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Assessment and determining factors of the awareness and knowledge of healthcare providers about Cardiogenic Oscillations and its effect on mechanically ventilated patients: A multivariate logistic modeling

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ABSTRACT

Cardiogenic oscillations (COs) are small waves produced by heartbeats with significant clinical implications. Therefore, the current study was designed to determine the magnitude of COs' knowledge and awareness gaps and their associated determining factors. An observational, cross-sectional study was conducted electronically from December 2022 to February 2023, during which data was collected from the targeted population of healthcare providers in Saudi Arabia. The data were statistically analysed using SPSS software. A total of 407 participants were studied, with 58% being male (n = 237), 79.4% (n = 323) having Saudi citizenship, 68.5% (n = 279) being under 40 years old, and 31.4% (n = 128) being over 40 years old. Males had more general knowledge about COs than females, but the difference is not statistically significant, but it is higher among those over 50. Furthermore, it is observed to be considerably greater among physicians, anaesthesiologists, and respiratory therapists, respectively. The findings of the logistic regression model demonstrated that knowledge was significantly correlated with educational attainment (crude OR = 1.526) and clinical experience (crude OR = 0.653, $P<0.05$). A significant correlation was found between age (OR = 2.057), educational attainment (crude OR = 1.384), and clinical experience (crude OR = 0.549) in the logistic regression model for awareness. The amount of knowledge and awareness was unaffected by gender or nationality. Our study found that awareness and

knowledge of COs are low among healthcare providers but significantly higher among those with higher levels of education and longer clinical experience. Finally, this lack of knowledge necessitates the development of training programs.

Keywords: Cardiogenic oscillations, knowledge, awareness, mechanical ventilation, auto triggering

1. INTRODUCTION

Cardiogenic oscillations (COs) are synchronous wave variations caused by heartbeats superimposed on pressure and flow signals at the airway opening (Sevoz-Couche and Laborde, 2022; Tusman et al., 2009). Although the mechanism of COs is not fully understood, several possible contributing factors exist. The source of the COs wave is thought to be pulmonary artery plasticity, a hemodynamic parameter that indicates the pulse pressure of the right atrium and pulmonary artery (Lim and Gustafsson, 2020; Suarez-Sipmann et al., 2013).

West and Hugh-Jonas, (1961) on the other hand, explain that changes in the volume of the beating heart cause intrathoracic pressure changes through which air can enter and leave. In addition, heart movement can cause compression or expansion of the adjacent lung, resulting in gas movement in the airways (Imanaka et al., 2000; West and Hugh-Jones, 1961). Because the two organs are still in close contact, many researchers conclude that the primary cause of COs is the purely physical transmission of heartbeats to the lungs (Ferrando et al., 2018; Shaffer et al., 2014; Suarez-Sipmann et al., 2013).

COs are considered to be an intrinsic cause of automatic ventilator triggering; moreover, they may be visible on ventilator signal waveforms during apnea, and they are thought to be due to changes in the cardiac output and physical movement of the heart during each ventricular systole (Aarrestad, 2020; Mac-Intyre et al., 2021). The change in intrathoracic pressure caused by airflow and the displacement of adjacent lung tissue play a role in automatic ventilator triggering (Noujeim et al., 2013; Zhou et al., 2021). This phenomenon can occur both in a patient with brain death and in a patient without brain death.

According to various research findings, such waves are triggered by cyclic pressure and flow changes in the pulmonary artery rather than by the physical transmission of heartbeats to the lungs (Michard, 2005; Noujeim et al., 2013; Suarez-Sipmann et al., 2013). Cardiogenic oscillatory flows were first measured directly in the lobar airways by West and Hugh-Jones, (1961) and Dubsky et al., (2018) these oscillations can be observed from birth, and these oscillations can cause internal flows that can potentially improve gas mixing in the lungs.

Cardiogenic auto-triggering in brain-dead patients often leads to misunderstandings in determining brain death among staff, physicians, and the patient's relatives. This leads to false expectations of recovery among family members and the stress and anxiety associated with such situations. COs can prolong the stay in the intensive care units (ICU) and jeopardize the determination of brain death. Patients also appear to be breathing independently, which can contribute to the wrong decision to wean them off ventilators and raise false hopes for recovery (Kaloria et al., 2015; Noujeim et al., 2013; Perry et al., 2023).

Drawing from the aforementioned comprehensive and varied discourse on COs and their role within the healthcare system. It was imperative to assess the level of knowledge and awareness among healthcare providers. The present investigation endeavors to evaluate the level of knowledge and awareness among healthcare providers regarding COs and its impact on patients who require mechanical ventilation. In addition, this study is the first of its kind to deal with these aspects of the health service in Saudi Arabia.

2. MATERIALS AND METHODS

Study design, population and area

This is an observational, descriptive, cross-sectional study in which a validated electronic questionnaire was distributed among all healthcare providers operating in all Saudi provinces using social media, through which the survey was distributed to all healthcare providers willing to participate. This study targeted all adult healthcare providers in the Kingdom of Saudi Arabia (KSA) who are responsible for treating critically ill and mechanically ventilated patients. The study was conducted from December 2022 to February 2023.

Sample size calculation

The size of the sample was calculated using the Cochran's equation (Nanjundeswaraswamy and Divakar, 2021):

$$n = \frac{p(1-p)z^2}{e^2}$$

Where n: Sample size, p: Proportion of population ($p = 0.1$), e: Acceptable sampling error ($e = 0.05$), z: z value at the reliability or significance level. The used formula considered the latest national statistics in KSA which showed that there are approximately 485,688 health care providers in KSA (Almutairi et al., 2019). Thus, according to the above formula, the sample size is 384. Data were collected from 407 people after adding about 5% as a margin of error to the calculated number of the sample.

Validation, study measures, and data collection

The final questionnaire consisted of 22 questions divided into two parts and was designed based on current literature (Imanaka et al., 2014; Riegel et al., 2022). The questionnaire was used after being tested for validity with a small group of participants and consisted of structured responses with multiple-choice questions. Preliminary data from this pilot study were not included in the final study. The first section contained demographic information about the respondents, such as age, gender, nationality, education level, profession, geographic location, clinical experience, and clinical unit.

The second section consisted of 15 questions about current knowledge and awareness of COS in mechanically ventilated patients. The dependent factors utilized in the study were knowledge and awareness, which were measured through two distinct models. The data was stratified into two distinct levels using the median as the demarcation point, resulting in two distinct categories: A high category and a low category. Data were collected using a self-administered electronic English questionnaire requiring participant consent. Using social media tools such as Whats App, Twitter, and Telegram, the electronic questionnaire was distributed using an authenticated survey link (https://www.surveymonkey.com/r/MKG7XNH).

Inclusion and Exclusion criteria

Participants with critically ill patients have documented educational degrees in their specialty that the Ministry of Health recognizes in Saudi Arabia. They are current Saudi Arabian residents and have completed the entire survey. Any violation of any of the conditions will result in the immediate exclusion of the participant from the response. Medical students who still needed to complete their studies were excluded. The non-medical staff working in the intensive care unit and all current participants not from Saudi Arabia were also excluded.

Data presentation and statistical analysis

Data were collected electronically and analyzed statistically using IBM SPSS Statistics version 25. Frequency and percentages were used to describe categorical data. Continuous variables were expressed as mean±SD. The student's t-test and analysis of variance (ANOVA) were sued to assess the difference between various categories of the demographic factors. Multivariate logistic regression was used to determine the relationship between the dependent and independent variables. In this modeled analysis, knowledge and awareness in two models were used as dependent factors.

Where it was classified into two levels based on the median into two categories: A category of high knowledge and a category of low knowledge. Independent factors (gender, nationality, age, educational level, and profession, clinical experience) were used to explain their effect on levels of knowledge and awareness. A probability value p-value < 0.05 was considered statistically significant, and a p-value < 0.01 was considered highly significant.

Ethical consideration

The Standing Committee for Scientific Research at Jazan University approved the study's ethical approval (reference number: REC-44/04/377); we also got everyone's consent. The research participants were not harmed in any way. The privacy of the study participants was ensured.

3. RESULTS

Demographic characteristics

This study is based on the results of a survey that 407 people who met the criteria for eligibility filled out. 58% were male (n = 237), 79.4% (n = 323) had Saudi citizenship, 68.5% (n = 279) were ≤ 40 years of age, and 31.4% (n = 128) were > 40 years of age (Table 1). As for the geographic location, 26% were from the southern province, and 21.9%, 20.1%, 16.5%, and 15.5% were from the central, western, eastern, and northern provinces, respectively. When comparing healthcare providers based on specialty, 35.6% were respiratory therapists, 27.3% were physicians, 26.8% were nurses, 9.6% were anesthesiologists, and 0.7% was others (Table 1).

According to the educational level of the participants, it was found that a higher percentage had only a bachelor's degree (50.9%), and only 17.4% and 8.8% had higher education. In addition, 35.1% of the participants have ten years of work experience,

25.8% have six to ten years of work experience, and the same percentages have one to five years of work experience. According to the work area where they are assigned, 69.5% are in ICU, 50.9% are in CCU (Cardiac Care Unit), 44% are allocated in ED, 35.9% are in PICU (Paediatric Intensive Care Unit), and near this percentage (31.2%) are assigned in NICU (Neonate Intensive Care Unit), while 28% are in the OR (Operation room) group (Table 1).

Table 1 Socio-demographic characteristics of the research sample

	Frequency	Percentage
Gender		
Male	237	58.2
Female	170	41.8
Nationality		
Saudi	323	79.4
Non-Saudi	84	20.6
Age		
20-30 years old	145	35.6
31-40 years old	134	32.9
41-50 years old	92	22.6
>50 years old	36	8.8
Geographical location		
Central Province	106	26.0
Eastern Province	67	16.5
Northern Province	63	15.5
Southern Province	89	21.9
Western Province	82	20.1
Participants' Profession		
Anaesthesiologist	39	9.6
Nurse	109	26.8
Physician	111	27.3
Respiratory therapist	145	35.6
Other	3	0.7
Educational level		
Bachelor degree	207	50.9
Diploma qualification	26	6.4
Master degree	63	15.5
Medical Doctorate (MD)	71	17.4
Philosophical Doctor (PhD)	36	8.8
Other	4	1.0
Clinical experience		
< 1 year	54	13.3
1-5 years	105	25.8
6-10 year	105	25.8
> 10 years	143	35.1
Unit		
Intensive Care Unit (ICU)	283	69.5
Cardiac Care Unit (CCU)	207	50.9
Operation room (OR)	114	28.0
Emergency Room	181	44.5
Paediatric Intensive Care Unit (PICU)	146	35.9
Neonate Intensive Care Unit (NICU)	127	31.2

Total	407	100.0

General knowledge regarding COs

In the study group, 68.6% had been trained in mechanical ventilation and 11.3% had treated patients who were being mechanically ventilated and had COs (Table 2). Of those surveyed, 31.4% thought hypertension is the cause of COs, and 25.3% thought it could be caused by pulmonary artery pulsatility, whereas 17.0% thought it would occur in patients with decreased pulmonary resistance, 31.0% thought it happened in patients with cardiomegaly, 26.0% thought it happened after cardiac surgery, and 14.0% linked it to brain death, and 57.2% had no idea.

Twenty-four percent of participants believed that sedative medications could reduce automatic ventilator triggering when COs occur, 14.7% reported that inspiratory muscle contractions could occur during COs, and 32.9% think it can cause the ventilator to auto-trigger, 24.1% who knew that it could delay extubation; 10.6% believed it overestimated expiratory volume; 10.6% believed it delayed triggering; 25.8% thought it caused asynchrony between patient and ventilator; and 61.4% did not know. On the basis of the median, both levels of knowledge and awareness were divided into two categories: A high category and a low category. The sample was divided into low and high knowledge groups of 59.7% (243) and 40.3% (164), respectively. As for awareness, the category of high awareness was 35.1% (143), and the category of low awareness was 64.9% (264) (Table 3).

Table 2 General knowledge regarding COs

Items	Categories	Frequency	Percentage
Training in mechanical ventilation	Yes	279	68.6
	No	108	26.5
	I don't know	20	4.91
Previous experience on Cos	Yes	46	11.30
	No	183	44.96
	I don't know	178	43.73
Cause of Cos	Hypertension	128	31.5
	Brain death	57	14.0
	Pulmonary artery pulsatility	103	25.3
	Cardiomegaly	126	31.00
	Post cardiac surgery	106	26.0
	Decrease pulmonary resistance	69	17.0
	I don't know	233	57.3
	Others	1	0.3
Is there an inspiratory muscle contraction during cardiogenic oscillations	Yes	60	14.7
	No	93	22.9
	I don't know	254	62.4
	Ventilation auto-triggering	134	32.9
	Delay extubation	98	24.1
	Overestimate exhale tidal volume	43	10.6
	Delay patient triggering	43	10.6
	Cause patient-ventilation Asynchrony	105	25.8
	I don't know	250	61.4
	Other	0.00	0.00
		407	100

Table 3 Awareness and knowledge of healthcare providers about COs and its effect on mechanically ventilated patients

Categorization	Awareness		Knowledge	
Low	264	64.9%	243	59.7%
High	143	35.1%	164	40.3%
Total	407 (100%)			

Role of demographic factors on the overall knowledge on COs

As in Table 4, males (0.35±0.35) had more general knowledge about COs than females (0.29±0.34), but the difference was not statistically significant (*P<0.081*). It is also found to be higher among those over the age of 50 (*P = 0.002*). Furthermore, overall knowledge is found to be significantly (*P<0.05*) higher among Physicians, Anaesthesiologists, and Respiratory Therapists, (0.44±0.34), (0.40±0.36), and (0.40±0.36), respectively. It is also significantly (*P<0.05*) higher among Philosophical Doctor (PhD), Medical Doctorate (MD), and Master degree holders than the other qualifications (0.50±0.30), (0.44±0.36), and (0.32± 0.34), respectively.

Table 4 shows that those with < one year of work experience have a significantly (*P<0.05*) higher degree of knowledge (0.42±0.37), those with (6-10) years of work experience (0.30±0.33), and those with >10 years of work experience (0.37±0.35). Healthcare providers with experiences (1-5 years) and (6-10 years) have higher levels of knowledge than those with < 1 year of experience, respectively. Furthermore, those with > 10 years of experience have more knowledge than those with 1-5 years, and there is no knowledge gap between those with > 10 years of experience and those with 6-10 years of experience (Table 4).

Table 4 Role of demographic factors on the overall knowledge on COs

General information		Overall Knowledge		P-value*
		Mean	Std. Deviation	
Gender	Male	0.35	0.35	0.081
	Female	0.29	0.34	
Nationality	Saudi	0.32	0.34	0.976
	Non-Saudi	0.32	0.35	
Age	20-30 years old	0.30	0.35	0.002
	31-40 years old	0.28	0.32	
	41-50 years old	0.35	0.36	
	>50 years old	0.51	0.31	
Geographical location	Central Province	0.28	0.34	0.142
	Eastern Province	0.35	0.32	
	Northern Province	0.30	0.34	
	Southern Province	0.40	0.37	
	Western Province	0.29	0.34	
Profession	Anaesthesiologist	0.40	0.36	0.000
	Nurse	0.15	0.29	
	Physician	0.44	0.34	
	Respiratory therapist	0.34	0.34	
	Other	0.25	0.22	
Educational level	Bachelor degree	0.27	0.33	0.000
	Diploma qualification	0.19	0.32	
	Master degree	0.32	0.34	
	Medical Doctorate (MD)	0.44	0.36	
	Philosophical Doctor (PhD)	0.50	0.30	
	Other	0.47	0.37	
Clinical experience	< 1 year	0.42	0.37	0.004
	1-5 years	0.24	0.31	
	6-10 year	0.30	0.33	
	> 10 years	0.37	0.35	
Total		0.32	0.34	

*A probability value p-value < 0.05 was considered statistically significant, and a p-value < 0.01 was considered highly significant.

Perception and awareness on COs

COs are perceived to be harmful by 19.2% of those surveyed, beneficial by 5.2%, both by 18.7%, and unknown by 57% (Figure 1). Many participants are unaware of COs, with 65.4% being unaware, 34.6% being aware, and 23.3% becoming aware through self-learning, 17.9% becoming aware through education, and 13.8% becoming aware through their medical training (Figure 2). However, 57.7% of those polled said they couldn't describe them, 29.7% stated that they were visible small fluctuations caused by the beating heart, 13.5% claimed that they were variations superimposed on flow and pressure signals caused by the patient's respirator and respiratory muscles, and 9.6% replied that they were large waves caused by heartbeats superimposed on pressure and flow signals at the airway opening.

In terms of COs detection methods, 48.6% have no idea, 21.6% said it can be detected by capnography end-tidal carbon dioxide (etCO2), 16.7% said it can be detected by ECG monitoring, and 13.0% said it can be detected by Ventilator waveform (pressure/flow). When COs occurred, 61.4% of the study group had no idea how to handle it, while 26.8% said it could be managed by decreasing trigger sensitivity, 24.1% said it could be dealt by switching from flow to pressure trigger, 20.4% said it could be resolved by administering sedatives and muscle relaxants, and 4.7% said it could be handled by temporal hyperventilation.

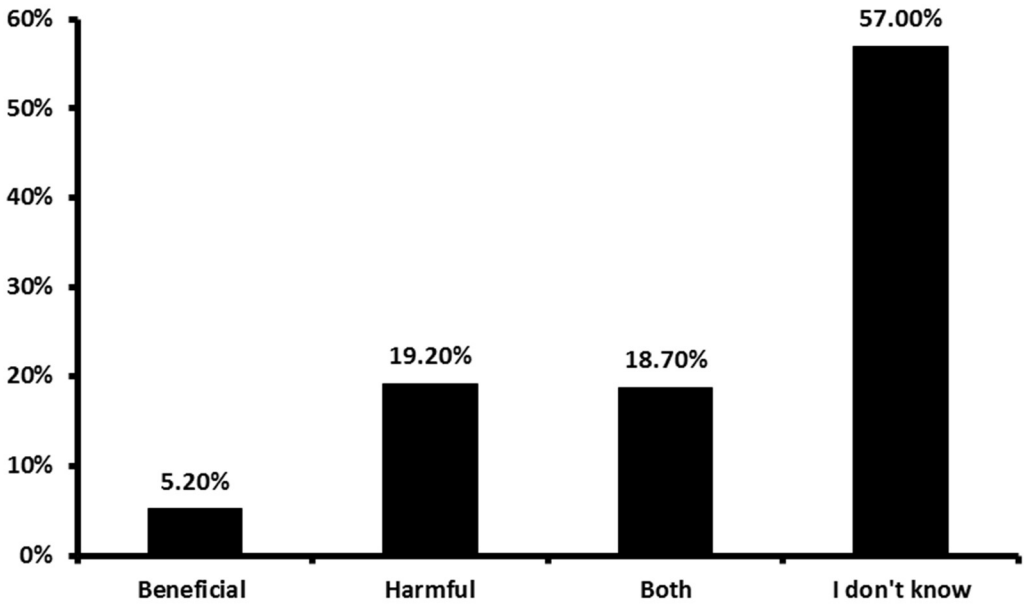

Figure 1 Perception of sample study towards the cardiogenic oscillation

Role of demographic factors on the awareness regarding COs

In the overall assessment of awareness by gender, males (0.40±0.28) are more aware than females (0.32±0.30), with a noticeable significant difference (P<0.01) (Table 5). There are no significant differences in the overall assessment of awareness regarding nationality. By age, awareness is higher among the age groups > 50 years old (0.55±30) and 41–50 years old (0.40±31), respectively (P<0.05), as well as among anesthesiologists, physicians, and respiratory therapists with averages of 0.51±0.32, 0.43±0.31, and 0.43±0.26, respectively. It is also significantly (P<0.05) higher among Philosophical Doctor (PhD), Medical Doctorate (MD), and Master's degree than the other qualifications (Table 5).

It is found that there is a significant (P<0.05) higher degree of awareness amongst those with working experiences > 10 years (0.42±0.32), and those with working experiences (6–10 years) it is (0.33±0.27), a lower degree of working experiences 1 year (0.38 ±0.30) (Table 5).

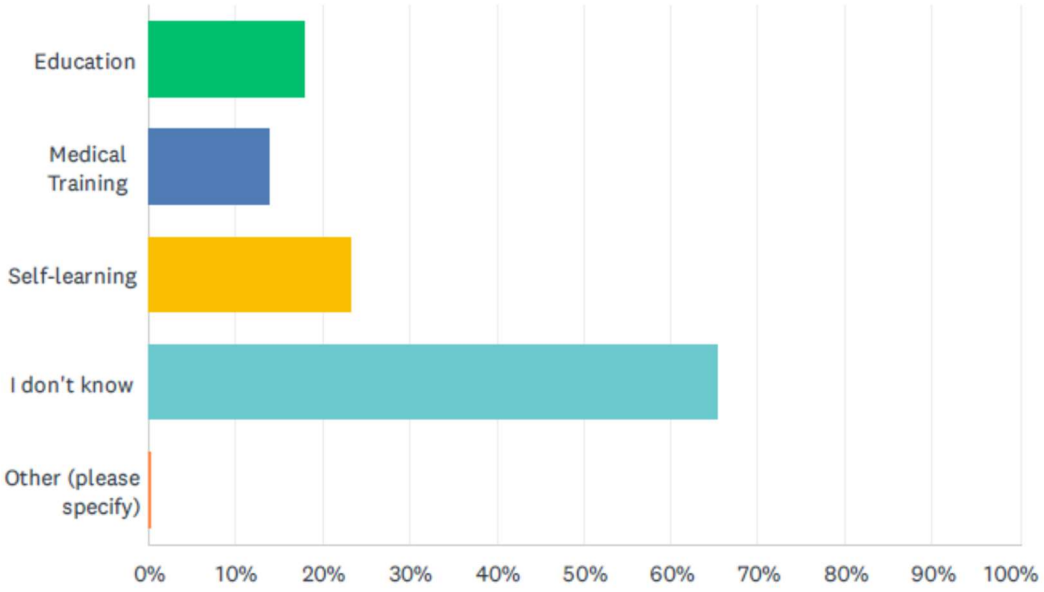

Figure 2 Source of awareness regarding Cos

Table 5 Compare means for general information with Overall Awareness

General information		Overall Awareness		P-value*
		Mean	Std. Deviation	
Gender	Male	0.40	0.28	0.008
	Female	0.32	0.30	
Nationality	Saudi	0.36	0.30	0.949
	Non-Saudi	0.37	0.28	
Age	20-30 years old	0.34	0.28	0.000
	31-40 years old	0.31	0.27	
	41-50 years old	0.40	0.31	
	>50 years old	0.55	0.30	
Geographical location	Central Province	0.35	0.30	0.969
	Eastern Province	0.38	0.27	
	Northern Province	0.36	0.29	
	Southern Province	0.37	0.30	
	Western Province	0.37	0.29	
Your profession	Anesthesiologist	0.51	0.32	0.000
	Nurse	0.17	0.21	
	Physician	0.43	0.31	
	Respiratory therapist	0.43	0.26	
	Other	0.08	0.14	
Educational level	Bachelor degree	0.33	0.26	0.000*
	Diploma qualification	0.22	0.26	
	Master degree	0.34	0.31	
	Medical Doctorate (MD)	0.47	0.29	
	Philosophical Doctor (PhD)	0.50	0.33	

	Other	0.19	0.24	
Clinical experience	< 1 year	0.38	0.30	0.032
	1-5 years	0.32	0.26	
	6-10 year	0.33	0.27	
	> 10 years	0.42	0.32	

*A probability value p-value < 0.05 was considered statistically significant, and a p-value < 0.01 was considered highly significant.

Multivariate logistic modeling

Two logistic regression models for knowledge (Table 6) and awareness (Table 7) with demographic factors were built independently using SPSS. Gender, nationality, age, educational level, and clinical experience were included in the model to explain the variability in knowledge and awareness of healthcare providers about COs and its effect on mechanically ventilated patients. The results of the logistic regression model showed that educational level (crude OR = 1.526, p<0.05) and clinical experience (crude OR = 0.653; *P<0.05*) were substantially associated with knowledge. The logistic regression model for awareness (Table 7) indicated a significant association between age (OR = 2.057; *P<0.05*), educational level (crude OR = 1.384; p<0.05) and clinical experience (crude OR = 0.549; p<0.05). Gender and nationality did not affect the level of knowledge and awareness.

Table 6 Multivariate logistic for Knowledge with demographic data

Factors	P-value	Odds ratio
Gender	0.376	0.823
Nationality	0.071	0.589
Age	0.067	1.440
Educational level	0.000	1.528
Clinical experience	0.011	0.653

Table 7 Multivariate logistic for Knowledge with demographic data

Variables in the Equation	P-value	Odds ratio
Gender	0.316	0.794
Nationality	0.149	0.651
Age	0.001	2.057
Educational level	0.001	1.384
Clinical experience	0.001	0.549

4. DISCUSSION

According to our knowledge and data from previous literacy and studies, this is the first cross-sectional study in the Kingdom of Saudi Arabia on healthcare providers' awareness and knowledge of COs and their effect on mechanically ventilated patients. The fact that this research was carried out on a nationwide scale is one of the many merits of the project. There haven't been a lot of research done anywhere in the globe that focus on filling this knowledge gap.

To speed up the reaction time of the ventilator, sensitive flow or pressure triggers are frequently used. On the other hand, triggers that are excessively sensitive run the danger of auto-triggering, a kind of asynchrony in which a breath is initiated without any contraction of the inspiratory muscles. Cardiogenic oscillations, which are characterized by cyclical changes in pressure and flow waveforms brought on by heart contractions, are a common reason for auto-triggering (Plens et al., 2018). Conclusions: Patients undergoing post cardiac surgery frequently experience auto-triggering brought on by cardiogenic oscillation when flow triggering is employed. Patients whose circulation was more active experienced auto-triggering more frequently. Lung hyperinflation and respiratory alkalosis were brought on by auto-triggering (Imanaka et al., 2000).

Among the studied sample, a high percentage of participants (57.0%) have yet to learn about the effect of COs on mechanically ventilated patients. In comparison, 19.2% believe it is harmful, and 5.2% believe it is beneficial. Previous studies have reported that COs are capable of detecting intra-tidal recruitment and over-distension and are, therefore, helpful in guiding Positive end-expiratory pressure (PEEP) and tidal volume (VT) settings that optimize respiratory mechanics (Bates and Smith, 2018; Hartmann et al., 2012; Schumann et al., 2018).

Several authors have studied the origins or underlying causes of COs, determining that the primary reason for COs is the direct physical transfer of heartbeats to the lungs due to the close contact between the two organs (Morton and Snow, 2018; Schumann et al., 2010; Suarez-Sipmann et al., 2013), and 31.0% of our study's respondents said cardiomegaly was responsible. However, 25.3% agreed that pulmonary artery pulsatility was the leading cause, similar to the findings of Suarez-Sipmann et al., (2013). Fukuchi et al., (1976) found persistent COs in dogs whose pulmonary arteries were blocked with Swan-Ganz catheters, whereas 26.0% thought that it could occur following cardiac surgery, similar to what was discussed by Imanaka et al., (2000).

However, Lichtwarck-Aschoff et al., (2004) refer to the beating heart as a "natural oscillator". There is no explanation for why mechanical ventilators automatically trigger due to COs in 61.9% of those surveyed; 15.2% believe it is due to pressure and flow; 12.3% believe flow triggers automatically trigger MV; and 10.6% believe MV are pressure triggers. AT has been described as flow-triggered in mechanically ventilated patients after cardiac surgery by Imanaka et al., (2000) and Imanaka et al., (2014) and pressure-triggered by Plens et al., (2018).

COs are one of the leading causes of auto-triggering, as described by Plens et al., (2018), and as a result, they can induce respiratory alkalosis, intrinsic PEEP (positive end-expiratory pressure) with cardiac instability, barotrauma, or late declaration of death in brain-dead patients, precluding organ transplants, and, during a spontaneous breathing trial to assess patient readiness for weaning, it may produce a mistaken perception of a failed test. The surveyed group's response regarding how to detect these COs among mechanically ventilated patients has no ideas: 21.6% agree on capnography end-tidal carbon dioxide ($etCO_2$), 16.7% think it can be detected by ECG, and 13.0% believe it can be detected by ventilator waveform (pressure/flow).

Collier et al., (2015) describe COs by MRI and simultaneously with ECG waves. 65.4% of the surveyed group have yet to learn or have received any training regarding COs. In comparison, 23.3% become aware of it through a self-learning program, 17.9% through medical education, and 13.8% through medical training, implying a significant gap in knowledge and awareness that necessitates learning and teaching programs. The logistic regression model found significant associations between education level (crude OR = 1.526, $P<0.05$) and clinical experience (crude OR = 0.653, $P<0.05$). Age (OR = 2.057; $P<0.05$), education level (crude OR = 1.384; $P<0.05$), and clinical experience (crude OR = 0.549; $P<0.05$) were also shown to be significantly associated with awareness in the logistic regression model (Table 5).

Knowledge and awareness were not influenced by either gender or nationality. In the majority of nations throughout the world, women and men now have the same opportunities to participate in educational opportunities (OECD, 2023). Despite the estimated number of non-Saudi healthcare providers, it was observed that nationality had no effect on the knowledge gap between Saudis and other nationalities. This demonstrates two points. The Saudi Ministry of Health recruits qualified foreigners, and non-Saudi healthcare professionals possess the same level of expertise.

Several limitations of the present investigation must be taken into account. First, the research is based on observational data collected using a cross-sectional design, which may prohibit us from determining the direction of the correlation between knowledge and the predictors; consequently, the results should be interpreted with caution. A self-administered, one-time questionnaire was used to acquire the data.

5. CONCLUSION

Auto-triggering by cardiogenic oscillation must be expected in apparently ventilated patients because it could be interpreted as inconsistent with the diagnosis of brain death, a fact that intensivists and nurses should be aware of and consider avoiding misdiagnoses. Our study found that awareness and knowledge of COs are low among health care providers but significantly higher among those with higher levels of education and longer clinical experience. Nonetheless, there needs to be more knowledge and awareness about COs, their effects, how to recognize them, how to manage complications caused by COs insurance volume, and how to manage them in the best interest of the patient. Finally, the lack of awareness and knowledge about COs is due to a lack of medical education and training about this phenomenon.

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Author contribution

All authors have contributed equally to this project. All authors have read and agreed to the published version of the manuscript.

Ethical approval

Ethics approval for the study was obtained from the Jazan University Research Ethics Committee.

Informed Consent

Written & Oral informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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