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ORIGINAL ARTICLE

An evidence-based assessment of CPR knowledge among healthcare providers in Saudi Arabia

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ABSTRACT

Background: Cardiopulmonary resuscitation (CPR) skills are simple and can be mastered easily. Knowledge about these interventions and their potential benefits can aid resuscitative efforts and improve survival. These facts mandate that all healthcare providers, irrespective of their specialty, level of training, or work setting, be competent in initiating and performing CPR.

Aim: To assess the level of knowledge of healthcare providers about which CPR modalities, interventions, and medications for nontraumatic cardiac arrest have been proven beneficial in terms of return of spontaneous circulation, intact neurological function, and mortality.

Methods: This was a cross-sectional study. A standardized electronic questionnaire was formed based on a literature review to assess the knowledge of healthcare providers working in Saudi Arabia about CPR interventions and medications. Responses of the participants were collected via Google Forms and SurveyMonkey. The data were analyzed in Statistical Package for the Social Science V27 to answer the questions of interest.

Results: Only 16% of the participants had good knowledge (score >80%) of which CPR modalities have benefit. Physicians ranked the highest, followed by technicians, while nurses and emergency medical services professionals ranked the lowest among the study participants. Being certified in life support courses was not associated with a higher level of knowledge.

Conclusion: The overall level of knowledge of healthcare providers of different CPR modalities was average (score = 60%-80%) which is below expectation. Efforts should be made to improve this knowledge among healthcare providers to understand which modalities benefit patients in cardiopulmonary arrest better.

Keywords: Cardiac arrest, cardiopulmonary resuscitation, epinephrine, emergencies, life support, survival, prognosis.

Background

Cardiopulmonary resuscitation (CPR) skills are simple and can be mastered easily. Published literature has demonstrated the substantial benefits of some CPR modalities for return of spontaneous circulation (ROSC) and survival to hospital discharge. Knowledge about these interventional modalities (chest compression, defibrillation, and pharmacological therapies) and their potential benefits can aid resuscitative efforts and improve survival. These facts mandate that all healthcare providers (HCPs), irrespective of their specialty, level of training, or work setting, be competent in initiating and performing CPR [1-3].

Knowledge of CPR among HCPs is strongly influenced by training, and it is a significant determinant of successful CPR. For that reason, routine training on CPR is required [4]. In the Kingdom of Saudi Arabia (KSA), the healthcare practice bylaw mandates that all HCPs be certified in necessary patient-care centered courses such as basic life support (BLS) [5].

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Each cardiac arrest is unique, and there are several factors to consider during resuscitation, including time, cause, and prognosis. In some cases, ROSC is the priority, such as a myocardial infarction patient who goes into ventricular fibrillation arrest, while in other cases, the prognosis is as crucial as ROSC, such as in the drowning patient brought in 30 minutes after the arrest. Life support courses teach HCPs a unified algorithmic approach to CPR, but they do not necessarily teach which interventions or medications would likely improve ROSC, neurological function, and mortality. Knowing the evidence behind each intervention and medication is crucial to raise the standard of care.

Aim

The primary objective is to assess the knowledge of HCPs working in the KSA about which CPR modalities, interventions, and medications for nontraumatic cardiac arrest have proven benefits for ROSC, return of normal neurological function (RONNF), and mortality. The secondary objectives were performing subgroup analyses and determine the relationship between certification in life support courses and the level of knowledge.

Subjects and Methods

This study is a cross-sectional study. The precise number of HCPs in KSA was not accessible, so the study statistician calculated the sample size (n = 350) using the RAOSOFT sample size calculator, assuming a 95% confidence level and 5% sampling error and 50% probability of prevalence. The study sample was a convenience sample.

The inclusion criteria were any HCPs of any age and sex who worked in the KSA. The exclusion criteria were HCPs who worked outside the KSA and those who worked in healthcare facilities but were not HCPs (such as administration, management, human resources, custodians…).

An electronic questionnaire was designed in English to evaluate HCPs' knowledge about the clinical benefits of different CPR management modalities that have been proven by evidence to improve ROSC, RONNF, and mortality. The questionnaire was reviewed and approved by a statistician and by expert researchers from the Ministry of National Guard Health Affairs (MNGHA) in Jeddah. A model answer was formulated based on the literature review to compare the responses. The Institutional Review Board of King Abdullah International Medical Research Center in MNGHA, Jeddah, approved the research proposal, questionnaire, and the model answer.

The questionnaire was distributed through SurveyMonkey and Google Forms to HCPs from different cities across the KSA.

The questionnaire included demographic data and two questions of interest (each question consisted of 8 options; each option was scored out of 1 point depending on the participant's response, and the maximum score for both questions was 16). Question 1 asked which CPR modalities and interventions were proven beneficial to ROSC, RONNF, and mortality. Question 2 asked which CPR medications were proven beneficial to ROSC, RONNF, and mortality. Based on the reviewed evidence, the correct answers were determined "Yes" to early bystander CPR, early chest compression, early defibrillation, and post-arrest hypothermia, and "No" to open airway, bag-valve-mask (BVM) ventilation, early endotracheal tube (ET) intubation, early extraglottic device (EGD) use, oxygen, epinephrine, atropine, vasopressin, lidocaine, amiodarone, dopamine, and norepinephrine.

Demographic data included sex, age, job, specialty, level of training, institute, city of practice, and state of BLS and advanced cardiac life support (ACLS) certification.

The data collected from responses were entered into Statistical Package for the Social Science (SPSS) V27 for statistical analysis. The Kolmogorov-Smirnov and Shapiro-Wilk tests were run to assess the normality of the distributions. Parametric tests were used to test for significance between categorical variables and quantitative variables. For data that did not fulfill the criteria of parametric tests, nonparametric tests (including Kruskal-Wallis and Mann-Whitney U) were used. The Chi-square test was used to compare different subgroups of the study population. A p-value of <0.05 was considered to be statistically significant. Both SPSS V27 and Microsoft Excel were used to produce graphs.

Results

Demographic data

A total of (448) participants have filled the questionnaire. Only 416 have met the inclusion criteria and had a response rate of 100%.

Most of the participants were males (70.7%), and the majority were aged <35 years (66.8%). The most frequently reported jobs were physician (70.9%), followed by nurse (13.2%) and Emergency medical services (EMS; emergency medical technicians, and paramedics) (11.2%). Residents and board-certified physicians (BCPs) represented 49.5% and 28.3%, respectively, of the physicians. More than half of the participants were from Jeddah (52.6%). The MNGHA and the Ministry of Health (MOH) were the most frequently reported employment sectors. A total of 58.2% of the participants worked in the critical care field (emergency medicine, pediatric emergency medicine, intensive care unit, anesthesia, burn unit, trauma surgery, cardiac catheterization, cardiology, EMS, and nurses working in these departments). 41.8% of the participants were BLS certified, while 38.5% were double certified in BLS and ACLS (Table 1).

Total score and overall level of knowledge of the study population

The level of knowledge of CPR management modalities of the participants was average in 62% (score = 60%-80%), while 22% had poor knowledge (score <60%), and 16% had good knowledge (score = 81%-100%) (Figure 1).

Table 1. *Sociodemographic data of study participants (n = 416).*

Frequencies			N	%
Sex	Male		294	70.7
	Female		122	29.3
Age	<35 years old		278	66.8
	>35 years old		138	33.2
Job	Physicians:	BCP subgroup	84	28.3
		Non-BCP subgroup	213	71.7
		Junior residents (JR) subgroup	77	52.3
		Senior residents (SR) subgroup	70	47.6
		Total physicians count	297	70.9
	Nurses		55	13.2
	EMS		48	11.5
	Technologists / laboratory science		10	2.4
	Other HCPs		6	1.4
Field of work		Critical care subgroup	242	58.2
		Non-critical care subgroup	174	41.8
City	Riyadh		76	18.3
	Jeddah		219	52.6
	Makkah		40	9.6
	Al-Madinah		67	16.1
	Other cities		14	3.4
Sector of employment	MOH		155	37.3
	National Guard		168	40.4
	Armed Forces Hospital		22	5.3
	King Abdullah Medical Complexes		3	0.7
	King Faisal Specialist Hospitals		8	1.9
	Ministry of Higher Education		28	6.7
	Security Forces Medical Services		3	0.7
	Private sector		11	2.6
	Other sectors		18	4.3
Life support courses	BLS only		174	41.8
	ACLS only		13	3.1
	Both BLS and ACLS		160	38.5
	None		69	16.6

BCP: Board-certified physicians, MOH: Ministry of Health.

The scores of HCPs in each question are shown in Table 2. Physicians ranked higher than the rest of the group in the total score on both questions, followed by technologists, other HCPs, nurses, and EMS ($H = 35$, p-value < 0.001) (Table 3). The correlations between different subgroups' total scores are shown in Table 4.

Question-1 CPR modalities with proven benefits in terms of ROSC, RONNF, and mortality

The level of knowledge of the participants on the individual elements of question-1 was good (>80%) on early EGD use, average (60%-80%) on early ET intubation, BVM ventilation, and early chest compression, and poor (<60%) on opening the airway, early bystander CPR, early defibrillation, and post-arrest hypothermia (Figure 2). The majority answered this question with average scores. BCPs scored the highest, while EMS and surgical specialties scored the lowest. The scores' distribution and correlations between different subgroups in scores to Question-1 are shown in Tables 2 and 5.

Question-2 CPR medications with proven benefits in terms of ROSC, RONNF, and mortality

The level of knowledge of the participants on the individual elements of question-2 was good (>80%) on vasopressin, lidocaine, dopamine, and norepinephrine, average (60%-80%) on atropine and amiodarone. However, it was poor (<60%) on oxygen and epinephrine (Figure 3). This question was answered better with good scores. BCPs scored the highest, while nurses and

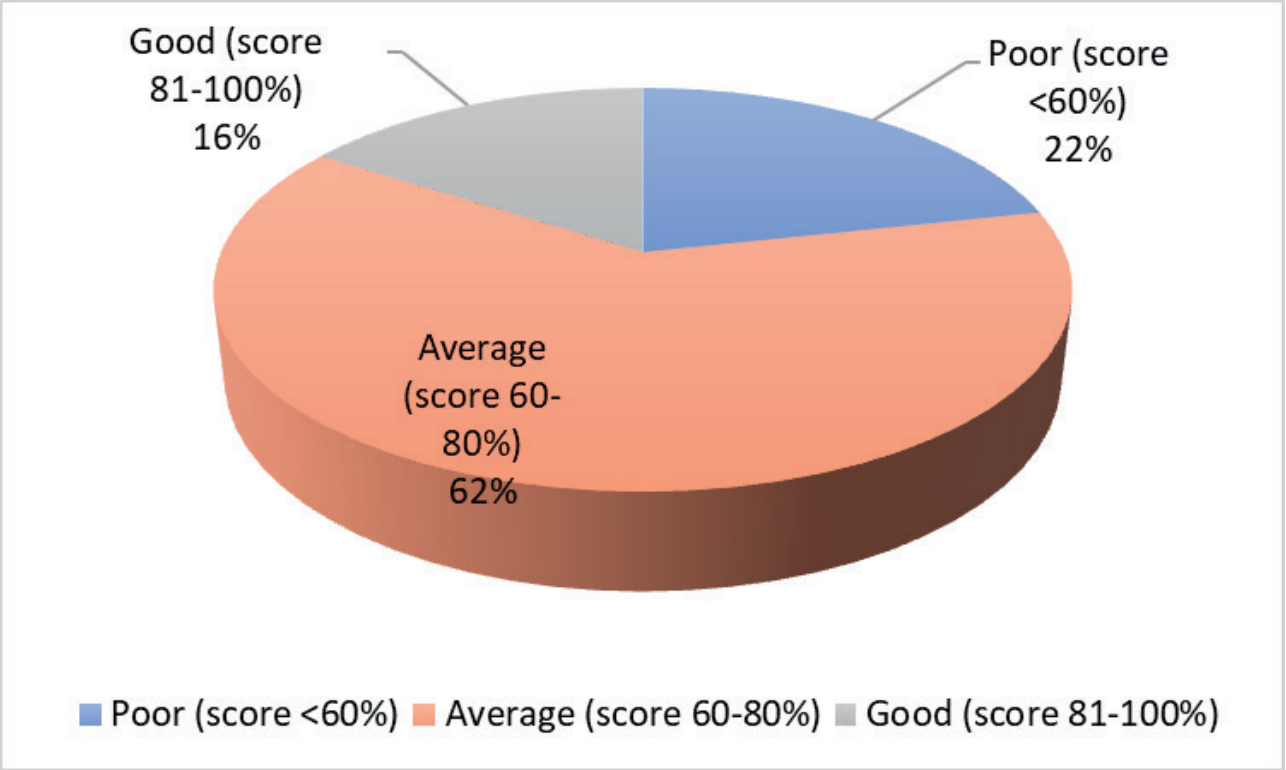

Figure 1. *Level of knowledge represented by the percentage of correct answers to both questions among the study population.*

Table 2. *HCPs scores in Question-1 (CPR modalities) and Question-2 (CPR medications).*

Score distribution	Question-1 CPR modalities scores			Question-2 CPR medications scores		
	Good >80%	Average 60%-80%	Poor <60%	Good >80%	Average 60%-80%	Poor <60%
All HCPs	9.9	56	34.1	47.4	34.6	18
Physicians	11.1	59.3	29.6	53.9	34	12.1
Nurses	12.7	50.9	36.4	23.6	43.7	32.7
EMS	2.1	41.6	56.3	33.3	33.4	33.3
Tech/lab.	0	70	30	50	30	20
Life support trained	8.6	56.5	34.9	45.8	35.2	19
Single-trained (BLS or ACLS)	5.3	56.2	38.5	49.7	35.3	15
Double-trained (BLS & ACLS)	12.5	56.9	30.6	41.2	35	23.8
Not trained	15.9	53.7	30.4	55.1	31.9	13
BCP	17.9	60.7	21.4	61.9	28.6	9.5
Non-BCP	8.5	58.6	32.9	50.7	36.2	13.1
JR	7.8	54.5	37.7	49.4	35	15.6
SR	11.4	61.5	27.1	50	37.1	12.9
Critical care	14	56.7	29.3	46.3	35.5	18.2
Non-critical care	4	55.2	40.8	48.9	33.3	17.8
Medical	11.5	57	31.5	47.3	33.5	19.2
Surgical	0	50.8	49.2	47.5	41	11.5

EMS scored the lowest. The distribution of scores and correlations between different subgroups in scores to Question-2 are shown in Tables 2 and 6.

Subgroup analysis (Tables 2-6)

1. Age (<35 years *vs.* >35 years) & Sex (male *vs.* female): Statistically, the older group ranked higher in knowledge than the younger group (p-value = 0. 015), as did the male participants when compared to female participants (p-value = 0. 024).

2. Life support courses certification (BLS, ACLS, or neither): Being (double or single) trained in BLS and ACLS or not trained did not significantly affect the level of knowledge.

Table 3. *Kruskal-Wallis Test. Ranking of HCPs knowledge scores.*

Job	Total score distribution			Mean rank[a]	Test statistic	*p*-value
	Good >80%	Average 60%-80%	Poor <60%			
Physicians	19.5	64	16.5	229.62	35.016[b]	<0.001*
Nurses	9.1	60	30.9	162.19		
EMS	2.1	60.4	37.5	140.01		
Technologist / laboratory science	10	60	30	188.45		
Other HCPs	16.7	33.3	50	169.00		

[a]: Higher mean rank = higher scores, [b]: Test statistic adjusted for ties.
*: **p**-value <0.05 indicates an unequal level of knowledge.

Table 4. *Mann-Whitney U test. Ranking total scores of different subgroups.*

Variable	Subgroup	Total score distribution			Mean rank[a]	Mann-Whitney U	*p*-value
		Good >80%	Average 60%-80%	Poor <60%			
Sex	Male	15.3	65.7	19	216.94	15,452.500	0.024*
	Female	17.2	54.9	27.9	188.16		
Age	<35 years old	15.1	61.2	23.7	198.55	16,415.500	0.015*
	>35 years old	17.4	65.2	17.4	228.55		
Life support courses subgroups	Trained	13.8	64.3	21.9	204.65	10,637	0.137
	Not trained	26.1	53.6	20.3	227.84		
	Single trained	12.3	67.9	19.8	173.36	14,841	0.896
	Double trained	15.6	60	24.4	174.74		
Field of work subgroups	Critical care	20.7	57.8	21.5	220.70	18,101	0.013*
	Non-critical care	9.2	69	21.8	191.53		
	Medical specialty	18	60.9	21.1	213.25	9,141	0.048*
	Surgical specialty	3.3	72.1	24.6	180.85		
Physicians subgroups	BCP	27.4	60.7	11.9	173.07	6,924	0.002*
	Non-BCP	16.4	65.3	18.3	139.51		
	JR	16.9	59.7	23.4	70.01	2,387.500	0.226
	SR	24.3	58.6	17.1	78.39		
Physicians versus nurses	Physicians	19.5	64	16.5	185.56	5,477.500	<0.001*
	Nurses	9.1	60	30.9	127.59		
Physicians versus EMS	Physicians	19.5	64	16.5	183.32	4,063.500	<0.001*
	EMS	2.1	60.4	37.5	109.16		
Physicians versus non-physicians	Physicians	19.5	64	16.5	229.62	11,399.500	<0.001*
	Non-physicians	6.7	58.8	34.5	115.79		
Nurses versus EMS	Nurses	9.1	60	30.9	54.95	1,158	0.276
	EMS	2.1	60.4	37.5	48.63		
Nurses versus non-nurse	Nurses	9.1	60	30.9	162.19	7,380.500	0.002*
	Non-nurses	16.9	62.9	20.2	215.56		
EMS versus non-EMS	EMS	2.1	60.4	37.5	140.01	5,544.500	<0.001*
	Non-EMS	17.7	62.7	19.6	217.43		
Health sector subgroups	MOH	11	66.4	22.6	198.56	18,687.500	0.186
	Non-MOH	18.8	60.1	21.1	214.40		
	Military Hospitals	16.6	62.2	21.2	208.47	21,514	0.996
	Non-Military Hospitals	15.2	62.8	22	208.52		
Location of practice subgroups	Jeddah	17.4	65.2	17.4	216.88	19,735.500	0.127
	Other cities	14.2	59.4	26.4	199.18		
	West coast	13.9	65.5	20.6	206.32	13,470	0.461
	Other regions	23.3	51.1	25.6	216.87		

[a]Higher mean rank = higher scores.
***p**-value < 0.05 indicates an unequal level of knowledge.

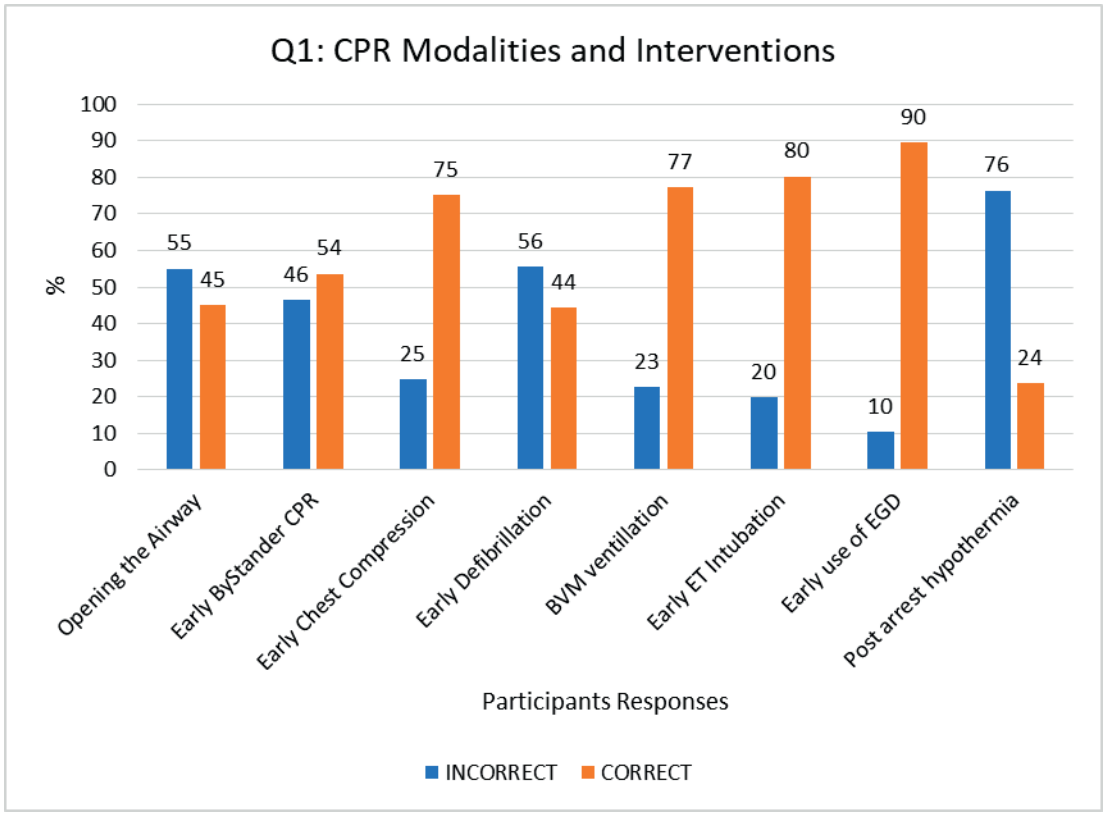

Figure 2. *Participants' responses to question 1 in percentages.*

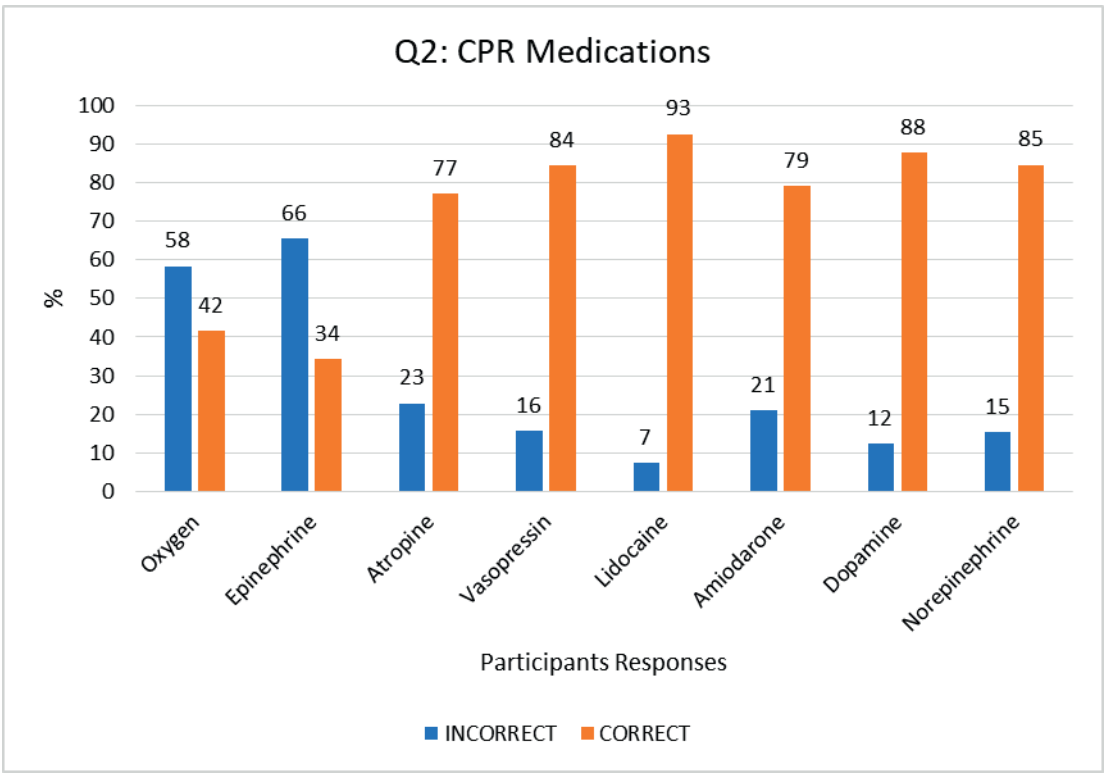

Figure 3. *Participants' responses to question 2 in percentages.*

3. Critical care specialties versus non-critical care HCPs: The critical care group ranked higher in knowledge than the non-critical care group (p-value = 0.013).

4. Medical field (adult and pediatric emergency medicine, internal medicine, family medicine, pediatrics, intensive care, burn unit, cardiology, neurology, gastroenterology, infectious diseases, dermatology, endocrinology, anesthesia, immunology, psychiatry, general radiology, others, EMS, and nurses working these departments) versus surgical field (general surgery, orthopedics,

Table 5. Comparison of different subgroups in question 1 responses.

Question 1 CPR modalities		Open airway			Early bystander CPR			Early chest compression			Early defibrillation			BVM ventilation			Early ET intubation			Early EGD use			Post arrest hypothermia		
		T	%	*p*	T	%	*p*	T	%	*p*	T	%	*p*	T	%	*p*	T	%	*p*	T	%	*p*	T	%	*p*
Sex	Male	140	47.6	0.09	162	55	0.34	218	74.1	0.4	131	44.6	0.9	231	78.6	0.37	236	80.3	0.9	260	88.4	0.2	66	22.4	0.4
	Female	47	38.5		61	50		95	77.9		54	44.3		91	74.6		98	80.3		113	92.6		32	26.2	
Younger versus older	<35 years	112	40.3	0.007*	150	54.0	0.8	209	75.2	0.9	119	42.8	0.3	208	74.8	0.07	223	80.2	0.9	248	89.2	0.6	64	23.0	0.7
	>35 years	75	54.3		73	52.9		104	75.4		66	47.8		114	82.6		111	80.4		125	90.6		34	24.6	
Life support courses sub-groups	Trained	152	43.8	0.29	190	54.8	0.29	261	75.2	0.9	151	43.5	0.3	264	76.1	0.14	281	81.0	0.4	311	89.6	0.9	79	22.8	0.3
	Not trained	35	50.7		33	47.8		52	75.4		34	49.3		58	84.1		53	76.8		62	89.9		19	27.5	
	Single	77	41.2	0.2	96	51.3	0.1	130	69.5	0.008*	63	33.7	<0.001*	151	80.7	0.02*	158	84.5	0.07	174	93.0	0.02*	31	16.6	0.003*
	Double	75	46.9		94	58.8		131	81.9		88	55.0		113	70.6		123	76.9		137	85.6		48	30.0	
Field of work sub-groups	Critical care	124	51.2	0.002*	139	57.4	0.06	199	82.2	<0.001*	133	55.0	<0.001*	171	70.7	<0.001*	186	76.9	0.03*	206	85.1	<0.001*	76	31.4	<0.001*
	Non-critical care	63	36.2		84	48.3		114	65.5		52	29.9		151	86.8		148	85.1		167	96.0		22	12.6	
	Medical	163	45.9	0.3	200	56.3	0.007*	276	77.7	0.004*	174	49.0	<0.001*	266	74.9	0.004*	283	79.7	0.4	313	88.2	0.01*	93	26.2	0.002*
	Surgical	24	39.3		23	37.7		37	60.7		11	18.0		56	91.8		51	83.6		60	98.4		5	8.2	
Physicians sub-groups	BCP	59	70.2	<0.001*	45	53.6	0.4	61	72.6	0.6	40	47.6	0.1	71	84.5	0.6	72	85.7	0.8	77	91.7	0.4	20	23.8	0.1
	Non-BCP	95	44.6		103	48.4		160	75.1		80	37.6		185	86.9		181	85.0		200	93.9		36	16.9	
	JR	28	36.4	0.04*	47	61.0	0.02*	59	76.6	0.7	30	39.0	0.7	62	80.5	0.1	64	83.1	0.3	69	89.6	0.1	11	14.3	0.2
	SR	37	52.9		30	42.9		55	78.6		29	41.4		63	90.0		62	88.6		67	95.7		15	21.4	
Physicians versus nurses	Physicians	154	51.9	0.009*	148	49.8	0.1	221	74.4	0.1	120	40.4	0.3	256	86.2	<0.001*	253	85.2	0.004*	277	93.3	0.1	56	18.9	<0.001*
	Nurses	18	32.7		34	61.8		46	83.6		26	47.3		34	61.8		38	69.1		48	87.3		27	49.1	
Physicians versus EMS	Physicians	154	51.9	<0.001*	148	49.8	0.01*	221	74.4	0.8	120	40.4	0.004*	256	86.2	<0.001*	253	85.2	<0.001*	277	93.3	<0.001*	56	18.9	0.3
	EMS	10	20.8		33	68.8		35	72.9		30	62.5		22	45.8		31	64.6		35	72.9		12	25	
Physicians versus all	Physicians	154	51.9	<0.001*	148	49.8	0.01*	221	74.4	0.53	120	40.4	0.008*	256	86.2	<0.001*	253	85.2	<0.001*	277	93.3	<0.001*	56	18.9	<0.001*
	All other	33	27.7		75	63		92	77.3		65	54.6		66	55.5		81	68.1		96	80.7		42	35.3	
Nurses versus EMS	Nurse	18	32.7	0.1	34	61.8	0.4	46	83.6	0.1	26	47.3	0.1	34	61.8	0.1	38	69.1	0.6	48	87.3	0.06	27	49.1	0.01*
	EMS	10	20.8		33	68.8		35	72.9		30	62.5		22	45.8		31	64.6		35	72.9		12	25	
Nurses versus all	Nurse	18	32.7	0.05	34	61.8	0.1	46	83.6	0.1	26	47.3	0.6	34	61.8	0.003*	38	69.1	0.02*	48	87.3	0.5	27	49.1	<0.001*
	All other	169	46.8		189	52.4		267	74.0		159	44.0		288	79.8		296	82.0		325	90.0		71	19.7	
EMS versus all	EMS	10	20.8	<0.001*	33	68.8	0.02*	35	72.9	0.6	30	62.5	0.008*	22	45.8	<0.001*	31	64.6	0.004*	35	72.9	<0.001*	12	25	0.8
	All other	177	48.1		190	51.6		278	75.5		155	42.1		300	81.5		303	82.3		338	91.8		86	23.4	
Health sector sub-groups	MOH	64	41.3	0.2	76	49.0	0.1	104	67.1	0.003*	59	38.1	0.04*	127	81.9	0.08	126	81.3	0.6	143	92.3	0.1	27	17.4	0.02*
	Non-MOH	123	47.1		147	56.3		209	80.1		126	48.3		195	74.7		208	79.7		230	88.1		71	27.2	
	Military	88	45.6	0.8	110	57.0	0.1	163	84.5	<0.001*	91	47.2	0.3	138	71.5	0.007*	151	78.2	0.3	167	86.5	0.051	55	28.5	0.02*
	Non-Military	99	44.4		113	50.7		150	67.3		94	42.2		184	82.5		183	82.1		206	92.4		43	19.3	
Location of practice sub-groups	Jeddah	102	46.6	0.4	123	56.2	0.2	177	80.8	0.005*	93	42.5	0.3	174	79.5	0.2	180	82.2	0.3	204	93.2	0.01*	48	21.9	0.4
	Other cities	85	43.1		100	50.8		136	69.0		92	46.7		148	75.1		154	78.2		169	85.8		50	25.4	
	West coast	148	44.8	0.9	171	51.8	0.1	245	74.2	0.3	137	41.5	0.01*	268	81.2	<0.001*	269	81.5	0.2	307	93.0	<0.001*	66	20.0	<0.001*
	All other	39	45.3		52	60.5		68	79.1		48	55.8		54	62.8		65	75.6		66	76.7		32	37.2	

(T): True (correct) answer; (**p**): **p**-value.
(*): **p**-value < 0.05.

***Table 6**. Comparison of different subgroups in question 2 responses.*

Question 2 CPR medications		Oxygen			Epinephrine			Atropine			Vasopressin			Lidocaine			Amiodarone			Dopamine			Norepinephrine		
		T	%	*p*	T	%	*p*	T	%	*p*	T	%	*p*	T	%	*p*	T	%	*p*	T	%	*p*	T	%	*p*
Sex	Male	128	43.5	0.2	104	35.4	0.5	232	78.9	0.1	253	86.1	0.1	272	92.5	0.9	233	79.3	0.8	261	88.8	0.3	254	86.4	0.1
	Female	45	36.9		39	32.0		89	73.0		98	80.3		113	92.6		96	78.7		104	85.2		98	80.3	
Younger versus older	<35 years	117	42.1	0.7	95	34.2	0.9	208	74.8	0.1	232	83.5	0.4	253	91.0	0.08	218	78.4	0.6	241	86.7	0.3	232	83.5	0.3
	>35 years	56	40.6		48	34.8		113	81.9		119	86.2		132	95.7		111	80.4		124	89.9		120	87.0	
Life support courses sub-groups	Trained	141	40.6	0.3	119	34.3	0.9	262	75.5	0.07	288	83.0	0.08	321	92.5	0.9	273	78.7	0.6	303	87.3	0.5	290	83.6	0.1
	Not trained	32	46.4		24	34.8		59	85.5		63	91.3		64	92.8		56	81.2		62	89.9		62	89.9	
	Single	73	39.0	0.5	81	43.3	<0.001*	137	73.3	0.2	165	88.2	0.005*	173	92.5	0.9	160	85.6	<0.001*	162	86.6	0.6	161	86.1	0.1
	Double	68	42.5		38	23.8		125	78.1		123	76.9		148	92.5		113	70.6		141	88.1		129	80.6	
Field of work sub-groups	Critical care	113	46.7	0.01*	69	28.5	0.003*	195	80.6	0.05	204	84.3	0.9	219	90.5	0.06	181	74.8	0.01*	214	88.4	0.6	204	84.3	0.8
	non-critical care	60	34.5		74	42.5		126	72.4		147	84.5		166	95.4		148	85.1		151	86.8		148	85.1	
	Medical	155	43.7	0.03*	114	32.1	0.01*	273	76.9	0.7	299	84.2	0.8	325	91.5	0.6	272	76.6	0.003*	312	87.9	0.8	299	84.2	0.5
	Surgical	18	29.5		29	47.5		48	78.7		351	84.4		60	98.4		57	93.4		53	86.9		53	86.9	
Physi-cians sub-groups	BCP	47	56.0	0.03*	35	41.7	0.5	71	84.5	0.3	74	88.1	0.7	80	95.2	0.8	72	85.7	0.5	79	94.0	0.2	75	89.3	0.8
	Non-BCP	90	42.3		81	38.0		171	80.3		190	89.2		204	95.8		176	82.6		192	90.1		189	88.7	
	JR	34	44.2	0.6	29	37.7	0.5	59	76.6	0.4	68	88.3	0.7	72	93.5	0.5	65	84.4	0.7	67	87.0	0.5	65	84.4	0.1
	SR	28	40.0		30	42.9		57	81.4		63	90.0		67	95.7		58	82.9		63	90.0		64	91.4	
Physi-cians versus nurses	Physicians	137	46.1	0.004*	116	39.1	<0.001*	242	81.5	0.07	264	88.9	0.001*	284	95.6	0.049*	248	83.5	0.057	271	91.2	0.3	264	88.9	0.004*
	Nurses	14	25.5		7	12.7		39	70.9		40	72.7		49	89.1		40	72.7		48	87.3		41	74.5	
Physi-cians versus EMS	Physicians	137	46.1	0.09	116	39.1	0.06	242	81.5	0.04*	264	88.9	0.003*	284	95.6	<0.001*	248	83.5	<0.001*	271	91.2	<0.001*	264	88.9	0.003*
	EMS	16	33.3		12	25.0		33	68.8		35	72.9		39	81.3		29	60.4		35	72.9		35	72.9	
Physi-cians versus all	Physicians	137	46.1	0.003*	116	39.1	0.001*	242	81.5	<0.001*	264	88.9	<0.001*	284	95.6	<0.001*	248	83.5	<0.001*	271	91.2	<0.001*	264	88.9	<0.001*
	All other	36	30.3		27	22.7		79	66.4		87	73.1		101	84.9		81	68.1		94	79.0		88	73.9	
Nurses versus EMS	Nurse	14	25.5	0.3	7	12.7	0.1	39	70.9	0.8	40	72.7	0.9	49	89.1	0.2	40	72.7	0.1	48	87.3	0.06	41	74.5	0.8
	EMS	16	33.3		12	25.0		33	68.8		35	72.9		39	81.3		29	60.4		35	72.9		35	72.9	
Nurses versus all	Nurse	14	25.5	0.009*	7	12.7	<0.001*	39	70.9	0.2	40	72.7	0.01*	49	89.1	0.2	40	72.7	0.2	48	87.3	0.9	41	74.5	0.02*
	All other	159	44.0		136	37.7		282	78.1		311	86.1		336	93.1		289	80.1		317	87.8		311	86.1	
EMS versus all	EMS	16	33.3	0.2	12	25.0	0.1	33	68.8	0.1	35	72.9	0.02*	39	81.3	0.002*	29	60.4	<0.001*	35	72.9	<0.001*	35	72.9	0.01*
	All other	157	42.7		131	35.6		288	78.3		316	85.9		346	94.0		300	81.5		330	89.7		317	86.1	
Health Sector sub-groups	MOH	56	36.1	0.08	63	40.6	0.03*	111	71.6	0.03*	131	84.5	0.9	144	92.9	0.8	126	81.3	0.3	136	87.7	0.99	142	91.6	0.002*
	Non-MOH	117	44.8		80	30.7		210	80.5		220	84.3		241	92.3		203	77.8		229	87.7		210	80.5	
	Military	80	41.5	0.9	55	28.5	0.01*	160	82.9	0.009*	161	83.4	0.6	178	92.2	0.8	146	75.6	0.1	171	88.6	0.6	153	79.3	0.005*
	Non-Military	93	41.7		88	39.5		161	72.2		190	85.2		207	92.8		183	82.1		194	87.0		199	89.2	
Location of practice sub-groups	Jeddah	84	38.4	0.1	73	33.3	0.6	178	81.3	0.03*	191	87.2	0.9	208	95.0	0.04*	182	83.1	0.03*	198	90.4	0.08	198	90.4	0.8
	Other cities	89	45.2		70	35.5		143	72.6		160	81.2		177	89.8		147	74.6		167	84.8		167	84.8	
	West coast	128	38.8	0.02*	112	33.9	0.7	254	77.0	0.8	280	84.8	0.6	309	93.6	0.09	264	80.0	0.3	293	88.8	0.2	284	86.1	0.1
	All other	45	52.3		31	36.0		67	77.9		71	82.6		76	88.4		65	75.6		72	83.7		68	79.1	

(T): True (correct) answer; (**p**): **p**-value.
*__p__-value <0.05.

otorhinolaryngology, ophthalmology, urology, neurosurgery, obstetrics and gynecology, plastic surgery, cardiac surgery, trauma surgery): The medical specialty group ranked higher in knowledge than the surgical specialty group (p-value = 0.048).

5. BCP (assistant, associate, full consultants, and fellows) versus non-BCP (staff physicians and residents): The BCP group ranked higher in knowledge than the non-BCP group (p-value = 0.002).

6. Residents (JR; Junior residents vs. SR; Senior residents): Both ranked roughly the same in knowledge without significant differences.

7. Physicians versus others: Physicians ranked higher in knowledge than nurses, EMS, and non-physician subgroups (p-value < 0.001).

8. Nurses & EMS: Both groups ranked similarly without significant differences. Nurses and EMS ranked much lower in knowledge when compared to non-nurses and non-EMS (p-value = 0.002, p-value < 0.001, respectively).

9. Sector and city of practice: Neither has shown a significant effect on the level of knowledge.

Discussion

Many studies have addressed the benefits of different CPR interventional modalities in achieving ROSC, survival to hospital admission, and discharge with good neurological outcome.

Early bystander CPR, early chest compressions, early defibrillation, and post-ROSC therapeutic hypothermia are CPR interventions proven by evidence to improve ROSC, RONNF, and mortality [1,6-10].

None of the airway maneuvers, including opening the airway, BVM, ET intubation or EGD, or any of the medications used, or recommended, during cardiac arrest, has significantly impacted ROSC, RONNF, and mortality [11-17].

Oxygen was not studied by any randomized clinical trial, which is understandable because of ethical implications. Nevertheless, none of the studies has specifically mentioned its effect on ROSC or RONNF in cardiac arrest [12]. Epinephrine has been studied extensively and has been shown to improve ROSC, but none of these studies have documented improved RONNF. The PARAMEDIC2 trial showed increased 30-day survival among the epinephrine group, but this group had severe neurological morbidity compared to the placebo group [11,13-14]. Vasopressin was not superior to epinephrine, and there are no available data comparing vasopressin to placebo in cardiac arrest [12]. Atropine was removed from the cardiac arrest guidelines in 2010 due to a lack of clear evidence of benefits [11]. Amiodarone has improved ROSC in ventricular fibrillation and pulseless ventricular tachycardia arrest but does not improve RONNF. Lidocaine also increased ROSC in shock-resistant ventricular fibrillation and pulseless ventricular tachycardia arrest but had no significant effect on RONNF [15]. Dopamine is reserved until after ROSC, and there is no sufficient evidence recommending norepinephrine use during cardiac arrest [16,17]. To the best of our knowledge, this is the first study in the KSA to evaluate healthcare providers' knowledge of the clinical benefits of the different CPR management modalities from an evidence-based point of view.

This study showed that 60% of HCPs in the KSA had an average (score 60%-80%) level of knowledge about different CPR management modalities, which might be explained by a lack of literature review by HCPs or simply because the evidence behind CPR is enormous and not formally taught in life support courses or healthcare schools. Although this study used a different method to assess the levels of knowledge, what we found was similar to what was reported in other studies done in the KSA among students and HCPs. Our study has reported a level of knowledge that was higher than those levels reported in studies that took place in Asia, Europe, and Africa [4,18-25]. Physicians are expected to be knowledgeable about CPR benefits since they are considered by default to be responsible for patients' lives. Indeed, the study findings showed that their level of knowledge was significantly higher than that of other HCPs, which was consistent with other studies [19,22-24]. BCPs scored the highest among all HCPs, which is expected since one would expect consultants to be better trained and more knowledgeable. The levels of knowledge between senior and junior residents did not show a significant difference which was not expected as senior residents should have more experience and knowledge than junior residents. A possible explanation is that senior residents are not practicing independently from consultants, which could have a negative impact on their performance. However, this finding was consistent with a study done in Pakistan [22]. Male participants had better knowledge scores than females, which is in line with Saquib et al.'s [19] findings but against Nambiar et al.'s [4] findings. The low number of females in this study could have biased these results. Participants aged >35 years had a better level of knowledge than younger participants, which could be because they are older, wiser, expert, and knowledgeable, these findings are consistent with other studies [23-25]. Those who worked in the critical care field and those with medical specialties (nonsurgical) scored better than their counterparts. HCPs working in medical specialties are expected to be better since they are more likely to encounter sicker patients [21]. Surprisingly, being certified in any life support courses was not associated with a better level of knowledge. This finding could be explained by the fact that these courses provide the participants with sufficient knowledge and skills to participate in or lead CPR rather than teaching the evidence behind each CPR management modality which needs to be sought out individually. However, this finding is consistent with a study by Nambiar et al. [4] but inconsistent with the findings of other studies [19-27]. EMS and nurses unexpectedly scored the lowest among all participants. EMS scored very low on both questions (interventions and medications),

while nurses scored better in question-1 but scored the lowest on medications (Table 2). EMS and nurses are usually at the frontline and have the first contact with patients either in the field or in hospitals. Both are expected to match the physicians' knowledge of CPR management modalities, and medications since resuscitation teams usually comprise EMS, nurses, and physicians. These findings could be due to chance; however, other studies reported conflicting results about nurses' level of knowledge [4,19-25]. On the other hand, poor knowledge of EMS about CPR has been reported by other studies [25,28].

In this study, neither the employment sector nor the city of practice impacted HCPs' level of knowledge which was expected.

Conclusion

Resuscitating a dying patient is an art. It is mastered through frequent deliberate practice, supervised training, reading, and experience. It is paramount that resuscitationists orient themselves with the evidence behind each intervention and medication, which allows them to prioritize critical actions. Additionally, it is essential to consider the benefits that the patients would get, the values and preferences of the patients and their families, the prognosis and the irreversible neurological sequelae that would be inflicted on the patient and put a burden on resources, intensive care unit occupancy and the health care system.

The primary outcome of our study showed that the level of knowledge of HCPs about different CPR interventions and medications in the KSA is average, with a score below expectations. Secondary outcomes showed that being older than 35 years of age, working in the critical care field, or working as a physician (specially BCPs) was associated with a higher level of knowledge while being a nurse or EMS was associated with a lower level of knowledge. Another interesting finding in the secondary outcomes is that being certified in life support courses was not associated with a better knowledge of CPR.

Recommendations

Encourage evidence review and establish hospital-based educational programs such as periodic seminars, journal clubs or debates targeting all HCPs aiming for better knowledge and raising the standard of care.

Consider adding sessions to life support courses that teach which CPR management modalities have better outcomes for patients.

Emphasize ACLS and BLS training and recertification.

The authors would like to invite other researchers who are interested in replicating this study to do so to understand the situation better.

Limitations

This study has several limitations. For instance, this cross-sectional study can show associations only, and these observations can change over time or be attributed to chance. In addition, the sampling technique was nonprobability convenience sampling, which may have biased the results and make the findings not generalizable to all HCPs in the KSA. Another limitation faced during the literature review was that no similar studies had assessed healthcare providers' knowledge of different CPR modalities from an evidence-based point of view. Finally, during the submission process of this article, a new study was published on June 17, 2021: The Targeted Temperature Management-2 trial showed that post-arrest hypothermia has no benefit on mortality or neurological outcome, although, till the publication of this study, it was not removed from the cardiac arrest guidelines [29].

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List of Abbreviations

ACLS	Advanced cardiac life support
BCP	Board-certified physicians
BLS	Basic life support
BVM	Bag-valve-mask
CPR	Cardiopulmonary resuscitation
EGD	Extra-glottic device
EMS	Emergency medical services
ET	Endotracheal tube
HCP	Health care provider
JR	Junior Residents
KSA	Kingdom of Saudi Arabia
MNGHA	Ministry of National Guard Health Affairs
MOH	Ministry of Health
RONNF	Return of normal neurological function
ROSC	Return of spontaneous circulation
SPSS	Statistical Package for the Social Science
SR	Senior residents
vs.	Versus

Conflict of interest
The authors declare that there is no conflict of interest regarding the publication of this article.

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