Assessment of Selected Determinants of Nurses Compliance to Infection Control Guidelines in Gastrointestinal Endoscopy Units

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Background: *Gastrointestinal endoscopy (GIE) is a widely performed procedure for the diagnosis and treatment of gastrointestinal diseases. The risk of infection for patients undergoing these procedures has been progressively reduced by the implementation of infection control guidelines and adequate training of nursing staff. Therefore the current study was conducted to assess the selected determinants of nurses' compliance to infection control guidelines in gastrointestinal endoscopy units.*

Methods: *A convenient sample of 30 nurses working at three selected endoscopy units at one of the biggestteaching hospitalsin CairoGovernoratewere recruited to fulfill the aim of this study. A descriptive, exploratory research design was utilized. Three tools were used to collect the data: (i) semi structured interview questionnaire, (ii) observational checklist for nurses' practice (endoscope reprocessing procedure), and(iii) microbiological report.*

Results:*76.7% of the subjects were females with a mean of age 39.8± 7.7 years. All of them hold secondary school nursing diploma, and 86.7% of them work as staff nurse. More than two thirds of them (73.3%) had un-satisfactory level of knowledge in accordance with the national guideline for the endoscope reprocessing. Also, more than 90%of them had unsatisfactory performance level in all the eight reprocessing steps; especially the storage stepwhere76.66% had unsatisfactory level.There was a statistically significant difference (p < 0.05) across the three endoscopy units, nurses in Unit-C had a higher mean rank in knowledge level and many steps of reprocessing procedure (i.e. pre-cleaning, leak test, rinsing, drying and storage) than nurses in other two units. Out of 44 endoscope swabs, 27.27% were positive for Pseudomonas Aeruginosa before using the endoscope suggesting present of biofilms, and Staph Aureus after endoscope reprocessing suggesting mal-reprocessing procedure.*

Conclusion: *Service education programs should be designed and implemented for nurses to improve their knowledge and performance in the field of endoscope reprocessing and infection control.There is a need also to follow up of the endoscope disinfection efficiency by doing microbiological cultures and regular surveillance.*

Key words*: Endoscope reprocessing, infection control, nurses, compliance*

I. Introduction

Endoscopy is a medical procedure that aims to looking inside the body for diagnostic and treating purposes using an endoscope that is inserted directly into the organ. An endoscope may be inserted into the human body by using a natural orifice (anus, cervix, mouth, and urethra) or through a tiny surgical incision. Gastrointestinal endoscopy (GIE) is a widely performed procedure for the diagnosis and treatment of gastrointestinal diseases [1, 2]**.**

Endoscope is a very complex biomedical device. And this complexity because of the need for fiber optic bundles and several long narrow channels that must be involved within a tubular structure that is limited by the size of the body cavity opening [3]**.**The parts that represent the greatest challenge to cleaning and disinfection are the suction channel and instruments channel. As these parts are exposed to the patients' body fluids, are the most difficult to clean and disinfect, and represent the greatest risk to patient safety [4].

There are three basic types of endoscopes: rigid, semi-rigid, and flexible based on the materials of synthesis. Rigid and semi-rigid endoscope has a stainless steel body and glass rod lenses or fiber optic lenses which allow the surgeon to visualize the structure or organ. Because of the rigid materials the previous two types are limiting the flexibility of visualization of the endoscope which only allowed by the lens degree, the flexible endoscope that has a flexible, plastic insertion tube that is easily to be bended was innovated. This flexibility allows the physician to reach and view more areas of the body [5]

Endoscopy nurses play a critical role in the provision of safe, high quality endoscopy. They provide nursing care, which includes supporting, disease prevention, health education, training, management and infection prevention [6]. Also the endoscopy nurse is the main person responsible for reprocessing and storage of the endoscopes equipment and it's accessories after using it with the patients, so she is the main responsible about the infection control (IC) in the endoscopy units. Lack of knowledge or unfamiliarity with endoscope accessories, channels and specific steps of reprocessing has been related to increase hazard of infection transmission and bio film formation (Bio film refers to a matrix of different types of bacteria and extracellular material that can tightly adhere to the interior surfaces of endoscopes) [7]. Well-educated nursewho performs disinfection, including pre-cleaning, cleaning and the actual disinfection (manual or better automated disinfection);the knowledge of endoscope storage in cabinets may prevent transmission of infections and ensure financial benefit for the institution [8]. Also the endoscopy nurse has a very critical role in determining the structure of the reprocessing room in the endoscopy units.

Complications of GIE, in general, include perforation, reaction to sedation, bleeding pancreatitis and infection [9]. Improper endoscope reprocessing through cleaning, disinfection and drying will increase the possibility of transmission of infection from one patient to another. Any slight deviation from the recommended reprocessing guideline can lead to the survival of microorganisms and an increased risk of infection [10].Thus there is an urgent need to conduct the current study to assess compliance of endoscopy nurses to the infection control guidelines as indicated by knowledge, performance, microbiological reports and reprocessing room structure.

1.1. Significance of the study

Upper gastrointestinal endoscopy is a very common diagnostic and treatment method in the medical field, each year in the United States (US) alone; approximately 34 million gastrointestinal procedures are performed using flexible endoscopes [7]. In Egypt, particularly in the selected three units where this study conducted (details in the methodology section), around15-50 upper endoscopy are performed daily [11].

The Ministry of Health and Population (MOHP), in collaboration with the United States (US) Naval Medical Research Unit, and the World Health Organization (WHO), developed a national plan to initiate an infection control (IC) program with the objectives of improving quality of care and reducing transmission of hospital-acquired infections. Implementation of the program started in late 2001 [12].It has been reported that a total of 72 hospitals in 13 governorates have been enrolled in the IC program, and 235 IC professionals were trained. However, IC application is facing many challenges including administrative, financial, and motivational difficulties [12].

For instance, a recent study in Egypt reported that out of 40 nurses working in endoscopy unit, 92.5% had total unsatisfactory level of knowledge. [6]. Where most of these nurses had inadequate practices regarding any area of endoscope reprocessing; such as wearing protective clothes (82.5%), pre manual cleaning steps (87.5%), leak test (97.5%), manual cleaning (95,0%), rinsing (60,0%), sterilization, (67.5,%), drying (97.5%) and transferring, storage and documentation (100,0%) [6]. This means that little is known about the knowledge level of Egyptian endoscopy nurses and their practices regarding endoscopy reprocessing as there is a shortage in literature in this area.. So, it was so important to conduct the currentstudy for further assessment of infection control behavior among endoscopy nurses.

Conceptual Framework

The most comprehensive model used for health care evaluation is Donabedian model; it was presented in 1966, defining three distinct aspects of quality, which include structure, process and outcome [13].**Structure** includes all the factors that affect the context in which care is delivered, including the physical facility, equipment, and human resources, and organizational characteristics. These factors control how providers and patients in a healthcare system act and are measuredof the average quality of care within a facility or system. Structure may be the upstream cause of problems identified in process [14]. **Process** is the sum of all actions that make up healthcare, which includes, for example, diagnosis, treatment, preventive care….etc. Processes can be further classified as technical processes, how care is delivered, or interpersonal processes, which all encompass the manner in which care is delivered [15]. According to Donabedian, the measurement of process is nearly equivalent to the measurement of quality of care because process contains all acts of healthcare delivery [14]. Information about process can be obtained from medical records, interviews with patients and practitioners, or direct observations of healthcare activities.**Outcome** contains all the effects of healthcare on patients or populations, including changes to health status, behavior, or knowledge as well as patient satisfaction and health-related quality of life. Outcomes are sometimes seen as the most important indicators of quality of care services because improving patient health status is the primary goal of healthcare [15].

The adapted model describes the related elements underneath each category that suits the purpose of the current study as it has beenshown in Figure 1.

1. **Structural** include demographic characteristicsof care providers (i.e. nurses). Also it included nurses, knowledge level in accordance with the national guideline for the endoscope and its accessories reprocessing.
2. **Process elements** include study subjects' performance level in accordance with the national guidelines for the endoscope and its accessories reprocessing.
3. **Outcomes**includeadverse events, (i.e. microbiological results of the endoscopes swabs in the three selected endoscopy units.
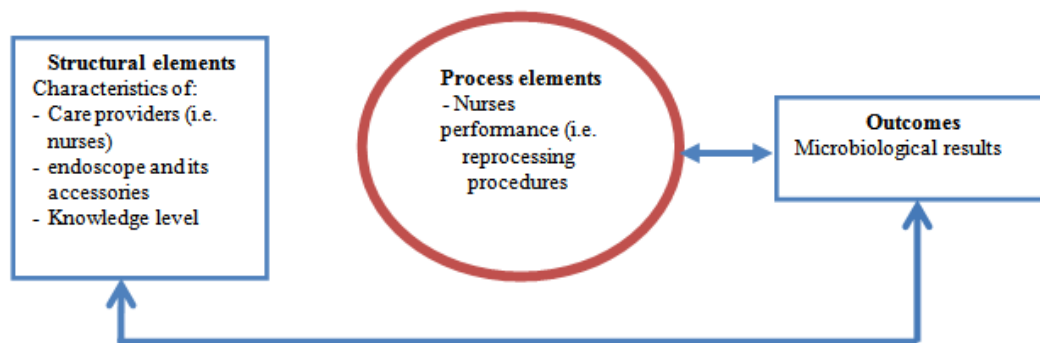

Figure 1: The adapted Donabedian model

II.   Material and Methods

The current study aimed forassessment of selected determinants of nurses' compliance to infection control guidelines in gastrointestinal endoscopy units. The following fourresearch questions were postulated:

1. Do endoscopy nurses have the knowledge in accordance with the national guideline for the endoscope and its accessories reprocessing?
2. Is the performance of the endoscopy nurses matched to the national guideline for endoscope and its accessories reprocessing?
3. What is the outcome of the reprocessing of the endoscope and its accessories as determined by microbiological swabbing?

2.1. Design

A descriptive, exploratory research design was utilized to describe, observe and document in details some process, events, and outcomes. This design was used aslittle is known about a study phenomenon. It wasuseful to help in describinga situation or an event in a population in relation to specified characteristics to generate a new knowledge [16, 17].

2.2. Setting

This study was conducted at three endoscopy units at one of the biggest teaching hospital at Cairo governorate, and for ethical consideration their names were not mentioned and they assigned a codeletter as Unit-A, Unit-B and Unit-C in order to maintain these settings' confidentiality.Structurally wise, these three units seemed similar and consist of sixareas: (1) registration area: where the secretary registers the patient's data, (2) waiting area: in which the patients wait for their turn, (3) endoscopy procedure room: where the endoscopy procedures are done and also the first step of endoscopy reprocessing (Pre-cleaning step) takes place, (4)recovery room: where the patients are waiting till the light anesthesia given during the endoscopy procedure gone, (5) reprocessing room: where the cleaning and disinfection of the endoscopes apparatus take place, and (6) storage room: where the endoscopes apparatus are stored in.

2.3. Sample:

A convenient sample of 30 nurses working at endoscopy units ofthe three selected uniteswere invited to participate in this study. To be working in reprocessing roomwas the main inclusion criteria for participation in this study.

2.4. Data collection tools:

Three tools were utilized to gather thisstudy's data as follow:

2.4.1. Semi structured interview questionnaire:

It includes three sections: (i) section-1 includes nurse's socio-demographic data, such as age, gender, level of education, position……etc., (ii) section-2 includes fourclosed ended questions about the nurses' general

information of the endoscope unit, and (iii) section-3assesses nurses' knowledge level about the endoscope reprocessing procedure, and it contains25 closed ended questions about infection control that assess nurse's basic knowledge regarding universal precautions. The original author [6] permission was obtained before using this tool (the second and third sections of this tool only).

2.4.2. An observational checklist for nurses' practice
This checklistincludes three sections: First section was developed by the researcher based upon literature review, and it includes items related to wearing protective barrier. Second section includes eight steps of endoscopy and its accessories reprocessing [6].
2.4.3. Microbiological Report:
This tool usedtorecord the identified microbial infection on the endoscopes before using it and after its reprocessing; such as Streptococcus, SerratiaMarcescens, KlebsiellaPneumoniae, Pseudomonas Aeruginosa, Meicillin-Resistant Staphylococcus Aureus (MRSA), EnterobacterCoacae, Escherichia Coli, and Candida Albicans[6].
Content Validity &Reliability The Content validity of the tools were reviewed by a panel of two experts in the field of infection control and microbiology and two experts in the field of medical-surgical nursing plus three experts in the field of administration nursing. Also its internal consistency and reliability was statistically examined.

2.5. Pilot study
A pilot study was conducted on 10% of the sample; to ensure objectivity and clarity, feasibility, and reliability of the study tools and to determine the time required to fill the different data collection tools. Necessary modifications were done. Due to shortage of the staff nurses working in the selected unites, pilot sample was included in the actual study sample as there was no major change in the tools components that can make any sampling bias.

2.6. Ethical considerations
Primary approval was obtained from the research ethics committee (REC) at the Faculty of Nursing, Cairo University. Also an official permission was obtained from hospital/unites administrators to conduct the study. Each study subjectswas informed about the purpose of the study and its importance. Each subject hadthe right to withdrawal from the study when s/he wants. Written informed consent was obtained from each subject. Anonymity and confidentiality were assured through coding the data.

2.7. Procedure for data collection:
Once official permission was granted to proceed with the study, nurses who agreed to participate were approached individually by the investigator according to their work schedule. Then the nature and purpose of the current study were explained to them. Written informed consent was obtained from eachnurse who was willing to participate in this study. Firstly, semi structured interview questionnairewas self completedby the participants. Secondly, observational checklist was checked by observing thenurses' performance during endoscope its accessories reprocessing.Thirdly, two swabs were obtained from the endoscope, one before using it with the patient to determine the presence of any biofilms on the endoscope, and one after reprocessing it at the end of the procedure to confirm that the results of the second swab reflects the actual nurse's performance.

2.8. Statistical analysis:
Obtained data was tabulated, computed and analyzed using Statistical Package for the Social Sciences(SPSS) program version 20. Descriptive statistics including frequency, percentage distribution, means and standard deviation, and relation between variables using chi-square was utilized. Probability level of 0.05 was adopted as the level of significance.

III. Results

Results of the study are presented in three sections; Section-1presents the subjects' demographic characteristics.Section-2 displays the study subjects' knowledge andperformance level in accordance with the national guideline for the endoscope and its accessories reprocessing. Section-3 shows the reported microorganisms as determined by the microbiological swabbing of the endoscopies before using and after reprocessing.

Section-1: Subjects' demographic characteristics
As shown in table (1)the study subjects consisted of 30 adult nurses; 76.7% were females and their ages ranged from 24 years to 53 years with a mean of 39.8± 7.7 years. All of them hold secondary school nursing diploma, and 86.7% of them work as staff nurse.

Table (1): Frequency and percentage distribution of demographic characteristics among the study subjects (n=30)

Variables	Category	Frequency (%)
Age	• From 24 to 38	12 (40%)
	• From 40 to 53	18 (60%)
Gender	• Male	7 (23.3%)
	• Female	23 (76.7%)
Education	• Secondary school nursing diploma	30 (100%)
	• Higher education	0 (0%)
Position	• Charge nurse	4 (13.3%)
	Staff nurse	26 (86.7%)

Section-2: Nurses' knowledge and performance

Table (2)and figure (2), show that 73.3% of subjects had unsatisfactory level of knowledge in accordance with the national guideline for the endoscope reprocessing.Figure (3) also shows the subjects' performance in terms of eight steps of endoscope reprocessing. Accordingly, the majority of ($\geq$ 90%)the subjects had unsatisfactory performance level in all the eight reprocessing steps; while 76.66% had unsatisfactory level in storage step.

Table (2) Endoscope reprocessing knowledge & performance level among the study subjects (n=30):

| ariable	Mean ±SD
Endoscopy reprocessing knowledge level (score 0-25)	13.27± 2.39
Endoscopy reprocessing performance level:	
1. Wearing personal protective equipment (PPE) (score 0-21)	6.87 ±1.30
2. Pre cleaning step (score 0-21)	7.13 ±2.42
3. Leak test step (score 0-6)	.60 ± 1.83
4. Manual cleaning (score 0-24)	8.40 ±3.58
5. Rinsing step (score 0-15)	1.30 ±2.58
6. Drying step (score 0-12)	1.33 ±.99
7. Storage step (score 0-6)	4.53 ±1.07
8. Recording step (score 0-6)	2.10 ±.71
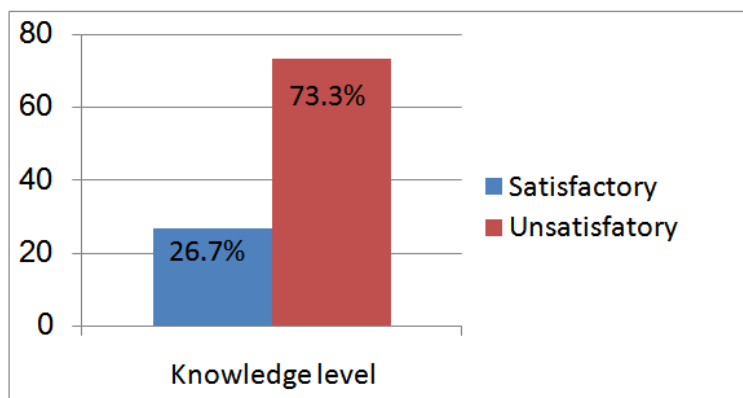
Figure2.Frequency distribution of endoscope reprocessing knowledge level among the study subjects (n=30)
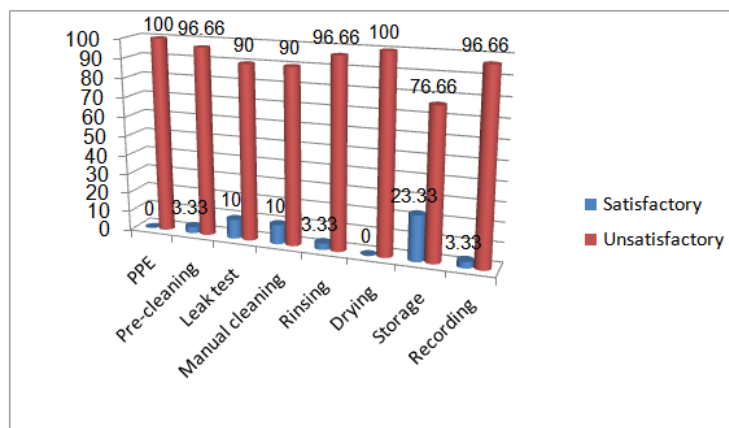

Figure3.Frequency distribution of endoscope reprocessing performance level (the eight steps of reprocessing)among the study subjects(n=30)

Section-3: Frequency of reported microorganisms

Table (3) shows that out of 44 swabs that were analyzed, 12 (27.27%) were positive for microorganisms. In Unit-A, there was biofilm formed on the endoscope as proved by positive swabsthat were obtained before using the endoscope. For instance, 40% of the analyzed swabs were positive for Pseudomonas Aeruginosa, suggesting mal previous reprocessing procedures and biofilms formation. Interestingly, 60% of the swabbed that were analyzed after reprocessingthe endoscope were positive for microorganisms, suggesting mal current reprocessing procedures and unsatisfactory level of nurses' performance. In Unit-B no biofilm formed on endoscope as reflected by the negative analyzed swabs (n = 6) that were obtained before using the endoscopes. Also there was defect in the reprocessing procedures reflected by occurrence of (16.7%) positive swab for Staph Aureus after endoscope reprocessing. Unit-C was similar to Unit-B.

Table (3) Prevalence of microorganisms as determined by the microbiological swabs in the three endoscope units

Endoscopy unit	No. of swabs	Swab results before using the endoscope	Swab results after endoscope reprocessing
Unit-A	10 swabs	40%of the swabs were positive for Pseudomonas Aeruginosa	60% of the10 swabs were positive for: • Pseudomonas Aeruginosa(5swab) • Staph Aureus(1 swab) Positives wabs were heavy growth
Unit-B	6 swabs	100% of the swabs were negative	16.7% out of 6 was positive for Staph Aureus, but only 3 colonies
Unit-C	6 swabs	100% of the swabs were negative	16.7% out of 6 was positive for Staph Aureus, but only one colony

Table (4) reveals that there was a statistically significant difference across the three settings (Unit-A, n= 10, Unit-B, n= 9 &Unit-C, n= 11) (total number = 30). Nurses in Unit-C had a higher mean rank in knowledge level and many steps of reprocessing procedure (i.e. pre-cleaning, leak test, rinsing, drying and storage). Nurses in Unit-A had a higher mean rank at steps of manual cleaning and recording, while nurses in Unit-B showed a higher rank in one of the reprocessing steps (i.e. wearing PPE).

Table (4) Comparison of the nurses 'knowledge & performance levels according to the unit(n=30):

Variable	Unit-A	Unit-B	Unit-C	Chi-square	p-value
	(Mean rank)				
Knowledge Level	9.15	15.72	21.09	5.98	**0.05***
Performance level					
1. Wearing personal protective equipment (PPE)	15.00	20.50	11.86	7.30	**0.03***
2. Pre-cleaning step	16.90	5.00	22.77	16.36	**0.00****
3. Leak test	15.50	14.00	16.73	1.81	0.40 (NS)
4. Manual cleaning step	25.35	7.44	13.14	19.09	**0.00****
5. Rinsing step	12.00	12.00	21.55	15.77	**0.00****
6. Drying step	14.00	11.44	20.18	15.77	**0.00****
7. Storage step	13.10	16.56	16.82	3.96	0.138 (NS)
8. Documentation	18.85	14.50	13.27	6.67	**0.04***

* Significant at the 0.01 level
** Significant at the 0.001 level.
 Ns: not significance.

IV. Discussion

This section presents discussion of this study's findings in the context of the adapted version of the Donabedian model.

1.   Structural elements:

This phase includes the demographic characteristics, the background about the subjects' knowledge level in accordance with the national guideline for the endoscope and its accessories reprocessing. The results of the current study revealed that about two thirds of the study subjects were females in the middle age. This is the often reported pattern representing nurses' characteristics in similar settings [18, 19].The high percentage of female nurses may be due to the increased in the number of female nurses in general as compared with male nurses in Egypt as reported by Ali and Taha, 2014 [6]. However, the study did not identify any influence of nurses' gender or age on their practice of endoscope reprocessing. This might be as a result of small sample of males in this study. All the study subjects were secondary school nursing diploma. Only four subjectswork as charge nurses and the rest were staff nurses. However there was no significant effect of education level on knowledge or performance levels.

Subjects' knowledge level in accordance with the national guideline for the endoscope and its accessories reprocessing;
The present study highlighted that almost quarter of the subjects has a total satisfactory level of knowledge about endoscope reprocessing in accordance with the national guideline for the endoscope reprocessing. In agreement with Ali and Taha [6]who revealed that endoscopy nurses level of knowledge constitute less than tenth out of the studied nurses (n= 40) had a total satisfactory knowledge about reprocessing procedure.

2. Process elements:
This phase includes study subjects' performance level in accordance with the national guideline for the endoscope and its accessories reprocessing.

The current study revealed that the performance level was unsatisfactory in all reprocessing steps. This finding was quite expected as a result of the unsatisfactory level of knowledge. The finding about the subjects' performance matched with Ali and Taha[6] who showed that most of nurses had inadequate practices regarding any area of endoscope reprocessing as wearing protective clothes (82.5%), pre manual cleaning steps (87.5,%), leak test (97.5), manual cleaning (95,0%), rinsing (60,0%), sterilization, (67.5,%), drying (97.5),% and transferring, storage and documentation (100,0%). it has been recommended that following well standardized reprocessing guideline is very critical to avoid transmission of pathogens by endoscopes[6].On the other hands, these findings contradicted with Hong, et. al.,[18], who founded that compliance rates with the reprocessing guideline represented the majority (98.9%) among the Korean study subjects.

3. Outcomes:
This phase includes microbiological results of the endoscopes swabs in the three selected endoscopy units. The current study used the microbiological surveillance as another determinant of the study subjects' compliance to endoscope reprocessing guidelines. It was proved in the current study that out of 44 swabs less than one third was positive for Pseudomonas Aeruginosa and Staph Aureus. These findings are in congruence with Public Health Agency of Canada(PHAC), 2010 [3], which stated that the most common exogenous microbial contamination of endoscopies are Mycobacterium Tuberculosis, Pseudomonas Aeruginosa, Helicobacter Pylori, Salmonella Species, Enterobacteriaceae and Staph Aureus. Also these results are similar to Ali &Taha, 2014 [6] who found that the most common microbial contamination were Streptococcus, Neisseria, H. Pylori grew, KlebsiellaPneumoniae, P. Aeruginosa, and Klebsiella.This means that the patients are in high risk for infectious disease as a result of these microorganisms.

The comparison of the nurses, knowledge & performance level according to the units.
Another important point appeared after analysis of the current study is the study subjects' behavior while dealing with clean and soil endoscope and other items in the endoscopy units. After comparison of the nurses' knowledge and performance in the three endoscopy units it was apparent that in Unit-A; the study subjects were the best in manual cleaning step of endoscope reprocessing. Despite the importance of the manual cleaning step in endoscope reprocessing, but the microbiological surveillance was the worst in that unit as more than half of the swab samples were infected with heavy growth of P.aeruginosa and Staph Aureus.

V. Conclusion
The study revealed that most of the endoscopy nurses were females and their middle ages. All of them hold secondary school nursing diploma, and majority of them work as staff nurse. According to nurses' knowledge; more than two thirdsof the subjects had un-satisfactory level of knowledge in accordance with the national guidelines for the endoscope reprocessing. The results also showed that majority of the subjects had unsatisfactory performance level in all the eight reprocessing steps; while more than three quarters had unsatisfactory level in storage step. By conclusion it was revealed that the nurses' compliance to the endoscope reprocessing guidelines did not meet the satisfactory level as evidenced by the incidence of microbial growth in the cultures done.

VI. Limitations, implications and recommendations
Study limitations
although this study has been contributed to the current knowledge in this research area, we should acknowledge that this study have some limitations: (1) the number of the study sample was small, despite they were invited from three settings, this made it difficult to generalize the study results to all Egyptian nurses working in such units. 2) The researcher used a simple flush technique rather than a flush/brush/flush technique to sample the inner surface of the endoscopy channels. This may be less sensitive in detecting all types of microorganisms present in channel lumens. But this was because of the unavailability of resources. However, no method has been established as a standard for assessing the outcome of endoscope reprocessing till now.

Therefore further research studies that aim to compare between two methods' sensitivity in determining all microorganisms present in channel lumens are required.

Implications and recommendations
Based on these study findings we recommend the following:
o Endoscopy nurses must follow the national guidelines.
o The IC team in the endoscopy unites should regularly review the endoscopy IC program and guideline to avoid any lapses in reprocessing.
o Nurses should never use the reprocessing room for any purpose other than reprocessing (i.e., eating or drinking)
o Nurses must follow the instructions of the manufacturers of the endoscope apparatus and automated endoscope preprocessors, as any deviation leads to failure of reprocessing procedures.
o Nurses must perform pre-cleaning step immediately after finishing endoscopic procedure in the procedure room.
o Nurses must transfer the endoscope in a covered container and never using hands.
o The steps of manual cleaning should be done thoroughly before using disinfectants even if automated endoscope preprocessors used.
o The workflow should be unidirectional to prevent cross contaminations of disinfectant equipment
o Rinsing step should be done before using disinfection solutions to shorten the contact period between the enzymatic detergent and the endoscope apparatus as the microorganisms may use the proteins in these detergents to feed up.
o The final rinse should done using filtered water, and in this respect the water supply for rinsing should be monitored frequently using microbiological swabbing as it may harbor microorganisms.
o The enzymatic detergent diluting should be according to the manufacturers' instructions.
o The cleaning brushes should be changed frequently, and if reused it must be cleaned in the same rigor of endoscope.
o The storage cabinets should be regularly cleaned and monitored for presence of microorganisms.
o The sink used for the step of manual cleaning must be cleaned as biofilms may be consisted inside it.
o The staff should ask for and review the competency reports of their performance.
o The patients undergoing endoscopy procedures should be carefully screened for any infectious disease to deal with cautiously with the equipment used with them.

Recommendations for further researches
Based on this study's findings, it is highly recommended to:
• Replicate this study on a larger probability sample selected from different geographical areas in Egypt is recommended to obtain more information in this area.
• Assess the impact of training program on the knowledge and performance of the endoscopy nurses.
• Assess risk factors that contribute to poor understanding of endoscopy nurses to steps of endoscope reprocessing as posted in the guidelines.
• Determine the relationship between noncompliance of the endoscopy nurse to reprocessing guidelines and other variables such as unavailability of supplies or increase the work load.
• Investigate the biofilms formation in the endoscopes storage cabinets.
• Examine the efficacy and sensitivity of adenosine triphosphate and electronic microscopes on the detection of presence of microorganisms and biofilms inside the endoscope channels.

Recommendations for hospital administrators and infection control team
• Service education programs should be designed and implemented to improve and upgrade nurses' knowledge and improve their performance in the field of endoscope reprocessing and infection control.
• Raise the endoscopy units' team awareness about the new trends and technologies in the field of endoscope, decontaminations and microbiological monitoring.
• Frequent follow up of the endoscope disinfection efficiency by doing microbiological cultures.
• Doing regular competency test for endoscopy staff to ensure that they met the standard level, to protect the endoscope apparatus and to modify the training programs in accordance.
• The endoscope reprocessing guidelines and infection control protocols must be available for all the staff in the endoscopy units in the form of posters, procures or guideline bookswhen needed.
• Modifying the endoscopy units design if possible to be unidirectional in workflow and any new unit should be established according to the standard design.
• Providing the needed supplies and equipment for effective reprocessing procedures.
• Microbiological surveillance for the automated reprocessing machines .

Acknowledgment

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