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Assessment of electrocardiography interpretation competency of Ethiopian medical interns: a multi-site study

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Accurate electrocardiogram (ECG) interpretation is critical for early diagnosis of cardiac conditions, yet competency among medical interns in Ethiopia remains understudied. While an earlier study offered initial insights, it was limited to two institutions. This multi-site study aimed to provide a more current and comprehensive assessment of ECG interpretation skills and associated factors among Ethiopian medical interns. A multi-site cross-sectional study was conducted with 220 interns from four randomly selected institutions. Data were collected via a structured questionnaire, adapted from validated instruments, and analyzed using SPSS 25. Competency was defined as scoring ≥ 80% on a 14-item ECG interpretation test. Multivariable logistic regression was used to identify determinants of competency. A statistically significant P-value was set at less than 0.05. The overall competency rate was 19.1%, with significant institutional variation ($p < 0.001$), ranging from 7.1% to 32.7%. Confidence in ECG interpretation (AOR = 9.10, 95% CI: 1.22–12.67) and emergency department (ED) rotations during clinical years (AOR = 3.87, 95% CI: 1.86–8.05) and internship (AOR = 4.07, 95% CI: 1.68–9.85) were key predictors of competency. This study highlights a persistent low competency in ECG interpretation among Ethiopian medical interns. These findings highlight the importance of structured ECG training, incorporating dedicated ED rotations, and building self-confidence through practical, simulation-based learning to improve skills and patient outcomes.

Keywords Electrocardiogram, ECG interpretation competency, Medical intern, Emergency department, Cardiovascular disease

Electrocardiography (ECG) is the graphical display of the heart's electrical activity. It is a fundamental, cost-effective, and non-invasive tool for diagnosing a wide range of cardiac conditions and electrolyte abnormalities[1,2]. Its clinical power lies in the breadth of critical information it can provide; a single ECG can diagnose life-threatening conditions like myocardial infarction, dangerous arrhythmias, or the effects of a massive pulmonary embolism[1,3]. During each heartbeat, a healthy heart has an orderly progression of depolarization that starts in the sinoatrial node, spreads through the atria, passes through the atrioventricular (AV) node, and moves through the ventricles via the Bundle of His and Purkinje fibers[2].

Mastery of ECG interpretation is an essential skill for medical professionals, particularly interns, as it is crucial for the timely recognition and management of cardiac emergencies[2,4]. However, ECG interpretation is a complex skill to learn, and misinterpretation can lead to inappropriate diagnoses and clinical decisions[4]. Research has shown that medical students and interns often lack adequate competence globally[4–7]. A previous study in Ethiopia by Getachew et al. reported a low competency rate of 20.8% among interns at two institutions[8]. Given the time elapsed since that study and its limited scope, a current, multi-site assessment is necessary to understand the national landscape and institutional variations in ECG training.

ECG interpretation competency involves a combination of skills: proficient lead placement, ability in continuous monitoring, familiarity with interpreting a wide range of patterns, and a proper attitude towards its clinical importance[2,4]. Competent individuals possess sufficient knowledge of pathophysiological mechanisms, can accurately judge recording quality, and understand the evidence behind various diagnoses[4].

The aim of this study was to assess the ECG interpretation competency and its determinants among medical interns across four Ethiopian institutions in 2024.

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Methodology

Study setting, design, and period

A multi-site cross-sectional study was conducted from June 3, 2024, to December 27, 2024. Four institutions were randomly selected from Ethiopia's 22 medical colleges: St. Paul's Hospital Millennium Medical College (SPHMMC), Black Lion Hospital (BLH), Jimma University Medical College (JUMC), and Adama Hospital Medical College (AHMC). SPHMMC and BLH interns had emergency medicine rotations during both clinical years and internship, AHMC during clinical years only, while JUMC had no emergency medicine rotations.

Study population and eligibility criteria

The source population was all medical students enrolled at the selected schools. The study population comprised all graduating medical interns (final-year medical students undertaking their mandatory one-year internship before full licensure) from the schools who met the inclusion criteria. Inclusion criteria were being a graduating intern in 2025 and providing informed consent. Exclusion criteria were unwillingness or inability to participate.

Sample size determination and sampling technique

The sample size was calculated using a single population proportion formula with the following assumptions: based on previous research[8], a competency proportion of 35%, a 95% confidence level, a 5% margin of error, and a 15% non-response rate. The final calculated sample size was 220. Proportional random sampling was employed across the four institutions based on their intern cohort sizes. From each school's final-year intern pool, participants were randomly selected in proportion to their institutional representation. All 220 selected interns agreed to participate, yielding a 100% response rate from each institution (SPHMMC: 49/49; BLH: 79/79; JUMC: 70/70; AHMC: 22/22).

Study variables and data collection tool

The dependent variable was *competency* in ECG interpretation (competent/non-competent). Independent variables included age, sex, adequacy of ECG training, presence of emergency medicine rotation during clinical years and internship, and self-reported confidence.

The data collection tool was a structured questionnaire adapted from previously validated instruments used in similar studies[5,8]. It was administered in English and comprised four sections:[1] demographic characteristics and training history (8 questions)[2], interpretation of fundamental ECG parameters like rate, rhythm, and axis (3 questions)[3], diagnosis of critical cardiovascular conditions (4 questions), and[4] identification of common ECG abnormalities (7 questions). The questionnaire was adapted for the Ethiopian context by selecting 14 ECG tracings that represented basic parameters and common, critical abnormalities relevant to the local clinical setting from the larger pools used in the original studies. The demographic and self-assessment sections were also modified to align with the structure of Ethiopian medical training programs.

Operational definitions

Competency was assessed using 14 questions representing basic and common ECG abnormalities. The total score ranged from 0 to 14. Participants with a score of 11 or more (≥ 79%) were classified as competent.

Data quality control and analysis

Trained data collectors administered the questionnaire under supervision. The principal investigator performed daily quality checks for completeness. Data were coded, entered electronically, and cleaned to identify outliers or missing values before analysis in SPSS version 25.

Descriptive statistics (frequencies, percentages, mean, median, standard deviation) summarized participant characteristics. The Chi-square test was used to compare competency rates across institutions. Bivariate and multivariable logistic regression analyses were performed to identify factors associated with competency. Variables with a p-value < 0.25 in bivariate analysis were included in the initial multivariable model. A backward stepwise elimination method was used, with a significance level of $p < 0.05$ for variables to be retained in the final model. The results are presented as Adjusted Odds Ratios (AOR) with 95% Confidence Intervals (CI).

Ethical considerations

Ethical clearance was obtained from the Institutional Review Board (IRB) of St. Paul Hospital Millennium Medical College. The study was conducted per the Declaration of Helsinki. Informed consent was obtained from each participant, and all data were kept anonymous and confidential.

Results

Socio-demographic characteristics

A total of 220 interns participated. The distribution was 79 (35.9%) from BLH, 70 (31.8%) from JUMC, 49 (22.3%) from SPHMMC, and 22 (10%) from AHMC. Among the participants, 122 (55.5%) were male, and 98 (44.5%) were female. The majority, 139 (63.2%), were aged 23–25 years, with a median age of 25 years and a mean of 25.48 (± 0.80) years (Table 1).

ECG training and interpretation

Only 63 (28.6%) participants felt they had sufficient ECG training in medical school. Most interns, 150 (68.2%), had a separate ED rotation during clinical years, but only 128 (58.2%) had one during internship. Regarding confidence, 93 (42.3%) felt somewhat confident in interpreting basic ECG components, while the majority expressed a desire for more training (214, 97.3%) (Table 2).

Variables		Place of study				
		SPHMMC, *n* (%)	BLH, *n* (%)	JUMC, *n* (%)	AHMC, *n* (%)	Total
Age (mean +-SD)		25.29 + 0.935	25.35 + 0.892	25.27 + 0.741	27 + 2.289	25.48(0.80)
Age Group	23–25 Years	35 (15.9)	49 (22.3)	47 (21.4)	8 (3.6)	139 (63.2)
	26–31 Years	14 (6.4)	30 (13.6)	23 (10.5)	14 (6.4)	81 (36.8)
Sex	Female	26 (11.8)	27 (12.3)	39 (17.7)	6 (2.7)	98 (44.5)
	Male	23 (10.5)	52 (23.6)	31 (14.1)	16 (7.3)	122 (55.5)

Table 1. Socio-demographic of medical interns participated in ECG competency assessment in Ethiopia, 2024. SPHMMC, St. Paul's Hospital Millennium Medical College; BLH, Black Lion Hospital; JUMC, Jimma University Medical College; AHMC, Adama Hospital Medical College.

Participants' characteristics related to ECG training and interpretation		Place of study				
		SPHMMC	BLH	JUMC	AHMC	Total
		N (%)	N (%)	N (%)	N (%)	N (%)
Sufficient training on ECG interpretation	Yes	15(30.6%)	43(54.4%)	5(7.1%)	0(0.0%)	63(28.6%)
	No	34(69.4%)	36(45.6%)	65(92.9%)	22(100.0%)	157(71.4%)
Separate ED rotation during clinical years	Yes	49(100%)	79(100%)	0(0.0%)	22(100%)	150(68%)
	No	0(0.0%)	0(0.0%)	70(100%)	0(0.0%)	70(32%)
Separate ED rotation during internship	Yes	49(100%)	79(100%)	0(0.0%)	0(0.0%)	128(58%)
	No	0(0.0%)	0(0.0%)	70(100%)	22(100%)	92(42%)
Confidence in ability to interpret basic ECG components	Not at all confident	5(10.2%)	6(7.6%)	19(27.1%)	5(22.2%)	35(15.9%)
	Somewhat unconfident	15(30.6%)	30(38.0%)	25(35.7%)	11(50.0%)	81(36.8%)
	Somewhat confident	26(53.1%)	37(46.8%)	25(35.7%)	5(22.7%)	93(42.3%)
	Very confident	3(6.1%)	6(7.6%)	1(1.4%)	1(4.5%)	11(5.0%)
Confidence in ability to interpret emergency and common ECG abnormalities	Not at all confident	8(16.3%)	13(16.5%)	19(27.1%)	6(27.3%)	46(20.9%)
	Somewhat unconfident	16(32.7%)	30(24.4%)	32(45.7%)	8(36.4%)	80(56.4%)
	Somewhat confident	23(46.9%)	34(43.0%)	19(7.1%)	7(31.8%)	83(37.7%)
	Very confident	2(4.1%)	8(10.1%)	0(0.0%)	1(4.5%)	11(5.0%)
Frequency of ECG interpretation during internship in a month	Rarely (< 5)	16(32.7%)	19(24.1%)	35(50.0%)	8(36.4%)	78(35.5%)
	Occasionally (5–10)	31(63.5)	50(63. %)	32(44.3%)	12(54.5%)	124(56.4%)
	Frequently (10–15)	2(4.1%)	10(12.7%)	4(5.7%)	2(9.1%)	18(8.2%)
	Very frequently (> 15)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)
Satisfaction with level of feedback and guidance from supervisors and senior colleagues	Very satisfied	0(0.0%)	4(5.1%)	0(0.0%)	090.0%)	4(1.8%)
	Satisfied	4(8.2%)	21(26.6%)	4(5.7%)	2(9.1%)	31(14.1%)
	Neutral	20(40.8%)	21(26.6%)	34(48.6%)	5922.7%)	80(36.4%)
	Dissatisfied	21(42.9%)	31(39.2%)	22(31.4%)	11(50.0%)	85(38.6%)
	Very dissatisfied	4(8.2%)	2(2.5%)	10(14.3%)	4(18.2%)	20(9.1%)
Would you like more training oonecg interpretation	Yes	48(98.0%)	76(96.2%)	68(97.1%)	22(100.0%)	214(97.5%)
	No	1(2.0%)	3(3.8%)	2(2.9%)	0(0.0%)	6(2.7%)
Importance of accurate ecg interpretation as intern	Not at all important	1(2.0%)	3(3.8%)	0(0.0%)	0(0.0%)	3(1.8%)
	Slightly important	8(16.3%)	9(11.4%)	11(15.7%)	1(4.5%)	29(13.2%)
	Very important	25(51.0%)	54(68.4%)	41(58.6%)	18(81.8%)	138(62.7%)
	Extremely important	15(30.6%)	13(16.5%)	18(25.7%)	3(13.6%)	49(22.3%)
Importance of accurate ecg interpretation as future physician	Not at all important	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)
	Slightly important	1(2.0%)	6(7.6%)	10(14.3%)	1(4.5%)	18(8.2%)
	Very important	26(53.1%)	46(58.2%)	37(52.9%)	11(50.0%)	120(54.5%)
	Extremely important	22(44.9%)	29(34.2%)	23(32.9%)	10(45.5%)	84(37.3%)

Table 2. ECG training and interpretation among medical interns participated in ECG competency assessment in Ethiopia, 2024. SPHMMC, St. Paul's Hospital Millennium Medical College; BLH, Black Lion Hospital; JUMC, Jimma University Medical College; AHMC, Adama Hospital Medical College; ED, Emergency Department.

Competency in ECG interpretation

The average ECG interpretation score across all participants was 65.93%. There was a statistically significant difference in competency rates between institutions ($p < 0.001$). Interns from SPHMMC demonstrated the highest competency rate at 32.7% (16/49), followed by BLH at 21.5% (17/79), AHMC at 18.2% (4/22), and JUMC at 7.1% (5/70). Competency in rhythm recognition was consistently high across all institutions (Table 3).

Determinants of ECG interpretation competency

In multivariable logistic regression analysis, interns with ED rotations during clinical years (AOR = 3.87; 95%CI: 1.86–8.05) and internship (AOR = 4.07; 95%CI: 1.68–9.85) demonstrated significantly higher odds of competency. Those reporting 'very high' confidence had substantially increased odds of competency in interpreting both basic ECG parameters (AOR = 8.20; 95%CI: 1.63–11.66) and emergency ECG abnormalities (AOR = 9.10; 95%CI: 1.22–12.67) compared to their less confident peers (Table 4).

Discussion

Electrocardiogram (ECG) interpretation is an essential skill for medical professionals, especially interns, as it plays a crucial role in the timely diagnosis and management of cardiac conditions[2]. This multi-site study assessed the competency of Ethiopian medical interns and revealed an overall low competency rate of 19.1%, with significant institutional variation. This finding aligns with a concerning global trend of inadequate ECG interpretation skills among medical trainees[4,7,8].

Our results are consistent with studies from various geographical and economic contexts. For example, a study at George Washington University reported a competency rate of 37% among graduating medical students at George Washington University, who correctly interpreted an average of 8.2 out of 22 ECGs[7]. Similarly, a study at Hebrew University reported an average competency score of 3.23 ± 1.81 out of 8[9]. A previous Ethiopian study by Getachew et al. is particularly relevant, reporting a competency rate of 20.8% among medical interns at Black Lion Hospital (BLH) and Haramaya University Medical College[8]. Our study, conducted several years later with a larger sample across four institutions, confirms that this critical educational gap persists. The significant institutional variation we observed ($p < 0.001$), with rates ranging from 7.1% at JUMC to 32.7% at SPHMMC, underscores the impact of local curriculum and training quality.

Interestingly, studies from the Middle East and Latin America indicate relatively higher competency rates[6,10,11]. Research in Saudi Arabia found that nearly all interns (91.7%) recognized basic ECG elements[10], while a Peruvian university study revealed medium to high levels of knowledge among graduating interns[11]. These discrepancies may be attributed to more structured teaching methodologies, dedicated ECG interpretation courses, and integrated simulation-based training in those regions, highlighting a potential pathway for educational intervention in the Ethiopian context.

When examining specific ECG patterns, our study found high recognition rates for life-threatening conditions like ventricular fibrillation (84%) and ST-elevation myocardial infarction (STEMI) (85.9%), which is encouraging. However, competency dropped for more nuanced abnormalities such as second-degree heart block (41.8%) and atrial flutter (58.2%). This pattern suggests interns may be better trained to recognize "high-alarm" conditions but lack the systematic approach needed for comprehensive interpretation. A Polish study

	Place of study				
	SPHMMC	BLH	JUMC	AHMC	Total
Correct answer for each ECG abnormalities.	Column *N* %	Column *N* %	Column *N* %	Column *N* %	Column *N* %
Rate	37(75.5%)	62(78.5%)	27(38.6%)	15(68.2%)	141(64%)
Rhythm	47(95.9%)	77(97.5%)	65(92.9%)	22(100.0%)	211(95.9%)
Left axis deviation	31(63.3%)	57(72.2%)	34(48.6%)	16(72.7%)	138(62.7%)
Atrial fibrillation	43(87.8%)	64(81.0%)	57(81.4%)	17(77.3%)	171(82.3%)
Asystole	48(98.0%)	78(98.7%)	62(88.6%)	21(95.5%)	209(95%)
Ventricular tachycardia	41(83.7%)	65(82.3%)	34(48.6%)	6(27.3%)	130(66%)
Ventricular fibrillation	46(93.9%)	73(92.4%)	52(74.3%)	14(63.6%)	185(84%)
2nd degree block	24(49.0%)	31(39.2%)	32(45.7%)	5(22.7%)	92(41.8%)
STEMI	43(87.8%)	70(88.6%)	55(78.6%)	21(95.5%)	189(85.9%)
Hyperkalemia	43(87.8%)	68(86.1%)	52(74.3%)	10(45.5%)	173(78.6%)
Left ventricular hypertrophy	43(67.3%)	61(77.2%)	37(52.9%)	16(72.7%)	147(66.8%)
Atrial flutter	33(67.3%)	50(63.3%)	32(45.7%)	13(59.1%)	128(58.2%)
Right ventricular hypertrophy	33(65.3%)	37(46.8%)	35(50.0%)	12(54.5%)	116(52.7%)
Sinus tachycardia	43(87.8%)	68(86.1%)	57(81.4%)	20(90.9%)	188(85.5%)
Average competency percentage	70.7%	69.29%	60.5%	60.3	65.93%

Table 3. :Correct response on ECG abnormality among medical interns participated in ECG competency assessment in Ethiopia, 2024. SPHMMC, St. Paul's Hospital Millennium Medical College; BLH, Black Lion Hospital; JUMC, Jimma University Medical College; AHMC, Adama Hospital Medical College; STEMI, ST-Elevation Myocardial Infarction.

Determinants of ECG interpretation		Competency		COR (95% CI)	AOR (95%CI)	P-value
		Yes(0.80%)	No(< 80%)			
Separated ED rotation during clinical years	Yes	92.9%	67.4%	6.28(1.864–6.231)	3.87(1.086–4.331)	0.003*
	No (Ref.)	7.1%	32.6%	1	1	
Separated ED rotation during clinical years	Yes	81.0%	57.3%	3.17(1.387–7.229)	4.07(1.679–9.552)	0.006*
	No (Ref.)	19.0%	42.7%	1	1	
Confidence in ability to interpret basic ECG components	Very confident	9.5%	3.9%	19.43(1.876–2.175)	8.20(1.633–11.266)	0.001*
	Somewhat confident	71.4%	35.4%	6.04(1.413–3.818)	3.04(1.012–5.815)	0.023*
	Somewhat unconfident	16.7%	41.6%	1.20(0.326–4.417)	2.70(0.465–4.464)	0.002
	Not at all confident (Ref.)	2.4%	19.2%	1	1	
Confidence in ability to interpret emergency ECG abnormalities	Very confident	9.5%	3.9%	9.20(1.77–15.66)	9.10(1.221–12.667)	0.000*
	Somewhat confident	66.7%	30.9%	4(0.991–1.152)	3.8(1.01–4.22)	0.033*
	Somewhat unconfident	23.8%	39.3%	1.12(0.307–4.160)	1.55(0.7-2.213)	0.001
	Not at all confident (Ref.)	0.0%	25.8%	1	1	
Satisfaction with the level of feedback and guidance from supervisors and senior colleagues	Very satisfied	0.0%	2.25	1.037(0.158–6.823)	1.002(0.448–4.357)	0.038
	Satisfied	7.1%	15.7%	0.669(0.456–0.993)	0.429(0.731–1.316)	0.043
	Neutral	26.2%	38.8%	0.697(0.142–2.34)	0.396(0.137–1.66)	0.044
	Dissatisfied	61.9%	33.1%	0.252(0.054–1.16)	0.244(0.164–1.09)	0.049
	Very dissatisfied (Ref.)	4.8%	10.1%	1	1	

Table 4. Determinants of ECG interpretation competency among medical interns participated in ECG competency assessment in Ethiopia, 2024. COR, Crude Odds Ratio; AOR, Adjusted Odds Ratio; CI, Confidence Interval; ED, Emergency Department; Ref., Reference category. Statistically significant variable ($p < 0.05$)

highlighted a similar issue, where one-third of students failed to recognize life-threatening arrhythmias[5], indicating a common challenge in balancing breadth and depth in ECG education.

This study identified several key modifiable factors influencing competency. The most significant was the presence of dedicated Emergency Department (ED) rotations during both clinical years and internship. Interns from institutions with such structured rotations (SPHMMC and BLH) demonstrated markedly higher competency than those from JUMC, which had no rotations. This finding strongly supports the role of immersive, high-acuity clinical exposure in reinforcing theoretical knowledge. Exposure to acute cardiac cases allows for deliberate practice and real-time feedback, which is essential for developing diagnostic proficiency. A systematic review by Oh et al. highlighted that hands-on training in emergency medicine significantly improves the ability to identify critical ECG patterns[12]. Our results corroborate the findings of Getachew et al., who showed that interns with undergraduate emergency medicine rotation were nine times more likely to be competent[8].

Self-reported confidence in interpreting ECGs was another powerful predictor of actual competency. Interns with high confidence levels had up to nine times greater odds of being competent. This correlation between confidence and accuracy has been observed in other settings, such as Malaysia and at King Faisal University, regardless of seniority[13,14]. This suggests that educational strategies should not only focus on knowledge transfer but also on building confidence through supervised practice, positive reinforcement, and mastery experiences.

A critical, albeit expected, finding was the overwhelming dissatisfaction with the current level of ECG training and feedback. A mere 15.9% of interns were satisfied with the guidance from supervisors, and 97.3% expressed a desire for more training. This reflects a significant quantitative and qualitative deficiency in current instructional methods. While structured feedback has been shown to improve accuracy[15,16], it was not a significant independent predictor in our final model, likely due to its scarcity. The strong demand for practical, ward-based training indicates that interns themselves recognize the value of experiential learning over passive, lecture-based methods.

Limitations

This study has several limitations. Its cross-sectional design precludes the establishment of causal relationships between educational factors and competency. While the sample was substantial, its focus on four institutions may limit the generalizability of the findings to all medical interns in Ethiopia. Furthermore, the use of self-reported data for confidence and training history may be subject to recall and social desirability bias. Finally, the analysis was limited to the specific determinants we measured and may not account for other influential factors such as the quality of preclinical teaching or individual motivation. Furthermore, the use of a quantitative survey limited the depth of our understanding of the underlying reasons for low competency. A mixed-methods design incorporating qualitative interviews would have provided richer insights into the educational gaps and intern experiences.

Conclusion

This study revealed an overall low competency rate of 19% in ECG interpretation among Ethiopian medical interns, with significant variation across training institutions. The main factors influencing competency were

the presence of dedicated emergency department rotations during clinical training and internship, and high self-confidence in interpretation skills.

Based on these findings, we recommend the following practical implications to improve medical education and clinical practice:

1. For University Curriculum Planners and Medical School Deans: Implement mandatory, structured ED rotations during both clinical years and internship, as our data show this is a key predictor of competency.
2. For Clinical Educators and Faculty: Develop and integrate simulation-based and practical, ward-based ECG training modules to build both competence and the self-confidence that our analysis shows is critically linked to performance.
3. For National Health and Education Policymakers: Establish standardized national ECG interpretation benchmarks and feedback mechanisms, informed by the significant institutional variation we observed, to ensure a uniform quality of graduate competency across Ethiopia.

Data availability

The data will be available with the corresponding author upon request.

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Author contributions

All authors shared equal responsibility in designing the study, acquiring and interpreting data, revising the manuscript, and approving the final version for submission.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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