Web-Based Intervention Improves Surgical Units Nurses' Performance about Infection Control Precautions during Coronavirus Outbreaks

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Abstract

Background: Patients are at high risk of infection in surgical units due to patient comorbidities and a variety of human, environmental, and procedural factors. Not only are health professionals learning about infection control concepts right now, but the entire world also has been learning about infection control precautions during the Coronavirus outbreak. **This study aimed to** evaluate the effect of web-based intervention regarding infection control precautions for nurses' performance in surgical units during coronavirus outbreaks. **Research design:** Pre-posttest one-group quasi-experimental design was used in this study. **Sample:** A purposive sample of 200 nurses working at surgical units of Suez Canal University Hospital in Ismailia City was enrolled. **Study's Tools**: The researchers used three tools for collecting data. It covered demographic data, nurses' knowledge about infection control, and practices performed in surgical units. Those tools an online Google forms that were sent to the respondents' nurses via Facebook and WhatsApp groups. **Results**: There were statistically significant differences between nurses' knowledge and practices at pre-and post-web-based intervention. **Conclusion**: The present study concluded that utilizing web-based intervention has effectively improved the nurses' knowledge and practices regarding infection control precautions. **Recommendations**: Provision of continuing follow-up education programs on regular basis is recommended to refresh and update nurses' knowledge and practices regarding infection control.

Keywords*:* Coronavirus; Clinical Competence; Disease Outbreaks; Infection-control; Internet-Based Intervention; Nurses' knowledge; Practices.

Introduction:

Coronavirus disease (COVID-19) is a highly infectious respiratory disease caused by the SARS-CoV-2 virus. It was discovered in China in December 2019 and then spread around the world, causing an unprecedented public health crisis disease. This virus results in the deadliest pandemic epidemic of the new century **(Khoshaim et al., 2020 &Viner et al., 2020).** On 12 March 2020, the World Health Organization (WHO) announced COVID-19 a pandemic**.** Worldwide, about 3 million positive cases have been verified as of April 2020; 20,000 people had died as a result**.** The period following the onset of symptoms is classically approximately five days but may range from two days to two weeks. As the last second week of May 2020, more than 4.35 million cases have been reported across 185 countries and territories, more than 1.55 million people have recovered and more than 297,000 deaths. Egypt has been one of the worst-hit nations in the Eastern Mediterranean, with 11,228 confirmed cases and 592 fatalities **(WHO, 2020).**

This rapid rise in confirmed cases and deaths has caused stress, anxiety, and depression in both medical staff and the general population **(Bai et al., 2020**). **Therefore,** Changes in everyday life have been rapid and drastic, with virus surge outbreaks, the death rate escalating, and stringent steps to control the disease spread increasing across regions of the world, while significant attention has been paid to efforts to diagnose people with coronavirus infection, recognizing the mental health needs of people **(Bao et al., 2020**).

Infection control is a high-quality standard of patient care for the patients' well-being, safety for both nurses and patients. Three agents are necessary to spread infectious pathogens in a healthcare system: a reservoir, a vulnerablehost, and a route of transmissions. In

the hospital setting, health care personnel and visitors are vulnerable hosts (**Buetti et al., 201**7).

The use of numerous medical devices, such as urine catheters, central venous pressure monitors, wound draining catheters, and enteral feeding systems, as well as all invasive and noninvasive patient care procedures, all influence the risk of healthcare-associated infection. Evidently, Healthcare-associated infection is the most common hospitalization-related patient condition globally. Consequently, current nursing knowledge and understanding of infection control guidelines are critical to infections control, and nursing staff has the opportunity to exercise infection control guidelines regularly as part of patient care. Infection control standards are the most effective methods for preventing the transmission of health-care-associated pathogens in clinical settings, including surgical and medical departments (**Alrubaiee et al., 2017**). Thus, Inadequate adherence to infection control measures, including risky procedures such as injections, infusions, and all medication procedures, continues to result in the transmission of all pathogenic bacteria to healthcare professionals via regularly scheduled health care protocols (**Buetti et al., 2017**).

Infection control standards like proper hand-washing, sharp objects safety, using protective equipment including gloves, gowns, protective clothing, and eye goggles, equipment safety, and also the application of appropriate infection control standard precautions during invasive and noninvasive techniques are all components of the nursing care principles when directly in touch of body materials. The nursing care guidelines are considered the most simple and low-cost strategies that improve patient health care outcomes. The non-compliance to these infection control guidelines leads to an increase in the liability of infection occurrence whether systemic or localized, in all patients and medical staff (**Chenoweth et al, 2015&Bentivegna et al., 2020**).

Understanding the transmission of a pathogen resulting in colonization or infection requires the following six vital links: causative agent, infectious reservoir, portal of exit, mode of transmission, portal of entry into host, and susceptible host. Therefore, breaking any of the links can prevent infection. Isolation precautions seek to disrupt these links. Recent infection prevention guidelines published in the United States and Canada are based on the principles that certain precautions are required for the care of all patients, regardless of diagnosis, and are determined by the task performed, and that additional measures are required for patients with certain infections and are determined by the route of infection transmission. (**Center for Disease Control and Prevention**, **2020a**).

The Nurse in Infection Prevention and Control Specialist's role is straightforward: identity, prevent, and control infection outbreaks in health care settings and the community; however, the activities, knowledge, and skills required are exceptionally advanced and complex. While the role is simple, the range of activities required to meet the role's responsibilities is broad, and the methods used are wide-ranging **(Emily& Trish, 2017).** Additionally, the nurse is thinking about taking the first step toward improving clinical practice. It was critical to evaluate nurses' ability to effect positive change in the workplace. Continuous technological advancements increased the work complexity and put patients at a higher risk of infection **(Abd Elsatir, 2017).**

Nowadays, modern technical developments and procedures used to decrease illness transmission between people, such as keeping at home, limiting access to nursing homes, and preventing meetings at places, are used to minimize disease transmission between people (**Masonbrink & Hurley, 2020).** Individuals in the community use information technology mean like social media to raise awareness, educate, and track health-related events in the wake of the COVID-19 lockdown (**Kamel Boulos, 2019).** This will facilitate the delivery of high-quality health care for patients and a safe working environment for our healthcare workers. (**Abou El-Enein & EL Mahdy, 2018).**

Social media is defined in **Oxford Dictionary. (2019)** as websites and programs that enable users to generate and share information or

participate in social networking. Social media tools are platforms and communities, such as Facebook, WhatsApp, Facebook, and Messenger that allow several people to communicate and interact at the same time **(Barrett & Mac Sweeney, 2019).** The role of social media varies according to users and non-users, age groups, and demographic populations. Because technological change is linked to linguistic and cultural shift patterns, the role of social media is changing constantly **(Statsita, 2019).** The use of social media in healthcare is becoming more common to improve communication speed, disseminate accurate information, promote knowledge of support, treatments, and self-care options **(Cherak et al., 2020).**

Significance of the study

Healthcare-associated infection is the most dangerous complication occurred during hospitalization in all clinical settings as medical-surgical departments. It is the primary cause of death within that population and causes an additional patient burden. **Hammoud et al** (**2020)** declared that 1 in 20 hospitalized patients is at risk of developing an infection, which might be the dangerous cause of death in approximately 99.000 cases per year. In any healthcare setting, evaluating the nurse's commitment to patient safety requirements is critical in the infection control improvement process. This study will add to the existing literature and nursing interventions that develop the nurses' skills **(Center for Disease Control and Prevention, 2020b).**

During the COVID-19 pandemic, **CDC (2020b)** recommends employing additional infection control methods to the existing measures as routine care for all patients. These guidelines had intended for all patients, not just those who have been diagnosed with SARS-CoV-2. Rules & procedures must be prepared by facilities to assure that the instructions had implemented. Therefore, developing and applying nursing intervention for nurses about infection control of some procedures in the surgical units is very important and beneficial in terms of quality of care. It is essential to promote the further evaluation of the nurse's knowledge and its related practices regarding the standards.

One of the effective methods to attain continuing education is social media like WhatsApp reminder massages. It may help in acquiring adequate knowledge and skills regarding infection control precautions. Because WhatsApp reminder massages depend on repeating and remembering massages for them through photos, videos, power points to enhance and develop their knowledge, practice. **Hence, the study aimed to** evaluate the effect of web-based intervention regarding infection control precautions for nurses' performance in surgical units during coronavirus.

This Aim is achieved by:

1) Assess the nurses' knowledge and practices regarding infection control precautions in the surgical units.
2) Develop and apply web-based intervention regarding infection control precautions for nurses in surgical units.
3) Determine the effect of the web-based intervention regarding infection control precautions for nurses' knowledge and their practices in surgical units during coronavirus.

Research Hypotheses:

H 1: Nurses who are exposed to the web-based intervention regarding infection control will have a higher knowledge score after the intervention than before, and will have better practices after the intervention**.**

H 2: There will be a positive correlation between the study nurses' knowledge and practice post the infection control web-based intervention is implemented**.**

Subjects & Method

Research design:

Pre-posttest one-group quasi-experimental design was used to achieve the aim of this study. A quasi-experimental design is one type of experimental design that is very similar to the true experimental design except there are loss one criteria which are control, manipulation, or randomization (**Burns & Grove, 2012).**

Setting: The study was conducted at surgical units of Suez Canal University Hospital in Ismailia City. It included 15 surgical units and contained about 10 to 12 beds. Each unit was included from 12-13 nurses.

Sample: A purposive sample of 200 nurses working in surgical units was enrolled for the study and invited to participate in an online electronic questionnaire by using Google forms.

The sample size was calculated statistically at a 95 % confidence level to be 200 nurses using the following equation:

$$Ss \text{ (sample size)} = \frac{Z^2 * (p) * (1-p)}{c2}$$

Where:

Z = Is the value of Z (1.96 for 95% confidence level)

p = percentage of people who make a decision represented as decimal (0.5 used for sample size needed) c = confidence interval

Inclusion criteria:

1. The staff nurses are at least one year of experience.
2. Their age ranged from 20 to 45 years old.
3. Agree to participate in the study.

Exclusion criteria:

1. Refusing to participate in the study.
2. Nurses on special leave.

Tools for Data Collection:

Tool (I): A structured interview questionnaire sheet in the Arabic language was used for the studied nurses as pre/posttest. It was designed by the research investigator after an extensive review of the related literature (**Control Diseases Center CDC, (2014**). It is composed of the following parts:

Part I: Demographic data related to the nurses' age, gender, qualification, years of experience, and previous attending courses in infection control.

Part II: Nurses' knowledge related to infection control in surgical units. It involved 30 items of closed-ended questions and was divided into two groups: a. knowledge about infection control in general. It consisted of 25 items; b. 5 items about infection in surgical units.

Scoring system: For knowledge; the total score (90), was categorized into two levels unsatisfactory if scoreless than 75%, and satisfactory for more than 75%. For each part, the score of the items was summed up and the total was divided by several items, giving a mean score for the area. These scores were converted into a percent score and mean and standard deviations were computed. These scores were converted into a percent score.

Part III: Nurses' reported practices related to infection control in surgical units that was adopted from **Control Diseases Center CDC, (2020b**) (National Center for emerging and zoonotic infectious diseases division of health quality promotion) to assess the nurses' reported practices regarding infection control procedures in surgical unites which include (handwashing, Personal protective equipment like gloves, mask, and gown, Well Handling of sharp instruments, Safe injection disposal practice, Safe IM injection and giving intravenous Injection, Safe handling of escaped blood during daily, Safe protocol of cough for both patients and Staff, Safe handling during perioperative patients Transfer, Safe handling of all intraoperative sterile equipment, Safe handling during all invasive catheterization or intubation during the perioperative period, Safe handling of the recommended isolated Patient, and Safe handling of correct patient assignments in the clinical area.

Scoring system:

The nurses reported practices evaluated as done or not done where a score of one was given for done correctly, a score of zero was given for not done practice these scores were converted into a percentage score. The nurses' reported practice was considered competent if the percent score is 75% or more and incompetent if less than 75%. For each part, the score of the items was summed up and the total was divided by several items, giving a mean score for the area. These scores were converted into a percent score and mean and standard deviations were computed. These scores were converted into a percent score.

Tool Validity and Reliability:

The content validity of the tools, their clarity, comprehensiveness, appropriateness, and relevance were reviewed by five expert professors; two experts in medical-surgical nursing, one expert in oncology, and two experts' physicians from the medical-surgical department). Modifications were made according to the panel judgment to ensure sentence clarity and content appropriateness.

Test-retest reliability was used to assess the tools' internal consistency by repeatedly giving the same tool to the participants under the same settings. The correlation coefficients were 0.89 by Cronbach's alpha.

Pilot study:

A pilot study was carried out on (10%) twenty nurses from the selected units using the previously mentioned tools, to evaluate their applicability, clarity, and estimate time for each

tool. Nurses involved in the pilot study were included in the main study subjects.

Ethical consideration:

Official permission was obtained through an issued letter from the Dean of Faculty of Nursing, Suez Canal University to conduct this study. On the first page of the online questionnaire, an informed consent form was included. The cover page of the questionnaire included a brief introduction to the study's objectives, the researchers informed the participants that, the study was voluntary, they were allowed to refuse to participate and they had the right to withdraw from the study at any time, without giving any reason, declarations of anonymity, confidentiality, and instructions for completing the questionnaire, as well as the link and quick response (QR) code for the online questionnaire. After reading the consent form, nurses completed the questionnaire.

Procedure:

After lockdown, because of the outbreaking of COVID-19, data were collected from 30 June 2020 to the end of July 2020.

The actual study was divided into three phases:

A- Assessment phase:

The researchers began by introducing themselves to the nurses and explaining the nature and purpose of the study. A Google Form was created online, and participants were invited to fill it out and submit it. During the COVID-19 pandemic, the Google form link was shared with nurses via Facebook and WhatsApp groups. To collect baseline data, each nurse was assessed using an online- administered questionnaire as a (pretest) before the online videos and presentation. On the first page of the online questionnaire, nurses were informed about the study's purpose and expected outcomes, the tools' contents, and how to respond.

B-Planning Phase:

- This phase was formulated based on the assessment phase and extensive literature review. Goals and expected outcome criteria were considered when planning web-based intervention for the studied nurses. Nurses attended a total of 3 sessions. These sessions were scheduled as three sessions for two weeks. Each session was lasted for about an hour. The researchers used the following learning materials: images, videos, and PowerPoint presentations.

C-Implementing Phase:

In this phase, the researchers met the study subjects online through Zoom meetings, voice calls, videos, and chat.

- **The first session** covered knowledge content about infection, infection control precautions such as hand washing, personal protective measures, and handling sharp instruments. It was given in about one hour.
- **The second session** was geared toward the clinical application of handwashing, personal protective measures, and dealing with sharp instruments. It was given in about one hour.
- **The third session** was regarding the clinical application of environmental hygiene, clinical application of dealing with sharp instruments, caring of wound dressing, intramuscular injection (IM) injection and giving intravenous infusion), It was given in about one hour.

A soft copy of the booklet was distributed through the Facebook and WhatsApp groups of those who took part in the pre-test via the Google Form. To clarify it for nurses, the researchers posted appropriate videos, PowerPoint presentations, and posters regarding infection control precautions. In addition, the researchers produced online videos and recordings explaining the contents of the booklet hopefully improving nurses' knowledge and practice regarding infection control during COVID 19 lockdown.

D- Evaluation phase:

After one month of sending the booklet, videos, PowerPoint presentation, and posters, the questionnaire was re-posted to the participants on the Google Form for collection (post-test) and evaluated again.

Statistical Analysis:

The researchers entered and analyzed Data by using SPSS (Statistical Package for Social Science) statistical package version 22. Graphics were done using the Excel program. Quantitative data were presented by mean (X), standard deviation (SD), and a student t-test used for comparing two means. Qualitative data were presented in the form of frequency distribution tables, numbers, and percentages. It was analyzed by the chi-square (χ^2) test. However, if an expected value of any cell in the table was less than 5, Fisher Exact test was used. If the total

number of table cells were more than four cells, the Likelihood Ratio (LR) test was used. All tests were two-sided, and a p level < 0.05 was considered significant.

Results:

Table (1) shows that (54%) of the studied nurses were between 20 to less than 30 years old with a mean age was 32.26±6.07, (63%) of the studied nurses were female, while (37%) were male. More than two-fifth of the studied nurses (43%) have a diploma from secondary nursing school. Regarding years of experience**,** 40% of the studied nurses have less than ten years of experience. As regards previous attendance of training courses, 80% of the studied nurses reported that they did not attend training courses.

Table (2): Illustrates that there were highly statistically significant differences found between nurses' knowledge pre/post- web-based intervention (P<0.001).

Figure (1): Demonstrates that (40%) of the studied nurses had satisfactory knowledge regarding infection control precautions pre- web-based intervention which improved post-intervention and becomes 97% of them had satisfactory knowledge. A highly statistically significant difference was detected between nurses' knowledge pre/post-web-based intervention (P<0.001).

In the comparison of the studied nurses' practice regarding infection control precautions table (3) illustrated that there were highly statistically significant differences between nurses' practice at pre and post- web-based Intervention (p<0.001) Regarding all aspects of infection control precautions.

Figure 2: Portrays the nurses' total practice regarding infection control precautions pre-and post- web-based intervention, and indicated that (43%) of the studied nurses had an incompetent level of practice pre- web-based intervention, but post-web-based intervention (90%) of them had a competent level of practice.

Table (4) showed that there was a statistically significant positive correlation between the total knowledge and total practice scores of the studied nurses' pre and post-web-based intervention (p<0.001**).

Table (1): Percentage distribution of the studied nurses regarding their demographic characteristics

Variables.	The Studied Nurses (n=200)	
	N	%
Age :		
• 20 < 30	108	54.0
• 30 < 40	50	25.0
• ≥40	42	21.0
(X ±SD): 32.26±6.07		
Gender:		
• Male	74	37.0
•Female	126	63.0
Qualification:		
• Nursing Diploma.	86	43.0
• Bachelor of nursing.	64	32.0
• Master of nursing.	50	25.0
Years of experience:		
• < 5	78	39.0
• <10	80	40.0
• >10	42	21.0
previous attending courses in infection control		
• Yes.	40	20.0
• No	160	80.0

Table (2): Comparison of Nurses' Knowledge related to Infection Control Pre and Post web-based intervention (N-200)

Knowledge items	Pre-intervention		Post-intervention		X^2	P-value
	N	%	N	%		
Definition of nosocomial infection control process.	100	50	200	100	137.42	0.001
Chain of the process of infection	106	53	194	97	162.23	0.001
Methods of prevention of nosocomial infection control	112	56	190	95	113.25	0.001
Methods of transmission	84	42	192	96	135.67	0.001
Standard universal precautions	96	48	186	93	83.16	0.001
Transmission-based universal precautions	104	52	188	94	56.38	0.001

***Highly significance at 0.001 levels**

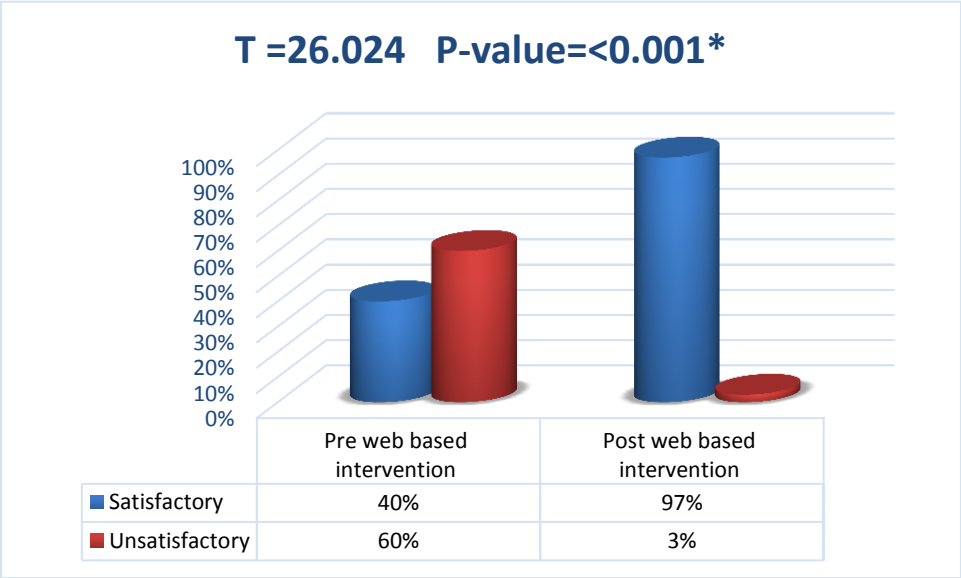
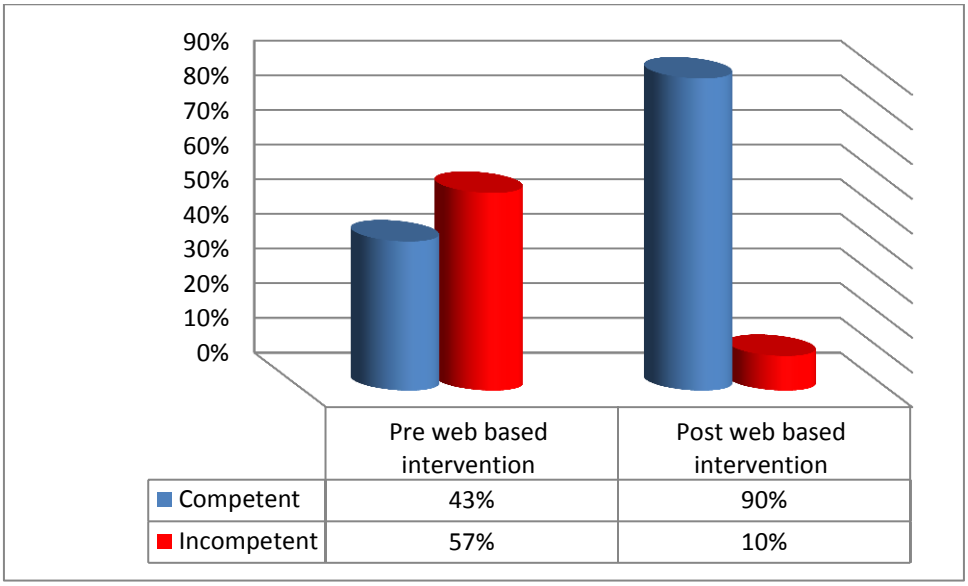


Figure (1): Percentage distribution of the studied nurses' total knowledge regarding infection control precautions pre and post-web-based intervention (N-200)

Table (3): Comparison of nurses' practice of infection control precautions during Corona Virus Pre / Post web-based Intervention.

Practices of Infection Control precautions	Studied nurses (n= 200)				X^2	P-value
	Pre-intervention		Post-intervention			
	N	%	N	%		
Hand washing	90	45	200	100	65.09	0.0001**
Personal protective equipment like gloves, mask, gown	112	56	184	92	104.03	0.0001**
Well Handling of sharp instruments	68	34	186	93	65.83	0.0001**
Safe injection disposal practice	78	39	190	95	97.96	0.0001**
Safe IM injection and giving intravenous Injection	94	47	194	97	16.78	0.0001**
Safe handling of escaped blood during daily	78	39	196	98	83.86	0.0001**
Safe protocol of cough for both patients and Staff	98	49	186	93	16.78	0.0001**
Safe handling during perioperative patients Transfer	104	52	188	94	18.88	0.0001**
Safe handling of all intraoperative sterile equipment	92	46	186	93	124.31	0.0001**
Safe handling during all invasive catheterization or intubation during the perioperative period	92	46	190	95	205.76	0.0001**
Safe handling of the recommended isolated Patient	102	51	186	93	68.17	0.0001**
Safe handling of correct patient assignments in the clinical area	90	45	182	91	65.33	0.0001**



*Highly Significance at P-value 0.0001 levels

Figure (2): differences between nurses' total practice pre and post-web-based intervention regarding infection control precautions (n=200)

Table (4): Correlation between total knowledge and total practices scores of the studied nurses pre and postweb-based intervention (n=100).

Variables	Pearson correlation coefficient			
	Total knowledge score			
	Pre-web-based intervention (n=50)		Post web base intervention (n=50)	
	r	P	R	P
Total practices score	.463	0.001**	.632	0.001*

**** Correlation is significant at the 0.01 level**

Discussion:

The current study hypothesized that the knowledge of the studied nurses will improve after receiving web-based nursing intervention regarding infection control precautions during COVID-19. Additionally, Nurses' practices will improve after receiving web-based nursing during COVID-19. Hence, the study aimed to evaluate the effect of web-based intervention regarding infection control precautions for nurses' performances in surgical units during coronavirus outbreaks.

In terms of previous training course attendance, the majority of the nurses polled stated that they had never attended any. This highlights the need for and significance of implementing a web-based intervention.

Results of the current study revealed that there were highly statistically significant differences found between nurses' knowledge pre/post- web-based intervention. From the researchers' point of view, this result reflects the positive effect of the web-based intervention, which meets the studied nurses' needs and provides them with sufficient knowledge to prevent infection.

Likewise, **Cruz & Bashtawi**, **(2016)** studied "Predictors of hand hygiene practice among Saudi nursing students" and reported that in-service training program implementation was effective in improving the nursing health system. As well, **Cruz et al., (2015**), conducted a study about "Gender differences in hand hygiene among Saudi nursing students" and showed that the educational programs were effective in promoting the participants' knowledge regarding infection control and prevention measures. Also**,**

D'Alessandro et al., (2019) reported that the application of such programs is beneficial in improving the nurses' knowledge of infection prevention and recommended that infection control programs should be included in in-service training programs.

Similarly, **Fashafsheh, et al., (2017**) found in their study about "Knowledge and Practice of Nursing Staff towards Infection Control Measures in The Palestinian Hospitals." that most study participants had a considerable improvement in their level of knowledge regarding transmission-based universal precautions after the guideline's intervention compared to one third before the guideline's intervention, according to the findings.

This current study found that two-fifths of the studied nurses had satisfactory knowledge regarding infection control precautions pre- web-based intervention which improved post-intervention and becomes most of them had satisfactory knowledge. Similarly, the study conducted by **Hammoud et al., (2017**) about " Nurses' awareness of infection control measures, and the role and effect inpatient and family education" reported that, a statistically significant increase in the level of knowledge regarding all general measures of infection control, and also a significant improvement in overall knowledge from an average to a high level after the guideline's intervention.

One interesting finding is that there are highly statistically significant differences between nurses' practice at pre-and post- web-based Interventions regarding all aspects of infection control precautions.

This result is in the same line with (**D'Alessandro et al., (2019**) who assess the prevention of healthcare-associated infections: Medical and nursing students' knowledge in Italy and training on infection control measures" and reported that their practice was more effective and improved after the educational training program on infection control guidelines. Also, **Dombrádi et al., (2015**) investigate the conditions affecting the joining of Hungarian hospitals to an accreditation program" and found that their practice was more effective and improved after the educational training program on infection control guidelines. From the researchers' point of view, it reflected the good impact of the web-based intervention on improving practices**.** These are confirmed the significant modifications in the nurses' practice that reflected the main goals of the implementation of the web-based intervention.

The result is matched with the study of **the World Health Organization (2020)** which indicated the positive effect of educational program implementation regarding infection control guidelines on the improvement of the nurses' total knowledge and practice level.

the study findings portrayed the nurses' total practice regarding infection control precautions pre-and post- web-based intervention and indicated that more than one-third of the studied nurses had an incompetent level of practice pre-web-based intervention, whereas, post-web-based intervention most of them had a competent level of practice. Similarly, **LeRose et al.,** (**2020)** evaluated the knowledge and practice of nursing staff towards infection control measures and "the impact of COVID-19 response on central-line–associated bloodstream infections and blood culture contamination rates at a tertiary-care center in the greater Detroit area" revealed that nearly more than one-quarter of the participants had a fair level of knowledge that mainly due to deficiency of infection control training courses. The researcher explained this result was due to the similarity of shortage in programs and courses in most universities and nursing institutions and inadequate in-service training programs.

Additionally, **Ponce-Alonso et al., (2020**) assessed the nurses' practice level regarding infection control measures during coronavirus disease and demonstrate that the majority of the study participants had good practice levels regarding the infection control to be higher after the educational program than that what was reported before the intervention.

The present study revealed that there was a statistically significant positive correlation between the total knowledge and total practice scores of the studied nurses' pre and post-web-based intervention. From the researchers' point of view, this reflected the importance of improving nurses' knowledge and practice to help acquire good knowledge and apply it. A possible explanation for this association might be that, when the studied nurses had sufficient

knowledge, they can practice well. This was in line with the results of **Hammoud et al., (2020**) who studied found "Patient education on infection control " and discovered a significant positive relationship between knowledge and performance.

Additionally, **Fan et al**., (**2020)** reported that health behavior changes when gaining the right knowledge and adopting the practice**.** Likewise**,** recently, **Rana et al., (2020)** illustrated that sufficient individual knowledge is associated with effective management of disease and promotion of a person's health**.** A study by **Ricardo et al., (2018)** supported that; knowledge deficit is associated with poor health and maladaptive disease preventive behavior**.**

Finally, the study findings supported the researchers' hypotheses that the web-based intervention for infection control during the Coronavirus helped promote the nurses' knowledge score and improved practice score after the web-based intervention compared to their knowledge score and practice before the web-based intervention.

Conclusion:

Based on the results and hypotheses of the present study, this research concluded that implementing web-based has effectively improved the nurses' knowledge and practices regarding infection control precautions at pre-and post-intervention during COVID-19 outbreaks. There was a statistically significant positive relationship between the total knowledge and total practice scores of the studied nurses' pre- and post-web-based intervention

Recommendations:

Based on the findings of this study, the following recommendations are suggested:

- Provision of continuing follow-up education programs on regular basis is recommended to refresh and update nurses' knowledge and practices regarding infection control.
- Replication of the current study with a larger sample of nurses in different settings is required for generalizing the results**.**

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