

Assessment of Knowledge, Barrier in Implementation, and Compliance to Ventilator Bundle among Resident Doctors and Nurses Working in Intensive Care Units of a Tertiary Care Center of Western India: A Cross-sectional Survey

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ABSTRACT

Introduction: Appropriate implementation of a ventilator bundle (VB) is the key step in the prevention of ventilator-associated pneumonia (VAP). However, knowledge and compliance of critical care staff for VB are inconsistent in developing countries. This cross-sectional survey was planned to evaluate critical care practitioners' knowledge of, adherence to, and barriers toward implementation of VB in the ICUs of a tertiary care institute.

Methodology: All registered nurses and resident doctors who are direct care providers to patients of the ICU were included. Two sets of questionnaires were given to assess knowledge and to identify potential barriers in the implementation of VB. To determine compliance with the VB, direct observation was done for three nonconsecutive days, and mean compliance per component of the bundle and overall compliance to VB was determined. Data were analyzed using descriptive and analytic statistics.

Results: Of these 75 participants, 43 (57.33%) were resident doctors and 32 (42.67%) were staff nurses. The median knowledge score of resident doctors and staff nurses for VB was 7 (range 3–10) and 6 (range 2–9), respectively, with an overall score of 7 (range 2–10). Self-reported adherence to individual components of VB ranged from 75% to 95%, among these, adherence to oral care protocol, including use of chlorhexidine oral rinse, was most, and adherence to DVT prophylaxis was least. The most common potential barriers identified were fear of potential adverse effects and unawareness of guidelines.

Conclusion: Considerable gap is observed between knowledge and implementation of VB among critical care practitioners. Despite knowledge, fear of adverse events and lack of proper training are key barriers in implementation of VB.

Keywords: Intensive care unit, Knowledge level, Questionnaire, Ventilator bundle, Ventilator-associated pneumonia

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HIGHLIGHTS

- Adoption of bundled approach is crucial in prevention of VAP. Adequate knowledge and elimination of barriers are the first step to increase the adherence to VB.
- Considerable gap exists among knowledge and implementation of VB.
- Fear of adverse events and lack of proper training are key barriers in the implementation of VB.

INTRODUCTION

The ventilator-associated events (VAE) or VAP are potentially avoidable adverse event domains of healthcare-associated infections, eliminating them is stated as a winnable battle by the US Centers for Disease Control and Prevention (CDC). Centers for Disease Control and Prevention has defined VAP based on clinical, laboratory, and radiologic findings with the onset of lung parenchymal infection after 48 hours of invasive mechanical ventilation.^{1,2} Ventilator-associated pneumonia is recognized as a major issue worldwide, however, mortality rate, increased length of stay, and associated morbidities attributed to VAP are significantly higher in resource-limited countries compared with developed countries.

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Literature has shown that bundled approach as suggested by the Institute of Healthcare Improvement (IHI) has reduced the incidence of VAP by more than 30%.³ The VB consists of five key elements, including oral hygiene (chlorhexidine oral rinse), daily

sedation vacation and assessment of readiness to extubate, peptic ulcer prophylaxis, deep venous thrombosis (DVT) prophylaxis, and elevation of the head of the bed by 30–45°.⁴

For appropriate implementation of VB by healthcare practitioners, adequate knowledge and elimination of barriers are the first step to increase the adherence to evidence-based practice. Presently, however, institutional policies and procedures related to VB are inconsistent and healthcare workers, including resident doctors and staff nurses, have insufficient knowledge and practice to adopt VB in patient care of ICU-admitted patients. Studies have shown that the knowledge and skill level of healthcare staff to prevent healthcare-associated infections, including VAP, are considerably lower in low- and middle-income countries compared with developed countries. Adherence to VB practice is also suboptimal in developing countries like India.^{5,6} Therefore, we planned a cross-sectional survey with the aim to evaluate critical care practitioner's (resident doctors and staff nurses) knowledge of, adherence to, and barriers toward implementation of VB in the ICUs of a tertiary care institute. We hypothesized that knowledge and practice of healthcare workers in our ICU may differ from other settings, so this survey would help to identify the problems related to implementation of VB and to better understand the ways to improve and facilitate the use of current guidelines and protocols in our setup.

METHODOLOGY

After approval from the Institute Review Committee (reference no: SNMC/IEC/2022/1840-41), the present study was conducted as an institution-based, cross-sectional descriptive study using quantitative and qualitative methods. The ICU comprises of 30 beds where we admit adult patients with mixed medical–surgical diagnosis with a nurse-to-patient ratio of 1:1.5 and a resident-to-patient ratio of 1:4.

All registered nurses and resident doctors who are direct care providers to patients in the ICU were included in the study. The nursing staff or doctor who refuses to participate in the study was excluded from the study. The principal investigator made a group of all the participants on WhatsApp and formally invited all the participants by information circulated on WhatsApp, and a written informed consent was obtained to participate in the study.

Cross-sectional Survey on Knowledge and Barrier to Implement VB Protocol in the ICU

Two sets of questionnaires were given to all the participants. A random number was assigned to each participant who was expected to respond. The first set of questionnaires was a modified version of the ventilator-bundle questionnaire (VBQ) by Labeau et al.⁷ and was validated by three experts (Appendix 1). It comprised of 10 objective closed-ended questions to measure the level of knowledge of participants about evidence-based guidelines on VAP prevention. One correct answer was given one point, so the total scores ranged from 0 to 10.

The second set of questionnaires was a modified version of VBQ by Jansson et al.,⁸ which was again validated by three experts (Appendix 2). Self-reported adherence to the VB and the barriers encountered in the implementation of VB in the ICU were determined by the second set of questionnaires. For adherence to each item, one point was given. One to eight predefined barriers to the implementation of individual components were indicated

by participants if they were not agreeing to adherence to that component.

Compliance to VB

To determine compliance with the VB, the second investigator directly observed ICU nurses and residents for three non-consecutive days during the 6 am to 6 pm shift time. He observed the compliance to each bundle element observation period for about 3–5 minutes every day, totaling 15 different observation events for each component. To eliminate bias in determining adherence to the VB, all the participants were unaware that they were being observed as the part of the study. One point was assigned for compliance to each component of the bundle. Thereafter, mean compliance per component of the bundle and overall compliance to VB was determined.

All data were compiled and compared by a third investigator to evaluate the knowledge, adherence, and barriers to implementation of VB in mechanically ventilated patients by critical care practitioners. Simultaneously, overall compliance with each component of VB was also evaluated, and the component that is most and least compliant was determined to identify the scope for further improvement in the implementation of VB in our ICU.

Statistical Analysis

We used descriptive statistics and determined frequency distributions of demographic and clinical characteristics for quantitative variables. Median and interquartile range were used for knowledge scores. To analyze, categorize, and quantify the answers to the open-ended questions, all answers to the questions were collected in subcategories based on the respondents' descriptions using open coding. The overall knowledge score between nurses and residents was compared and *p* value <0.05 was considered statistically significant.

RESULTS

Eighty participants met the inclusion criteria, of these, three denied to participate, and two did not return the questionnaire, so the respondent rate was 97.4%. Of these 75 participants, 43 (57.33%) were resident doctors and 32 (42.67%) were ICU staff nurses. The basic demographic data, their educational qualifications, and years of experience in the critical care unit are summarized in Table 1. In total, 66 (88%) respondents stated that they have not received any training or seminars on VB components and their role in VAP prevention.

The median knowledge score of resident doctors and staff nurses for VB was 7 (range 3–10) and 6 (range 2–9), respectively, with an overall median knowledge score of 7 (range 2–10). Questionnaires to access knowledge regarding oral hygiene, patient positioning, and hand hygiene were answered correctly by more than 80% of respondents (Table 2).

Self-reported adherence to individual components of VB ranged from 75% to 95%; among these, adherence to oral care protocol, including use of chlorhexidine oral rinse, was most and adherence to DVT prophylaxis was least. The most common potential barrier identified was fear of potential adverse effects and unawareness of guidelines (Table 3). Through direct observation, overall compliance to VB was reported to be 40.74%, the component of VB, which was found most and least compliant was peptic ulcer prophylaxis and daily sedation interruption, respectively (Fig. 1).

Table 1: Demographic distribution

Indices	Total (n = 75)	Resident doctors	ICU staff nurses	Other
Total number	75	43 (57.33%)	32 (42.66%)	-
Gender				
Male	36 (48%)	22 (51.6 %)	14 (43.75%)	<i>p</i> = 0.525081
Female	39 (52%)	21 (48.83%)	18 (56.25%)	
Age (years)				
Mean ± SD	28.69 ± 3.82	27.81 ± 2.52	29.87 ± 4.86	<i>p</i> = 0.19667
Median	28	27	28	-
Service/ICU experience				
<1 year	28 (37.33%)	17 (39.53%)	11 (34.37%)	<i>p</i> = 0.64772
>1 year	47 (62.66%)	26 (60.46%)	21 (65.62%)	
Education				
MBBS/MD	43 (57.33)			-
B.Sc. nursing	13 (17.33%)			-
GNM	19 (25.33%)			-
Received Training/Seminars on EBGs on VAP prevention				
Yes	9 (12%)	1 (2.3%)	8 (25%)	-
No	66 (88%)	42 (97.62%)	24 (75%)	

Table 2: Knowledge of evidence-based guidelines (EBGs) on VAP prevention

Q. no.	Questions	Correct response			<i>p</i> -value
		Overall (n = 75)	Resident doctors (n = 43)	Staff nurses (n = 32)	
1	Oral vs nasal route for endotracheal intubation	56%	62.79%	46.87%	0.169641
2	Which of the following is not a standard component of the VAP bundle (VB)?	54.66%	58.14%	50%	0.483716
3	Which of the following does not increase the incidence of VAP?	44%	58.14%	25%	0.004242
4	To reduce the risk of VAP, the head end of the bed should be elevated to	57.33%	55.81%	59.37%	0.757781
5	How often should you attempt awakening and spontaneous breathing trials?	46.66%	39.53%	56.25%	0.151256
6	How often should you perform hand hygiene?	89.33%	88.37%	90.62%	0.754578
7	Endotracheal tubes with an extra lumen for drainage of subglottic secretions	73.33%	74.41%	59.37%	0.167174
8	Kinetic vs standard beds	72%	83.72%	50%	0.001734
9	Patient positioning	81.33%	86.04%	75%	0.224622
10	Use of 0.12% chlorhexidine gluconate antiseptic oral rinse	80%	90.69%	65.62%	0.007256
Median knowledge score (range)		7 (2–10)	7 (3–10)	6 (2–9)	0.078726

DISCUSSION

Our study findings highlight the gap between knowledge and implementation of VB among critical care practitioners, including resident doctors and ICU nurses. Importantly, despite having knowledge and self-reported adherence to individual components of VB, overall compliance to VB was only 40.74% on direct observation. Common barriers to implementation were identified such as fear of adverse events and lack of proper training. Also, the importance of a checklist is observed as peptic ulcer prophylaxis is noted in the daily treatment chart, so this component of VB was found to be the most compliant.

Despite established evidence in favor of a bundled approach to decrease the incidence of VAP, a knowledge gap exists among

healthcare workers of ICUs and there is much need of improvement in clinical practice and continued education of all the staff. Prevention guidelines to address the issue of VAP have highlighted the importance of VB, however, VAP remains the common and severe nosocomial infection among intubated patients.^{9,10}

Our study demonstrates that the knowledge score of staff nurses and resident doctors is low, and both the groups are working at ground level round the clock. Knowledge assessment regarding the spontaneous breathing trial (SBT), daily awakening, and awareness on factors to decrease the incidence of VAP, was answered least correctly by respondents. The knowledge score on VAP among healthcare workers has been studied in various previous studies. A foundation study by Labeau et al. in 2007

Table 3: Self-reported adherence and barriers to the institutional VAP bundle

Q. no.	Question	Adherence (%)	Most common barrier (%)
1	I always comply with the institutional VAP bundle	68%	Lack of guidelines (10.67%)
2	I adhere to the existing oral care protocol	86.66%	Lack of guidelines (5.33%)
3	I always use chlorhexidine oral rinse as recommended	94.66%	Other reason (2.67%)
4	I assess the depth of sedation as often as recommended	81.33%	Lack of guidelines (5.33%)
5	I interrupt continuous sedative infusions as recommended	82.66%	Disagreement with reported trial results (5.33%) and patient discomfort (5.33%)
6	I perform a spontaneous breathing test as recommended	84%	Lack of education (4%)
7	I always keep the head of the bed elevated to 30–45°	80%	Patient discomfort (5.33%)
8	I always make sure that mechanical DVT prophylaxis are inserted as recommended	80%	Fear of potential adverse effects (6.67%)
9	I always give pharmacological DVT prophylaxis, as recommended	74.66%	Fear of potential adverse effects (12%)
10	I always give pharmacological peptic ulcer prophylaxis, as recommended	88%	Fear of potential adverse effects (4%)

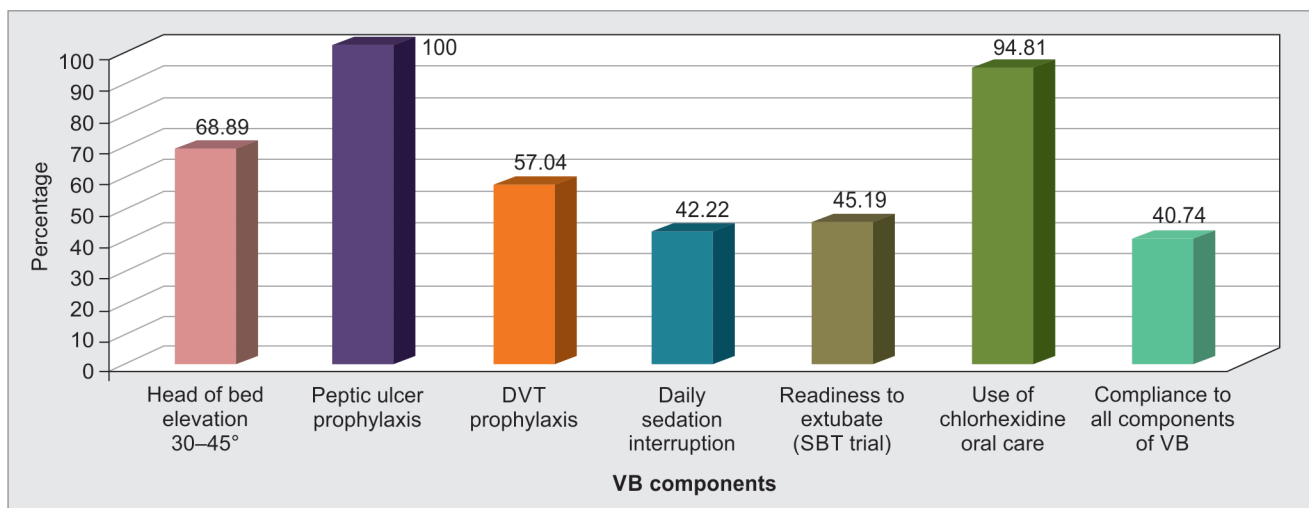


Fig. 1: Actual observed compliance of individual ventilator bundle compliance

evaluated the overall knowledge score of nurses working in the critical care units by assessing their responses from a validated questionnaire on nursing-related interventions taken from the evidence-based guidelines to decrease the incidence of VAP.⁷ The average knowledge score reported was 45%. This questionnaire has been modified and has been evaluated in different countries and different subgroups to assess knowledge, but a consistently low score has been obtained. A recent study by Abad et al. also showed a knowledge gap and poor adherence to components of VB among ICU nurses and intensive care practitioners. The mean knowledge score regarding evidence-based guidelines on VAP was 5 (range 3–8) out of 10 points among 60 participants.⁵ Another study also reported a low mean knowledge score (3.86 ± 1.56) related to VAP prevention guidelines among ICU nurses.⁸ So despite years of established evidence to support implementation of VB, knowledge gap and poor adherence exist.

In our study, knowledge question regarding the importance of SBT and daily awakening was incorrectly answered by 39.5% of residents, showing that resident doctors are less familiar regarding ICU sedation protocol and its importance. Similarly, ICU staff nurses were also not aware of the factors responsible for the increased incidence of VAP. Regarding self-adherence to individual

components of VB, DVT prophylaxis, head-end elevation, and sedation vacation were found difficult to adhere respondents. The reluctance and potential barriers to perform these components of VB were fear of potential adverse effects with DVT prophylaxis and precipitating patient discomfort with head-end elevation or sedation vacation. In one study it was speculated that consistent teaching and formal training for all ICU healthcare workers are required to eliminate these fears and myths.¹¹

Adherence to oral care protocol and peptic ulcer prophylaxis was reported almost 100% by respondents as well as during observed actual compliance to an individual component of VB. The importance of a checklist or daily treatment chart is observed as these two instructions have been written in the treatment chart daily, so were followed without being missed. The importance of a checklist has been emphasized after the initiation of the WHO surgical safety checklist to improve the surgical safety of patients without additional source utilization.¹² Similarly, incorporation of a checklist for accomplishing all components of VB in the daily treatment chart might ensure standardization and increased compliance for VB among team members.

The impact of training and educational activities on VAP prevention strategies has been shown to improve the compliance of

healthcare workers to VB and thereby reduction in the incidence of VAP.^{13–15} A continuous educational program, including of teaching, video presentation, seminars and group discussion, repeat training of new employees, and continuous educational activities of healthcare workers in a 20-bed ICU for a 2-year period, has shown to improve the median composite score from a baseline of 2–5 points over time and VAP incidence also decreased by 51%.¹⁶ Another study also has shown that education and training of staff nurses for VB for a certain period do not lead to reduction in the incidence of VAP; however, intensive and continued training, bedside skill demonstration, and feedback are essential.¹⁷ The use of close-suction system or subglottic drainage tube, whose effect in prevention of VAP is yet to be determined,¹⁸ was not included in our study.

Our study highlights that despite more than a decade of established evidence of the effectiveness of VB in prevention of VAP, knowledge, and compliance of healthcare workers toward VB are below satisfactory. Formidable efforts for continuous training, education, and simultaneous monitoring of the intervention are the need of the hour to improve the rate of VB implementation, which is currently lacking in many ICUs of developing countries. Also, in the ICU, the faculty/incharge should evaluate the knowledge score and compliance of their staff to VB and VAP prevention strategies by evaluating them using this simple evidence-based clinical questionnaire. A baseline knowledge level will help in identifying the potential barriers in adherence to clinical practice so that appropriate educational interventions can be planned and their impact can be evaluated. Simultaneous incorporation of VB checklist in the daily treatment chart can improve compliance and will ensure that the task assigned will be completed.

The limitations of our study include a single-centric study, including a small number of participants. This study included a questionnaire based on the VB interventions, which are more amenable to answer, and other prevention strategies, such as the role of noninvasive ventilation, use of humidifiers, change of ventilator circuit, and nebulization practices, were not included in this study.

To conclude, this survey is an initial attempt to see the knowledge, attitude, and compliance of healthcare workers toward implementation of VB in ICU-admitted patients. There exists a considerable gap between knowledge and implementation of VB among critical care practitioners, including resident doctors and ICU nurses. Despite knowledge, fear of adverse events and lack of proper training are the key barriers in implementation of VB. So there is a huge need for quality improvement to implement VB in the ICU, and regular training, supervision, and incorporation of a checklist in daily treatment chart should be done for prevention of VAP.

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APPENDIX 1**Knowledge of Evidence-based Guidelines (EBGs) on VAP Prevention**

Number: _____

Job description: Resident doctor _____ ICU staff _____

Age/Sex: _____

Years in service: _____

ICU experience: _____

Education: _____

Have you ever had training or seminars regarding EBGs on VAP prevention? Y _____ N _____

Instructions: Encircle the letter corresponding to your answer.

1. Oral vs nasal route for endotracheal intubation:
 - a. Oral intubation is preferred over nasal route for VAP prevention
 - b. Nasal intubation is preferred over oral route for VAP prevention
 - c. No difference in VAP incidence between both routes
 - d. I do not know
2. Which of the following is not a standard component of VAP bundle (VB)?
 - a. Head-end elevation
 - b. Peptic ulcer prophylaxis
 - c. DVT prophylaxis
 - d. Nebulization with antibiotic
 - e. Daily sedation vacation and assessment of readiness to extubate
3. Which of the following does not increase the incidence of VAP?
 - a. Intermittent sedation
 - b. Aspiration of oropharyngeal and gastric secretion
 - c. Reduced clinical staffing
 - d. Prolonged mechanical ventilation
4. To reduce the risk of VAP, the head end of the bed should be elevated to:
 - a. 5–10°
 - b. 10–20°
 - c. 20–30°
 - d. 30–45°
5. How often should you attempt awakening and spontaneous breathing trials?
 - a. 12 hourly
 - b. 6 hourly
 - c. Daily
 - d. Never
6. How often should you perform hand hygiene?
 - a. Before and after contact with the ventilator or ventilator circuit
 - b. Before entering the ICU
 - c. Before and after touching the patient
 - d. All of the above
7. Endotracheal tubes with extra lumen for drainage of subglottic secretions
 - a. These endotracheal tubes reduce the risk of VAP
 - b. These endotracheal tubes increase the risk of VAP
 - c. These endotracheal tubes do not influence the risk of VAP
 - d. I do not know
8. Kinetic vs standard beds
 - a. Kinetic beds increase the risk of VAP
 - b. Kinetic beds reduce the risk of VAP
 - c. The use of kinetic beds does not influence the risk of VAP
 - d. I do not know
9. Patient positioning
 - a. Supine positioning is preferred for VAP prevention
 - b. Semi-recumbent positioning is preferred for VAP prevention
 - c. The position of the patient does not influence the risk of VAP
 - d. I do not know
10. Use of 0.12% chlorhexidine gluconate antiseptic oral rinse
 - a. 0.12% chlorhexidine gluconate antiseptic oral rinse reduces the risk of VAP
 - b. 0.12% chlorhexidine gluconate antiseptic oral rinse increases the risk of VAP
 - c. 0.12% chlorhexidine gluconate antiseptic oral rinse does not influence the risk of VAP
 - d. I do not know

APPENDIX 2**Self-reported Adherence and Barriers to the Institutional VAP Bundle**

Number: _____

Instructions: Place a check on the corresponding answer

1. I always comply with the Institutional VAP bundle.
Yes _____ No _____

If no, why not? (encircle all that applies)

- a. Disagreement with reported trial results
- b. Inadequate resources
- c. Fear of potential adverse effects
- d. Costs
- e. Patient discomfort
- f. Lack of education
- g. Lack of guidelines
- h. Other reason, what? _____

2. I adhere to existing oral care protocol.
Yes _____ No _____

If no, why not? (encircle all that applies)

- a. Disagreement with reported trial results
- b. Inadequate resources
- c. Fear of potential adverse effects
- d. Costs
- e. Patient discomfort
- f. Lack of education
- g. Lack of guidelines
- h. Other reason, what? _____

3. I always use chlorhexidine oral rinse as recommended.
Yes _____ No _____

If no, why not? (encircle all that applies)

- a. Disagreement with reported trial results
- b. Inadequate resources
- c. Fear of potential adverse effects
- d. Costs
- e. Patient discomfort
- f. Lack of education
- g. Lack of guidelines
- h. Other reason, what? _____

4. I assess the depth of sedation as often as recommended.
Yes _____ No _____

If no, why not? (encircle all that applies)

- a. Disagreement with reported trial results
- b. Inadequate resources
- c. Fear of potential adverse effects
- d. Costs
- e. Patient discomfort
- f. Lack of education
- g. Lack of guidelines
- h. Other reason, what? _____

5. I interrupt continuous sedative infusions as recommended.
Yes _____ No _____

If no, why not? (encircle all that applies)

- a. Disagreement with reported trial results
- b. Inadequate resources
- c. Fear of potential adverse effects
- d. Costs
- e. Patient discomfort

- f. Lack of education
- g. Lack of guidelines
- h. Other reason, what? _____

6. I perform spontaneous breathing test as recommended.
Yes _____ No _____

If no, why not? (encircle all that applies)

- a. Disagreement with reported trial results
- b. Inadequate resources
- c. Fear of potential adverse effects
- d. Costs
- e. Patient discomfort
- f. Lack of education
- g. Lack of guidelines
- h. Other reason, what? _____

7. I always keep head of bed elevated to 30–45°.
Yes _____ No _____

If no, why not? (encircle all that applies)

- a. Disagreement with reported trial results
- b. Inadequate resources
- c. Fear of potential adverse effects
- d. Costs
- e. Patient discomfort
- f. Lack of education
- g. Lack of guidelines
- h. Other reason, what? _____

8. I always make sure that mechanical DVT prophylaxis is inserted as recommended. Yes _____ No _____

If no, why not? (encircle all that applies)

- a. Disagreement with reported trial results
- b. Inadequate resources
- c. Fear of potential adverse effects
- d. Costs
- e. Patient discomfort
- f. Lack of education
- g. Lack of guidelines
- h. Other reason, what? _____

9. I always give pharmacological DVT prophylaxis as recommended.
Yes _____ No _____

If no, why not? (encircle all that applies)

- a. Disagreement with reported trial results
- b. Inadequate resources
- c. Fear of potential adverse effects
- d. Costs
- e. Patient discomfort
- f. Lack of education
- g. Lack of guidelines
- h. Other reason, what? _____

10. I always give pharmacological peptic ulcer prophylaxis as recommended. Yes _____ No _____

If no, why not? (encircle all that applies)

- a. Disagreement with reported trial results
- b. Inadequate resources
- c. Fear of potential adverse effects
- d. Costs
- e. Patient discomfort
- f. Lack of education
- g. Lack of guidelines
- h. Other reason, what? _____