Effect of Evidence-Based Measures protocol on Nurses' Performance regarding Prevention of Surgical Site Infection

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ABSTRACT

Background: Surgical site infection (SSI) is a serious complication of surgical procedures and the most common type of healthcare-associated infections in low- and middle-income countries. Although, SSI prevention is complex and requires the integration of a range of measures before, during, and after surgery; except that up to 60% of these infections are estimated to be largely preventable by using evidence-based guidelines. Hence, as frontline caregivers, nurses can play a golden role in SSI preventing efforts through advancing their knowledge, attitude, and practice in accordance with the latest evidence-based preventive measures of SSI. ***Study aim:*** to evaluate the effect of evidence-based measures protocol on nurses' performance regarding prevention of surgical site infection. ***Study Design:*** a quasi-experimental design. ***Setting:*** General surgery departments and surgical operating theater at Zagazig University Hospitals, Al Sharkia Governorate, Egypt. ***Subject:*** A convenience sample of all available nurses (70), who are working at the previously mentioned settings. ***Tools:*** A self-administered questionnaire to assess nurses' socio-demographic characteristics and knowledge; Likert scale to assess attitudes, and observation checklist to assess nurses' practice of evidence-based SSI preventive measures. ***Results***: There was a lack in nurses' knowledge, positive attitude, and practice about evidence-based preventive measures for SSI in the pre-intervention phase of the evidence-based measures protocol, with mean±SD of 14.6±3.7,17.1 ± 8.5, and 56.7±12.2 respectively, which increased in post phase of the protocol intervention with mean±SD of 20.2±3.9, 20.6±11, and 66.2±10.5 respectively, also there was a highly statistically significant difference and improvement in total nurses' knowledge, attitude and practice post-intervention ($p<0.001$), with a percentage of improvement equal 38%, 20.65%, and 16.89% in nurses' knowledge, attitude, and practice respectively. ***Conclusions:*** Evidence-based measures protocol implementation had improved nurses' knowledge that in turn had shaped their positive attitude, which results in improving nurses' practice of evidence-based preventive measures of SSI, as each one connected with the other. ***Recommendations:*** Evidence-based preventive measures of SSI should be incorporated into comprehensive surgical nursing quality improvement programs to improve patient safety.

Keywords: Evidence-Based measures protocol, Nurses' Performance, Surgical site infection prevention.

Introduction:

A surgical site infection (SSI) is a contagion that happens within thirty days next any surgery if no implant is positioned or within 1 year if an implant is positioned **(Badia et al., 2017)**. Even though preventable, SSI happens in up to 30% of surgeries, represent 14% of HAIs, 11% of patients who undergo surgery are infected in this process, it is associated with significant morbidity, mortality, and expanded health care costs **(Patil et al., 2018 &WHO, 2018)**. It is considered a healthcare-related problem in which a wound infection happens after surgical interventions **(Maurya & Mendhe, 2014)**. Around the world, at least 312.9 million surgical procedures were performed yearly **(Weiser et al., 2015)**.

Most surgical procedures result in wounds that may be associated with surgical site complications **(World Union of Wound Healing Societies, 2016)**. SSI is considered one of the serious complications that can cause undesired patients' health outcomes after surgery, in spite of advancements in surgical procedures, technological progression within the health care facilities, environmental improvements, and the use of prophylactic antibiotics. The highest prevalence rates of healthcare-associated infections (HCAIs) were observed in intensive care units and surgery wards **(Gillespie et al., 2014 ; Ilié & Markovié-Denié, 2009)**.

Surgical site infection prevention is a vital issue in both high- and low-income nations; in spite of the fact that all bacterial diseases can't be avoided, a significant number of diseases can be maintained a strategic distance from by taking safety measures during preoperative, operative, and postoperative phases and by actualizing evidence-based infection control strategies **(Ding et al., 2016)**. In addition, the prevention of surgical complications is based on the awareness of health care professionals especially nurses about evidence-based practices to provide high-quality nursing care **(Gillespie et al., 2015)**. So that, Healthcare facilities' goals should be directed toward excellence in safe surgery practices, and the implementation of evidence-based measures using a quality advancement process to makes a difference towards accomplishing effective and sustainable results **(Ling et al., 2016)**.

A set of preventive measures have been published and recommended for the prevention or play down of surgical site infection morbidity within preoperative, operative, postoperative phases **(Berríos-Torres et al., 2017)**, such as those of the World Health Organization **(WHO, 2019)**, National Institute for Health and Clinical Excellence **(NICE, 2019)**, Asia Pacific Society of Infection Control **(APSIC, 2019)**, Canadian Association of Wound Care **(CAWC, 2018)**, and Centers of Disease Control and Prevention, which have identified a number of practices that healthcare workers should adopt. However, adherence to the suggested measures or practices according to the SSI prevention guidelines among nurses still remains low **(CDC, 2017)**.

Generally, the best measures or practices in different SSI preventive guidelines were focused on the following areas: (1) Hair removal; hair should either be not removed or removed by clipper alone on the day of operation in the outside area of the operating room, when absolutely necessary; (2) Preoperative showering by soap, either the day before or on the day of an operation; (3) Preoperative skin preparation, prepare skin at the surgical site immediately before incision using an antiseptic solution, the first choice of an alcohol-based solution of chlorhexidine, unless contraindicated. (4) Prophylactic antibiotics should be administered within 120 minutes prior to incision, taking into account antibiotic half-life; (5) Surgical hand preparation should be done before the application of sterile gloves, with the appropriate antimicrobial soap and water or by using suitable alcohol-based hand rub;(6) Proper practices of hand hygiene must be carried out before and after any procedure, and (7) Use of an aseptic non-touch technique for dressing change and removal **(NICE, 2019; WHO, 2019 ; De Jonge et al., 2017)**.

The nurses are significant individuals of the surgical care team, who remains around 24 hours with the patient. It is greatly vital for surgical nurses to completely understanding the essentials of pre and post-operative surgical site infection avoidance and control measures **(Wick et al., 2008)**. It is estimated that nurses can avoid 25 percent of infections by actualizing standard safety measures during the care of surgical patients. Besides, the nurses can help prevent SSI, decrease the financial burden of patients and hospital costs, and improve patients' quality of life by applying evidence-based knowledge and prescribed practices **(Sickder et al., 2014)**.

Despite the broad international presentation of top-level evidence-based recommendations for the avoidance of SSI like that of the WHO global guideline, SSI rates have not measurably fallen especially in developing nations and process-related risk factors are playing a critical part in this impact **(WHO, 2016a ; CDC, 2014)**. Furthermore, the breakdown of nurses' knowledge and low standard practice can cause the transmission of infection particularly among

open wound/site surgeries **(Sadia et al., 2017; Rolstad et al., 2012)**. Hence, nurses' education and reinforcement is considered as the cornerstone and the first step in preventing infections **(CDC, 2010)**.

On the other hand, the training of healthcare professionals can improve the level of knowledge, thereby promoting the implementation of anti-infection measures that contribute directly to the reduction of health-related infections especially SSI **(Belowska et al., 2014)**. Therefore the present study was conducted to evaluate the effect of evidence-based measures protocol on nurses' performance regarding prevention of surgical site infection.

Significance of the study:

Surgical site infection has a dangerous effect on the health care system worldwide and contributes to longer recovery, increased hospital stay, additional healthcare costs, additional pain, further risk of other complications, and, in some cases, permanent disability, and death **(Ding et al., 2017)**. The incidence rate of SSI varied between countries with 9.4% for high, 14.0% for middle, and 23.2% for low-income countries **(Bhangu et al., 2018)**. The foremost vital factor in improving the quality of surgical care and avoiding SSI is the concentrate on evidence-based practice and absolute adherence of health care professionals with the SSI prevention measures in the evidence-based guidelines **(Qasem & Hweidi, 2017)**. Besides, nursing performance is a critical part of patient care and plays a fateful role in preventing SSI **(Sadia et al., 2017)**. So, it is extremely recommended that the knowledge and practice of nurses be advanced in accordance with the most recent evidence-based measures for avoiding SSI **(Aucamp, 2016; WHO, 2016a)**.

Aim of the study:

The current study aimed to evaluate the effect of evidence-based measures protocol on nurses' performance regarding prevention of SSI through:

- Assess existing nurses' knowledge, attitude, and practice of evidence-based preventive measures for surgical site infection.
- Design and implement evidence-based measures protocol based on previously explored nurses' actual needs regarding prevention of SSI.
- Evaluate the effect of applying evidence-based measures protocol on nurses' knowledge, attitude, and practice of evidence-based SSI preventive measures.
- Determine the statistical relation between nurses' knowledge, attitude, and their practice of evidence-based SSI preventive measures.

Research hypotheses:

To achieve the study's aim the following research hypotheses were formulated:

1. **H1:** Implementation of evidence-based measures protocol will improve nurses' knowledge, attitude, and practice regarding prevention of SSI.
2. **H2:** There will be a statistically significant relation between nurses' knowledge, attitude, and their practice of evidence-based SSI preventive measures.

Subjects and methods:

Research design:

A quasi-experimental design was used to achieve the study's aim.

Setting:

The study was performed in the general surgery department and surgical operating theater at Zagazig University Hospitals, Al Sharkia governorate, Egypt.

Subjects:

A convenience sample of all available nurses (70), who works at the previously mentioned settings, involved in direct clinical care with patients, and accepts to participate in this study.

Tools of data collection: Three data collection tools were used:

Tool I: A self-administered questionnaire: It composed of two parts:

1. **Nurses' Socio-demographic characteristics:** it included ten items incorporated information on the nurses' age, gender, social state, academic qualification, residential area, income, job experience years in the nursing field, job experience years in the general surgical department or surgical operating theater, previous attendance of training courses about SSI prevention, and the presence of a guidelines in the ward related to SSI preventive measures.
2. **Nurses' knowledge assessment questionnaire:** to assess nurses' knowledge about surgical site infection and evidence-based SSI preventive measures. It was adapted from **Mengesha, (2018) and Sickder et al., (2014)** and modified by the researchers based on SSI prevention guidelines of WHO, **(2019)** and an extensive review of pertinent literature **(Mert Boga, 2019; Dubois et al., 2018)**; which contained 30 multiple-choice questions covered the SSI definition, signs, and symptoms, risk factors, diagnosis, laboratory investigation, proper preoperative shaving or hair removal, appropriate preoperative skin disinfection and preparation, prophylactic antibiotic use (appropriate selection, the timing of the first dose, and discontinuation postoperatively), appropriate preoperative showering, the disinfectant agents, assessment and maintenance nutritional status, controlling of underlying medical conditions of surgical patients, hand washing, aseptic precautions of incision site care, the principles of wound assessment, wound dressing and wound dressing solution, etc.

- **Knowledge scoring system:** Each correct answer was given a score of one and the incorrect answer a score of zero. The total knowledge score = 30, knowledge was considered satisfactory if the percent score was ≥80% and unsatisfactory if <80% based on data entering and statistical analysis.

Tool II: Nurses' attitudes Likert scale:

This tool was used to assess nurses' attitudes toward evidence-based preventive measures of SSI; it was designed by the researchers after reviewing the related literature **(Chisanga, 2017; Kolade et al., 2017)**. It composed of ten statements that were positively worded as the following " It is important to have evidence-based SSI preventive measures guideline at the ward, should be adhering to evidence-based SSI preventive measures at all times, should attend in-service training/workshop related to SSI prevention and control regularly, the workload doesn't affect my ability to apply SSI preventive measures, it is my responsibility to comply with SSI preventive measures, following the evidence-based preventive measures of SSI don't take too much time, following evidence-based preventive measures of SSI make my work easier, adherence to evidence-based preventive measures of SSI makes patient care very restful, I should follow the procedure guidelines of the ward to prevent SSI infection, and following the evidence-based preventive measures will reduce rates of SSI.

- **Attitude scoring system:** in which responses were answered in a 4-point Likert scale ranging from "strongly agrees to- strongly disagree", as the choice of strongly agree was given "three points", agree was given "two points", and disagree was given "one point", while strongly disagree was given "zero". The total attitude score = 30, the attitude was considered "positive" if the percent score was ≥80% and "negative" if <80% based on data entering and statistical analysis.

Tool III: Nurses' practice Observational checklist:

This tool was used to assess the nurses' practice of evidence-based preventive measures for SSI; it was adapted from **Getaneh et al., (2019) and Sickder et al., (2014)**, then modified by the researchers based on Evidence-based clinical practice guidelines (CPG), and standards specific to prevention of SSIs that have been published and updated by World Health Organization **(WHO, 2019)**, and after reviewing of the related literature **(Albishi et al., 2019; Mengesha, 2018)**. It consisted of "30" steps that covered nurses' application for preoperative and postoperative measures of SSI prevention such as hand hygiene, preparation of the patient (pre-operative showering and appropriate hair removal at the surgical site), appropriately and timely administration of antibiotics, pre and post-operative glycemic control, nutritional status assessment, nutritional support, and postoperative incisional care (using aseptic technique, wound assessment and monitoring of SSI), etc.

- **Practice scoring system**: each practice item observed to be done was scored "1" and the not-done "zero". The total knowledge score = 30, the practice was considered competent if the percent score was ≥80% and incompetent if <80% based on data entering and statistical analysis. This high cutoff-point was set due to the critical situation the nurse is dealing with, which necessitates a very high level of knowledge and practice.

Tools validity and reliability:

Once the data collection tools were prepared in their preliminary form, it was presented to a panel of five experts from different nursing and medical specialties to measure its content validity. The panel included two Medical-Surgical nursing professors, one General Surgery professor, and two experts from the Infection Control Unit at Zagazig University hospital. These experts reviewed the tools for relevance comprehensiveness, clarity, and ease of administration. Minor modifications were done according to the experts' judgment. Internal consistency reliability of all items of the tools was assessed using a Chronbach's Alpha test; it was 0.91 for knowledge (tool I), 0.81 for attitude (tool II), and 0.87 for practice (tool III).

Ethical considerations:

Official permission was obtained from the Dean of the Faculty of nursing and directors of the previously mentioned settings before starting the study. Before collecting data, oral consent was obtained from participating nurses who were informed of nature, purpose, and methods of the study to ensure maximum cooperation as well as to make arrangements for the attendance of the participants. The participants were also informed of their right to participate or withdraw at any time from the study. Strict confidentiality was ensured throughout the study process, and all nurses were assured that their data was used for research purposes only.

Pilot study:

It was carried out on 10% (7 nurses) of the main study sample, to test the tools' clarity, relevance, comprehensiveness, understanding, applicability, and ease for implementation. It also helped to estimate the time needed to fill in the forms. Since no modifications were done in the tool, nurses who shared in the pilot study were included in the actual study sample.

Field work:

The study was conducted in three phases (preparatory phase, implementation phase, and evaluation phase).

(1) The preparatory phase:

- The data of the current study had collected from the beginning of August 2020 to January 2021. The implementation of the Evidence-based measures protocol had done over six months, as one month for the preparatory phase, one month for the theoretical part, and three months for the practical part, then collecting the post- protocol or program data that took one month. Through the preparatory phase, the researchers secured all necessary permissions from the Director of Zagazig University Hospital and the study settings directors. The researchers visited the study settings, met with the directors, explained to them the aim of the study as well as the process of data collection to maintain their cooperation during data collection and to set its schedule so that it does not interfere with nurses' work. The researchers then met with the nurses individually, explained to them the aim of the study and the process of collection of the data, and invited them to participate after being informed about their rights.
- The nurses who gave their consent were given the self-administered questionnaire to assess their actual needs of knowledge, and attitude concerning evidence-based preventive measures for surgical site infection, and were instructed in how to fill it. The researchers were present at all times to clarify any ambiguities and respond to any queries. Then, the filled forms were collected and revised for completeness. This took 20-30 minutes from each nurse. For assessment of the nurses' practice regarding evidence-based measures for prevention SSI, the researchers used the observation checklist; this was done during the routine daily work of the nurse. Each nurse was observed for applying SSI prevention activities or measures while providing care to the patient in surgical wards through pre and postoperative periods like hand hygiene, preparation of the patient, postoperative incisional care, etc.

(2) The implementation phase:

- Once the assessment phase was completed, the identified needs were translated to objectives; then the evidence-based measures protocol was designed by the researchers according to previously assessed nurses' needs obtained from the assessment phase, objectives, and educational background of nurses. It was designed for improving and updating nurses' knowledge, attitude, and practice regarding evidence-based surgical site infection preventive measures. It was designed as a booklet in a simple Arabic Language according to last published and updated guidelines specific to the prevention of SSIs that published by the World health organization **(WHO, 2019)** and other organization from the United Kingdom **(NICE, 2019)**, the United States **(CDC, 2017)**, and Australia **(Australian Wound Association, 2016)**, also based on experts' opinions and reviews of relevant literature (nursing textbooks, journals, and internet resources) about SSI preventive measures, then each participant nurse obtained a copy of it.
- The researcher scheduled with nurses the teaching sessions for both theoretical and practical parts of the Evidence-based measures protocol. The nurses had divided into ten small groups; each group contained seven nurses because it was difficult to gather all the nurses at one time. The researchers were available three days per week during the morning and afternoon shifts. The Evidence-based measures protocol was conducted by researchers through "18" educational sessions (6 sessions for the theoretical part, and 12 for the practical part) as the following:

A. ***The theoretical part*** covered three sections, the first section included A brief about surgical operations (as types of surgical operations, supplies for surgery and anesthesia, antiseptics and disinfectants, surgical techniques, a typical surgery), General measures for surgical operations (as preparing for the day of surgery, a general measures at and after surgery day), and Postoperative complications. The second section included SSI (as Definition, Causes, Sources, Risk factors, Signs & symptoms, Types, Mode of transmission, Diagnosis, and Management of SSI). The third section included SSI Preventive measures (Pre-, Intra-, and Post-operative measures); each session had taken about 30 minutes.

B. ***The practical part*** covered the evidence-based preventive measures for SSI as Hand washing procedure (Routine, Medical, and Surgical hand washing), Pre-operative showering technique, Appropriate hair removal technique at the surgical site, Donning and Doffing personal protective equipment procedure (Face shield, Goggles, Mask, Gown, and Gloves), Incisional care procedure, Medical, and Surgical instruments Cleaning, Disinfection, and Sterilization procedures, and Waste disposal; also, Glycemic control procedures as blood glucose monitoring and insulin injection procedure as a part of SSI preventive measures of surgical patients. Each session gets even 45 minutes and usually started with a summary of what has been taught during the preceding sessions and the objectives of the new one. Giving praise and/or recognition to the interested nurses was used for motivation during protocol implementation.

- Evidence-based measures protocol was implemented through a presentation, group discussion, role play, demonstration, and re-demonstration of different previously practical aspect, various teaching aids were citified including a booklet, posters, colored handout, audiovisual materials, and real equipment such as face shield, goggles, mask, gown, gloves, overhead, overshoes, and real surgical instruments were used.

(3) The evaluation phase:

- To evaluate the effect of evidence-based measures protocol on nurses' performance regarding prevention of SSI, the studied nurses' knowledge, attitude, and practice was evaluated before and after complete implementation of protocol; a post-test was done by using the same pretest self-administered questionnaire and an observational checklist **(Tool I, II, and Tool III)**. The effectiveness of evidence-based measures protocol was based on the finding of differences or no between the pre-intervention stage (baseline evaluation) and post-intervention stage

Statistical analysis of the data:

All data were collected, tabulated, and statistically analyzed using SPSS 20.0 for windows (SPSS Inc., Chicago, IL, USA 2011). Quantitative data were expressed as the mean ± SD & (range), and qualitative data were expressed as absolute frequencies (number) & relative frequencies (percentage). Percent of categorical variables were compared using the Chi-square test or Fisher's exact test when

appropriate. The Mcnemar test was used to compare two dependent groups of categorical data. Spearman correlation coefficient was calculated to assess the relationship between various study variables, (+) sign indicate direct correlation & (-) sign indicate inverse correlation; also values near to 1 indicate a strong correlation, and values near 0 indicate a weak correlation. All tests were two-sided. P-value ≤ 0.05 was considered statistically significant (S), p-value < 0.001 was considered highly statistically significant (HS), and p-value > 0.05 was considered statistically insignificant (NS). Percent of improvement (%) = (pre-intervention score - post-intervention score) pre-intervention score multiply by 100%.

Results:

Table 1: Socio-demographic characteristics of studied nurses (n=70):

Socio-demographic characteristics	No.	%
Age per years:		
▪ ≤30 years	**48**	**68.6**
▪ > 30 years	**22**	**31.4**
Gender:		
▪ Male	**16**	**22.9**
▪ Female	**54**	**77.1**
Social State:		
▪ Married	**59**	**84.3**
▪ Unmarried	**11**	**15.7**
Residential area:		
▪ Rural area	**14**	**20.0**
▪ Urban area	**56**	**80.0**
Academic Qualification:		
▪ Diploma	**30**	**42.9**
▪ Technical institute	**36**	**51.4**
▪ Bachelors	**4**	**5.7**
Income:		
▪ Sufficient	**42**	**60.0**
▪ Insufficient	**28**	**40.0**
Job experience years in the nursing field:		
▪ ≤5	**35**	**50.0**
▪ >5	**35**	**50.0**
Job experience years at general surgery department:		
▪ ≤5	**11**	**15.7**
▪ >5	**59**	**84.3**
Attending previous training courses about SSI prevention:		
▪ Yes	**28**	**40.0**
▪ No	**42**	**60.0**
Presence of SSI prevention guidelines in the ward:		
▪ Yes	**54**	**77.1**
▪ No	**16**	**22.9**

Table 1 reveals that more than two-thirds (68.6%) of studied nurses were ≤ 30 years old, more than three-quarters of them (77.1%) were females, and 84.3% of them married, the majority of them (80%, 84.3%) lives in urban areas and had job experience > 5 years at general surgery department respectively; furthermore only 5.7% of nurses had bachelors graduate in nursing, while more than half of them (51.4%) had nursing technical institute and 42.9% had diploma degree. Moreover, about two-thirds of the studied nurses (60%) hadn't attended previous training courses about SSI prevention, and 77.1 % of them have reported the presence of guidelines for SSI prevention in their ward.

Table 2: Nurses' total knowledge about evidence-based preventive measures for SSI throughout protocol intervention phases (n= 70):

Items	Nurses' Knowledge Throughout Protocol Phases				MC p- value
	Pre Intervention		Post Intervention		
	No.	%	No.	%	
Nurses' Knowledge about SSI preventive measures :					**<0.001**
▪ Satisfactory	**7**	**10.0**	**52**	**74.3**	
▪ Un satisfactory	**63**	**90.0**	**18**	**25.7**	
Mean± SD	**14.6±3.7**		**20.2±3.9**		
Range	**5-21**		**12-25**		
Mean difference	**5.55**				
Percentage of Improvement	**38%**				

Mc=Mcnemar test **p<0.05 statistically significant**

Table 2 reveals that most (90%) of studied nurses had unsatisfactory knowledge about evidence-based preventive measures for SSI in the pre-intervention phase of the protocol, while 74.3% of them had satisfactory knowledge in the post-intervention phase of the protocol. Generally, there was a highly statistically significant difference and improvement in total nurses' knowledge post-intervention of the protocol as compared to pre-intervention of it (p<0.001), with a mean difference, equal 5.55 and percentage of improvement in nurses' knowledge was 38%.

Table 3: Nurses' total attitudes toward evidence-based preventive measures for SSI **throughout protocol intervention phases** (n= 70):

Items	Nurses' Attitude Throughout Protocol Phases				MC p- value
	Pre Intervention		Post Intervention		
	No.	%	No.	%	
Nurses' Attitudes toward SSI preventive measures :					**<0.001**
▪ Positive	**15**	**21.4**	**48**	**68.6**	
▪ Negative	**55**	**78.6**	**22**	**31.4**	
Mean± SD	**17.1 ± 8.5**		**20.6 ± 11**		
Range	**1 - 28**		**1 - 30**		
Mean difference	**3.53**				
Percentage of Improvement	**20.65%**				

Mc=Mcnemar test **p<0.05 statistically significant**

Table 3 shows that only 21.4% of studied nurses in a pre-intervention phase of the protocol had a positive attitude toward evidence-based preventive measures for SSI, and 78.6% of them had a negative attitude, while in the post-intervention phase of the protocol more than two-thirds of studied nurses (68.6%) had a positive attitude, and 31.4% of them had a negative attitude. Generally, there was a highly statistically significant difference and improvement in nurses' positive attitude post-intervention of the protocol as compared to pre-protocol (p<0.001), with a mean difference, equal to 3.53 and an improvement percentage was 20.65%.

Table 4: Nurses' total practices of evidence-based preventive measures for SSI throughout protocol intervention phases (n= 70):

Items	Nurses' Practice Throughout Protocol Phases				MC p- value
	Pre Intervention		Post Intervention		
	No.	%	No.	%	
Nurses' Practice of SSI preventive measures :					**<0.001**
▪ Competent	**31**	**43.3**	**62**	**88.6**	
▪ Incompetent	**39**	**55.7**	**8**	**11.4**	
Mean± SD	**56.7±12.2**		**66.2±10.5**		
Range	**33-72**		**37-75**		
Mean difference	**9.57**				
Percentage of Improvement	**16.89%**				

Mc=Mcnemar test **p<0.05 statistically significant**

Table 4 clarifies that more than half of the studied nurses (55.7%) had an incompetent practice of evidence-based preventive measures for SSI in the pre-intervention phase of the protocol, while the majority of them (88.6%) had competent practice post-intervention phase of the protocol. In addition to a highly statistically significant difference and improvement in nurses' practices of evidence-based SSI preventive measures post-intervention of the protocol as compared to pre-intervention of it (p<0.001), with a mean difference, equal to 9.57 and percentage of improvement in nurses' practice was 16.89%.

Table 5: Relation between nurses' total knowledge about evidence-based preventive measures for SSI and their demographic characteristics, attitude, and practice at the post-intervention phase of protocol (n=70):

Demographic characteristics	Post Nurses' Knowledge Level				χ^2	f p-value
	Satisfactory ≥80% N=52		Unsatisfactory <80% N=18			
	No.	%	No.	%		
Age per years:						
▪ ≤30 years	**31**	**64.6**	**17**	**35.4**	**7.53**	**0.006***
▪ > 30 years	**21**	**95.5**	**1**	**4.5**		
Gender:						
▪ Male	**7**	**43.7**	**9**	**56.3**	**10.12**	**0.001***
▪ Female	**45**	**83.3**	**9**	**16.7**		
Social State:						
▪ Married	**47**	**79.7**	**12**	**20.3**	**5.68**	**0.02***
▪ Unmarried	**5**	**45.5**	**6**	**54.5**		
Residential area:						
▪ Rural area	**4**	**28.6**	**10**	**71.4**	**19.15**	**0.0001***
▪ Urban area	**48**	**85.7**	**8**	**14.3**		
Academic Qualification:						
▪ Diploma	**20**	**66.7**	**10**	**33.3**	**2.53**	**0.28**
▪ Technical institute	**28**	**77.8**	**8**	**22.2**		
▪ Bachelors	**4**	**100.0**	**0**	**0.0**		
Income:						
▪ Sufficient	**33**	**78.6**	**9**	**21.4**	**1.01**	**0.32**
▪ Insufficient	**19**	**67.9**	**9**	**32.1**		
Job experience years in the nursing field:						
▪ ≤5	**20**	**57.1**	**15**	**42.9**	**10.77**	**0.001***
▪ >5	**32**	**91.4**	**3**	**8.6**		
Job experience years at general surgery department:						
▪ ≤5	**8**	**72.7**	**3**	**27.3**	**0.02**	**0.89**
▪ >5	**44**	**74.6**	**15**	**25.4**		
Attending training courses about SSI prevention:	**23**	**82.1**	**5**	**17.9**	**1.51**	**0.22**

▪ Yes ▪ No	29	69.0	13	31.0		
Presence of SSI prevention guidelines in the ward: ▪ Yes ▪ No	45 7	83.3 43.7	9 9	16.7 56.3	10.12	0.001*
Nurses' attitude: ▪ Positive ▪ Negative	45 7	93.8 31.8	3 15	6.3 68.2	30.29	0.0001*
Nurses' Practice: ▪ Satisfactory ▪ Unsatisfactory	50 2	80.6 25.0	12 6	19.4 75.0	11.49	0.001*

χ^2 = Chi-square test f= Fisher exact test (*) Significant p≤0.05 Insignificant p>0.05

Table 5 shows that there was a statistically significant relation of nurses' knowledge level at the post-intervention phase of the protocol with nurses' age (p=0.006), gender (p=0.001), social state (p=0.02), residence (p=0.0001), nurses' experience years in nursing (p =0.001), and presence of guidelines for SSI prevention in their ward (p=0.001). It is obvious that female married nurses, who aged more than 30 years and their experience more than five years in nursing, who live in the urban area and reported the presence of guidelines for SSI prevention in their ward had satisfactory knowledge level post-intervention of protocol more than other nurses. Furthermore, the current table clarifies that there was a highly statistically significant relation of nurses' satisfying knowledge with positive nurses' attitude (p=0.0001) and nurses' satisfactory practice (p =0.001)

Table 6: Relation between nurses' total attitudes toward evidence-based preventive measures for SSI and their demographic characteristics at the post-intervention phase of protocol (n=70):

Demographic characteristics	Post Nurses' Attitude Level				χ^2	f p-value
	Positive Attitude ≥80% N=48		Negative Attitude <80% N=22			
	No.	%	No.	%		
Age per years: ▪ ≤30 years ▪ > 30 years	27 21	56.3 95.5	21 1	43.7 4.5	10.7	0.001*
Gender: ▪ Male ▪ Female	3 45	18.8 83.3	13 9	81.2 16.7	23.8	0.0001*
Social State: ▪ Married ▪ Unmarried	43 5	72.9 45.5	16 6	27.1 54.5	f	0.09
Residential area: ▪ Rural area ▪ Urban area	1 47	7.1 83.9	13 9	92.9 16.1	f	0.0001*
Academic Qualification: ▪ Diploma ▪ Technical institute ▪ Bachelors	15 29 4	50.0 80.6 100.0	15 7 0	50.0 19.4 0.0	9.03	0.01*
Income: ▪ Sufficient ▪ Insufficient	34 14	81.0 50.0	8 14	19.0 50.0	7.5	0.006*
Job experience years in the nursing field: ▪ ≤5 ▪ >5	18 30	51.4 85.7	17 5	48.6 14.3	9.5	0.002*
Job experience at general surgery department: ▪ ≤5 ▪ >5	8 40	72.7 67.8	3 19	27.3 32.2	f	0.99
Attending training courses about SSI prevention: ▪ Yes ▪ No	23 25	82.1 59.5	5 17	17.9 40.5	3.9	0.046*
Presence of SSI prevention guidelines in the ward: ▪ Yes ▪ No	45 3	83.3 18.8	9 13	16.7 81.3	23.8	0.0001*

χ^2 = Chi-square test f= Fisher exact test (*) Significant p≤0.05 Insignificant p>0.05

Table 6 illustrates that there was statistically significant relation of nurses' attitude at post-intervention phase of protocol with nurses' age (p=0.001), gender (p=0.0001), residence (p=0.0001), academic qualification (p=0.01), income (p=0.006), nurses' experience years in nursing field (p =0.002), and attending training courses (p=0.046) and presence of guidelines for SSI prevention in their ward (p=0.0001). It appears that female nurses, whose age more than 30 years, residing in the urban area, whose experience more than five years, and who had bachelors graduated had a positive attitude post-intervention of protocol more than other nurses. Also, the nurses who had sufficient income, attending training courses, and who reported the presence of guidelines for SSI prevention in their ward had a positive attitude post-intervention of protocol more than other nurses.

Table 7: Relation between nurses' total practices of evidence-based preventive measures for SSI and their demographic characteristics at the post-intervention phase of protocol (n=70):

Demographic characteristics	Post Nurses' Practice Level				χ^2	f p-value
	Competent Practice ≥80% N=62		Incompetent Practice <80% N=8			
	No.	%	No.	%		
Age per years: ▪ ≤30 years ▪ > 30 years	41 21	85.4 95.5	7 1	14.6 4.5	f	0.42
Gender: ▪ Male ▪ Female	10 52	62.5 96.3	6 2	37.5 3.7	f	0.001*
Social State:	54	91.5	5	8.5	f	0.1

Demographic characteristics	Post Nurses' Practice Level				χ^2	f p-value
	Competent Practice ≥80% N=62		Incompetent Practice <80% N=8			
	No.	%	No.	%		
▪ Married	8	72.7	3	27.3		
▪ Unmarried						
Residential area:						
▪ Rural area	9	64.3	5	35.7	f	0.006*
▪ Urban area	53	94.6	3	5.4		
Academic Qualification:						
▪ Diploma	24	80.0	6	20.0	3.9	0.14
▪ Technical institute	34	94.4	2	5.6		
▪ Bachelors	4	100.0	0	.0		
Income:						
▪ Sufficient	39	92.9	3	7.1	f	0.25
▪ Insufficient	23	82.1	5	17.9		
Job experience years in the nursing field:						
▪ ≤5	29	82.9	6	17.1	f	0.26
▪ >5	33	94.3	2	5.7		
Job experience years at general surgery department:						
▪ ≤5	10	90.9	1	9.1	f	0.99
▪ >5	52	88.1	7	11.9		
Attending training courses about SSI prevention:						
▪ Yes	25	89.3	3	10.7	f	0.99
▪ No	37	88.1	5	11.9		
Presence of SSI prevention guidelines in the ward:						
▪ Yes	52	96.3	2	3.7	f	0.001*
▪ No	10	62.5	6	37.5		

χ^2 = Chi-square test f= Fisher exact test (*) Significant p≤0.05 Insignificant p>0.05

Table 7 demonstrates that there was a statistically significant relation between nurses' practices level regarding evidence-based preventive measures for SSI at the post-intervention phase of protocol and nurses' gender (p=0.001), residence (p=0.006), and presence of guidelines for SSI prevention in their ward (p=0.001). It evident that female nurses, who live in the urban area and reported the presence of guidelines for SSI prevention in their ward had a competent practice level regarding the application of SSI preventive measures at the post-intervention phase of protocol more than other nurses.

Table 8: Correlation matrix between knowledge, practice, and attitude score regarding evidence-based preventive measures of SSI throughout protocol intervention phases (n=70)

Parameters	Pre - Intervention Phase			
	Knowledge score		Practice score	
	(r)	P	(r)	P
Practice score	0.21	0.08		
Attitude score	0.02	0.86	0.39	0.001**
	Post- Intervention Phase			
Practice score	0.29	0.013*		
Attitude score	0.59	0.0001**	0.46	0.0001**

(r) Correlation coefficient * Significant p<0.05 **Highly significant p<0.01

Table 8 illustrates that there was a statistically significant positive correlation at the pre-intervention phase of nurses' practice score for evidence-based preventive measures of SSI with nurses' attitude score (p=0.001). On the same line at the post-intervention phase; there was a statistically significant positive correlation of nurses' knowledge score about evidence–based preventive measures of SSI with nurses' practice (p=0.013), and nurses' attitude score (p=0.0001). Also, there was a statistically significant positive correlation between nurses' practice scores with nurses' attitude scores (p=0.0001).

Discussion:

Surgical site infection is a serious and undesirable outcome of surgery; it is the foremost frequent complication in surgery in African nations **(Biccard et al., 2018 ; Badia et al., 2017)**. Although SSIs are among the most preventable HAIs, it has been recorded as a critical issue that's influencing the quality of health care and contains a genuine effect on patients' security **(CDC, 2016)**. Numerous studies reported that this infection can be caused by health care specialists and the larger part of them are nurses; they have a more prominent hazard for both self-acquiring and transmitting infections to others **(Sadia et al., 2017)**.

SSI prevention is complex as the risk results from several factors arising from the surgical patient journey, including sometimes after discharge, but similar to any other HAI, SSI is largely avoidable and up to one-half can generally be prevented through the successful implementation of clinical practice guidelines using a multimodal improvement strategy **(Allegranzi et al., 2018)**. SSI can be prevented or reduced by many methods that could decrease the costs and are highly effective, such as surgical scrubbing; nutritional support; preoperative bathing; mechanical bowel preparation; use of oral antibiotics; hair removal; and surgical site skin preparation. This can be achieved simply by medical awareness **(Albishi et al., 2019)**.

Taking account of the epidemiological significance of SSI and its preventive nature, the WHO has decided on priorities to develop measures based on evidence for preventing SSI **(Allegranzi et al., 2016)**. The measures contained within the WHO guidelines on core components of infection prevention and control programs **(WHO, 2016b)**, support HAI prevention especially SSI as one of the building blocks for achieving impacts on patient outcomes **(Biccard et al., 2018; GlobalSurg Collaborative, 2018)**.

Healths care providers and the forefront of them nurses play a key role in preventing SSI **(Labeau et al., 2010)**. Since nurses are spent their most time with patients and cover most of the SSI prevention measures, they are the most significant responsible bodies, that can play a central and broad role in preventing SSIs by improving the quality of care they deliver, for example; improving the improper use of prophylactic antibiotics, poor hand hygiene and skin preparation practices and proper implementation of all other surgical safety checklists **(Greene, 2015)**.

The nursing staff must be conscious of SSI, its categorizations, risk factors and more susceptible patients, signs and symptoms, prophylactic use of antibiotics, skin preparations before the operation, post-operative surgical field care, infection control measures, and surgical site infection preventive measures. Moreover, the nurses should have knowledge and skills of high-quality nursing care; and reasons, effects, management, and evidence-based recommendations of SSI prevention **(Qasem & Hweidi, 2017)**. Therefore, the current study aimed to evaluate the effect of evidence-based measures protocol on nurses' performance

regarding the prevention of SSI. A discussion of the results will cover eight main areas in the following sequence:

Firstly, the socio-demographic characteristics of studied nurses:

Regarding Sociodemographic characteristics of studied nurses, the current study found that more than two-thirds of studied nurses were ≤ 30 years old, more than three-quarters of them were females, the majority of them were married and had job experience > 5 years in the surgical department. Furthermore, more than half of nurses had nursing technical institute and 42.9% had diploma degree, while only 5.7% of them had bachelors graduate in nursing, about two-thirds of the studied nurses hadn't attended previous training courses about SSI prevention and more than three-quarters of them were reported presence of guideline for SSI prevention in their ward.

From the researchers' point of view, the dominance of females over males in the study may be attributed to, that the majority of nursing force working in Zagazig University hospitals are females, this finding may due to the nursing education in the past was specialized only to females. Also, the presence of only 5.7% of nurses who had bachelors graduate in nursing might be related to a shortage of high graduated nurses attached and working at Zagazig University Hospital, who was always busy with administrative duties.

The current result consistent with the study of **Mohsen et al., (2020)** that examined the "Compliance and Barriers Facing Nurses with Surgical Site Infection Prevention Guidelines", and noted that more than one-third of the sample was in the age group of 20 - 30 years, the two-thirds of the studied sample were females, and 81.5% of nurses did not attend surgical site infection prevention guidelines training program previously. While the current result inconsistent with his study in some findings, as more than half of nurses were having a bachelors' degree in nursing, and the highest percentage of them were having 1 - 5 years of experience in the surgical ward.

Meanwhile, **Mengesha et al., (2020)** mentioned that 60.4% of studied nurses were females, their mean age score was 31.16, and the median was 30 years, 54% were married, and participants had a minimum of 1 year and a maximum of 22 years of experience in the surgical units. While the current result inconsistent with his study in some findings, as most of the participants (84.1%) were BSc holders followed by (10%) masters and (5.9%) diploma nurses, and 54.8% claim they have taken training regarding infection control methods.

Also, the current results congruent with the study of **Getaneh et al., (2019)** that examined the "Surgical Site Infection Prevention Practices and Associated Factors among Nurses Working in Government Hospitals of Harari Regional State, Eastern Ethiopia" and revealed that almost half of the study participants were married, the mean (±SD) experience of study participants was 8.91 (±7.59) years and almost two-fifths of them were trained on infection prevention activities. While the current result inconsistent with his study in some findings, as from a total number of respondents, 53.6% were males, 80.8% of study participants were bachelor of sciences (BSc) nurses, and 58.8% of respondents reported they had no infection prevention guidelines in their working unit.

Moreover, the current results agree with **Sadia et al., (2017)** who mentioned in a study about "Assessment of Nurses' Knowledge and Practices Regarding Prevention of Surgical Site Infection" that mostly selected sample was based on 20-25 years of nurses and only 8.4% having bachelor degree and the majority of staff nurses having qualifications of diploma nursing. These results agree with **Abd Elhay et al., (2016)**, who illustrated in a study in Egypt about " Nurses' knowledge and practice regarding wound infection in Surgery Unit" that more than half of the studied nurses were in the age group from 25 to <30 years old, the highest percentage of nurses had experience from 5 to <10 years, while the current result disagreement with his study in some findings, as half of the studied nurses, were graduated from the nursing school, and the majority of them attended training courses about infection control.

Furthermore, the current results in the same line with **Abd-Al Rahman (2015)** who stated that more than half of nurses were less than 25 years old, while the current result disagreement with him in some findings, as more than half of the studied nurses, had experience from 5 to less than 10 years and more than half of them had attended training programs. Also, **Eskander et al., (2013)** revealed in a study in Egypt entitled "Intensive Care Nurses' knowledge & Practices regarding Infection Control Standard Precautions at a Selected Egyptian Cancer Hospital" that nearly two-thirds of the studied sample aged between 20 to 30 years old and demonstrated the dominance of females than males. Moreover, this finding is in concordance with **Labrague et al., (2012)**, who found in their study about "knowledge and compliance with standards precautions" that the mean age was slightly lesser and revealed the dominance of females among more than most of their studied samples.

Secondly, nurses' knowledge about evidence-based preventive measures for SSI throughout protocol intervention phases:

The present study found that the most of studied nurses had unsatisfied knowledge about evidence-based preventive measures for SSI in the pre-intervention phase of the protocol, while about three-quarters of them had satisfactory knowledge in the post-intervention phase of the protocol. Generally, there was a highly statistically significant difference and improvement in total nurses' knowledge post-intervention of the protocol as compared to pre-intervention of it, with a 38% percentage of improvement in nurses' knowledge.

From the researchers' point of view, the unsatisfactory knowledge of the studied nurses in the present study before protocol intervention may be attributed to that more than two-thirds of studied nurses were new graduates (≤ 30 years old), only 5.7% of nurses had bachelors graduate in nursing, while the most of them had either nursing technical institute or diploma degree and about two-thirds of them hadn't attended training courses about SSI prevention. Furthermore, lack of knowledge is considered the main barrier to implement the standard of care in controlling SSI, which is negatively impacting the quality of care delivered to the surgical patients and patients' safety.

The current findings in the same line with **AbuAlkishik et al., (2020)**, who reported that nurses require adequate knowledge and practical skills of SSI prevention measures since previous studies have ascertained the practical benefits of the appropriate knowledge of nurses about the prevention of SSIs. Furthermore, studies confirm the ability of training in enhancing nursing knowledge of surgical site infection prevention strategies. Based on such empirical data, it becomes apparent that the prevention measures rotate around the adherence to policies, inculcating strict hygiene, and improving nurses' knowledge.

Besides, the current results confirmed by **Mohsen et al., (2020)**, who clarified that most of the nurses have inadequate knowledge about surgical site infection, as about two-thirds of nurses (65.5%) were in a low level of knowledge with a mean knowledge score of (6.00 ± 5.97). Also, **Bamoosa et al., (2020)** stated that about 39.2% of respondents nurses had poor knowledge, 50% had fair knowledge while only 13.7% had good knowledge. Also, **Zucco et al., (2019)** revealed that there were some knowledge gaps among nursing staff. Indeed, about half of the sample had inadequate knowledge.

The current results are congruent with the study of **Alabdulrazaq et al., (2018)** that examined " The healthcare professionals knowledge and practice towards prevention of surgical wound infection in Buraidah city, Saudi Arabia", and indicated that most of the nurses in the study are having insufficient knowledge, and the proportion of doctors who were knowledgeable about the prevention of SSI is 22.10% out of 104, which also indicates that knowledge about SSI prevention is inadequate among doctors and physicians. These results were also consistent with **Sadaf et al. (2018)**, who found that the nursing staff had insufficient knowledge about surgical site infections.

Moreover, the current findings are corresponding with **Qasem & Hweidi (2017)**, who conducted a study to identify the level of knowledge of SSI prevention standard guidelines among nurses in Jordan. They showed that the overall Jordanian nurses' knowledge level regarding evidence-based guidelines for the prevention of SSIs was low, and observed a significant difference in the level of knowledge regarding prevention of SSI guidelines between nurses who were attending courses in surgical training and those who were not.

Meanwhile, the current findings agree with **Sadia et al., (2017)**, who showed that the overall knowledge of staff nurses for surgical site infection prevention was poor. Also, similar results were found in a study by **Teshager et al., (2015)** conducted in Ethiopia, which indicated that many nurses had insufficient knowledge regarding the prevention of SSI. Also, these findings were in line with those of another study by **Famakinwa et al., (2014)**; **Mater (2014)** conducted in Nigeria and revealed that the majority of nurses had inadequate knowledge of SSI prevention and recommended that the healthcare providers obtain

preventive educational programs and signify the importance of that to raise the level of knowledge.

In addition, **Eskander et al., (2013)** discovered that around two-thirds of the sample studied has insufficient knowledge of standard precautions for infection control, with a mean overall knowledge score of 102.5 ± 13.7. Furthermore, **Ezz-Eldien et al., (2012)** reported that a highly significant difference was found concerning total nurses' knowledge scores about infection prevention in post-implementation of the educational program.

On the other hand, **Kabir, (2010**) reported that nurses had a weak level of knowledge about Surgical Site Infection. This is supported by **Labeau et al., (2010)** who stated that the higher nurses' level of knowledge, the fewer occurrence of surgical site infections. Also, **Abolwafa, (2009); Ebrahem (2009**) found that before the training program, nurses had poor knowledge and practice and this was indicated by their low scores.

While the current results are in disagreement with **Abd Elhay et al., (2016)**, who noticed that majority (86.7) of nurses had a satisfactory level of knowledge related to wound infection and preoperative care. Also, disagree with **Abd-Al Rahman, (2015)**, who revealed that the majority of nurses had high scores of knowledge. Moreover, **Labrague et al., (2012)**, referred that more than half of nurses scored (excellent) while 38.09% scored very good knowledge, and this supported by **Ali, (2011)** who demonstrated that the studied nurses were better in their total percent score of knowledge than other health team members about wound infection.

Thirdly, nurses' attitude toward evidence-based preventive measures for SSI throughout protocol intervention phases:

The current study found that only one fifth of studied nurses in the pre-intervention phase of the protocol had a positive attitude toward evidence-based preventive measures for SSI, while in the post-intervention phase of the protocol more than two-thirds of studied nurses had a positive attitude. Generally, there was a highly statistically significant difference and improvement in nurses' positive attitude post-intervention of a protocol as compared to pre-protocol intervention, with a twenty percentage of improvement in nurses' attitude. From the researchers' point of view, the young age of the studied nurses in the current study may reflect the ability of studied nurses to acquire knowledge, practice, and change their behaviors based on the submission of evidence-based knowledge through education or training programs.

The current results are consistent with **Getaneh et al., (2019)** who mentioned that less than half of the studied sample had good knowledge and a good attitude toward SSI prevention practices. Also, this finding is supported by **Zucco et al., (2019)**, who concluded that while changing behavior is very complex, promoting education about SSIs, risk of SSIs and preventive methods focused on enabling compliance with effective prevention practices to reduce risk to all patients, appears to lead to changes in attitudes and to improve practices. Changes in behavior should also aim to abandon outdated practices and adopting and maintaining evidence-based practices. Moreover, **Chisanga (2017)** stated that the rate of hospital-acquired infections may be reduced by a positive attitude toward infection prevention and control.

Meanwhile, **Kolade et al., (2017)** showed that there was a relatively poor attitude of studied nurses towards SSIs prevention and this is suspected to affect practice. Furthermore, the current results are aligned with **Mohammed et al., (2016)** study, which assessed the knowledge, attitude, and practice of nurses in Port Said Hospitals concerning the monitoring of infections control in operating rooms, and found that most studied nurses, had unacceptable attitudes, and more than half of them had insufficient practice.

Additionally, the current results are in proportion with the study conducted by **Sarani et al., (2015)** evaluating the knowledge, attitude, and skills of nurses about standard precautions for hospital-acquired infections and findings show that 43% of nurses were poorly attitude, 37% had a moderate attitude and only 33% had a good attitude towards standard precautions. Furthermore, the current findings confirmed by **Brisibe et al., (2014)** who reported similar results among health care providers working in selected tertiary health institutions in Port Harcourt, Nigeria. On the issue of the actual practice of SSI prevention guidelines, results showed a worrisome percentage of respondents who demonstrated a weak attitude and indifference towards the practice of these guidelines.

Meanwhile, **Birgand et al., (2014)** assured that inadequate staff attitudes can lead to environmental pollution in the operating room and subsequent surgical site infection. As well, the current results compatible with **Ocran &Tagoe (2014)** who conducted a study to "Assess knowledge and attitude of health caregivers and patients on Hospital-Acquired Infections in the central regional hospital in Ghana" and indicated that attitudinal modification is the best means for prevention. The study showed an elevation in the number of subjects in each category scoring good and excellent in the post-education program.

On the other hand, the current results are harmonious with the study of **Galal et al., (2014)**, who assessed "The effect of health education program regarding infection control measures on nurse' knowledge and attitude in pediatric intensive care units", and stated that the role of nurses is important in preventing hazards, sequels of healthcare-associated infections and concluded that there is a scope for improvement in knowledge and attitude after the educational program was offered to the nursing staff.

Likewise, the current findings confirmed by **MacGaw et al., (2012)** who investigated health-care workers attitudes and compliance with infection control practices in the operating department of a Jamaican teaching hospital, and intending to obtain data to design evidence-based interventions, and concluded that HCWs had sub-optimal levels of attitude and compliance with standard infection control guidelines as only 17% of all participants were compliant with all seven infection control policies. While, our findings contradict the study of **Sessa et al., (2011)** that assessed "the level of knowledge, attitudes, and practices regarding disinfection procedures among nurses in Italian hospitals" and revealed an extremely positive attitude towards the utility of guidelines and protocols for disinfection procedures.

Fourthly, nurses' practice of evidence-based preventive measures for SSI throughout protocol intervention phases:

The present study found that slightly more than half of the studied nurses had an incompetent practice of evidence-based preventive measures for SSI in the pre-intervention phase of the protocol, while the majority of them had competent practice post protocol intervention. In addition to a highly statistically significant difference and improvement in nurses' practices for prevention SSI post-protocol intervention as compared to a pre-protocol, with 16.89% percentage of improvement in nurses' practice. From the researchers' point of view, the incompetent practice of the studied nurses in the pre-protocol intervention phase may be attributed to lack of studied nurses' knowledge and training, so the studied nurses' practice became more competent post-intervention of evidence-based measures protocol.

The current results are in agreement with the study of **Mengesha et al., (2020)** which evaluated "Practices of and associated factors regarding avoidance of surgical site infection among nurses working in the surgical units of public hospitals in Addis Ababa city" that, the highest percentage of the participants have inadequate practice regarding avoidance of SSI, and stated that training nurses are making SSI prevention guidelines more accessible and ensuring acquired knowledge by nurses is strong enough to be translated into desired actions. Also, **Mohsen et al., (2020)**, illustrated that the lowest percentage of studied nurses always performed the items of SSI prevention guidelines. As well, most of the nurses have poor practice about SSI, as 74.5% were in the low level of practice with a mean practice score of (14.71 ± 4.65).

Furthermore, the current results are supported by **Getaneh et al., (2019)**, who mentioned that only 40.8% of study participants reported good practices in SSI prevention activities, and the mean (±SD) practice score of nurses on SSI prevention was 6.14 (±3.38). In addition, **Sadaf et al., (2018)** concluded that the practice of the nurses regarding surgical site infection is not satisfactory. Meanwhile, this finding is in harmonization with studies of **Aloush et al., (2017), Narendranath et al., (2017) and Jahansefat et al., (2016),** which illustrated poor compliance among nurses. As well, **Rizwan et al., (2017) and Alhirish et al., (2016)** reported a significant increase in nosocomial infection in Pakistan as a result of poor compliance with infection prevention guidelines.

Meanwhile, the current results are in the same line with the study of **Sickder et al., (2017) and Teshager et al., (2015)** that conducted in Bangladesh, Nigeria, Tanzania, and Ethiopia, in which the overall proportion of nurses who always practiced SSI prevention activities was only 44.5% and the level of nurses' practice towards

prevention of SSIs was at a low level. Also, **Abd Elhay et al., (2016)** noticed that 60.0% of the studied nurses had unsatisfactory total score level of practice. These findings indicated that nurses need to improve their practices regarding standard /universal precautions by activating the role of the infection control team to monitor and correct the performance of nurses.

Likewise, **El-Saed et al., (2016) and Shaban et al., (2016)** showed that there was satisfactory compliance after implementation of a nursing care program. Also, **Mater (2014)** was concluded that surgeons' practices towards the prevention of SSI were inadequate and not in compliance with the CDC's guidelines. Moreover, the current findings supported by **Henman et al., (2012)**, who detected that changing current practices and implementing suggested guidelines at the Australian hospital was able to decrease SSI rates from 6.9% to 3.3%, also the researchers found a decrease in the incidence of SSIs, readmission rates, length of hospital stay, and promote patient outcomes.

While the current results contradict with the study of **Alabdulrazaq et al., (2018)** at Saudi Arabia, about "Knowledge and practice towards prevention of surgical site infection among healthcare professionals in Buraidah city" who found that the proportion of Charge and Staff nurses who were applying a good practice to the prevention of SSI is 100% out of 28 and 91.20% out of 68 respectively. In which this indicates a perfect practical level of preventive measures towards the prevention of SSI. Moreover, the proportion of doctors who were practicing proper preventive measures towards SSI is 90.0% out of 90, thus the level of practice towards SSI prevention is outstanding among healthcare professionals.

Furthermore, the current results conflict with **Sadia et al., (2017)** who revealed that the overall practice of nurses regarding preventing and managing SSI was at a good level. Moreover, **Sherpa et al., (2016)** illustrated higher adherence of staff nurses for the SSI prevention guidelines, involving hand washing, and using sterile gloves. Also, **Sickder et al., (2014) and Eskander et al., (2013)** showed that more than half (57.1%) of the studied sample had satisfactory performance levels regarding infection control standard precautions. These differences might be attributed to variations in sample size, attitude, training, the workload of nurses regarding prevention of SSI, and the developmental level of the countries, and the resulting shortage of resources.

Fifthly, the relation between nurses' knowledge and their socio-demographic characteristics, attitude, and practice at the post-protocol intervention phase:

The current study found that there was a statistically significant relation of nurses' knowledge level with nurses' age, gender, social state, residence, nurses' experience years in nursing, and presence of guidelines for SSI prevention in their ward. Furthermore, there was a statistically significant relation between nurses' satisfying knowledge with nurses' positive attitude and nurses' satisfactory practice. This may be attributed to that knowledge is important in shaping the right attitude, and the right attitude will result in improving SSI prevention practices, as each one associated with the other.

The current results in the same line with **Mohsen et al., (2020)**, who indicated that there was a strong statistically significant correlation among age, experience years, knowledge, compliance, and practice of nurses about surgical site infection prevention guidelines; indicating those older nurses who are more knowledgeable and practice, the more compliance with surgical site infection prevention guidelines, while there was no statistical difference among nurses who attended surgical site infection prevention guidelines training program previously and who did not. Meanwhile, these results are consistent with **Getaneh et al., (2019)**, who found that being a knowledgeable and good attitude, have management support, and experience for ≥5 years, were found to be significantly connected with SSI prevention practice. Also, **Bamoosa et al., (2019)** stated that there was an association between years of experience and level of knowledge.

Likewise, the current results congruous with **Alabdulrazaq et al., (2018)** who revealed that gender is significantly associated with knowledge of SSI prevention; females are more likely to be knowledgeable than males. Additionally, the age of the participants was measured concerning the knowledge and practice score which showed that participants aging 60-69 years old having the best knowledge and practice score among other participants age groups, and this may be explained by the experience period which has improved their practice from month to month and year to year.

Moreover, the current findings are supported by **Qasem and Hweidi (2017)** who illustrated that there were statistically significant correlations between the total knowledge score and age, total years of work experience in nursing, total years of work experience in the surgical care unit, number of credit hours spent in surgical training courses, and monthly income. Additionally, **Jahansefat et al., (2016) and Jordan et al., (2014)** revealed that previous education, and more years of experience, were important factors seeming to increase nurses' compliance. These results emphasized the importance of education and training for improving the compliance of nurses and the quality of care and supported the previous studies' reports.

Moreover, the current findings coincide with **Sickder et al., (2014)** who stated that staff nurses must have enough experience especially in the surgical ward by which they can easily identify the signs and complications of surgical site infection. Also, **Eskander et al., (2013)** illustrated that there is a positive correlation between mean knowledge scores and mean practice scores; with age and years of experience. Further, **Ezz-Eldien et al., (2012)** reported that there was a statistically significant relation of nurses' knowledge related to infection prevention with their age (< 25 years), experience (4-6 years), experience, qualification, and training ($p < 0.005$) of the intervention group compared to the control group.

Sixthly, the relation between nurses' attitudes toward evidence-based SSI preventive measures and their demographic characteristics:

The current study found that there was a statistically significant relation of nurses' attitude with nurses' age, gender, residence, academic qualification, income; nurses' experience years in the nursing field, and attending training courses, and presence of guideline for SSI prevention in their ward. It appears that female nurses, whose age more than 30 years, residing in the urban area, whose experience more than five years, and with bachelors graduated had a positive attitude post-intervention of protocol more than other nurses. Also, the nurses had sufficient income, attending training courses, and who reported the presence of guideline for SSI prevention in their ward had a positive attitude post-intervention of protocol more than other nurses.

The current result is in the same line with **Mohammed et al., (2016)** who showed that a statistically significant association between nurses' attitude regarding infection control and nurses' experience years. Furthermore, the current results are consistent with **Pameggiani et al., (2010)** who found that education is one of the factors that affect compliance with good practices; indeed, education works synergistically with other factors, attitude and practice. Meanwhile, **McCann et al., (2006)** reported that older and more qualified nurses had a more supportive attitude than younger and less experienced nurses. Also, **Burns et al., (2001)** revealed that the nurses who have a higher level of nursing education those who have the extra positive attitude regarding infection control strategies.

Seventhly, the relation between nurses' practices of evidence-based preventive measures for SSI and their demographic characteristics at the post-intervention phase of protocol:

The current study found that there was a statistically significant relation of nurses' practices level regarding evidence-based preventive measures for SSI with nurses' gender, residence, and presence of guidelines for SSI prevention in their ward. It evident that female nurses, who live in the urban area and reported the presence of guidelines for SSI prevention in their ward had a competent practice level regarding the application of SSI preventive measures at the post-intervention phase of protocol more than other nurses.

The current results are congruous with **Mengesha et al., (2020)** who demonstrated on the multivariate analysis that, using available infection prevention (IP) guidelines were significantly associated with the practice of nurses, for those who use available IP guidelines in their routine practice, the odds ratio was about 3 folds higher to have a good practice than those who did not. Meanwhile, The current results are consistent with **Alabdulrazaq et al., (2018)** who revealed that another socio-demographic factor which is gender, was measured in the functional proportion area which is found that female respondents are practicing proper preventive measures towards SSI prevention than

males, and found that no significant relationship was found between enrolment in SSI prevention program and practice score.

Eighthly, Correlation between knowledge, attitude, and practice score regarding evidence-based preventive measures of SSI throughout protocol intervention phases

The present study illustrated that a statistically significant positive correlation at the pre-intervention phase between nurses' practice score for evidence-based preventive measures of SSI and nurses' attitude. On the same line at the post-intervention phase of protocol; there was a statistically significant positive correlation between nurses' knowledge score about evidence-based preventive measures of SSI with nurses' practice, and nurses' attitude score. Also, there was a statistically significant positive correlation of nurses' practice with their attitude toward evidence-based preventive measures of SSI.

The current results are in agreement with **Mengesha et al., (2020)** who demonstrated that insufficient knowledge, inadequate resources to implement surgical safety checklists, insufficient performance monitoring systems, lack of surgical site infection assessment and preventive measure feedback systems, lack of training, and insufficient orientation programs during unit rotation were identified as factors affecting the nurse's practice regarding prevention of SSIs.

Furthermore, the current results coincide with **Getaneh et al., (2019)** who mentioned that the knowledge and attitude of nurses were significantly associated with SSI prevention practice. Meanwhile, **Sadaf et al., (2018)** demonstrated that the link between knowledge and practice is positive and association is critical. As well, knowledge could be necessary that affects performance. Also, **Sickder et al., (2017)** identified that insufficient knowledge among nurses regarding SSI prevention tended to routinely affect their degree of proper practice in their clinical settings.

Meanwhile, the current findings correspond to **Kolade et al., (2017)** who demonstrated that knowledge and the attitude toward SSI prevention are positively, moderately, and significantly related just as there is the same relationship between knowledge and SSIs' prevention practice. Again, the attitude and practice of prevention of SSIs are highly, positively, and significantly linked. Additionally, **Marwati1 et al., (2016)** mentioned that insufficient knowledge is a major factor impeding the appropriate implementation of SSI prevention. Also, the current findings are compatible with many similar studies of **Stanirowski et al., (2016); Turenne et al., (2016); Owens et al., (2015) and Teshager et al., (2015)** who highlighted how an update in knowledge regarding SSI prevention performed through educational programs could positively affect attitudes and, ultimately, tendency to perform current evidence-based practices.

Also, **Sarani et al., (2015)** added that each individual's knowledge level in various areas tends to affect his or her behavioral patterns. This result also supported by **Ezz-Eldeen (2012)** who reported that barriers such as attitude, lack of motivation and supervision, lack of knowledge interfere with healthy infection prevention practice. As well, **Behiry (2010)** found that a significant improvement of infection control practice with knowledge improvement. In the meantime, also **Collins (2008)** found that practice and attitude are influenced by knowledge.

While, the current findings are inconsistent with the study of **Sadia et al., (2017) and Sickder et al., (2014)** who revealed that a strong significant negative relation was found between knowledge and practice of nurses regarding preventing surgical site infection, but still knowledge is linked to practice but in a different direction. Furthermore, **Mohammed et al., (2016)** found a negative relation between nurses' Knowledge and nurses' attitude regarding infection control in the operating room as well as a negative correlation between nurses' practice and attitude.

Conclusion:

Evidence-based measures protocol implementation had improving nurses' knowledge about evidence-based preventive measures of surgical site infection, that in turn had shaped their positive attitude, which results in improving nurses' practice of evidence-based preventive measures of SSI, and this had ascertained by the Correlation matrix that had illustrated the presence of a statistically significant positive correlation of nurses' knowledge with their attitude and practice after the intervention of Evidence-based measures protocol, also had illustrated presence a statistically significant positive correlation of nurses' practice with their attitude toward application of evidence-based preventive measures of SSI.

Recommendation:

Based on the results of the present study, the following recommendations can be proposed :

1. Evidence-based preventive measures of SSI should be incorporated into comprehensive surgical nursing quality improvement programs to maintain patient safety.
2. Routinely updating knowledge and practice of nurses through in-service continuing education programs associated with clinical training on the latest evidence-based practices of infection prevention especially SSI.
3. Develop a system for continuous, strict follow up for nurses during work, with a periodical evaluation of their attitudes and their adherence to evidence-based preventive measures for SSI.

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