to failure.[2] This predictor was inapplicable to measure among our participants and Abu-Zidan et al, where the majority of whom were also non-native English speakers.[4] Consistent with the literature, our study reaffirms a pattern where participants from surgical or trauma-related specialties tend to have higher passing rates. Mobily et al reported a particularly high failure rate among pediatric providers, and Abu-Zidan et al noted the same within family medicine.[2,4] While our study had a small sample of family medicine physicians (n=3), the fact that all failed suggests that this trend may also extend to our participants. Additionally, pediatricians in our cohort had a slightly but insignificantly higher rate of failure; preparing for fellowships in the ICU and ER might be a motivation among pediatric participants, which might impact their motivation and, consequently, enhance their performance on the ATLS course compared to Mobily et al. Our findings diverge significantly from previous studies regarding the specialties with the highest failure rates. OMFS and general practitioners had the highest rates of failure in our study, a deviation from the trend of higher failure rates in pediatricians and family medicine specialists noted by Mobily et al and Abu-Zidan et al. Surgeons, particularly general surgeons, neurosurgeons, and orthopedic surgeons, achieved the highest post-test multple choice question marks in our study, aligning with the trend noted in Abu-Zidan et al. However, OMFS specialists in our cohort did not follow this pattern, indicating that certain specialties might require additional targeted support to improve ATLS course outcomes.

The regression findings from our study present an interesting contrast when compared with those reported by Abu Zidan et al and Mobily et al. In our study, a linear regression analysis revealed that age also appears to play a role in the outcome. Older age increased the likelihood of success in the ATLS course, which contradicts Mobily et al, where age greater than 55 years was a predictor of failure. However, in our study, only 24 participants were over the age of 45, compared to Mobily et al, which had a higher number of older participants.[2] Our study suggests that the predominance of younger participants may have influenced the higher failure rate. This finding could be due to differing age distributions in the populations studied or variations in the professional experience that comes with level manifested by age, and it suggests that older physicians may have a greater foundation of knowledge or test-taking skills that benefit them in the course these findings are contributed to a bimodal distribution pattern. Our analysis also highlights that pre-test scores indicated success, which aligns with the findings Abu Zidan et al that a low pre-test score increases the chance of failure.[4] This consistency across studies emphasizes the predictive value of pre-test scores as an indicator of performance in the ATLS course, reinforcing the importance of baseline knowledge and preperation before undertaking the course. The role of refresher courses was underscored as a significant predictor of success in our study, with physicians who attended a refresher course markedly more likely to succeed. This finding is unique as neither Abu Zidan et al nor Mobily et al had reported impact refresher courses.[2,4] The effectiveness of such courses may reflect the value of continuous education and its potential to update and consolidate physicians knowledge and skills, but also could correlate with a higher level of practice. Interestingly, in our study, and after excluding interns from the predictive model, GPs and OMFS were less likely to succeed, while general surgeons and consultants of trauma-related specialties had higher odds of success. This aligns with ther results of Mobily et al, where non-trauma and non-emergency medicine providers were more likely to fail. Our multivariate analysis supports the notion that being a general surgeon is advantageous, with an increased odds ratio for success. This could imply that the ATLS course curriculum is particularly well-suited to the skills and experiences of surgeons. Conversely, Abu Zidan et al identified family medicine physicians as having a higher risk of failing, a finding not observed in our study due to the low number of family medicine participants in our study.[4]

This study underscores the necessity for targeted adaptations within the ATLS course to better accommodate its diverse participants, particularly those from non-trauma specialties or lack experience and demonstrated greater difficulties. The current course may not fully match the clinical realities these professionals encounter. To address these disparities, tailored pre-course preparation and an extension of the course duration for less experienced participants could provide the additional time needed to thoroughly assimilate and apply the material. It is important to note that these are proposed solutions without solid evidence yet. Continuous evaluation of the ATLS course is essential to optimize educational and subsequent clinical outcomes, and to that end, we will continue to assess our participants. As authors, we emphasize that we do

not advocate adapting the assessment tool itself but rather suggest focusing on enhancing preparation and addressing factors related to inadequate preparation.

Limitations

Our study carries with it certain limitations that warrant acknowledgment and future consideration. Aligned with the retrospective nature prevalent in much of the existing literature, our study's design was retrospective in nature as well.[2,4,12] However, in an effort to expand our insights, we introduced prospective components aimed at encompassing factors such as the engagement in a summer elective within trauma-related specialties, preferences regarding course duration, and the use of the ATLS manual for studying purposes. Moreover, the prospective phase also aimed to rectify missing data where applicable. Although our response rate was notably reasonable at 66.7%, it's important to acknowledge that complete data capture within the prospective variables remained challenging. Certain dimensions, including participant emotional states, motivational levels, the alma maters of interns, their performance during elective rotations, and factors related to instructors – encompassing their experience levels – remained unexplored in this study.

As instructors, we believe that the outcomes of the Saudi Medical Licensing Exam might influence the ATLS. This perspective stems from the SMLE encompassing pivotal ATLS-based multiple-choice questions. Additionally, enrolling in supplementary courses like basic life support, advanced cardiac life support, and pediatric life support could potentially foster heightened motivation levels and decrease stress among participants. However, it is essential to underscore that we need more data for these conclusions. Although these data are among this study's limitations, nonetheless we perceive them as subjects worthy of exploration in future research.

Conclusion

In Saudi Arabia, a 36.6% ATLS failure rate underscores the importance of refining training approaches, especially for certain levels and specialties. General practitioners and OMFS specialists were identified as predictors of failure. In contrast, general surgeons and consultants in trauma-related specialties exhibited higher success rates, showcasing the course's compatibility with their expertise and skills. Key predictors of success included age, pre-test scores, participation in a refresher course, and being a general surgeon or consultant in a trauma-related field. These insights advocate for implementing targeted, specialty, and level-specific interventions to enhance ATLS course outcomes.

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