

## Nurses' Knowledge, Interpretation and Practice Regard Measuring End-Carbon Dioxide by Capnography: Self Learning Package

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### Abstract

**Background:** Capnography is the gold standard for confirming endotracheal tube placement, help guide ventilation in conjunction with blood gases, as it provides an excellent picture of the respiratory process. **Aim:** Evaluate the effect of self-learning package on nurses' knowledge, interpretation and practice regard measuring End-Carbon dioxide by capnography. **Design:** A quasi-experimental (Pretest-Posttest design) was used. **Setting:** The study was carried in medicine intensive care units at Ain Shams University hospital. **Subjects:** All available nurses (45) in the previous mentioned setting. **Tools:** Structured nurses' assessment tool; included: **part (I):** Nurses' characteristics, **part (II):** Nurses' knowledge assessment questionnaire, **part (III):** Nurses' capnography waveforms diagram interpretation and **Part (IV):** Nurses' practice observational checklist. **Results:** showed that there was an obvious improvement in the studied nurses' total satisfactory level of knowledge, interpretation and practice post implementation of the self-learning package with a positive correlation between the independent variables of the study (knowledge, interpretation & practice)  $r = 0.71$  at  $P < 0.001$ ,  $r = 0.07$  at  $P < 0.04$  &  $r = 0.52$  at  $P < 0.05$  respectively. **Conclusion:** This study concluded that self-learning package implementation had a positive effect in improving nurses' knowledge, interpretation and practice regard measuring end-carbon dioxide by capnography. **Recommendation:** Provide periodic in-service training based on best practice guidelines for nurses who work in intensive care units and emergency units regarding measuring End-Carbon dioxide by capnography.

**Keywords:** Interpretation, End-Carbon dioxide, Capnography, Self-learning package.

### Introduction:

One of the main functions of human respiration is to get rid of Carbon dioxide (CO<sub>2</sub>). Accurate real-time information on CO<sub>2</sub> levels can be useful in assessing the adequacy of ventilation and perfusion (Thomas et al., 2016). Capnography is a non-invasive, feasible and practical approach to monitor CO<sub>2</sub> ventilation during exhalation in real time. It can be performed for a short period of time or continuously, both in mechanically ventilated and non-ventilated patients. End Tidal CO<sub>2</sub> (EtCO<sub>2</sub>) is the numeric measurement at the end of exhalation and recognize the highest peak of CO<sub>2</sub> concentration in the exhaled air. (South

### Western University Hospital & Clinics, 2017)

Respiratory compromise is one of the most common problems that occur post anesthesia and accounts for half of the causes of death in the post-operative. The use of pulse oximetry as a surrogate measure for ventilation fails to adequately recognize ventilatory effort by the virtual of its intended measurement. However, with appropriate monitoring like capnography, identification of respiratory depression or apnea can occur prior to the adverse respiratory events (ARE) when used in synchronism with pulse oximetry and other

standard monitors can be assessed and detected. Capnography gives a real-time assessment of ventilation and is superior to the pulse oximetry when assessing hypoventilation/apneic oxygenation (Geralemou, Probst, & Gan, 2016)

Advancements in technology such as capnography, the monitoring of the partial pressure of expired carbon dioxide (PetCO<sub>2</sub>), support nurses with a means to ensure the improvement of care delivery, provide a safe environment, and effectively achieve patients' safety (Kartal, 2011). Capnography can detect almost immediate ventilatory changes, and in an apneic patient this will show as a flat line. This can be especially effective when visual assessment of a patient during a procedure is obscured. The addition of capnography along with standard monitoring can greatly enhance the nurses' ability to safely monitor a patient and minimize the incidence of adverse respiratory events (ARE) within this minimal time. (Brast, et.al, 2016)

The application of capnography aims to decrease adverse events, more specifically adverse respiratory events. AREs include, but are not limited to hypoxemia, hypercapnia, tachypnea, disordered ventilation, apnea, and respiratory failure (Kellner et.al, 2018). Nurse should assess patient positioning requirements and/or limitations; orthopnea, sleep apnea, obesity, physical restrictions due to orthopedic or surgical procedures prior to use capnography. Also, must pay particular attention to these engaging co-morbidities which may impact capnography assessment: COPD/asthma, severe cardiac disease, CKD/ESRD, sleep apnea and instruct the patient regarding monitoring technology

used during their procedure. (Lam, et.al. 2017)

Nurses' lack of knowledge is considered to be one of the most presumed factors contributing to measuring end-carbon dioxide by capnography errors. Most errors do not harm patients, but it can result in serious outcomes. (Melissa et.al, 2014). Enough knowledge about measuring end-carbon dioxide by capnography is vital. The frequency of errors made by nurses and the results of these errors affect not only the health of the patient but also the overall cost of health care. These errors can cause maximize the patient disability and death, also cause prejudice to the nurse involved, in regard to his or her personal and professional status, confidence, and practice. (Weiniger et.al, 2018)

Nursing expertise for measuring end-carbon dioxide by capnography can vary according to experience, educational level and the knowledge (Chau et. al., 2011). Regarding evidence-based practice insufficient knowledge regarding current practice guideline may result in undesirable patient outcome. Confidence in performing safe and quality nursing care can also be affected by insufficient knowledge as mentioned by (Cook, 2016) and can lead nurses to make errors.

Capnography waveform interpretation can be performed for diagnosis and ventilator-trouble shooting. The CO<sub>2</sub> waveform can be analyzed for 5 characteristics: –Height–Frequency–Rhythm–Baseline–Shape. Interpretation has four phases. Phase I (inspiratory baseline) shows inspired gas, which is normally devoid of carbon dioxide. Phase II (expiratory upstroke) is the transition between VD, which does not

participate in gas exchange and alveolar gas from the respiratory bronchioles and alveoli. Phase III is the alveolar plateau. Traditionally, PCO<sub>2</sub> of the last alveolar gas sampled at the airway opening known as the PETCO<sub>2</sub>. Phase 0 is the inspiratory down stroke, the beginning of the next inspiration (Kodali, 2013).

Nurses should take into consideration the specific features during interpretation which are; Normal end-tidal PCO<sub>2</sub> is approximately: 38 mmHg or 5%, The alpha angle is the transition from Phase II to Phase III, The beta angle is the transition from Phase III to Phase I (the start of inspiration), An additional phase IV (terminal upstroke before phase 0) may be seen in pregnancy, and notes that, ETCO<sub>2</sub> only represents alveolar CO<sub>2</sub> when a relatively horizontal plateau phase (phase III) is seen (Nickson, 2020)

Nurses has an essential role in preventing capnography errors and complications as nurse is the first one who able to identify patients' risk, complications, errors and implement successful error prevention strategy in place. Nursing guidelines, program, self-learning and education about capnography aims at promote nurses' knowledge and practice to optimize health outcomes for patients and raising nurses' awareness, and skills about the capnography. (Leslie, 2021)

### Significant of study

Due to the increased complexity in healthcare and with the effort to improve the quality of care and safety of patients with capnography, many healthcare organizations strive to boost quality care improvement. Nurses can be the frontline staff in scoping adverse events that occur in the intensive

care units; therefore, education is a fundamental issue in this setting. Based on the review of the literatures, a self-learning package was developed to improve nurses' knowledge, interpretation and practice to enhance the quality of care provided to measure end carbon dioxide for the patients with capnography.

### Aim

The aim of this study was to evaluate the effect of Self Learning package on nurses' knowledge, interpretation and practice regard measuring End-Carbon dioxide by capnography through the following:

- Assess nurses' knowledge regard measuring End-Carbon dioxide by capnography pre and post self-learning package implementation.
- Assess nurses' interpretation regard measuring End-Carbon dioxide by capnography pre and post self-learning package implementation.
- Assess nurses' practice regard measuring End-Carbon dioxide by capnography pre and post self-learning package implementation.
- Implement a Self-Learning package regard measuring End-Carbon dioxide by capnography

### Research Hypotheses

In order to achieve the aim of this study, it was hypothesized that the implementation of the self-learning package for nurses will lead to positive significant improvement in their knowledge, interpretation and practice regard measuring End-Carbon dioxide by capnography.

## Subject & Method

**Study design:** A quasi-experimental (Pretest-Posttest design) was applied to conduct this study.

- The independent variable was the self-learning package.
- The dependent variables were the nurse's knowledge, interpretation and practice regard measuring End-Carbon dioxide by Capnography.

### Setting:

The study was carried out at medicine intensive care unit (A, B) at Ain Shams University Hospital which is affiliated to Ain Shams University, Cairo-Egypt.

### Subjects:

- A convenient sample of all available nurses (45) working in previously mentioned setting agreed to participate in the study.

### Tools of data collection:

**Structured nurses' assessment tool:** it was consisted of four parts.

- **Part (I): Nurses' characteristics:** It was concerned with demographic characteristics of the nurses under the study including (nurses' age, gender, qualification, years of experience, and attendance of training courses regarding measuring End-Carbon dioxide by Capnography).
- **Part (II): Nurses' Knowledge Assessment Questionnaire:** It was developed by the researchers in English language and translated into Arabic language; to meet the different level of qualifications of nurses. This tool used to assess

nurses' knowledge regarding measuring end of carbon dioxide by capnography after reviewing recent related literatures (Leslie, 2021, Weiniger et.al, 2018, and Kodali, 2013). It consisted of four sections with total 35 multiple choice questions as following: Anatomy and physiology of respiratory tract (four questions), Capnography overview (15 questions) included definition, indications, types of capnography & phases. Abnormal capnography waves causes (10 steps). Nursing role (six questions) as precautions to avoid device malfunction.

### Scoring system:

The correct answer was given one score, while the incorrect one was given zero with total score 35 degree and categorized into satisfactory and unsatisfactory as follow:

- Satisfactory level equal 100% = 35 degree
- Unsatisfactory level less than 100% < 35 degree

- **Part (III): Nurses' Capnography waveforms diagram interpretation:** it was developed by the researchers based on (AAGBI Safety Statement 2016; Phillip, Carla & Spulecki 2018; and Hisamuddin et al., 2009) to assess nurses' interpretation of capnography waves. It consisted of 11 illustration/photo for capnography normal and abnormal waves.

### Scoring system:

**For Capnography wave interpretation:** The total score were 11 grads, which was divided into two categories as follows:

- Satisfactory level equal 100% = 11degree

-Unsatisfactory level less than 100%  
< 11 degree

**Part (IV): Nurses' practice observational checklist.** It was adopted from (Brast, et.al, 2016; and Thomas et al., 2016) Association for Radiologic & Imaging Nursing Capnography Clinical Practice Guideline to assess nurses' practice regarding measuring end tidal carbon dioxide by capnography. It consisted of (32 steps) that included:

- Pre procedure preparation (Three steps).
- Intra procedure (26 steps)
- Post procedure (Three Steps)

**Scoring system:**

The correct step was given one score, while the incorrect one was given zero with total score 32 degree and categorized into satisfactory and unsatisfactory as follow:

-Satisfactory level equal 100% = 32 degree  
-Unsatisfactory level less than 100% < 32 degree

- **Validity & Reliability: Content validity;** the revision of the tool was done by a panel of seven expertise's (five professors and assistant professors in critical care and emergency nursing- at Faculty of Nursing-Ain Shams University); and two chest physicians (one lecturer and one assistant professors at Faculty of Medicine-Ain Shams University) to measure the content validity of the tools and necessary modifications were done accordingly.

**The reliability;** was tested for the tool; part II & III by using alpha Cronbach's test (0.765, and 0.835 respectively), those values indicated

moderate to high reliability of the used tool.

**Pilot study:** It was conducted on 10% (four nurses) in selected setting to evaluate the applicability and clarity of the tool, it was served to estimate the time required to fill the form. There was no modification done according to the result of pilot study and subsequently the nurses in the pilot study were included.

**Field work:**

- Data were collected by the researchers within four months from January 2023 to April 2023.

**Assessment phase**

This phase involved data collection prior to self-learning package application to assess the nurse's baseline.

- Permission to conduct the study obtained from the hospital responsible authorities, after explaining the aim and nature of the study. The tools were developed by the researcher based on the relevant literature reviewing.
- All nurses were met in the previous mentioned setting and purpose of the study was explained to them, the approval for participation was secured from each nurse.
- Assessment was done before implementing self-learning package to assess nurses' knowledge, interpretation and practice regarding capnography by using nurses' assessment tool (Part 1, 2, 3 & 4) and it took about six weeks as following:

- Nurses' assessment tool (Part I, II & III) was given for nurses individually or in small group (2 or 3 nurses) to fill the required data regarding measuring End-Carbon Dioxide by Capnography. The tool (part I & II) took about 10-15 minutes to be filled, part (III) concerned with capnography wave diagram interpretation took about 15 min.
- Nurses' assessment tool (Part IV); Observational checklist were used by the researchers to observe nurses' practice during their routine care for patients with capnography. It took about 5-10 minutes for each nurse.
- Data were analyzed initially to provide the nurses under the study with self-learning package regarding measuring End-Carbon dioxide by capnography

### Planning phase:

Based on data collection, the researchers designed the self-learning package content regarding measuring End-Carbon dioxide by capnography which was adapted from (Pham & Beauchamp, 2021; Jacop, et al., 2020; and Boulos & Gregory, 2016) and translated into an Arabic language to be suitable for all nurses regardless to their educational level then its content was revised and validated.

The self-learning package included the following two parts: **Part I: knowledge and interpretation of capnography waves:** It was designed in three chapters as follow; **Chapter (1):** Anatomy and physiology of respiratory tract, gas exchange, mechanism

of ventilation, oxygen transport, and regulation of respiration. **Chapter (2)** included related terminology, capnography overview, indications, device forms, and normal capnography waveform. **Chapter 3** included: abnormal capnography waveform causes and interpretation.

### Part II: Nurses practices regarding capnography:

It was concerned with nurses' practices regarding measuring End-Carbon dioxide by capnography in **Chapter 4.** It included **Pre procedure** preparation that consisted of assessments prior to procedural sedation, assess co-morbidities which may impact capnography and educate the patient regarding monitoring technology used during the procedure. **Intra procedure** that consisted of patient positioning, apply capnometry device according to patient's requirement, hemodynamic monitoring, ensure capnometry placement, review monitoring alarm setting, capnography interpretation, evaluate respirations & numeric capnography values, identify & intervene for any impending adverse respiratory events as: encourage deep breath, manage pain & anxiety, adjust airway, assist ventilations with Bag-valve-mask & consider need for emergent intubation. Documentation preprocedural and intraprocedural. **Post procedure** that consisted of monitoring patients until discharge criteria is met.

### Implementation phase

The researchers initiating a group on the telegram platform and added all the studied nurses. The designed self-learning package were downloaded with assisted learning videos and media regarding measuring End-Carbon dioxide by capnography over the course of four weeks; one week for each chapter. The researchers were available from 9 a.m to 6 p.m all the week except weekend to answer and clarify the knowledge.

### Evaluation phase:

This phase included evaluation of the effect of self-learning package on nurses' knowledge, interpretation and practice regard measuring End-Carbon dioxide by capnography that took six weeks as following; the researchers met the studied nurses face to face in their setting after one week of implementing the self-learning package using Nurses' assessment **tool; part II, III & part IV** that took five weeks.

### Ethical consideration:

- Research proposal was approved from Ethical Committee in the Faculty of Nursing.
- The study followed common ethical principles in this research.
- Nurses' confidentiality and anonymity were assured.
- Nurses had the right to refuse to participate and or withdraw from the study without any rational at any time.

**Statistical analysis:** The data obtained had reviewed, coded, analyzed and tabulated.

- Descriptive statistics (frequencies and percentages, mean and standard deviation, i.e.) were done using computer program (SPSS) version (28).
- Independent sample T-test, pearson correlation coefficient test used in the relationship between pre-study and post-study nurses' knowledge, interpretation and practice.
- It's considered significant when P value less than (0.05).

### Results:

Result in **table (1)** reveals that, the mean age of the studied nurses were  $22.8 \pm 10.65$  and (80%) of them were female. According to their qualification, (46.7%) of the studied

nurses had bachelor degree, while (8.9%) of them had a post graduate degree. Regarding to their years of experience and training courses, (57.8%) had experiences more than 10 years and (100%) did not receive any training courses.

**Figure (1):** represents a comparison between the percentage distribution of the studied nurses' total satisfactory level of knowledge, interpretation and practice regard measuring end-carbon dioxide by capnography pre, and post implementation of self-learning package and it showed that there was an obvious improvement in their satisfactory levels post implementing the self-learning package.

**Table (2)** clarifies that, there was a statistically significant difference between total satisfactory mean scores of nurses' knowledge regarding measuring End-Carbon dioxide by capnography post implementing the self-learning package and their age, qualification and years of experience as it improved post implementing self-learning package.

**Table (3)** illustrates that, there was a statistically significant difference between total satisfactory mean scores of nurses' interpretation regard measuring End-Carbon dioxide by capnography post implementation of the self-learning package and their age, qualification and years of experience as it improved post implementing self-learning package.

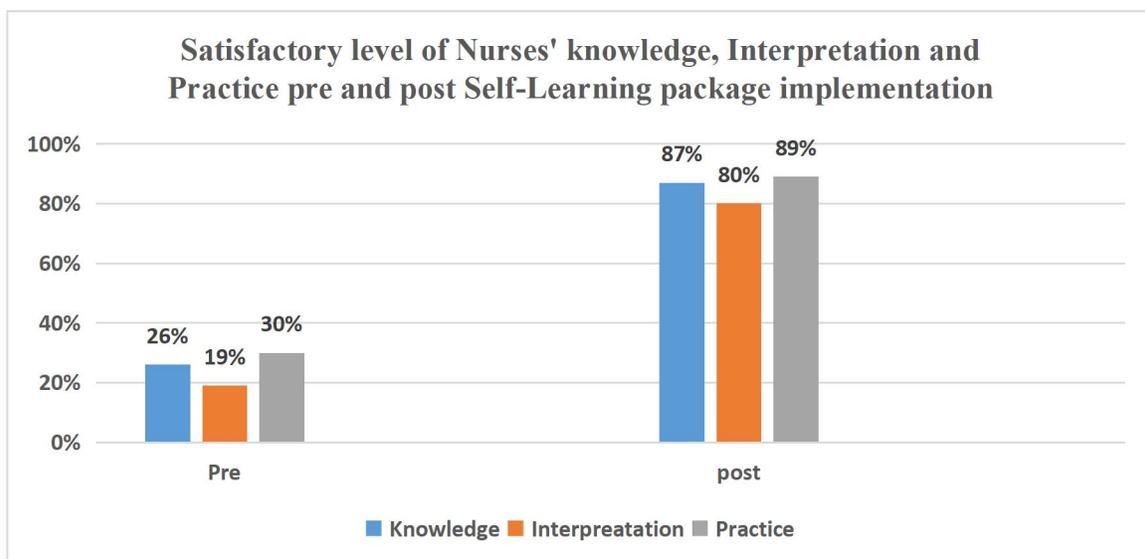
**Table (4)** shows that there was a statistically significant difference between total satisfactory mean scores of nurses' practices regard measuring End-Carbon dioxide by capnography post implementation of the self-learning package and their age, qualification and years of experience as it improved post implementing self-learning package.

**Table (5)** outlines a positive correlation between total nurses' satisfactory level of knowledge, interpretation and practice post

implementation of the self-learning package ( $r = 0.71$  at  $P < 0.001$ ,  $r = 0.07$  at  $P < 0.04$  &  $r = 0.52$  at  $P < 0.05$  respectively).

**Table (1): Frequency & percentage distribution of demographic characteristics of the studied nurses.**

Items	(N=45)	%
<b>Age group (years)</b>		
18 < 30	24	53.3
30 < 40	12	26.7
40 ≤ 60	9	20
<b>Mean±SD 22.8 ±10.65</b>		
<b>Gender</b>		
Female	36	80
Male	9	20
<b>Qualification:</b>		
Diplome	8	17.7
Technical institute	12	26.7
Bachelor degree	21	46.7
Master/ PHD	4	8.9
<b>Years of experience</b>		
< 10	19	42.2
≥ 10	26	57.8
<b>Received training courses</b>		
Yes	0	0
No	45	100



**Figure (1) Percentage distribution of total nurses' satisfactory level of knowledge, interpretation & practice regarding capnography pre and post implementing of self-learning package (no=45)**

**Table (2): Relations between total satisfactory mean score of nurses' knowledge and demographic characteristics pre and post self-learning package implementation regard measuring end-carbon dioxide by capnography (n=45).**

Demographic characteristics	Total satisfactory mean score of nurses' knowledge					
	Pre self-learning package			Post self-learning package		
	Mean ± SD	f/t	P value	Mean ± SD	f/t	P value
<b>Age (Years)</b>						
18< 30	16.7±3.2	1.794	0.204	31.7±2.3	4.625	0.018*
30 <40	14.4± 2.1			30.6±2.4		
≥40	12.1±3.1			29.8±3.2		
<b>Education</b>						
Diploma nurse	10.7±2.4	1.681	0.102	26.7±3.1	3.532	0.035*
High institute nurse	12.4± 1.4			30.1±1.2		
Bachelor nurse	17.1±2.5			31.2±3.4		
Master/ PHD	17.3±3.1			31.5±3.6		
<b>Years of experience</b>						
<10	12.7±3.2	1.331	0.192	27.2±3.7	2.763	0.014*
>10	18.4± 2.1			30.5±3.1		

*Non significant P>0.05 \* Statistical significant P<0.05*

**Table (3): Relations between total satisfactory mean score of nurses' interpretation and demographic characteristics pre and post self-learning package implementation regard measuring end-carbon dioxide by capnography (n=45).**

Demographic characteristics	Total satisfactory mean score of nurses' interpretation					
	Pre self-learning package			Post self-learning package		
	Mean ± SD	f/t	P value	Mean ± SD	f/t	P value
<b>Age (Years)</b>						
18< 30	3.7±1.2	1.251	0.102	8.2±1.3	5.964	0.028*
30 <40	2.2± 1.3			7.4±2.4		
≥40	1.1±3.1			6.8±2.2		
<b>Education</b>						
Diploma nurse	1.4±2.6	1.132	0.110	7.2± 1.4	4.514	0.049*
High institute nurse	3.9±2.2			8.4± 2.3		
Bachelor nurse	4 ±2.1			8 ± 2.2		
Master/ PHD	4.1 ±2.7			9.2± 1.2		
<b>Years of experience</b>						
<10	3.7±2.1	1.341	0.172	7.1±1.6	3.775	0.011*
>10	4.1± 2.6			8.9±2.2		

*Non significant P>0.05 \* Statistical significant P<0.05*

**Table 4): Relations between total satisfactory mean score of nurses' practice and demographic characteristics pre and post self-learning package implementation regard measuring end-carbon dioxide by capnography (n=45).**

Demographic characteristics	Total satisfactory mean score of nurses' practice					
	Pre self-learning package			Post self-learning package		
	Mean ± SD	f/t	P value	Mean ± SD	f/t	P value
<b>Age (Years)</b>						
18 < 30	17.5±2.2	1.874	0.213	25.4±3.7	3.741	0.041*
30 < 40	15.2± 3.1			23.4±3.4		
≥40	13.3±2.1			22.6±2.2		
<b>Education</b>						
Diploma nurse	10.1±2.1	1.785	0.201	24.7±3.1	4.212	0.032*
High institute nurse	13.2± 1.4			25.1±1.2		
Bachelor nurse	18.2±2.1			27.4±3.1		
Master/ PHD	19.1±3.4			28.7±2.9		
<b>Years of experience</b>						
<10	9.7±2.2	1.431	0.270	24.2±3.1	3.461	0.021*
>10	16± 2.4			27.5±2.6		

*Non significant P>0.05      \* Statistical significant P<0.05*

**Table (5): Correlation between total nurses' satisfactory level of knowledge, interpretation and practice post implementation of self-learning package.**

Items	Knowledge		Interpretation		Practice	
	r	P value	r	P value	r	P value
Knowledge			0.71	0.001*	0.07	0.04*
Interpretation					0.52	0.05*
Practice						

*Non significant P>0.05      \* Statistical significant P<0.05*

## **Discussion:**

Lifelong learning is essential for the nurse to maintain and increase competence in nursing practice. There are many different means to meet continuing professional development needs. Formal means include continuing education, staff development, academic education and research activities. The purpose here is to help the nurses to maintain and improve their competencies as required for the delivery of quality care to the consumer. Implementations based on

educational program, specifically designed nursing protocols, perceive gaps in their knowledge and would welcome the opportunity to be updated regularly.

The discussion of this study finding will prove our research hypothesis assumed that the implementation of the self-learning package for nurses will lead to positive significant improvement in their knowledge, interpretation and practice regarding measuring End-Carbon dioxide by capnography.

The present study revealed that, more than half of the studied nurses aged from 18 < 30, this result is in an agreement with **Mohamed (2019)** in his study entitled “Effect of Teaching Program on Nurses' Knowledge and Practice Regarding Measuring End-Carbon Dioxide by Capnography at Critical Care Units” who found that the vast majority of group was aged from 20y to < 35y with percentage (95%). Regarding to gender, the current study found that, majority of the studied nurses were females, these results were in the same line with **Mohamed (2019)** who stated majority of gender group were female with percentage (86.7%).

In relation to the educational level, the current study showed that, near half of the studied nurses were bachelor degree. This result may be due to the reflection of governmental direction regarding nursing development as it focused on university learning so the flow of students for faculties of nursing increased. In relation to years of experience, more than half of the studied nurses had experience more than 10 years, from the researchers 'opinion this result may be due to that more than half of studied nurses' aged between 18<30 years. This result in accordance with **Cook (2016)** who found that more than half the nurses (56.5%) had eleven or more years of experience working in the PACU in their study entitled “The winds of change – progress in the implementation of universal capnography”.

Concerning nurses' knowledge, interpretation and practice regarding measuring End-Carbon dioxide by capnography pre, immediate and post implementing self-learning package, the current study showed improvement in their levels post implementing the self-learning package. The improvement due to the

present self-learning package using information, adequate sessions and practical content which was given to the studied nurses with the continuous explanations, reinforcement and feedback as well as sufficient materials and supplies were provided for training. From the researcher's point of view comprehensive educational session regarding measuring End-Carbon dioxide by capnography should be held regularly. An appropriate evidenced-base clinical guidelines and protocols should be developed for safe clinical practices and reducing unnecessary complications. This research emphasized that utilization of research validated knowledge in clinical setting should be focused by the nurses to improve their clinical practice.

This goes with **Atherton & Spulecki, (2020)** in their study which revealed that an educational intervention improved nurses' confidence in implementing CO<sub>2</sub> monitoring in the PACU setting. As with any monitor, nurses must use capnography as an adjunct and not a replacement for clinical skills (eg, assessing the quality of respirations, capillary refill) to assess a patient's ventilatory status. The educational intervention improved both the confidence and knowledge of PACU RNs with both monitoring systems. They demonstrated a significant difference compared to their pre level regarding applying or interpreting a tcPCO<sub>2</sub> monitor. In the post-survey, RNs were comfortable applying EtCO<sub>2</sub> monitors and interpreting tcPCO<sub>2</sub> monitors. There was a significant improvement in their level of comfort with the application and interpreting of EtCO<sub>2</sub> monitors.

This result also agrees with **Mohamed (2019)** who found concerning the effect of the intervention program, there was very highly statistical difference between groups' statistically significant improvement in nurses' knowledge and practice regarding

capnography device, this was noticed immediately after program implementation in comparison to pretest to fulfill the hypotheses.

The researcher's explication for nurses' unsatisfactory level of knowledge, interpretation and practice pre self-learning package implementation that the nurses didn't attend any in-service training program related to measuring end-carbon dioxide by capnography. Also, near one fifth of the studied nurses were diploma graduates, and their knowledge was obtained during school study years and it might be forgotten. Therefore, lack of continuing education programs, in-service training and proper supervision, contribute to the problem. This poor knowledge and practice could possibly be attributed to both deficiencies in undergraduate nursing curricula and the lack of continuing education programs for nurses. Of further importance, these findings highlighted the need for implementing self-learning package about capnography.

As regard to relation between total nurses' satisfactory level of knowledge post implementing self-learning package and their qualification and years of experience. This study showed that, there was a statistically significant difference between total satisfactory level of nurses' knowledge regarding measuring End-Carbon dioxide by capnography post implementing the self-learning package and their qualification and years of experience. These results may be due to that more than half of the studied nurses had bachelor degree and near two third of them had more than 10 years of experience. This result in accordance with **Campbell et al., (2016)** who stated that there was no statistical difference between post-study knowledge and sociodemographic characteristics except for educational level and years of experience.

As regard to relation between total nurses' satisfactory level of interpretation post implementing self-learning package and their qualification and years of experience. This study showed that, there was a statistically significant difference between total satisfactory level of nurses' interpretation regarding measuring End-Carbon dioxide by capnography post implementing the self-learning package and their qualification and years of experience. These results may be due to that more than half of the studied nurses had bachelor degree and more than two third of them had more than 10 years of experience.

As regard to relation between total nurses' satisfactory level of practice post implementing self-learning package and their qualification and years of experience. This study showed that, there was a statistically significant difference between total satisfactory level of nurses' practice regarding measuring End-Carbon dioxide by capnography post implementing the self-learning package and their qualification and years of experience. These results may be due to that more than half of the studied nurses had bachelor degree and near two third of them had more than 10 years of experience.

Significant improvement post program implementation might be due to the effect of the in-service training program which did not only stress the acquisition of knowledge of capnography but also stressed on practical training to gain information and change work practice using adequate sessions, different teaching strategies as discussion, lecture, demonstration and re-demonstration, using media as handout including pictures and knowledge as well as availability of sufficient materials and supplies needed for achievement of the work, this motivated the studied nurses to achieve the desired

objectives through rewarding and acknowledgement of positive attitude and discouragement of negative attitudes. All nurses participated in the program had received a handout of the program content. Also, recurrent reinforcement for both knowledge and practice was done in each session.

Regarding correlation between total nurses' satisfactory level of knowledge, interpretation and practice post implementing self-learning package, the current study revealed that, there were positive correlation between nurses' knowledge, interpretation and practice. The researchers attributed this improvement to the self-learning package provided to nurses using capnography using simple and attractive media, simulation techniques, continuous demonstration and re-demonstration that affect positively on their knowledge, interpretation and subsequent their practice. Improving nurses' knowledge regarding capnography affected their interpretation and practice to ensure good prognosis and desirable patients' outcomes. This result also works in with **Li et al., (2018)** in their study which revealed that there was positive correlation between nurses' performance regard measuring End-Carbon dioxide by capnography.

Also, the knowledge is necessary for nurses to improve their practice. This is based on the recognition that nursing knowledge production must also be viewed in conjunction with practice as practice invades not only the use of knowledge but also gaining of knowledge. Nursing competencies depend largely on intuitive knowledge and skills. Therefore, the reasons for nurses, improper performance are usually the lack of nurses' knowledge and skills.

## Conclusion:

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Self-learning package implementation regard measuring End-Carbon Dioxide by Capnography had a positive significant effect on nurses' level of knowledge, interpretation and practice and thus the researcher's hypothesis was approved.

## Recommendations:

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- Self-learning package for measuring End-Carbon dioxide by capnography should be available and applied in all intensive care units to be followed by all nurses and should be up dated periodically.
- Periodic in-service training based on recent guidelines for measuring End-Carbon dioxide by capnography should be applied in intensive care and emergency units.

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