

1 SECOND REVIEW- NON MARKED VERSION

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3 **Title:** Prevention of ventilator-associated pneumonia: can knowledge and clinical
4 practice be simply assessed in a large institution?

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6 **Running head:** Survey on VAP prevention

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37

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39 **ABSTRACT**

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41 **PURPOSE:** User-friendly scores to assess knowledge of guidelines for prevention of
42 ventilator-associated pneumonia (VAP) are scarce and have mainly evaluated nurses,
43 but not students or physicians. Gaps between knowledge and actual clinical practice
44 have not been sufficiently analyzed. We assessed knowledge of and compliance with
45 guidelines for prevention of VAP among physicians, nurses, and students in adult
46 intensive care units (ICUs).

47 **METHODS:** All adult ICU health care workers (HCW) were invited to complete a 20-
48 point questionnaire. The first part assessed personal knowledge of international
49 guidelines for prevention of VAP; the second part assessed daily clinical practice.
50 Personal knowledge and daily practice were scored from 0 to 10 points.

51 **RESULTS:** We invited 257 ICU-HCWs to participate in the study, and 167 (65%)
52 accepted (32/54 physicians, 108/176 nurses, and 27/27 students). The median (IQR)
53 personal knowledge scores for physicians, nurses, and students were 6 (5-7), 5 (4-6),
54 and 5 (4-7). The median scores for daily clinical practice for physicians and nurses
55 were 5 (4-6) and 4 (3-5), respectively. HCWs with more than 1 year of ICU experience
56 scored significantly better in personal knowledge than those with less experience: 6 (5-
57 7) vs 4 (3-6); $p=0.004$.

58 **CONCLUSIONS:** A simple, easy-to-complete questionnaire enabled us to rapidly
59 evaluate personal knowledge and reported clinical practice in prevention of VAP in
60 large teaching institutions. These scores will be used as baseline figures to assess the
61 impact of educational and intervention campaigns.

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INTRODUCTION

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Ventilator-associated pneumonia (VAP) is the most frequent infection in patients admitted to intensive care units (ICUs) (1-6) and is associated with an increase in days of ICU stay, morbidity and mortality (2-4, 7, 8). Prevention of VAP is much more cost-effective than treatment, and several guidelines have recommended measures to decrease the incidence of VAP (9-15). The most important measures are continuous medical education (16-18), continuous aspiration of subglottic secretions (19), semi-recumbent position (11, 20-25), oral hygiene with chlorhexidine (26), and selective digestive decontamination (6, 27-31).

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Knowledge of guidelines for prevention of VAP among health care workers (HCW) has been infrequently assessed and mainly in staff nurses only. The gaps between individual knowledge of VAP prevention and actual daily clinical practice have not been compared (26, 32-36).

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Our objective was to assess and compare the knowledge of physicians, staff nurses, and medical and nursing students in adult ICUs and their compliance with guidelines in daily practice.

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MATERIAL AND METHODS

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Hospital and patients

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Our institution is a general referral hospital with approximately 1550 beds and between 50,000 and 60,000 admissions/year. We have 3 adult ICUs (medical, surgical, and heart surgery) with a total of 58 beds.

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Participating health care workers

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All staff physicians, nurses, and students in the 3 ICUs were invited to participate in the study by completing an anonymous questionnaire. As respiratory therapists in our institution only attend non-ventilated patients or chronically ventilated patients (tracheostomy), they were not included in the study.

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The Ethics Committee approved the study. We asked 10 questions related to personal knowledge of VAP prevention. Each question included 5 potential multiple-choice answers. A correct answer scored 1 point; therefore, the maximum score was 10 points and the minimum score 0 points (Table 2). An incorrect answer did not affect the score negatively. Participants were given 15 minutes to complete the questionnaire, which was then collected by one of the authors. This survey was conducted in December 2010.

102 The knowledge questionnaire was elaborated and discussed by all the authors
103 and internally evaluated by a panel of experts on VAP in our institution, following
104 international recommendations (ISO 9001:2008). The correct answers were based on
105 internationally accepted guidelines and carefully discussed by the hospital panel of
106 experts (9-11, 15). Questions were answered according to different guidelines,
107 although the arguments were generally sustained by most of them. When there were
108 discrepancies between the guidelines, such as in the level of recommendation of
109 selective digestive decontamination, the most common option was considered the
110 correct answer.

111 We followed the same approach in the actual practice questionnaire, although
112 excluding medical and nursing students, who had no basic responsibility. Table 3
113 summarizes the questions and the interpretation of answers. This questionnaire was
114 elaborated and validated in the same way as the knowledge questionnaire.

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116 ***Statistical analysis***

117 The qualitative variables appear with their frequency distribution. The
118 quantitative variables are summarized as the median and interquartile range. Non-
119 normally distributed continuous variables were compared using the Mann-Whitney test.
120 The χ^2 or Fisher exact test was used to compare categorical variables. All statistical
121 tests were 2-tailed. The level of significance was set at $p < 0.05$ for all the tests. The
122 statistical analysis was performed with SPSS 14.0 (SPSS Inc., Chicago, Illinois, USA)
123 and Stata 9.0 software.

124 We used the Pearson correlation test to assess the correlation between
125 knowledge and practice scores in the nurses and physicians subgroups. Inter-subject
126 agreement was assessed by the intra-class correlation coefficient (SPSS Reliability
127 test, Averaged-measures intra-class correlation coefficient).

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129 **RESULTS**

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131 The questionnaire was completed by 167 of the 257 ICU HCWs invited to
132 participate (65.0%). Of these, 32 were physicians (59.3%), 108 nurses (61.4%), and 27
133 students (100%) (Table 1). As for the physicians' specialty, 10 were intensivists and 22
134 anesthesiologists. Agreement to participate was significantly different between students
135 and nurses/physicians ($p < 0.001$).

136 Table 2 summarizes the questions assessing knowledge, the criteria used for
137 evaluation of adequacy, and the proportion of adequate answers per question and
138 HCW group.

139 Only the need to have written guidelines and the use of a semi-recumbent
140 position was adequately recognized by more than 90% of the HCWs. On the other
141 hand, the need for post-operative physiotherapy and the necessary frequency of
142 ventilator circuit changes were adequately known by less than 10% of HCWs. We were
143 unable to find significant differences between the knowledge of physicians and nurses
144 in 7 of the 10 questions. Knowledge of the need for hand hygiene and gloves before
145 manipulation and tracheal suctioning was significantly better in nurses ($p<0.01$);
146 knowledge of the change of ventilator circuits was better among physicians ($p<0.01$).
147 Physicians seem to have a better knowledge than nurses of the concept of selective
148 digestive decontamination and the controversy surrounding its efficacy and potential
149 drawbacks ($p<0.001$).

150 We also studied if there was a common knowledge shared by all the personnel
151 in each intensive care unit. The intraclass correlation coefficient showed a significant
152 agreement in two of the ICUS (surgical ICU $ro=0.52$, $p=0.005$ and MHS ICU $ro=0.55$,
153 $p=0.004$), but the agreement was lower in the medical ICU ($ro=0.37$, $p=0.072$). Inter-
154 subject agreement was high.

155 Answers related to actual daily practice in HCWs caring for patients under
156 mechanical ventilation are summarized in Table 3. As mentioned above, we excluded
157 students from the practice score, since they were not directly involved in practice. The
158 only practices properly performed more than 80% of the time were the semi-recumbent
159 position and assessment of endotracheal balloon pressure.

160 We used the medians of points obtained in the knowledge questionnaire to
161 create a knowledge score scale (Table 4). The median knowledge score was 5 points
162 (IQR, 4-6) and the median practice score was 4 points (IQR, 3-5). Physicians global
163 knowledge and practice scores were significantly higher (Table 4).

164 Table 4 also compares the combined scores of physicians and nurses
165 according to their years of ICU experience. Those in practice for more than 1 year had
166 better scores both in knowledge and in clinical practice. However, when HCWs with
167 more or less than 5 years of ICU experience were compared, only practice scores were
168 significantly different ($p<0.001$).

169 When physicians and nurses were studied separately, the knowledge score
170 was significantly higher in physicians with more than 1 year of experience (7 vs 5;
171 $p=0.007$) and in those with more than 5 years of experience (7 vs 6; $p=0.02$). In the
172 case of nurses, the only significant cutoff was 1 year of experience (5 vs 4; $p=0.003$).

173 Finally, we analyzed the correlation between knowledge and reported practice
174 scores in nurses and physicians. Nurses had a statistically significant correlation

175 between both scores (Pearson correlation 0.31; $p=0.001$). However, in the physicians
176 the correlation did not reach statistical significance (Pearson correlation 0.22, $p=0.2$).

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DISCUSSION

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180 The evaluation of HCW knowledge of well-accepted principles for the
181 prevention of VAP revealed much room for improvement and the need for continuous
182 education. In our study, knowledge was significantly different between nurses and
183 physicians, and it also varied with seniority in both groups

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185 VAP remains the most common and severe nosocomial infection in ventilated
186 patients and is associated with a high degree of morbidity and mortality (4, 6, 37).
187 Prevention is the main issue in VAP, and many groups and scientific societies have
188 provided prevention guidelines in the last 10 years (9, 10, 12, 14, 26, 38, 39). Present
189 guidelines, however, do not recommend a simple procedure to assess baseline
190 knowledge of VAP prevention and the evolution of this knowledge after educational
191 interventions.

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192 Despite the existence of a hospital-approved protocol for the prevention of
193 VAP, our study demonstrates that care provider knowledge is low and that it affects the
194 implementation of the recommendations. Our study included nurses, physicians, and
195 nursing and medical students. Although we found some differences between the
196 overall knowledge scores of physicians, nurses, and students, our study indicates that
197 strategies to implement prevention guidelines should be common to all HCWs. In any
198 case, the results of the evaluation of HCW knowledge of guidelines for prevention of
199 VAP reported in the literature are deceptively low and far from satisfactory (26, 33, 34,
200 40, 41).

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201 We were able to find only a number of publications assessing the quality of
202 knowledge of VAP prevention (16, 21, 26, 33, 34, 40, 42-44). Data regarding the
203 assessment of knowledge have been obtained mainly in nurses (26, 33, 34, 40, 45-47)
204 and only occasionally in physicians (16, 48). In 2007, Labeau et al (47) reported the
205 results of a questionnaire assessing critical care nurses' knowledge of evidence-based
206 guidelines for preventing VAP. Ten nursing-related interventions were assessed from a
207 review of evidence-based guidelines. The questionnaire was distributed to 22
208 European countries (40) between October 2006 and March 2007. The average
209 adequate score was 45.1%. Only 55% of respondents knew that the oral route was
210 recommended for intubation and only 35% knew that ventilator circuits should be
changed for each new patient. Professional seniority and number of ICU beds were

211 shown to be independently associated with better test scores. The assessment was
212 only aimed at nurses and did not include other HCWs.

213 The same questionnaire was also evaluated in different subgroups, including
214 nurses of the Flemish Society for Critical Care Nurses (Ghent, November 2005) (33)
215 and the nurses from several Mediterranean countries (26), with no significant
216 differences between different European groups.

217 The low knowledge scores obtained in most of the reported assessments
218 indicate that formidable efforts must be made in the education of all HCWs (20, 32, 49-
219 51). Knowledge and actual clinical practice do not necessarily have to run in parallel,
220 although our study shows that, unfortunately, they do. This means that to ensure
221 proper practice, innovative techniques such as electronic and mechanical alarms have
222 to be implemented, as do educational measures (20, 32, 49-51). Better strategies
223 should be adopted at the bedside to eliminate erroneous behavior and attitudes. On the
224 other hand, the implementation of some practices, such as subglottic aspiration of
225 respiratory secretions or selective digestive decontamination, does not depend on
226 personal knowledge or conviction, but on unit or hospital policies. Therefore, we
227 evaluated knowledge of the recommendations and clinical practice separately.

228 Our results suggest that seniority indicates better knowledge and approaches
229 to clinical practice, as do other studies (26, 33, 40, 48). At the same time, the results
230 claim for better compulsory educational programs for all staff involved or about to be
231 involved in bedside care. As an example, question number 8 of Table 3 highlighted a
232 considerable discrepancy between the practice of physicians and nurses with respect
233 to changing ventilator circuit tubes. Our analysis of this aspect revealed that the official
234 nurses' protocol was outdated and only recommended changing the circuits after 7
235 days. The protocol has now been modified. We also found that the physicians'
236 evaluation was flawed since, although their knowledge of the guidelines may be
237 adequate, they are not aware of the practices performed only by nurses, thus stressing
238 the need for close collaboration between the two groups. As an example, we can
239 mention the poor physicians score on question 6 of table 3 on the need of disinfecting
240 hands and wear gloves before tracheal suctioning, a practice usually performed by
241 nurses.

242 Our findings also reinforce the need for assessment with methods such as that
243 reported in this paper. The results of this survey were used to design an educational
244 program that has been delivered in all the ICUs of our institution. Particularly worrying
245 was the poor response obtained in question number six related to hand disinfection
246 and use of gloves before tracheal suctioning.

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248 We observed a significant correlation between knowledge and practice scores
249 among nurses but not among physicians, possibly because most of the questions dealt
250 with practices performed by nurses.

251 Although our study has the advantage of including all health care professionals
252 in the ICU, it is limited by the relatively small number of participants and the fact that it
253 was performed in a single tertiary university hospital. Our study is also limited by the
254 fact that the information given by the respondents (reported clinical practice) may not
255 correspond with their actual clinical practice. In addition, some possible preventive
256 measures were not included in our questionnaire (role of sedation, weaning protocols,
257 and noninvasive ventilation). Our bundle of preventive measures was designed by our
258 panel of experts, who chose those measures that were more amenable for intervention.

259 In our opinion, this simple, easily completed questionnaire may help large
260 institutions to rapidly evaluate staff knowledge and real clinical practice in the
261 prevention of VAP. These scores can be used as baseline figures to assess the impact
262 of educational interventions.

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268

269 Pérez-Granda MJ obtained the data in one of the units, collaborated in the analyses of
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271 Muñoz P collaborated in the analyses of the results and in the writing of the
272 manuscript.

273 Heras C obtained the data in one of the units and collaborated in the analysis

274 Sánchez G obtained the data in one of the units and collaborated in the analysis

275 Rello J collaborated in the analyses of the results and in the writing of the manuscript.

276 Bouza E designed the study and collaborated in the analyses of the results and in the
277 writing of the manuscript. **Guarantor of the paper.**

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Table 1. Number of health care workers in the intensive care units (ICU)

	Physicians	Nurses	Students	Total
Overall	54	176	27	257
Participating, No. (%)	32 (59.3)	108 (61.4)	27 (100)	167 (65.0)
Medical ICU	10	30	11	51
Surgical ICU	10	42	12	64
Heart surgery ICU	12	36	4	52

Table 2. Assessment of **individual knowledge**. Percentage of adequate answers by professional level (Answers based on refs 9-11, 15).

Questions (Used guidelines)	Adequate answer	Overall	Physicians	Nurses	Students	P
Q1. How do you value the need to have written guidelines for the prevention of VAP in your unit? (9-11, 15).	...highly needed or needed	95.2	96.9	95.4	92.5	0.37
Q2. Evolution of VAP in the ICU must be recorded as ... (9-11, 15).	...incidence and incidence density	64.7	75.0	63.0	59.3	0.20
Q3. The semi-recumbent position for the prevention of VAP is considered ... (9-11, 15).	...highly recommended or recommended.	92.8	96.9	92.6	88.9	0.43
Q4. What is the most recommended procedure for oral hygiene to prevent VAP? (9,10)	Chlorhexidine 0.12%	68.3	78.1	63.9	74.1	0.27
Q5. What is your opinion regarding respiratory physiotherapy for the prevention of VAP?	There is no evidence of efficacy	4.2	9.4	3.7	0.0	0.27
Q6. Barrier measures (hand hygiene and gloves) before tracheal suctioning and manipulation of ventilator circuits are ... (9-11, 15).	...highly recommended	58.1	37.5	63.9	59.3	<0.01
Q7. The recommendation for subglottic aspiration of respiratory secretions is ... (9-11)	...highly recommended or recommended	31.2	46.9	25.0	36.0	0.91
Q8. When should ventilator-circuits be changed? (9-11, 15).	When soiled or dirty or after each patient	7.2	28.1	2.8	0.0	<0.01
Q9. Control and maintenance of pressure of the tracheal balloon in patients undergoing subglottic aspiration is ... (10,15).	...highly recommended or recommended	85.7	90.7	85.2	24.8	0.39
Q10. Selective digestive decontamination with antibiotics is... (10,15).	...not generally recommended at present	26.3	56.3	18.5	22.2	<0.01

The reference of the guideline used for each question is included at the end of the question.

Table 3. Assessment of **daily clinical practice** in the prevention of VAP. The numbers indicate the percentage of positive answers in each group.

Questions regarding daily practice	Overall	Physicians	Nurses
Q1. Do you know the written guidelines of your unit?	25.9	31.3	24.1
Q2. Are you aware of the evolution of figures of incidence and incidence density of VAP in your unit?	55.1	78.1	58.3
Q3. Do you keep your patients in a semi-recumbent position (30-45°)?	85	84.4	87.7
Q4. Do you regularly use chlorhexidine for oral decontamination?	70.1	71.9	67.6
Q5. Do you regularly use respiratory physiotherapy to prevent VAP?	3.0	3.1	2.8
Q6. Do you regularly disinfect hands and wear gloves before tracheal suctioning?	31.1	21.9	35.2
Q7. In your unit, do you perform subglottic aspiration of respiratory secretions?	10.2	3.1	11.1
Q8. Do you change ventilator-circuit tubes only when soiled or after each patient?	22.2	53.2	13.9
Q9. Do you regularly control the pressure of the tracheal balloon during each shift?	91.6	84.4	94.4
Q10. Do you regularly perform oral decontamination to prevent VAP?	38.9	56.6	36.1

The reference of the guideline used for each question is included at the end of the question.

Table 4. Comparison of knowledge and practice scores by professional level and by years of practice

	Knowledge score	Practice score
Professional level		
Physicians (n=32)	6 (5-7)	5 (4-6)
Nurses (n=108)	5 (4-6)	4 (3-5)
Students (n=27)	5 (4-7)	
	<i>p=0.004</i>	<i>p=0.014</i>
Years of ICU experience (students excluded)		
≤5 years (n=76)	5 (4-6)	4 (3-5)
>5 years (n=64)	5 (4-7)	5 (4-6)
	<i>p=0.235</i>	<i>p<0.001</i>
<1 year (n=22)	4 (3-6)	4 (2-4)
≥1 year (n=118)	6 (5-7)	5 (4-5)
	<i>p=0.004</i>	<i>p=0.003</i>

Questions	Answer
Q1. How do you value the need to have written guidelines for the prevention of VAP in your unit?	1. Not needed 2. Highly needed or needed 3. Contraindicated 4. I do not know 5. Indifferent
Q2. Evolution of VAP in the ICU must be recorded as ...	1. incidence and incidence density 2. Prevalence 3. Surveillance is contraindicated 4. Not necessary 5. I do not know
Q3. The semi-recumbent position for the prevention of VAP is considered ...	1. Indifferent 2. Not recommended 3. Highly recommended or recommended. 4. There is no evidence of efficacy 5. I do not know
Q4. What is the most recommended procedure for oral hygiene to prevent VAP?	1. Bicarbonate 2. Not necessary 3. Chlorhexidine 0.12% 4. Indifferent 5. I do not know
Q5. What is your opinion regarding respiratory physiotherapy for the prevention of VAP?	1. There is no evidence of efficacy 2. Highly recommended 3. Not recommended 4. Indifferent 5. I do not know
Q6. Barrier measures (hand hygiene and gloves) before tracheal suctioning and manipulation of ventilator circuits are ...	1. Indifferent 2. Not recommended 3. Highly recommended 4. Recommended 5. I do not know
Q7. The recommendation for subglottic aspiration of respiratory secretions is ...	1. Highly recommended or recommended 2. Contraindicated 3. There is no evidence of efficacy 4. Indifferent 5. I do not know
Q8. When should ventilator-circuits be changed?	1. Weekly 2. When soiled or dirty or after each patient 3. Every 48 hours 4. Daily 5. I do not know
Q9. Control and maintenance of pressure of the tracheal balloon in patients undergoing subglottic aspiration is ...	1. Contraindicated 2. There is no evidence of efficacy 3. Indifferent 4. Highly recommended or recommended 5. I do not know
Q10. Selective digestive decontamination with antibiotics is...	1. Highly recommended 2. Not generally recommended at present 3. Indifferent 4. Contraindicated 5. I do not know