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An interventional study for reducing Ventilator Associated Pneumonia in Surgical Intensive Care Unit, Zagazig University Hospitals

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A B S T R A C T

Ventilator-associated pneumonia (VAP) is considered as a leading cause of infection related mortality and morbidity in intensive care units (ICUs) together with increasing the length of ICU stay and rising the cost of antibiotic treatment of VAP especially in developing coutries. Education of ICU healthcare providers is widely viewed as a fundamental measure in reducing VAP**.** So, this study aimed to improve health outcome of patients on mechanical ventilation through decreasing ventilator associated pneumonia in surgical intensive care unit at Zagazig University Hospitals through the following 1-To assess knowledge of health care providers in surgical intensive care units about the guidelines recommended by Association for Professionals in Infection Control & Epidemiology (APIC) to decrease ventilator associated pneumonia before and after health education intervention. 2- To calculate incidence rate of ventilator associated pneumonia in surgical intensive care unit over a period of six months before and six months after intervention. 3-To estimate length of ICU stay of ventilator associated pneumonia patients in surgical intensive care unit over a period of six months before and six months after intervention. 4-To estimate costs of antibiotic treatment of VAP in surgical intensive care unit over a period of six months before and six months after intervention a quazi experimental (pre-post test) study was conducted in surgical ICU at Zagazig University Hospital during the years 2014-2015. All health care providers in this unit (10 physicians & 29 nurses) were included in the study. All Patients on mechanical ventilation were consecutively enrolled in during the period of the pre and post intervention phases (82 &84) respectively. Two constructed questionnaires were answered to assess their knowledge about HAIs and VAP prevention measures before and after the intervention. The VAP incidence rate, length of stay (LOS) and cost of antibiotic treatment were calculated during each of pre and post intervention phases. The educational program involved physicians and nurses and included a message covering the guidelines recommended by Association for Professionals in Infection Control and Epidemiology (APIC). In the 1st phase, 31.7% of ventilated patients developed VAP while in the post intervention phase after the intervention, only 16.7% of patients were diagnosed as VAP cases with a statistically significant difference. The VAP incidence rate dropped by 25.7% from 29.5 VAP cases/1000 vent. days in phase 1 to 21.5 in phase 2. As regards to the LOS and the cost of antibiotic treatment of VAP, no statistically significant difference is found between both phases The effect of educational intervention on total knowledge improvement of physicians, knowledge about hospital acquired infection and VAP prevention measures improved significantly while knowledge of nurses improved significantly regarding HAI, VAP and VAP prevention measures. this study revealed that a relatively simple education program for implementation of guidelines recommended by APIC reduced the incidence rate of ventilator associated pneumonia in intensive care unit. 1.Continuous health education and training of ICU healthcare personnel regarding the knowledge, attitude and practice towards general infection control guidelines in the intensive care units, ventilator associated pneumonia (VAP) and the periodically updated evidence based guidelines for its prevention.2. Reevaluation of the intensive care unit policy to adopt the APIC prevention guidelines of VAP and other evidence based bundles for the prevention of different hospital acquired infections in the ICU.3. Standardize the case definition and the management protocol of VAP in all intensive care units.4. Enhancing appropriate use of antimicrobial treatment in the ICU setting to reduce antibiotic resistance and cost and to improve the patient's clinical response.5. Conduct more specific economic studies with longer follow up periods for evaluation of the economic cost and impact of VAP.6. Proper and full recording of different aspects of Zagazig hospital's costs for each department to facilitate economic or financial study analysis.

Introduction

Ventilator-associated pneumonia (VAP) is a pneumonia where the patient is on mechanical ventilation for >2 calendar days on the date of event, with day of ventilator placement being Day 1, and the ventilator was in place on the date of event or the day before (1). Locally occurring, VAP incidence rate in the surgical ICU at Zagazig university hospital at Al Sharqia governorate was estimated to be as high as 64.5 per 1000 ventilator days (2). VAP is associated with increases in death rates, length of stay and health care costs (3). Altough being one of the biggest challenges in the critical care team, the prevention of vap shows promising results, it improves the survival rate, decease both days of antibiotic use and days in the critical care unit (5). All ICU healthcare providers should be educated about and take an active role in VAP prevention (6).

Subjects and Method

Study type, setting and time: A quazi experimental (pre-post test) study was conducted in the surgical intensive care unit (SICU) at Zagazig University Hospital during the years 2014-2015.

All health care providers in that SICU were included (10 physicians and 29 nurses).

Study Population

All Patients on mechanical ventilation in the SICU were consecutively enrolled in during the period of study (6 months before intervention and 6 months after intervention). That is to say; 82 patients before intervention and 84 patients after intervention were included in the study. Inclusion criteria of patients: all the surgical ICU patients ventilated for more than two

(2) days throughout the duration of pre intervention and post intervention phases of the study were included. Exclusion criteria: 1- Non ventilated surgical ICU patients. 2- Surgical ICU patients, ventilated for less than two (2) days.

The study was carried out through 3 phases

The first and the third phases included the following: 1-An active surveillance for calculating incidence rate of ventilator associated pneumonia (VAP) as such: number of ventilator associated pneumonia cases/ number of ventilator days*1000. 2- Collecting data about VAP patients including: age, sex, underlying condition, total number of ventilator days, antimicrobial therapy prior to VAP onset, organism isolated from culture of tracheal aspirate specimen. 3- Assessment of knowledge of health care providers (physicians and nurses) about hospital acquired infections, VAP and guidelines recommended to prevent VAP. Two constructed questionnaires, English for physicians and Arabic for nurses were modified and revised by public health professors and they cover the following items:

Sociodemographic characteristics of health care providers in the studied ICU age, qualification, number of years of experience and previous attendance of infection control courses).

Knowledge about hospital acquired infection; what is the definition, risk factors, causes, sources, route of transmission and goal of infection control in the ICU.

Knowledge about ventilator associated pneumonia; such as definition and complications.

Knowledge about guidelines recommended by APICto decrease ventilator associated pneumonia.

Calculation of length of ICU stay of all VAP patients in each of the pre and post intervention phases from patient records including time of admission and discharge, referral to other department or death.

Calculation of costs of antibiotic treatment of VAP in each of the pre and post intervention phases using official records obtained from cost administration department and pharmacy records.

In the second phase, Guidelines recommended by Association for Professionals in Infection Control & Epidemiology (APIC) were disseminated in intensive care unit as: Booklets, Posters, lectures (power point) and open discussion.

An extra information was adopted in the message through adding:

World Health Organization (WHO) recommended hand washing and hand rub procedures

Detailed oral care including: oral swab and teeth brushing

Data Management was as follows

The VAP incidence rate was calculated as such: number of ventilator associated pneumonia cases/ number of ventilator days*1000.

Relative risk of no intervention was calculated as =incidence of VAP among those with no intervention\ incidence of VAP among those with intervention.

Percentage of change was used to describe the % of improvement in VAP incidence

rate after the intervention calculated as such =pre intervention-post intervention\ pre intervention*100

Unsatisfactory knowledge was considered ≤ the median (50%) of total correct knowledge score and scores > the median (50%) were considered as satisfactory knowledge.

Statistical Analysis

The collected data were analyzed by computer using a data base software program, Statistical Package of Social Services version 16and Epidemiological Information Package (EPi-Info) version 6.04. Qualitative data were represented as frequencies& percentages while quantitative data were represented by mean and standard deviation. Suitable tests of significance were used to detect relations & differences between different qualitative or quantitative variables. The results were considered statistically significant when the significant probability was less than or equal to ($p \leq 0.05$).

Administrative Design

An official permission was obtained from head manager of the New Surgery Hospital at Faculty of medicine and the head manager of surgical intensive care unit.

The approval of the Institutional Research Board (IRB) was obtained before the start of the study.

Ethical Consideration

1. The new surgery hospital at Faculty of medicine and surgical intensive care unit were informed about the nature and steps of the study.
2. The study participants (physicians and nurses) were informed about the nature and

the purpose of the study and an informed consent were taken before interview and were not exposed to any harm or risk.

3. All participants' data were confidential.

Results and Discussion

Concerning the mechanically ventilated patients in the surgical ICU, they were 82 patients before & 84 patients after intervention. Table (1) showed age, sex and underlying health problems of those patients. Following our intervention, the VAP incidence rate significantly dropped by 25.7% from29.5 to 21.5VAP cases/1000 vent. days, the relative risk(RR) of no intervention=1.37(Table 2)

Table (3) showed VAP patients age, sex and underlying health problems. No statistically significant difference is found between the underlying health problem, Antibiotic intake before VAP development or the no. of ventilator days (p value > 0.05).Also, the duration of ventilation is mostly > 30d in phase 1 and (10-20ds) in phase 2. Regarding the type of organisms isolated from sputum culture of VAP patients, Klebsiella and Acetinobacter were the most frequently isolated organisms in both phases without significant difference(Table4).

As regards to the LOS and the cost of antibiotic treatment of VAP, no statistically significant difference is found between both phases (Table5). The majority of physicians in the surgical ICU (70.0%) were of younger (20- <30 years) age group, had MBBCH and they had experience years less than 12 months. Only half of them attended infection control courses.

Assessment of the effect of the educational intervention among the physicians showed that the total knowledge about hospital

acquired infection and about VAP prevention measures improved significantly between pre and post intervention phases (P value <0.05) while as for the total knowledge about VAP, there was no statistically significant difference between both phases (P value >0.05) (Figure 1).

The majority of the ICU nurses (58.6%) were at younger age group (20- < 30) years, had diplomate degree (79.3%), had experience years less than 5 years (41.4%) and did not attend of infection control courses (58.6%).

Moreover, and regarding the effect of our educational intervention among the nurse staff of the SICU, we found statistically significant improvement of the total knowledge about hospital acquired infection, VAP and VAP prevention measures between both phases (P value < 0.05) (Figure 2).

In this study we were concerned with the incidence of VAP among the mechanically ventilated patients in both phases before and after health education intervention, the length of ICU stay of the VAP patients and the cost of antibiotic treatment of VAP, together with the effect of of our health education intervention on the total knowledge of physicians and nurses about HAI, VAP and VAP prevention measures.

Regarding the mechanically ventilated patients, we found in the 1st phase, most of them were males of significantly younger age than those in the post intervention phase (table1) that could be explained by the significant decrease in number of admissions due to polytrauma in the postintervention phase which is usually associated with younger males being more active outdoors and more accident prone.

Table.1 Frequency Distribution of some Socio Demographic and Medical Characteristics of the Studied Mechanically Ventilated Patients in both Pre and Post Intervention Phases of the Study

Demographic Character	pre intervention (n=82)		post intervention (n=84)		Test of significance	P value
	No	%	No	%		
Sex: Male Female	53 29	64.6 35.4	50 34	59.6 40.4	X^2test = 0.460	0.498
Underlying health problem: Postoperative complication Polytrauma CNS CVS	40 29 5 8	48.8 35.4 6.1 9.8	50 14 14 6	59.5 16.7 16.7 7.1	X^2test 1.929 7.551 4.573 0.366	0.165 0.005* 0.032* 0.544
Age (years) : Mean ± SD	41.9±19.		47.7±18.2		Mann Whitney	0.056*

* Statistically significant at P ≤ value

Table.2 VAP* Incidence rate among the Studied Mechanically Ventilated Patients in both Pre and Post Intervention Phases of the Study

Item	pre intervention (n=82)		post intervention (n=84)		Test of significance	P value
No. of ventilator days	882		651			
VAP development:	No	%	No.	%	X^2test = 5.132	0.023 *
Yes	26	31.7	14	16.7		
No	56	68.3	70	83.3		
VAP incidence rate (VAP cases/1000 vent. days)	29.5		21.5		Relative risk = 1.37	
					Percentage of improvement = 25.7%	

Table.3 Frequency Distribution of some Sociodemographic Characteristics of the Studied Ventilator Associated Pneumonia Patients in both Phases

| Sociodemographic characteristics	pre intervention (n=26)		post intervention (n=14)		Test of significance	P value
	No	%	No.	%		
Sex: Male Female	18 8	69.2 30.8	9 5	64.3 35.7	X^2test 0.101	0.750
Age (years): Mean±SD	34.6 ±17.8		37.7±18.1		Mann Whitney	0.723

Table.4 Frequency Distribution of some Medical Characteristics of the Studied
VAP Patients in Pre and Post Intervention Phases

Item	pre intervention (n=26)		post intervention (n=14)		Test of significance	P value
	No	%	No.	%		
Underlying health problem:						
Postoperative complications	6	23.1	4	28.6	Fischer exact	0.983
Polytrauma	14	53.8	7	50.0	X^2test =0.053	0.816
CNS	1	3.8	2	14.3	Fischer exact	0.550
CVS	5	19.2	1	7.1	Fischer exact	0.599
Antibiotic intake before VAP:						
Yes	21	80.8	14	100	Fischer exact test	
No	5	19.2	0	0.0		0.199
No. of ventilator days:					X^2test for trend	0.112
<10	3	11.5	1	7.1	=	
10-	8	30.8	9	64.3	2.58	
20-	6	23.1	3	21.4		
30+	9	34.6	1	7.1		
Isolated organisms:						
Klebsiella pneumoni	17	65.4	5	35.7	X^2test = 3.237	0.072
Acetinobacter	5	19.2	6	42.6	Fischer exact	0.552
Other	13	50.0	7	49.9	X^2test=0.015	0.901

Table.5 Length of ICU stay (LOS) and Cost of Antibiotic Treatment of (VAP) among the
Studied Ventilator Associated Pneumonia (VAP) Patients in both Phases

Item	pre intervention (n=26)	post intervention (n=14)	Test of significance	P value
Length of ICU stay (days):				
Mean ± SD	35.3±21.7	30.6±14.1		
Range	6-85	14-60	Mann Whitney	0.644
Cost of antibiotics (L.E) :				
Mean±SD	6461.6 ±3485.5	6715.8±2788.4		
			Mann Whitney	0.856

Fig.1 Effect of Health Education Intervention on the Total Satisfactory Knowledge of HAI, VAP
and VAP Prevention Measures among the Physician Staff
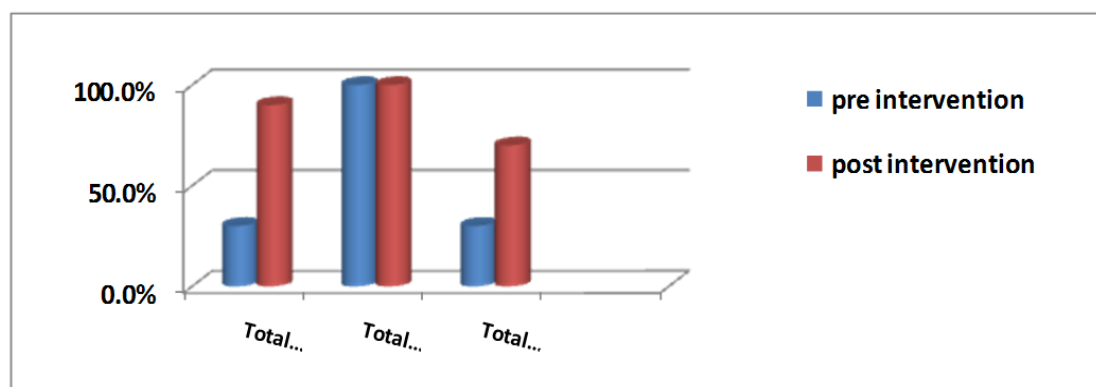
Fig.2 Effect of Health Education Intervention on the Total Satisfactory Knowledge of HAI, VAP and VAP Prevention Measures among Nurse Staff
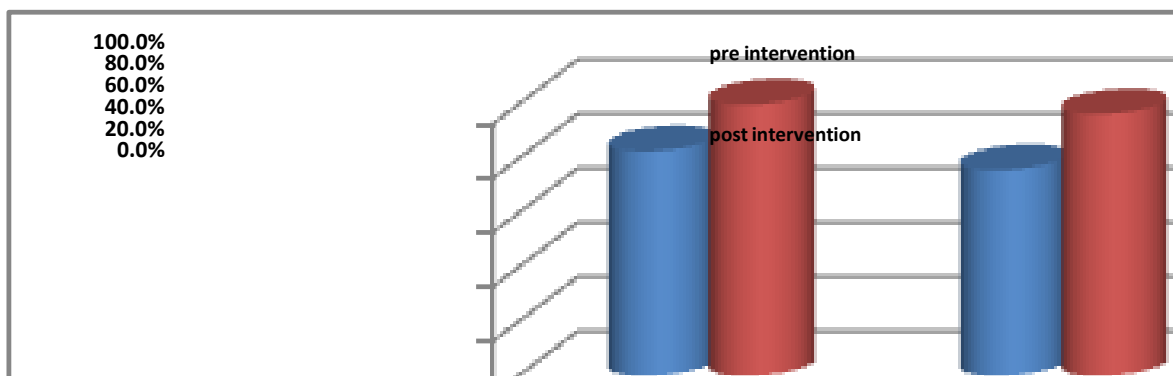
Regarding the distribution of underlying health problems, the majority in both phases were of postoperative complications and polytrauma (table 1), in contrast to Apisarnthanarak *et al*. (2007) & Hawe *et al*.(2009) who stated that the majority of admissions in their studies were due to medical causes.This could be explained by the policy of the surgical ICU of our study that gives the highest priority of admission for postoperative cases together with major trauma patients, while other ICUs in our hospitals basically accept other medical emergencies

The VAP incidence rate in the pre intervention phase was29.5 VAP cases/1000 vent.days (Table 2) which was nearly equal to that of El-Kholy *et al*. (2012)in Cairo (30.3 cases per 1000 ventilator days), less than that study results from Argentina by Rosenthal (2006) (35.5 cases per 1000 ventilator days) and higher than that of the study held in USA by Zack (2002)(12.6 cases per 1000 ventilator days) and that study carried out by Gatell *et al*. (2012)in Spain (9.9 cases per 1000 ventilator days)

Following our intervention, the VAP incidence rate improved by 25.7% (Table 2) that could be attributed to the effectiveness of our educational intervention with a

relative risk of no intervention= 1.4(Table 2). In a line with our results, Babcock, *et al*.(2004)declared that the VAP incidence rate in the 18 months following their intervention dropped but with a higher percentage of improvement (46.0%) that could reflect higher effectiveness of their intervention, higher practical compliance and adherence of care providers to the guidelines in the educational message or more strict institutional evaluation policy of providers' performance regarding VAP preventive guidelines and also might be attributed to the longer duration of post intervention phase (18 months) providing an opportunity for the intervention outputs to be more evident.

As for VAP patients, those in the 1st phase were mostly males, younger than those in the post intervention phase with no statistically significant difference (table3). Fortunately, this non significant difference between pre and post intervention phases regarding the age and sex provided some sort of matching between the samples of VAP patients before and after the intervention allowing for the study of effect of other factors on the development of VAP.

Regarding the underlying health problems of the VAP patients in our study, the majority

of them in both pre and the post intervention phases suffered from polytrauma (53.8% and 50%) followed by postoperative complications(23.1%, 28.6%) respectively with no statistically significant difference (Table 4). This was similar to El Nakera *et al*. (2012)in the same ICU in Zagazig & Baldwin and O'Neill (2015) in Germany while contradicted with Apostolopoulou *et al*. (2013)who found that the majority of patients were admitted due to medical diseases followed by surgical causes (32.9%) which could be attributed to variation in the ICU admission policies among different studies.

Most of VAP cases in both phases received antibiotic therapy prior to the development of VAP (80.8%, 100.0%) respectively with no significant difference (Table 4) which was similar to Apisarnthanarak *et al*.(2007)(13). Actually, the empirical prescription of antibiotics for the patients in our ICU was found to be mainly attributed to the physicians' attitude of lacking the trust in the effectiveness of infection control measures of the ICU together with the continuous availability of intravenous line of the patients facilitating the introduction of systemic antibiotics However, it is known that prior use of antibiotics is considered as a risk factor for HAIs (22). Moreover, a history of antibiotic use prior to the onset of ventilator-associated pneumonia (VAP) increases the probability of infection with multidrug-resistant (MDR) pathogens.(23).

Regarding the number of ventilation days of the VAP patients, the majority of them in the pre intervention phase (34.6%) were ventilated for more than 30 days and the majority of patients (64.3%) were ventilated for a duration of 10-20 days in the post intervention phase with no significant difference between them (Table 4), the same as the study in Alexandria by Elmenshawy *et al*. (2014)(24)

Concerning microorganisms isolated from sputum culture of VAP patients, *Klebsiella and Acetinobacter* formed the majority in phase 1(65.4%, 19.2%) respectively, while in 2nd phase, *Acetinobacter, Klebsiella* and *Staphylococcus* represented the most frequently isolated organisms (42.9%, 35.7% and 28.6%) respectively with no significant difference(Table 4). Similarly, Danchaivijitr *et al*. (2005)found *Acenitobacter baumannii* to be the most prevalent VAP-associated microorganisms in both phases (30.0%, 24.4%) with no statistically significant difference. Differently, Babcock, *et al*. (2004)from USA documented that Pseudomonas aeruginosa was the most commonly identified organism associated with VAP (22.3% pre intervention vs 23% post intervention) followed by *Staphylococcus aureus*. Also, the systematic review of VAP in developing countries by Arabi *et al*. (2008) (26)concluded that the most frequently isolated organisms in VAP studies were Pseudomonas aeruginosa, *Acenitobacter* followed by Candida species.

Although the mean length of ICU stay (LOS) of the VAP patients decreased from 35.3±21.7 days to 27.3±11.9 days following our intervention, yet there was no statistically significant difference between them (Table 5). This was in disagreement with Hawe *et al*. (2009)from UK who stated that the median LOS increased from 4.5 days in phase 1 to 5 days in phase 2 with no statistically significant difference (P > 0.05) and Elmenshawy *et al*. (2014)who found that the ICU stay didn't change before and after the intervention.

The base line LOS was longer than Madani *et al*., (2009)from Moracco who reported the mean LOS to be 10.6 days.

Calculated by the Egyptian pound currency,

the cost of antibiotic treatment of ventilator associated pneumonia among VAP patients slightly increased from the 1st phase (6324.4 ±3921.9) to (6715.8±2788.4) L.E in the post intervention phase without significant difference between both phases .As stated by some ICU consultants, the choice of antibiotic prescription in case of VAP diagnosis is usually affected by other associated infections which largely vary regarding the severity and sensitivity to antibiotics. Moreover, this could be explained by the increasing trend of prescription of more recent and expensive antibiotic medications to manage the increase in antibiotic resistance in different health care facilities, including the intensive care units in the present study. Actually, we have faced difficulties in obtaining the full precise data about antibiotic costs, being incomplete and lacking the formal format reflecting the need for more specialized economic studies in the ICUs. In disagreement with our findings, Apisarnthanarak *et al*.(2007) (13)calculated the monthly antibiotic cost for VAP treatment per United States (US) dollars to be 2901± 510   dollars in phase 1 which slightly decreased in the postintervention phase to 2884± 521 dollars with no statistically significant difference (Table 5). In addition, Joiner   *et al*. (1996)who prevented 18 cases of lower respiratory tract infection after intervention, declared a cost savings   of $126,000   within   one   year duration.

According to our study, Figure (1) illustrates that only (30.0%) of the physicians had adequate knowledge about hospital acquired infections in the pre intervention phase which calls for the urgent enforcement and auditing of the educational activities about basics of infection control to ensure the adequate attendance and participation of the working physician staff. Following our

intervention, it significantly improved to (90.0%) especially regarding the definition and sources of HAIs. This was in accordance with Bayomi (2012) while contradicted El Nemr *et al*. (2013) (30), both studies held in Zagazig University Hospital. Also, the total correct knowledge about VAP prevention measures increased from 30.0% before the intervention to 70.0% after the intervention with a statistically significant difference mainly regarding :the need to remove condensate from ventilatory circuits before repositioning the patient and avoiding long term enteral feeding in ventilated patient whenever possible. This improvement matched the results of Zack (2002) Apisarnthanarak *et al*.(2007) Jansson *et al*.(2013)(31) Elmenshawy *et al*. (2014) (24). No significant correlation was found between the sociodemographic & qualification characteristics of physicians and the percentage of improvement in the total knowledge of them.

Surprisngly, Although most of nurses did not attend IC courses yet, it was found that (82.8%) of them had adequate knowledge about hospital acquired infections in the pre intervention phase which significantly increased to (100.0%) (Figure2). This finding matched Galal *et al*. (2014) while was different from Eskander *et al*. (2013) who concluded that approximately two thirds (63.6%) of them had unsatisfactory knowledge.The same was found regarding total correct knowledge about VAP and that agreed with Tolentino-DelosReyes *et al*. (2007)

Nevertheless, correct knowledge about VAP prevention measures   was low (51.7%) which could possibly be explained by the unavailability of an institutional policy of continuous health education of nurse staff regarding these more specific topics concerning the   critical   care   practice.

Interestingly,it doubled to be100.0% after the intervention with especial regards to timing of hand washing, care for continuously fed patient, frequency of tooth brushing and oral swabbing. This improvement indicates most probably the effectiveness of our intervention. This increase was in line with Meharali *et al.* (2011) Gatell *et al.* (2012)(18). Differently, Ferrazzano (2014) recorded no improvement in knowledge.

There was no significant correlation between the sociodemographic characteristics and the percentage of improvement in the total knowledge of the nurse staff of the ICU which could be explained by that the age, experience duration and infection control courses of them nearly showed no evident variability in distribution.The same result was found and reported by Gomes (2010) from Johannesburg and (Lamsoh *et al.*, 2006) from Australia and different from that of Blot *et al.* (2007)

In conclusion, this study revealed that a relatively simple education program for implementation of guidelines recommended by Association for Professionals in Infection Control and Epidemiology (APIC) decreased the incidence rate of ventilator associated pneumonia (VAP) infection in the surgical intensive care unit by almost 25.7%. It showed also marked improvement in the total satisfactory knowledge of both physicians and nurses in the studied ICU. From that, we recommend the following: 1.Continuous health education and training of ICU healthcare personnel regarding the knowledge, attitude and practice towards general infection control guidelines in the intensive care units, ventilator associated pneumonia (VAP) and the periodically updated evidence based guidelines for its prevention.2. Reevaluation of the intensive care unit policy to adopt the APIC prevention guidelines of VAP and other evidence based bundles for the prevention of different hospital acquired infections in the ICU.3. Standardize the case definition and the management protocol of VAP in all intensive care units.4. Enhancing appropriate use of antimicrobial treatment in the ICU setting to reduce antibiotic resistance and cost and to improve the patient's clinical response.5. Conduct more specific economic studies with longer follow up periods for evaluation of the economic cost and impact of VAP.6. Proper and full recording of different aspects of Zagazig hospital's costs for each department to facilitate economic or financial study analysis.

Acknowledgement

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