Prevention of ventilator-associated pneumonia in intensive care units: an international online survey

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Abstract

Background: On average 7% of patients admitted to intensive care units (ICUs) suffer from a potentially preventable ventilator-associated pneumonia (VAP). Our objective was to survey attitudes and practices of ICUs doctors in the field of VAP prevention.

Methods: A questionnaire was made available online in 6 languages from April 1st to September 1st, 2012 and disseminated through international and national ICU societies. We investigated reported practices as regards (1) established clinical guidelines for VAP prevention, and (2) measurement of process and outcomes, under the assumption “if you cannot measure it, you cannot improve it”; as well as attitudes towards the implementation of a measurement system. Weighted estimations for Europe were computed based on countries for which at least 10 completed replies were available, using total country population as a weight. Data from other countries were pooled together. Detailed country-specific results are presented in an online additional file.

Results: A total of 1730 replies were received from 77 countries; 1281 from 16 countries were used to compute weighted European estimates, as follows: care for intubated patients, combined with a measure of compliance to this guideline at least once a year, was reported by 57% of the respondents (95% CI: 54–60) for hand hygiene, 28% (95% CI: 24–33) for systematic daily interruption of sedation and weaning protocol, and 27% (95% CI: 23–30) for oral care with chlorhexidine. Only 20% (95% CI: 17–22) were able to provide an estimation of outcome data (VAP rate) in their ICU, still 93% (95% CI: 91–94) agreed that “Monitoring of VAP-related measures stimulates quality improvement”. Results for 449 respondents from 61 countries not included in the European estimates are broadly comparable.

Conclusions: This study shows a low compliance with VAP prevention practices, as reported by ICU doctors in Europe and elsewhere, and identifies priorities for improvement.

Keywords: Healthcare associated infection, Ventilator-associated pneumonia, Patient safety, Preventive measures, Quality of care
Introduction

Ventilator-associated pneumonia (VAP) is a frequent and severe health-care associated infection. In Europe, pneumonia occur in 7.0% of patients staying at least 2 days in intensive care units (ICUs); 91% of these pneumonia are VAP [1]. The proportion of VAP which is preventable is debated [2] but there is no doubt that a serious potential for harm reduction does exist [3, 4] and VAP prevention is becoming a major patient safety issue. In the US for instance, VAP prevention has been proposed as a national safety goal [2].

VAP prevention requires clinical interventions (best practice guidelines) combined with non clinical interventions to ensure implementation and compliance with these guidelines.

Clinical interventions for VAP prevention fall in three categories [5]. The first, obvious one, is to limit exposure to mechanical ventilation by preferring non-mechanical ventilation when possible and limiting its duration when alternative options are not possible. Other prevention practices aim at reducing airways colonization (such as selective digestive decontamination, [9]) and preventing aspiration [5] (e.g. by nursing in the semi-recumbent position, or maintaining a sufficient cuff pressure). Clinical interventions should be combined, in what is often called a “care bundle”. The precise content of VAP care bundle varies between guidelines [7,8] because the number of items in a “bundle” should be limited, some prevention practices are controversial (e.g. selective digestive decontamination), [9] and recommending best practice regarding such measures requires compromise and pragmatism [8]. There is no universally accepted “VAP care bundle”. A study aiming at defining a “European care bundle” ranked VAP prevention measures by combining criteria such as the strength of the supporting evidence, ease of implementation, and expected impact [10]. The top 5 clinical interventions (we did not consider “trained staff” as a clinical intervention) were: 1) no ventilatory circuit change unless specifically indicated; 2) strict hand hygiene with alcohol especially before managing the airways; 3) daily sedation vacation and weaning protocol; 4) oral care with chlorhexidine; and 5) cuff pressure control at least every 24 hrs. It was beyond the scope of our study to assess the evidence behind each of these interventions, but none appears to be controversial.

Ensuring compliance with guidelines is a vast and complex field of research [11-13]. Common to any improvement strategy is the need for measurement; this serves evaluation purposes, measurement can also be the intervention, or a major component of it [14-16]. In a survey on infection control practices in the US, ICUs were only able to reduce healthcare-associated infection rates (including VAP), when they had a written policy, monitored compliance, and achieved a ≥95% compliance to all elements included in the local care bundle [11,17]. Under the unchallenged assumption “if you cannot measure it, you cannot improve it” (Lord Kelvin, 1824-1907), we considered here that monitoring process (compliance to guidelines) and outcomes is a necessary, if not sufficient, component of any intervention aiming at decreasing VAP.

Accurate diagnosis of VAP is a challenge, because many conditions commonly encountered in critically ill patients – such as pulmonary oedema, pulmonary hemorrhage and acute respiratory distress syndrome, can mimic the signs and symptoms of pneumonia [5]. Clinical diagnosis leads to treatment decisions, its primary aim is to be accurate, and it cannot be entirely standardized. By contrast measurement need primarily to be reproducible to ensure comparability of data overtime and allow evaluation of trends. Standardization is essential. Criteria for diagnosis and criteria for recording, therefore do not necessarily overlap entirely. Guidelines and definitions of VAP for recording and reporting exist in Europe [18] and in the United States [19]. Despite some changes in the US, current case-definitions are still considered useful for internal quality improvement purposes [20].

Our objectives were to document, using a web-based survey (1) reported VAP prevention practices in ICUs (clinical practices, and measurement) and (2) attitudes towards the implementation of a measurement system. Our primary interest laid in providing estimates at European level, but we did not define exclusion criteria based on geographical location; on the other hand country-specific results can be used to steer prevention initiatives at country level.

Methods

Study population

Our target group was physicians working in ICUs. An ICU was defined as an unit meeting all the following criteria: provides facilities for invasive mechanical ventilation, and pump-controlled administration of infusion, functions 24 hours a day and 7 days a week, and there is at least one doctor immediately available at all times to deal with emergencies.

Questionnaire

We developed a questionnaire with 3 parts: 1) Characteristics of the respondent and her/his ICU, 2) VAP prevention practices (clinical, and measurement). For clinical practices we focused on the top 5 clinical components of the European VAP care bundle [10] and added a commonly recommended practice (head of bed elevation) [5]. For measurement, we included questions on measurement of process (compliance to prevention
practices, average duration of intubation) and outcomes (measurement of VAP, definitions used for data collection – European, [18] or American, [19] and the ability to report selected indicators. 3) attitudes as regards the implementation of a data collection system, using a 5 point-Likert scale (1: strongly agree, 5: strongly disagree) [13,21]. The questionnaire was kept very short to improve participation. It was first developed and pre-tested in English, then translated into German, Italian, Spanish, Portuguese and French by intensive care doctors and/or infection control practitioners, native speakers in the targeted language. Each translation had to be independently checked by at least another native speaker doctor. We used Limesurvey 2.0, an open source web survey application, to collect the data [22]. Participation was anonymous.

Dissemination to target group
The questionnaire was available online from April 1 to September 1, 2012. It was endorsed by the European Society of Intensive Care Medicine (ESICM), posted on their website, and the link e-mailed to all its members. We contacted national ESICM representatives and key opinion leaders and requested their support in disseminating the survey in their country. The survey was endorsed by national ICU societies in Austria, France, Belgium, the Netherlands, Italy, and Greece. It was e-mailed to all subscribers of REMI (Revista Electronica de Medicina Intensiva), [23] an electronic newsletter on intensive care medicine in Spanish distributed in Spain, Portugal, and Latin America.

Data analysis
Descriptive statistics were used to characterize the study sample. Using total country population (2012 United Nations estimates [24]) as the weight, we computed weighted European estimates including all countries which provided at least 10 completed replies. This arbitrary threshold was chosen as a compromise between the number of countries included in the European estimates, and precision of the estimation. Statistical software STATA 10 was used for the analyses (svy command for survey data for weighted estimates). Replies from the remaining countries, both European and non European, were simply pooled together. We choose to present uncommented, detailed country-specific results as Additional file 1, for use by national stakeholders.

Results
A total of 1730 completed replies from 77 different countries were submitted (Table 1). Characteristics of the respondents, and their setting, are presented in Table 2.

| European countries | Replies | % |
|--------------------|---------|---|
| Spain              | 293     | 17% |
| France             | 251     | 15% |
| Italy              | 187     | 11% |
| Austria            | 130     | 8%  |
| United Kingdom     | 115     | 7%  |
| Germany            | 67      | 4%  |
| Portugal           | 50      | 3%  |
| Belgium            | 33      | 2%  |
| Netherlands        | 31      | 2%  |
| Switzerland        | 29      | 2%  |
| Greece             | 23      | 1%  |
| Romania            | 20      | 1%  |
| Denmark            | 15      | 1%  |
| Sweden             | 14      | 1%  |
| Ireland            | 13      | 1%  |
| Hungary            | 10      | 1%  |
| Total European countries with at least 10 replies* | 1281 | 74% |
| Other (18 different countries) | 55 | 3% |

| Non European countries | Replies | % |
|------------------------|---------|---|
| India                  | 63      | 4%  |
| Argentina              | 40      | 2%  |
| Colombia               | 31      | 2%  |
| Mexico                 | 31      | 2%  |
| Australia              | 23      | 1%  |
| Peru                   | 23      | 1%  |
| Brazil                 | 21      | 1%  |
| Ecuador                | 13      | 1%  |
| Chile                  | 12      | 1%  |
| Turkey**               | 12      | 1%  |
| United States          | 12      | 1%  |
| Saudi Arabia           | 11      | 1%  |
| United Arab Emirates   | 11      | 1%  |
| Venezuela              | 11      | 1%  |
| Other (29 different countries) | 80 | 5% |
| Survey - total         | 1730    | 100% |

* Used for European weighted estimates.
** Considered as non European as majority of population does not live in Europe.

Weighted European estimates are based on 1281 respondents from the 16 countries from which at least 10 completed replies were available.

VAP prevention practices are presented in Table 3 (clinical practices) and Table 4 (measurements).
Attitudes towards the implementation of a VAP measurement system are presented in Table 5.

**Discussion**

**Key results**

This is, to our knowledge, the first international survey assessing VAP prevention practices – (clinical, and measurement) – among ICUs doctors. Participation was large, and almost two thirds of respondents reported the existence of written VAP prevention guidelines in their ICU - pointing out the interest in, and awareness of the problem. If we combine the good clinical practice, AND measuring compliance to this practice at least once a year (a very pragmatic objective), this was reported by 57% (hand hygiene), 29% (daily interruption of sedation) and 26% (oral care with chlorhexidine) of the participants to this survey (European estimates). Interestingly, “head of bed elevation” - a practice ranked very low in the "European care bundle" because it was perceived as difficult to implement - was mentioned by 96% of the respondents; this clinical practice was known by 85% of European nurses participating in a knowledge test about VAP prevention practices [25].

As regards measurement of outcomes, European estimates show that only 54% count and record the number of VAP on a routine basis; and only 20% were able to provide data for their ICU on the main indicator used to monitor VAP - (VAP/1000 intubation-days). In contrast

### Table 2 Characteristics of the respondents, and of their setting

| Respondent | Weighted estimates for Europe (respondents from 16 countries with >=10 replies) | Other respondents (61 countries) |
|------------|-----------------------------------------------------------------------------------|---------------------------------|
|            | N=1281 95% CI                                                                 | N=449 95% CI                    |
| Years working in ICU (mean) | 12.8 12.2 13.3 | 12.9 12.1 13.6 |
| Admissions per year in their ICU (mean) | 1006 914 1098 | 900 787 1013 |
| N beds in ICU (mean) | 16 15 17 | 16 15.4 17.3 |

| %* | N | % |
|----|---|---|
| Gender (females) | 28 25 31 | 82 18 15 22 |
| Working in hospital with > 1000 beds | 17 14 20 | 18 4 2 6 |
| Working in hospital with 300–1000 beds | 55 52 56 | 145 33 28 37 |
| Working in hospital <300 beds | 28 26 31 | 282 63 58 67 |

* Absolute numbers are not reported because percentages are weighted estimates.

### Table 3 VAP prevention: clinical practices, as reported by ICU doctors

| Clinical practice | Weighted estimates for Europe (respondents from 16 countries with >=10 replies) | Other respondents (61 countries) |
|-------------------|-----------------------------------------------------------------------------------|---------------------------------|
|                   | N=1281 95% CI                                                                 | N=449 95% CI                    |

| %* | 95% CI | 95% CI |
|----|--------|--------|
| In my ICU, hand hygiene is done with alcohol hand rub, always, or most of the time | 95 94 97 | 395 88 85 91 |
| In my ICU, there are written guidelines for VAP prevention | 65 62 69 | 282 63 58 67 |
| Guidelines developed locally | 33 30 36 | 162 36 32 41 |
| Guidelines developed nationally | 31 28 34 | 117 26 22 30 |
| In my ICU, care for intubated patients includes... | | |
| No ventilatory circuit changes unless specifically indicated | 69 66 72 | 371 83 79 86 |
| Strict hand hygiene using alcohol, especially before managing the airways | 83 80 86 | 364 81 77 85 |
| Systematic daily interruption of sedation and weaning protocol | 49 46 53 | 285 63 59 68 |
| Oral care with chlorhexidine | 70 67 73 | 302 67 63 72 |
| Cuff pressure control at least every 24 hours | 83 81 85 | 347 77 73 81 |
| Head of bed elevation | 96 94 97 | 442 98 97 100 |

* Absolute numbers are not reported because percentages are weighted estimates.
**Table 4 VAP prevention: measurements, as reported by ICU doctors**

| Measurements | Weighted estimates for Europe (respondents from 16 countries with >=10 replies) | Other respondents (61 countries) |
|--------------|----------------------------------------------------------------------------------|----------------------------------|
|              | %* 95% CI                           | N  %  95% CI                      |
| Measurement of compliance at least once a year |                                                                                       |
| Hand hygiene recommendations | 57 54 60 | 265 60 54 64 |
| Systematic daily interruption of sedation and weaning protocol | 28 24 33 | 102 23 19 27 |
| Oral care with chlorhexidine | 27 23 30 | 126 28 24 32 |
| "In my ICU, there is a written definition of VAP for data collection" |                                                                                       |
| YES- European guidelines | 50 47 54 | 286 64 59 68 |
| YES- CDC guidelines | 26 23 29 | 37 8 6 11 |
| "In my ICU, we count and record, routinely..." (% saying ‘yes’) |                                                                                       |
| VAP | 55 51 58 | 287 64 59 68 |
| Intubation-days | 81 78 84 | 364 81 74 85 |
| Intubated patients | 90 88 92 | 367 82 78 85 |

* Absolute numbers are not reported because percentages are weighted estimates.

**Table 5 Attitudes towards the implementation of a measurement system of infections in ICUs**

| Weighted estimates for Europe (respondents from 16 countries with >=10 replies) | Other respondents (66 countries) |
|----------------------------------------------------------------------------------|----------------------------------|
|                                                                                       | N=1281                           | N=449                           |
|                                                                                       | Agree strongly/ agree  %  95% CI | Disagree/ disagree strongly  %  95% CI | Agree strongly/ agree  %  95% CI | Disagree/ disagree strongly  %  95% CI |
| **To what extent do you agree with the following comments** |                                                                                       |                                                                                       |
| If you cannot measure it, you cannot improve it | 83 80 85 | 11 9 13 | 84 80 87 | 11 8 14 |
| Monitoring of VAP related measures stimulates quality improvement | 93 91 94 | 2 1 3 | 97 94 98 | 1 0 3 |
| VAP-related measures in my ICU (if any) are reliable | 54 51 58 | 12 10 15 | 66 61 70 | 8 6 11 |
| I am willing to implement, or support, a VAP data collection system | 84 81 86 | 4 3 6 | 92 89 94 | 1 0 3 |
| Clinical diagnosis of VAP is difficult: this makes measurement systems unreliable | 46 43 50 | 32 29 36 | 43 38 47 | 36 32 41 |
| There is a difference between a definition of VAP for reporting, and a diagnosis of VAP for treatment | 45 42 49 | 32 28 35 | 46 41 50 | 30 26 35 |

* Please indicate what actions would facilitate the implementation of a measurement system of infections in ICUs

| Timely feed-back of data at ICU level | 92 90 94 | 1 1 2 | 96 93 97 | 0 0 2 |
| Administrative support | 88 86 90 | 2 1 3 | 95 92 97 | 1 0 2 |
| Dedicated software / IT resources | 91 89 93 | 2 1 3 | 92 89 94 | 0 0 2 |
| Reliable data | 95 93 96 | 1 0 2 | 96 94 98 | 0 0 1 |
with these low proportions 93% agreed that “monitoring of VAP-related measures stimulates quality improvement” and 84% said they were willing to implement, or support, a VAP data collection system. They expressed some distrust as regards the data (46% agreed with the statement “clinical diagnosis of VAP is difficult; this makes measurement unreliable”), on the other hand, only 50% were aware of a standardized case definition for VAP recording in their ICU; and only 45% understood the difference between a definition of VAP for recording, and a diagnosis of VAP. Overall, 95% of respondents agreed that reliable data would facilitate the implementation of a measurement system.

These European estimates mask large difference between countries. For example oral care with chlorhexidine was reported by 55% (139/251) of the respondents in France, and by 94% (276/293) in Spain. Respondents saying yes to the question “in my ICU, we count and record VAP on a routine basis” were 50% (57/115) in the UK, and 74% (218/293) in Spain. Daily sedation vacation and weaning protocol were reported by 81% (93/115) in the UK, and by 35% (66/187) in Italy (see country-specific data, as Additional file 1).

Results from the 449 respondents not included in the European estimates are surprisingly similar to those of the European estimates.

**Strengths and Limitations**

This survey has several limitations. First, we cannot claim that participants represent a random sample of ICU clinicians in Europe nor in their own country. Some categories of ICU doctors are likely to be overrepresented, such as members of ICU national, or international societies. These might be better informed, and apply VAP prevention guidelines more than the average clinician. The list of VAP prevention measures we used as a reference for good practices guidelines [10] could be criticized on several grounds, e.g. it does not include subglottic secretions drainage [26]. Our dissemination strategy obviously worked better in some countries than others. Another limitation is that some questions in the questionnaire apply to the individual physician and others to the ICU (“in my ICU, care for intubated patients includes...”) but the online questionnaire did not include questions allowing for the identification of the ICU, in order to preserve the anonymity of the respondents.

Respondents not included in the European estimates represent a very heterogeneous population with no clear geographical basis. We nevertheless considered it worthwhile to pool these results, because together these doctors are responsible for a large number of patients, and these data have identified weaknesses broadly similar to those observed in the European estimates.

Clearly, it cannot be concluded from a doctor’s reporting of a clinical practice in her/his setting, that this practice is used all the time for every patient who needs it: self-reports mainly provide information regarding clinicians’ knowledge of guideline recommendations, but they are subject to bias – overestimation – and should not be used as the sole measure of guideline adherence [27]. Measuring compliance to guidelines at local level once a year appears as an absolute minimum. We did not ask details on the methods used to measure compliance. This is not necessarily easy, for instance detailed guidelines exist for measuring compliance to hand hygiene recommendations; [28] and oral care in ventilated patients is a complex procedure that might require a check list [29].

It was not among the objectives of this survey to collect data on VAP incidence rate in ICUs – there are much better sources for this – e.g. surveillance data for Europe [1]. Rather we wanted to investigate the knowledge doctors had of the rates in their units. However data provided on VAP rates (not shown) are in the expected range as reported in surveillance networks [1], giving some validity to our results.

**Interpretation**

The large participation to this survey reflects the interest of the ICU community in the issue of VAP prevention. To the extent that the selection bias, and the reporting bias in our results lead to overestimating VAP prevention practices in ICUs, weaknesses identified appear robust enough as to support targeted interventions for improvement. The priority for improving care of intubated patients is promoting the clinical practices with the lowest reported use (daily sedation vacation, and weaning protocols, oral care with chlorhexidine, and no ventilatory circuit change unless specifically indicated). Improving knowledge of clinical guidelines is far from sufficient to improve practices [25,30] but it is a prerequisite. ICUs doctors overwhelmingly agree that monitoring of VAP-related measures stimulates quality improvement but very few do it, although most are willing to do it. They could be helped to do so by learning how to produce reliable data (standardized case definitions, methods for measuring compliance) with real-time feed-back at the ICU level; so that clinical staff could monitor their own trends over time. A compromise needs to be found between time-consuming data collection, and usefulness of data. Additional resources (human resources, information technology) might help, but some very simple measures can be implemented with minimal input, e.g. in some ICUs a panel with the number of days since last ICU-acquired infection (including VAP) is displayed on the board and updated.
daily (personal observations in Scotland, MLL). This study did not consider the issue of surveillance and reporting of outcome indicators at regional or national level, nor the merits (or otherwise) of evaluation of performance and feed-back, based on benchmarking (e.g. comparisons between units). Specific priorities might differ between countries.

Conclusions
This survey has documented a large potential for improvement in clinical and non-clinical practices aimed at preventing VAP in ICUs. Some results, such as a large agreement of the respondents that data collection is essential – “if you cannot measure it, you cannot improve it” - extend beyond the issue of VAP prevention. Promoting the implementation of guidelines for VAP prevention needs to be done together with promoting the measurement of compliance to these guidelines and measurement of outcomes as a tool for improvement, keeping data collection systems at ICU level as simple as possible: what is important is usefulness, not perfection [31].

Additional file
Additional file 1: Detailed country-specific results: number responding, respondents characteristics, reported practices, attitudes.

Competing interest
The authors declare that they have no competing interests.

Authors’ contributions
MLL, MP, AA, MH and UF designed the study. MLL and AI collected and analyzed the data. MLL wrote the first draft of the article. MP, AA, MH, AL, SB, AI and EPH revised the report. All authors saw and approved the final report.

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Data sharing
Data are freely available and have been deposited in the Dryad Digital Repository http://datadryad.org doi:10.5061/dryad.1d7f Further use and exploitation of these data is encouraged.

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