Author's response to reviews

Title: Has information technology finally been adopted in intensive care units? A survey and review of the literature.

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Author's response to reviews: see over
Dear editor,

We are pleased with the comments by the editor and the reviewers, which allows us to further improve our manuscript: “Has information technology finally been adopted in intensive care units? A survey and review of the literature” by K Colpaert, S Vanbelleghem, C Danneels, D Benoit, K. Steurbaut, S. Van Hoecke, F. De Turck and J. Decruyenaere.

We have modified the paper in order to address the requested ethical committee approval, the review by a native English speaking person and we took into account the recommendations proposed by the reviewers. Please find below a point-by-point explanation of the modifications we made in response to each of the reviewers’ suggestions.

Please feel free to contact us with any additional questions or remarks.

Sincere regards,

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Answers to editorial requests:

1) Please document ethical approval. Experimental research that is reported in the manuscript must have been performed with the approval of an appropriate ethics committee. Research carried out on humans must be in compliance with the Helsinki Declaration (http://www.wma.net/e/policy/b3.htm), and any experimental research on animals must follow internationally recognized guidelines. A statement to this effect must appear in the Methods section of the manuscript, including the name of the body which gave approval, with a reference number where appropriate.

Thank you for noticing this shortcoming. We added the following section:

The Local Ethical Committee of Ghent University Hospital approved the study. All answers were kept confidential.

2) We recommend that you ask a native English-speaking colleague to help you copyedit the paper. If this is not possible, you may need to use a professional copyediting service. Examples are those provided by the Manuscript Presentation Service (www.biomedes.co.uk), International Science Editing (http://www.internationalscienceediting.com/) and English Manager Science Editing (http://www.sciencemanager.com/). BioMed Central has no first-hand experience of these companies and can take no responsibility for the quality of their service.

In concordance with the advice given by the editor and the reviewers, the manuscript is thoroughly reviewed by a native english speaking person.

Reviewer #1 (Morris):

1. The authors extensive use of abbreviations is distracting and lends to confusion among readers. I suggest the authors abandon their use of abbreviations (acronyms).

We appreciate the comment on this matter, and substantially decreased the use of abbreviations wherever possible. For example in the abstract the results section was changed as follows:

Currently, the electronic consultation of laboratory and radiology results is omnipresent in Flemish ICUs, (100% and 93.5%, respectively) although the electronic ordering of these examinations only occurs exceptionally.

In the introduction the following sentence has been adapted:

The ICT adoption rate includes both the use of specific HIS components like the electronic patiënt record, the laboratory and radiology software, the electronic prescription (i.e. CPOE), as well as ICU-specific ICT software like ICIS.

2. The authors list a large number of computed percentages regarding presence of electronic elements. They do not bring these observations together in a convincing synthesis. The report’s value
is therefore limited. The observations that the use of electronic systems in Flemish ICUs seems to have increased over a 3.5 year period is not surprising and does not advance our understanding of important implementation issues.

Many reports address the problem of continuing slow implementation rates, although these are gradually improving. However, in our survey, by the end of 2008, 12 ICUs have adopted an ICIS, and another 30 intend to do so by the end of 2011. As can be seen in the figure (= year x total number of implementations in Flanders), it is possible that finally, “the implementation chasm will be crossed”, as has been stated by Lorenzi et al. (reference 28 in the article). It seems that in Flanders the “innovators” and “early adopters” already implemented an ICIS, and the time has come for the “early majority” to start implementing.

3. SPECIFIC COMMENTS: Abstract-Methods: Line 3: ITC is not defined. This is an incomplete sentence. Results: Line 1: PACS is undefined. Line 2: CPOE is undefined. Line 4: EPR is undefined. These acronyms have been replaced or expanded, and therefore we adapted the abstract as follows:

Methods:

We evaluated the actual Health IT adoption rate, as well as its evolution over a 3-year time frame.

Results:

Currently, the electronic consultation of laboratory and radiology results is omnipresent in Flemish ICUs, (100% and 93.5%, respectively) although the electronic ordering of these examinations only occurs exceptionally. The Electronic Patient Record (EPR) and the electronic prescription of medication are fairly widespread (65% and 49.2%, respectively), but only 27% of ICUs also computerized drug administration registration, mostly by using the features of their ICIS.
4. **Introduction**: I suggest the authors consider removing the first two sentences.

We changed the first sentences of the Introduction section as follows:

> Over the past decades there have been substantial changes in medicine, with more effective but also increasingly complex therapies, resulting in an increased life expectancy on the one hand, but also in an increase in the number of medical errors on the other hand.

5. **P 6 Para 3 Line 7-9**: The authors require 3 things for an intensive care information system to qualify in their survey. Interestingly, they do not require bedside decision-support, an important component of electronic systems.

We decided not to include bedside decision-support tools as a prerequisite for an intensive care information system (ICIS), as we assume that at least basic clinical decision support is available in the CPOE component of the ICIS (e.g. default values for drug doses, routes and frequencies). However, not every centre who is having an ICIS has, by now, the availability of more advanced decision support, although lately this gradually is improving. Furthermore, some centres who do have these decision support tools, chose not to have them activated because of problems with alert fatigue. Also, some ICISs do have, for example, drug-allergy checking, but only in a passive way, meaning that the allergy is viewed in the drug prescription window, but there will not be an active warning whenever a wrong drug is prescribed.

6. **P 7 Para 1 Line4-5**: the authors claim that Flanders is representative of other European regions but do not provide a citation to support this claim. A citation should be added.

This is in concordance with the remark made the second reviewer. As we could not find data to support this statement, we choose to remove the following sentence:

> “We focused on the ICUs in the region of Flanders, Belgium, which is quite representative for other European regions.”

7. **Materials and Methods**: No information concerning validation of the survey instrument is provided by the authors.

We agree that we have not given information regarding the validation of our survey instruments. This is a limitation of our study. Therefore we included the following sentence in the limitations section:

> Secondly, we did not use a validated questionnaire, therefore our results are possibly not reproducible.

8. **Region of Interest**: The authors claim, without citation or data, that all Flemish ICUs provided high quality care. This statement should be supported or eliminated.

With the term “high quality care” we wanted to emphasize that all Flemish ICUs provide mechanical ventilation (i.e. level 3 care). In contrast to surrounding countries, Belgian authorities do not make a distinction between levels of ICU care, as all ICUs provide mechanical ventilation. We changed the sentence as follows:
All these ICUs provide mechanical ventilation and are approved by the national government (see http://www.health.fgov.be).

9. P 8 Results, Para 1: Only 57% of the insinuations completed the written survey. However, in Paragraph 2 the authors claim the adoption rates over time are highly accurate, with the second (telephone) survey participations of 100% of institutions. This seems inconsistent. How can they be sure of adoptions rates when 43% of the sites failed to complete the first survey? This limitation will apply to all of their results.

We agree that this may seem inconsistent. However, in the second survey all ICUs were questioned about previous availability of ICT in their ICU, i.e. by the time of the first survey. Furthermore, at the time of the first survey, all non-respondents were contacted by phone, and most admitted they did not answer the questionnaire merely because they were not computerized.

Below you can find a figure illustrating the implementation rates of the different ICT in Flemish ICUs, where you can see that the differences between 2008 (with all respondents: n=63) and 2008 (n=31; these are only the ICUs who responded to the first survey) is not that much different.

10. P 9 Medication CPOE...Para 2 Line 6-7: Some ICUs use Microsoft Excel and others have homemade systems. This brings into focus the important challenge of interinstitutional compatibility of data and the searchability of data elements. Excel will not likely be satisfactory. This reviewer wonders about the compatibility of the other systems. these concerns do not preclude reporting use, as the authors have don\1. However, the authors should discuss these important challenges and the limitations, therefore, of the results they report. Line 9-14: the authors describe some important limitations and tangentially touch upon the way the clinical sites use the electronic information. Some apparently mix electronic and paper reports, and use the electronic information to generate paper reports for their medical charts. Such a mix of uses makes interpretations of the results more difficult. The absence of systematically reported usage details reduces the value of this report.

We agree that this makes the interpretations more difficult, as Excel is not designed for electronic prescribing of medications. Therefore we decided to exclude these users and changed the Result section as follows:
A greater proportion of ICUs reported using CPOE in 2008 compared to 2005: 41.3% vs. 19.3%. Currently, 11 of these electronic medication prescription programs are part of an ICIS, 7 are commercially bought for use in the entire hospital and another 8 CPOE programs are hospital-made. Many of these latter less sophisticated programs needed extensive adaptations however, especially for continuous infusion pump registration. Another 5 ICUs are using Microsoft office documenting (i.e. Excel), but as this is not a software which is originally constructed for electronic medication prescribing, we did not included these as CPOE.

The Discussion was changed as follows:

The electronic prescription of medication (i.e. medication CPOE) is readily being used, with an actual implementation rate of 41.3%, which is substantially higher than the 22% rate in Canadian ICUs [13], or the 5% to 15% of American ICUs [22-24]. Possibly the continuously increasing amount of literature regarding this topic is pushing this implementation rate forward [14-21]. It is worth noting that 5 other ICUs only use a very basic means of electronic medication prescription by using Excel programming without facilitated ordering possibilities, thereby excluding the full beneficial potential of electronic medication prescribing and only eliminating the eligibility errors.

And regarding the medication administration registration:

Possible reasons are the fact that many of those hospital-made CPOE programs are not primarily intended to be used in the critical care environment, which makes their use rather cumbersome. Typical examples are the problems with continuous infusions, or the prescription of medication according to certain physiologic parameters. This is of course never the case in those ICUs that have implemented an ICIS.

Furthermore, figure 1 has been changed accordingly:

![Bar chart showing medication prescription and administration rates in 2005 and 2008.]

The reason why currently more ICUs do prescribe drugs electronically, but fail to register the administration electronically, is mainly due to the installation of hospital-made cpoes in these ICUs.
Unfortunately these are generally not intended to be used in the critical care environment (for example: the syringe pumps are difficult to register in these systems), thereby creating problems for easy registration of administered drugs. In order to bypass these problems some ICUs chose to print out the medication prescriptions and use them as chart boards. Other ICUs on the contrary chose not to implement these CPOE systems, and they proceed with paper-based prescriptions.

11. P 11 Effective Use of Highly Detailed data Extraction... Para 2: The low use of systematic data extraction seems to be inconsistent with the initial claim that all Flemish ICUs are high quality. The decision-making process... Para 3 The authors list concerns and anticipated benefits without citations. Are these the opinions of the authors or are they derived from discipline-wide consensus or systematic studies?

We agree that this may seem inconsistent. We removed the claim that all Flemish ICUs are high quality (see recommendation nr 8).

The reason why most ICUs do not use their ICIS for data extraction, is the fact that, in order to be able to do so, physicians need to understand SQL, or at least learn to work with a data-warehousing program. This is a very time consuming task, and not every physician is interested in doing so. In these hospitals who do succeed in data extraction, this is merely due to the interest of one single physician who has made his hobby his job (at least partially). Unfortunately, there is rarely enough money to hire a professional.

14. They cite Table one as a list of concerns when Table one only contains a list of benefits. Table one, importantly and surprisingly, does not include bedside decision-support as a benefit. This seems a serious oversight.

Thank you for noting this ambiguity. It has been corrected in the text.

Table 1 about the main anticipated benefits: the respondents needed to select the most important anticipated benefits according to their view. The availability of clinical decision support (i.e. alerting features, advice, ...) was one of the items they could chose. Rarely enough they did not regarded this as an important feature. A possible explanation may be that many centres were not aware of the quality benefits of clinical decision support.

15. P 22 Figure Legends: Figure 1 does not add anything substantial and can be removed.

Our purpose was to improve the readers’ insight into the difficult matter of hospital ICT. But we agree that other sources are more qualified for this, and therefore removed the first figure.

Additionally, we removed the following sentence, as these were linked with figure 1.

“A HIS further includes a pharmacy ICT system, administrative ICT systems for staff management, scheduling software for operations, as well as ICT solutions for inventory management, billing and accounting.”
16. Figure 5 can be removed and would be better redone as a table.

The figures is removed and replaced by a table.

Table 1. Implementation rate of different commercial ICISs in Flemish ICUs. (Total n =12)

<table>
<thead>
<tr>
<th>Product</th>
<th>Vendor</th>
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<tbody>
<tr>
<td>Centricity™ Critical Care</td>
<td>GE Healthcare IT</td>
<td>3</td>
</tr>
<tr>
<td>ICM</td>
<td>Dräger</td>
<td>1</td>
</tr>
<tr>
<td>Icip Critical Care / Care Vue Chart</td>
<td>Philips</td>
<td>3</td>
</tr>
<tr>
<td>MetaVision® Clinical Information System</td>
<td>iMDsoft</td>
<td>3</td>
</tr>
<tr>
<td>Picis Critical Care Manager</td>
<td>Picis.</td>
<td>1</td>
</tr>
<tr>
<td>QCare ICU</td>
<td>Critical Care Company (C3)</td>
<td>1</td>
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</tbody>
</table>

Reviewer #2 (Schekelle):

1. “my only suggestions for improving this for readers is to be careful about the use of language ("substantially more frequent" when comparing 49.2% to 29.0%; however no statistical testing; and "there is a significant difference between the type of hospital and the availability of an ICIS" (p < 0.001")). When comparing proportions between 2005 and 2008, i would suggest using language like "a greater proportion reported using such and such in 2008 compared to 2005" if you are presenting the descriptive data, and reserve words like "substantially more frequent" and "a difference" for hypothesis tests, which then of course need to be accompanied by the data to support the statement.”

We agree and added a section of statistics we performed:

**Statistics**

Statistical analysis was performed using the SPSS 15 software package. The chi-square test was used to compare proportions. A P-value less than 0.05 was considered statistically significant.

Furthermore, we have taken all these suggestions into account and the indicated sentences have been reworded as suggested by the reviewer.

A greater proportion of ICU’s reported using CPOE in 2008 compared to 2005: 49.2% vs. 29.0%.

There is a significant difference between the type of hospital and the availability of an ICIS. (see fig. 4), which is far less available in general hospitals.

All other sentences in the Result section have been changed accordingly.

2. “i would also suggest looking for and removing or qualifying statements like "Flanders, Belgium, which is quite representative for the other European regions", when there are no data to support that statement. “

We agree, and as there are no real data to support that statement we removed this sentence.

3. “And is anyone else surprised that in just 3 years the number of ICUs in Flanders increased 17%? is there any rason to expect such a rapid expansion in ICU care in terms of need?”

It is true that this is a huge expansion, but this is caused by two important reasons:
1/ change in alliances between hospitals: the last 5 years there have been numerous changes in our country (in Flandres, but also in the rest of the country) regarding that matter. The first survey therefore has regarded some ICUs as one single ICU, and vice versa (although more limited).

2/ a number of extra ICUs were approved. The reasons for this are unclear to us.

The alinea was changed as follows:

The Region of Flanders had a total of 54 ICUs in 2005, and a total of 63 ICUs in 2008. Differences between these two figures are mainly due to changing alliances between hospitals or additionally approved ICUs (all part of general hospitals). All these ICUs are approved by the national government.(see http://www.health.fgov.be).

4. “My main suggestion for the authors is that for this paper to be of use to those interested in adoption of HIT there needs to be some presentation of the context in Flanders. For example, I assume from the text in the paper that there is no governmental or other financial incentives offered to spur HIT adoption (as was done in the UK and now also in America)? what about lay media interest in this?”

See 5.

5. “I would suggest that the authors conclusion - that more investigation into the benefits of HIT in the ICU - is probably very unlikely to have much effect on adoption. Rather, I would suggest they consider context in these four domains, and report on what they can, in terms of adoption of HIT in Flanders: organization characteristics - they touch on this some with their designation of hospitals as general, tertiary non-academic, and university, but what about size? location? existing HIT infrastructure?; external factors - financial incentives or disincentives for adopting HIT, the use of public reporting or pay for performance that might spur HIT adoption (as in the UK GP contract), patient safety problems that have widespread media coverage that might be a catalyst for change; the presence of culture/teamwork/leadership at the various ICU level; and then the presence or availability of various implementation tools to make things work: consultants, internal incentives, etc. It is far more likely that differences in these contextual factors are likely to produce changes in the adoption of HIT than any more information about the effectiveness of HIT in the ICU.”

We agree that the discussion of these issues is highly relevant and added following section to the discussion:

The larger, teaching hospitals in particular are the leading ICUs investing in an ICIS (see fig. 3), in contrast to general hospitals, where only a minority have adopted high-level ICT. The figures for the adoption rate of dedicated intensive care information systems have to be understood within the specific context of Flanders. The first element in this context is the organisation of intensive care medicine in Flanders. As was stated above, there are three different types of hospital in Flanders: general hospitals (52/63 or 82.6%), tertiary non-academic referral hospitals (8/63 or 12.7%), and university hospitals (3/63 or 4.7%). General hospitals have approximately 250 to 700 beds, tertiary non-academic referral hospitals 500 to 1100 beds and university hospitals 700 to 1600 beds. The number of ICU beds for the three types of hospital comprises 5 to 7% of the total (excluding post-anaesthesia care beds, specific coronary care unit beds and neonatology beds). This study shows that the larger, teaching hospitals in particular are the leading ICUs investing in ICISs (see fig. 3), in contrast to general hospitals, where only a minority have adopted high level ICT. This has also been found in Jha et al’s survey [25]. Possibly the innovative role of these teaching centres, together with their more powerful financial possibilities and their potential for scientific research facilitated by data extraction, have influenced the ultimate decision to surmount the barriers to implementation. Concerning data extraction, it is, however, remarkable how rarely this possibility is used. Only 4 out of 12 ICUs query and use data for management or research purposes. The specific expertise needed to perform a database query, i.e. the knowledge of Structured Query Language (SQL), together with the knowledge of the database structure, apparently remains an important obstacle, despite the availability of commercial data extraction software.
The second element in the Flemish context comprises external factors which may potentially influence the implementation of an ICT within a ICU. It is, therefore, important to understand that, contrary to the USA [29] or the UK [30] for example, there are no Flemish government financial incentives for the computerisation of ICUs. Yet this survey shows that the 3 most important obstacles to implementation are the high cost of purchase and implementation of an ICIS, the need for dedicated ICT personnel for configuration and end-user training and the need for linkage to hospital information systems (HIS) (cf. table 2). This finding is in accordance with the general literature on this issue [13,25]. The government is highly interested in the cost efficiency of high quality intensive care medicine and wishes to receive the necessary data for evaluation, and therefore is actually considering linking the present financing of intensive care to a form of performance-based financing in the future. The implementation of financial incentives for a far-reaching computerization of ICUs would result in a win-win situation both for the ICUs and for the government.

Next to organisational and external factors, there are two other important contextual factors regarding the adoption rate of ICISs: the presence of a culture of teamwork and strong ICU leadership and the availability of enough ICT expertise (internally, in the hospital and ICU or externally, via ICT consultants) to make an ICIS implementation successful. Our survey has revealed that the vast majority of ICIS implementations have been highly successful, thereby indicating that, at first sight, there are no serious problems regarding the proper culture and sufficient levels of ICT expertise in Flanders. It is not excluded, however, that strong hesitation in the implementation of ICISs in certain centres may be informed by problems regarding the right culture of teamwork, leadership and ICT expertise.

Reviewer #3 (Waldmann):

1. My only criticism is that the English needs to be improved in the abstract and in the main text; this could easily be done if the text is given to someone fluent in English. For instance in the Abstract introduction:- <<Intensive care medicine is one of the most data-rich specialism, making it especially favorable for extensive use of IT.>> And in the main Introduction:- <<However, the tremendous advancement of health care is not all roses.>> There are several examples of poor English that need to be revised before publication

We agree, and the article was extensively revised by a native English speaking person.