Author's response to reviews

Title: An Ontology-based Nurse Call Management System (oNCS) with Probabilistic Priority Assessment

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Author's response to reviews: see over
Dear Dr. Sonia Aguera,

We would like to thank you and the reviewers for the valuable feedback allowing us to improve our manuscript: “An Ontology-based Nurse Call Management System (oNCS) with Probabilistic Priority Assessment” by F. Ongenae, D. Myny, T. Dhaene, T. Defloor, D. Van Goubergen, P. Verhoeve, J. Decruyenaere and F. De Turck.

We are happy to send you the revised manuscript for submission to the BMC Health Services Research journal.

Below is the list of review comments and a description of how we took the feedback into account.

**Reviewer #1 (Dr. Joanne C Turnbull):**

We appreciate your thorough feedback on the manuscript and we hope the changes and incorporation of your comments in our revision fulfil your expectations.

**Revisions**

Question 2: Are the methods appropriate and well described?
Answer: As a non-IT person, it is hard for me to judge the technical details. I would question how much an HSR researcher would be interested all the detail presented on pages 8-11. For a paper in this sort of journal, I would say that there is almost too much information. The methods contain a huge amount information - some of which seems slightly repetitive and/or superfluous for a HSR audience (I'm sure an IT audience would view this differently). Having said this, the paper is clearly written and accessible for those not from an IT background. I think the algorithm section needs simplifying for a non-technical, 'lay audience' p12-13.

Question 4: Does the manuscript adhere to the relevant standards for reporting and data deposition?
Answer: My main concern with this paper is that it is very IT focused rather than HSR focused - but that is an issue for the editors to address. It is also exceptionally long. You would have to be very interested in this subject to want to read all this in detail.

The paper describes the design of an advanced nurse call system and a detailed evaluation of its benefits.
We agree that the Methods Section was quite elaborate and detailed for the HSR audience. For this reason much of the detail information presented on pages 8 through 11 was removed, such as:
✓ The following sentences, which contained detail information about the reliability, scalability and load balancing of the oNCS system, have been removed from the General Concept Subsection:
   “It runs on multiple servers to ensure reliability and scalability. When a server goes down, another server can still process all the requests. Standard load-balancing algorithms [15][16] can also be used to distribute the requests amongst the different servers.”
✓ The last paragraph of the General Concept Subsection about the scalability and logging features of the oNCS system has been removed:
   “To improve the scalability of the system, information that is no longer needed in the ontology can be stored in a database. This can for example be done at night. A lot of information can be removed from the ontology each day such as calls that have been completely handled or patients that have left the hospital. This data can then be stored in a database so that it can be used for studies or analysis. The server additionally also contains a logging feature. It logs all the actions of the systems such as who added which information to the ontology, which calls were launched and who handled them.”
✓ Detail information was also removed from the Profile management Subsection, such as:
   o “For this research, the Reasoner Pellet [18] was used. The ontology is periodically checked offline to detect contradictions or inconsistencies in the data.”
   o “When an assistance call is made inside a sanitary room it automatically becomes a sanitary assistance call.”
   o “Strict probabilities were used here, but they can easily be translated to intervals by using equal upper and lower limits. For example, probability 0.2 becomes probability interval [0.2,0.2].”
   o Etc.
✓ Etc.

We have also reduced the length rest of the Methods Section by removing technical detail information, for example:
✓ The following paragraph about the advantages of the OSGi framework for the implementation of the oNCS system has been removed from the oNCS platform Subsection:
   “The advantages of the OSGi framework for the implementation of the nurse call system are:
   • The life cycle of a bundle can be controlled from anywhere in the network.
   • Bundles can be removed, changed and added on the fly without having to interrupt the work of other bundles. This is very important in an application where minimal service is critical. New bundles could be tested and changed without having to shut down the entire system.
   • To minimize the coupling, as well as making these couplings manageable, the bundles can dynamically discover and use each other’s services. In an environment with a lot of wireless devices this is a very important feature.
   • It is a Java platform so it has advantages such as portability and object orientation.
   • The software is modular.”
✓ The following paragraph containing detail information about the Query Services and Context Providers has been removed:
The methods in the Context Providers and Query Services are implemented by using SPARQL [28] which is a language to query OWL ontologies. SPARQL-queries are used to collect the necessary information from the Knowledge Base. The Context Providers then use this information to either adapt or create new information in the ontology. So in short, the Context Providers translate the provided information to OWL constructs which are added to the Knowledge Base. The Query Services on the other hand use the queried information to create Java-objects which can be returned to the user or application. So basically, the Query Services translate the OWL constructs from the Knowledge Base to Java-objects.
The following paragraph, which contains detail information about the visualization and logging tools of the CASP framework, has also been removed:

The CASP framework also provides two useful tools. The KbInterpretedVisualizer allows visualizing and inspecting the information in the Knowledge Base. It shows both the model and the data. Different formats can be chosen to visualize the information such as N3 [34], Turtle [35] or RDF-XML [36]. The LogViewer visualizes the information that is logged during the execution of the program.

As the Rules that react to the time-out of a call are very similar to the Rules that react to the launch of a call, the detail description of these time-out Rules has been removed:

Code fragment 2 shows the Rule that reacts to the time-out of a normal call. As Rules do not foresee construct to work with timers, this Rule triggers immediately after a staff member has been assigned to handle the call. Therefore, the functor relaunchCall() starts with sleeping the period of time that is indicated in the Knowledge Base as Time-out time for this kind of call. Afterwards, it is checked if the call still has the status Active. If this is the case, the treated_by property is cleared. This will cause the first Rule, which assigns staff members to active calls, to be launched again.

```
[relaunch_normalcall_timeout:
(?x rdf:type ncs:Normal)
(?x ncs:treated_by_nurse ?y)
(?x ncs:has_status ?CallStatus)
(?CallStatus ncs:Kind 'Active')
->relaunchCall(?x)]
```

Code fragment 2: The Rule which is activated when the time-out time of a normal call is exceeded

As a result, the complete Methods Section was reduced with one and a half pages. Additionally, we have rewritten the Algorithms Section such that it is also more suitable for a non-technical audience. The first Subsection, Priority assessment of a call, was extended with an example to illustrate how the probabilistic information in the ontology can be used to determine the priority of a call (see Reviewer #2, Major Compulsory Revision 3). In both Subsections of the Algorithms Section technical detail information was removed to make the core functionality of the algorithms more easy understandable and concise, such as:

- “Pronto is an extension of the Reasoner Pellet Error! Reference source not found. which…”
- “Pronto offers algorithms to reason with the probabilistic knowledge. They consist of reducing the probabilistic problems to the non-probabilistic variants and letting the traditional algorithms handle it from there.”
- “Some problems occurred as classical and probabilistic reasoning are not correctly combined by Pronto on the instance level of the ontology. This was easily solved, by first performing classical reasoning on the non-probabilistic part of the ontology with for example Pellet. Secondly, the results are added to the ontology as generally true probabilistic statements, thus with interval [1,1]. Finally, Pronto is used to reason on all the probabilistic statements.”

Question 5: Are the discussion and conclusions well balanced and adequately supported by the data?
Answer: Yes, but the conclusion is brief. Clearly the authors are passionate about this technology and the benefits it could provide. This does make it very one sided. There are numerous examples technological failures in health care - much of this is about how to successfully embed new technologies into practice. Since this is a HSR journal, I would like to see some discussion about the implications of the technology in a real life environment - rather than a simple acceptance that this is/could be a great technological system.
We agree that the Conclusion was rather brief. We have therefore extended it with the following sentences (bold sentences are new):

This article showed that the current nurse call algorithms could be significantly improved by storing profile information about the staff members and patients in an ontology. Moreover, it introduces a software system that could easily be used to introduce portable nurse call buttons, which improve the mobility of patients, location-awareness and safety. The person-oriented nature of the platform was clearly illustrated by using the context information about the risk factors of a patient to dynamically determine the priority of the call this patient is making. By using probabilistic reasoning algorithms, the probability that a specific call made by a specific patient has a specific priority can be determined. These probabilities are derived from the different risk factors of this patient as these risk factors will influence the probability that a patient makes urgent calls. All these probabilistic values are combined in an intelligent manner to determine the most suitable priority for this call.

The benefits of this novel oNCS system are illustrated with realistic simulations about data collected from the Ghent University Hospital. The oNCS system significantly improves the assignment of nurses to calls. Calls generally have a nurse present faster, the workload-distribution amongst the nurses improves and the priorities and kinds of the calls are taken into account. The execution time of the nurse call algorithm is negligible. However, before the system can be widely deployed, it is important that first a thorough study is done to characterize the correlation between the risk factors of patients and the reasons for their calls.

Future work will mainly focus on improving the scalability of the probabilistic assessment algorithm to determine the priority of a call. Simultaneously, hardware and algorithms for the effective and accurate determination of the location of staff members and patients will be further studied. Finally, the performance and benefits of the system will be thoroughly studied by performing realistic tests on the large-scale sensor network available within the IBCN research group.

We agree that embedding a new technology into practice is not straightforward and needs to be treated with care. We have therefore extended the Discussion Section with the following paragraphs which discuss the implications of the technology in a real life environment:

Embedding a new technology into practice is not straightforward and needs to be treated with care. The adoption rate of using Information and Communication Technology (ICT) to improve the quality of care is still very low [42][43]. One of the main reasons for this slow adoption rate is the gap in communication between the ICT and medical domain. These projects unite people with different backgrounds, such as software developers, health service researchers and nurses. Uniting all these people in a team requires effort and commitment to overcome the gap in communication. This problem can be approached by using bridge personnel who have the knowledge of multiple disciplines used in this process [44]. However, this personnel is often difficult to find.

To increase the adoption rate, the oNCS system can be introduced in several phases. Each phase should be supported with the needed training for the staff members and user research to adapt the system to the needs and feedback of the users.

In the first phase, the oNCS system software can be introduced in one department. In this
phase, the new GUI is installed on the computer of the head nurse, which he/she can use to input the needed information about the staff members and patients, and the nurses are provided with PDAs to replace their Dects/beepers. However, the mobile, portable nurse call buttons are not introduced yet to the patients. The patients keep using the nurse call buttons fixed to the walls of their room. Nevertheless, the novel nurse call algorithm is already deployed.

It is important to pick an appropriate department to test the new technology. Several criteria should be taken into account, such as openness to embrace new technology, the current usage of the nurse call system and the number of patients and nurses. It would be good to introduce the technology first in a department that would gain a lot of benefit from it. These are the departments in which there are few nurses compared to the number of patients and the patients make a reasonable amount of calls.

The most important consideration during this phase is the introduction of the GUI to the head nurse and the PDAs to the nurses. They should receive proper training to learn all the features of the GUI and the PDA. User research should also be conducted during this period, which explores the user-friendliness of the GUI and PDA. Both should be able to be customized to the preferences of the user and regular updates should be done taking the feedback of the nurses into account. It is important to emphasize to the head nurse the importance of entering all the data about the patients correctly such as their risk factors. However, a lot of the data about the patients can already be collected from the Electronic Health Record (EHR). Entering the data about the patient might seem like a tedious job for the head nurse as it introduces extra work. Therefore it is of vital importance to illustrate the benefits it introduces.

The nurses will also have to change their behavior towards receiving a call. Now they are used to often ignoring the call as multiple nurses receive it. They should be made aware that only one person receives the call at a time in the new system and that this nurse is the most appropriate person to handle the call at that time. They should only ignore it if they cannot leave their current task behind. After the time-out time another nurse will be called. This change might not be straightforward. It is important to illustrate the advantages of the new nurse call algorithm to improve adoption. This could be done by organizing sessions between the user researchers and the nurses in which several real-life examples are shown and both nurse call algorithms are discussed. As a result the nurse call algorithm could also be updated to better suit the needs of the nurses.

When the software system is properly adopted in the first department, the second phase can start. In this phase, the portable, mobile software buttons are introduced to the patients. The patients can now freely roam through the hospital and still make calls. This is perhaps the most invasive change. It is important to convey to the patients not to abuse the system. When they are far away from the department, they should only make calls for urgent, medical calls and not for example for a glass of water. Otherwise nurses might have to walk long distances to answer simple calls, which might be rather frustrating. Nurses can now also be called for patients who are not in their department e.g. because a patient becomes unwell inside a staircase far away from his/her own department. The implications of this should be thoroughly studied e.g. rules for responsibilities for patients.

In the third phase, the oNCS system can be gradually introduced into other departments of the hospital. The adoption rate in these other departments should be quicker, as the system has been thoroughly tested in the first department. Moreover, this department can be used as an illustration of the advantages of the system.

Question 6: Are limitations of the work clearly stated?
Answer: No - there is no discussion about what the limitations of the study might be. The authors do however acknowledge there is further work to be undertaken.

To remediate the fact that the limitations of the study were not properly discussed, the Discussion Section of the paper has been extended with the following paragraphs:

However, our study also has some limitations. A first limitation is that the probabilities in the ontology were only determined by domain experts. These probabilities indicate the probability that a patient belongs to a certain risk group based on the risk factors of this patient. A complete list of risk factors and accompanying probabilities could be constructed based on a thorough study of the risk factors of patients and the thoroughness of the calls that they make. However, this study is not yet conducted as the goal was to give an idea of the benefits of incorporating probabilistic priority assessment in the oNCS system. Probabilities were also added to the ontology to express the probability that a call of a particular kind made by a patient from a particular risk group has a particular priority. These probabilities were also determined by domain experts. In the future, the oNCS system could automatically learn and adapt these probabilities based on logging data from the oNCS system. This would make the oNCS system self-learning.

A second limitation is that the system has not been deployed in a real life environment yet. Our results are purely based on simulations. Nevertheless, these simulations were based on realistic data obtained from a department of Ghent University Hospital. However, no real observations were done in this department. The data was gathered by questioning the staff who works at the department and by examining the logging data of the current place-oriented nurse call system used in the department. This data gives us a clear picture of how the patients and staff members currently move around the hospital and use the nurse call system. However, if the portable nurse call buttons would be introduced in this department, the walking behavior of the patients and nurses might change as these buttons give the patients more freedom to walk around. The usage of the nurse call buttons might also change as patients would be able to make calls from anywhere in the hospital.

Question 8: Do the title and abstract accurately convey what has been found?
Answer: They accurately convey what the study is about. Less attention is given to the results. The paper focuses on the technical detail of the system.

We have shifted the focus of the paper more towards the results by removing technical detail information from the Methods Section (cfr answers to Questions 2 and 4) and by extending the Discussion Section with the limitations of the study and the implications of deployment of the oNCS system in a real life environment (cfr answers to Questions 5 and 6).
Reviewer #2 (Dr. Frederica Paganelli):

We appreciate your profound evaluation of the manuscript and we hope our answers to your questions and the incorporation of your comments in our revision fulfill your expectations.

Major Compulsory Revisions

1. Pag 2. The authors says that “Building context-aware applications on top of an ontology can ideally do this as has been proven in the domain of medical decision making [4][5]. This approach has however not been exploited to improve the continuous care of patients.” This sentence should be motivated by an analysis of related work. For instance, just by searching “intelligent hospital context-aware” on google you may find these works:


I suggest to discuss related work (not necessarily the ones cited above) in order to clarify your contribution. This could help readers in having a brief picture of works in similar research areas and in understanding the contribution of your work.

We agree that this statement should be motivated with an analysis of the related work. We have therefore added the following new Related Work Subsection to the Background Section which discusses related work and clarifies our contribution:

Related Work

On one hand, general purpose frameworks and models have been proposed that capture general concepts about contexts in an ontology and provide reasoning on this contextual model. For example, In Preuveneers et al. [10] an adaptable and extensible ontology is proposed for creating context-aware computing infrastructures, ranging from small embedded devices to high-end service platforms. In Gu et al. [11] an OSGi-based infrastructure for context-aware applications is proposed and Chen et al. [12] defined a context ontology based on OWL to support ubiquitous agents. However, all these frameworks are not specific for the healthcare domain.

On the other hand, many ontologies have been developed for the healthcare domain to model context, mainly for medical decision making [13][14]. However, some ontologies that address the continuous care context have also been developed. For example, the ontology OntHos [15] was developed to model hospital scenarios and to facilitate their interoperability and Kataria et al. [16] implemented an ontology for an intelligent hospital ward to address data sharing and semantic heterogeneity. However, these papers do not address the context-aware reasoning that should take place on top of the ontology.

Yao et al. [17] tried to fill the gap between general purpose context-aware frameworks and a healthcare domain specific ontology. They propose the CIHO model, an extensible hospital ontology to represent, manipulate and access hospital information in intelligent environments. Additionally, they present examples of ontology reasoning and rule-based reasoning to show how context-aware services can be built. However, no complete service was built and evaluated.

In this paper we build further on the work of Yao et al. to unite the research on ontologies for continuous care with the research on frameworks for context-aware applications. A general purpose context-aware framework, namely the Context-Aware Service Platform
In the Methods section the authors provide a good detail of their work. However, I suggest to reorganize or sum up the content in order to make the content more readable. For instance, pag. 8 “It runs on multiple servers…” would better go to the Implementation section. In the “General concept” subsection there are too many references to the Implementation section.

As mentioned previously (see Reviewer #1, Questions 2 and 4), we have significantly shortened the Methods section by removing technical detail information, for example:

- Detail information was removed from the Profile management Subsection, such as:
  - “For this research, the Reasoner Pellet [18] was used. The ontology is periodically checked offline to detect contradictions or inconsistencies in the data.”
  - “When an assistance call is made inside a sanitary room it automatically becomes a sanitary assistance call.”
  - “Strict probabilities were used here, but they can easily be translated to intervals by using equal upper and lower limits. For example, probability 0.2 becomes probability interval [0.2,0.2].”
  - Etc.

- Detail information about the probabilistic Reasoner Pronto was removed from the Algorithms Subsection:
  - “Pronto is an extension of the Reasoner Pellet Error! Reference source not found. which…”
  - “Pronto offers algorithms to reason with the probabilistic knowledge. They consist of reducing the probabilistic problems to the non-probabilistic variants and letting the traditional algorithms handle it from there.”
  - “Some problems occurred as classical and probabilistic reasoning are not correctly combined by Pronto on the instance level of the ontology. This was easily solved, by first performing classical reasoning on the non-probabilistic part of the ontology with for example Pellet. Secondly, the results are added to the ontology as generally true
probabilistic statements, thus with interval \([1,1]\). Finally, Pronto is used to reason on all the probabilistic statements.”

✓ Etc.

A lot of technical detail information has been removed from the oNCS platform Subsection, such as:

- The paragraph about the advantages of the OSGi framework for the implementation of the oNCS system has been removed.
- The paragraph containing detail information about the Query Services and Context Providers has been removed.
- The paragraph, which contains detail information about the visualization and logging tools of the CASP framework, has also been removed.
- As the Rules that react to the time-out of a call are very similar to the Rules that react to the launch of a call, the detail description of these time-out Rules has been removed.

✓ Etc.

As a result, the complete Methods Section was reduced with one and a half pages.

As suggested, the implementation details from the General concept Subsection of the Methods Section were moved to the Implementation details Subsection, such as:

✓ The following sentences, which contained detail information about the reliability, scalability and load balancing of the oNCS system, were moved:

   “It runs on multiple servers to ensure reliability and scalability. When a server goes down, another server can still process all the requests. Standard load-balancing algorithms [15][16] can also be used to distribute the requests amongst the different servers.”

✓ The last paragraph of the about the scalability and logging features of the oNCS system has been moved:

   “To improve the scalability of the system, information that is no longer needed in the ontology can be stored in a database. This can for example be done at night. A lot of information can be removed from the ontology each day such as calls that have been completely handled or patients that have left the hospital. This data can then be stored in a database so that it can be used for studies or analysis. The server additionally also contains a logging feature. It logs all the actions of the systems such as who added which information to the ontology, which calls were launched and who handled them.”

As a consequence, the number of references from this subsection to the Implementation details Subsection has been reduced to 1.

3. The algorithm used to reason over Priority Assessment of a call should be better explained, even by means of examples

We agree that this algorithm was explained rather brief and technical. To increase the readability of the algorithm description, we have added an example as follows (bold sentences are new):

By using Pronto, the probability that a specific call made by a specific patient has a certain priority can be determined. For example, suppose we have a patient, called Patient1, who has two risk factors, namely Diabetes and a Heart disease. Patient1 then makes a Normal call. The ontology contains the probabilistic information (as probabilistic intervals) that a patient with one of these risk factors is a High, Medium and Low Risk patient, as can be seen in Table 1. Pronto reasons on this information
It is indeed possible to reconfigure the context-aware behavior in order to handle calls with different policies. Each kind of call is implemented by a different Rule, as illustrated in the oNCS platform Subsection of the Implementation details Section. This Rule fires when a new call is added to conclude that Patient1 has $[0.5,1]$, $[0,0.3]$ and $[0,0.1]$ chance of being a High, Medium and Low Risk patient respectively. The ontology also contains probabilistic information about the probability that a patient from a particular risk group makes a Normal call with a particular priority, as shown in Table 2. Pronto combines this information with the previously calculated probability intervals which indicate that Patient1 is a High, Medium and Low Risk patient. Pronto concludes that the Normal call of Patient1 has respectively $[0.1]$, $[0.1,0.6]$, $[0.3,0.8]$, $[0.1,0.6]$, $[0,1]$, $[0,1]$, $[0,1]$ chance of having the Highest, High, Above Normal, Normal, Below Normal, Low and Lowest priority.

As shown in the previous example, Pronto calculates for each of the seven possible priorities, the probability that the call has this priority. However, one priority needs to be assigned to the call, so this priority can be used in the nurse call algorithm, see The nurse call algorithm Subsection of the Algorithms Section. To resolve this issue, the following threshold algorithm was employed on the lower bound of the probabilistic intervals. If the probabilistic value for the highest priority class is higher than or equal to the threshold for the highest priority class, it gets the highest priority. If not, the same condition is checked for high, above normal, normal, below normal, low and lowest priority classes. The thresholds can be determined based on the specific characteristics, e.g. number of calls, needs and preferences of the department or hospital. The threshold that were used for the simulations are detailed in the Collected data Subsection of the Evaluation set-up Section. If the thresholds are 0.21, 0.3, 0.24, 0, 0.05, 0 and 0, ordered from the Highest to the Lowest priority, than the Normal call of Patient1 from the previous example gets the Above Normal priority according to this threshold algorithm.

<table>
<thead>
<tr>
<th>Patient has risk factor:</th>
<th>High Risk</th>
<th>Medium Risk</th>
<th>Low Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes</td>
<td>[0.5,1]</td>
<td>[0,0.3]</td>
<td>[0,0.2]</td>
</tr>
<tr>
<td>Heart disease</td>
<td>[0.5,1]</td>
<td>[0,0.4]</td>
<td>[0,0.1]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Priority:</th>
<th>Highest</th>
<th>High</th>
<th>Above Normal</th>
<th>Normal</th>
<th>Below Normal</th>
<th>Low</th>
<th>Lowest</th>
</tr>
</thead>
<tbody>
<tr>
<td>High risk patient makes a</td>
<td>Normal call</td>
<td>0.2</td>
<td>0.6</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium risk patient makes a</td>
<td>Normal call</td>
<td>0.3</td>
<td>0.6</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low risk patient makes a</td>
<td>Normal call</td>
<td>0.6</td>
<td>0.3</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. The algorithm for call handling is described with many details. However, it is not clear if the context-aware behaviour may be reconfigured in order to handle calls with different policies (different hospitals might have different call handling policies)
the ontology. As a result, the Rule calls a *functor*. A *functor* is a piece of java code. This code implements the nurse call algorithm for this kind of call. This code thus finds the most appropriate staff member to handle the call by using the algorithm for this kind of call described in the *The nurse call algorithm* Subsection of the *Methods* Section. If a different algorithm should be used because the hospital uses a different policy only this *functor* needs to be rewritten. This is very little work as a lot of re-usable methods have been written e.g. to collect the needed information from the ontology, compare the preferences of the patient with the characteristics of the staff members, find the closest staff member and so on. We agree that this was not explained in sufficient detail in the paper. We have therefore added the following paragraphs to the *oNCS platform* Subsection of the *Implementation details* Section:

Note, that if a different nurse call algorithm should be used, e.g. because another hospital might use a different nurse call policy, only the *functor* needs to be rewritten. This can be easily done as a lot of re-usable methods and code have been provided e.g. to collect the needed information from the ontology, compare the preferences of the patient with the characteristics of the staff members or find the closest staff member.

5. *The authors say that Web Services allow “easy” or transparent” access to data. The authors should clarify what they mean with this term.*

We agree that the meaning of these adjectives is not explicitly stated. First, we made sure to use the same adjective, namely transparent (and not easy), in the whole text. Second, we added the following sentence to the first occurrence of the term transparent in the *General concept* Subsection of the *Methods* Section to explain the meaning:

The platform offers a wide range of *Web Service* [24] methods to transparently gain access to this information. Transparent access means that applications or users, who want to input data into the *oNCS system* or extract data from it, do not have to be aware of the underlying structure of the data e.g. the ontology or database. The *Web Service* provides an interface to input or extract data from the system, while the translation to the correct ontology or database query is kept completely hidden. This *Web Service* can be called from anywhere in the network.

**Minor Essential Revisions**

1. *Figures showing ontology concepts are difficult to read (Figures 3 and 5). I understand this is due also to the quality of available graphical tools for ontologies, but these figures are a bit confusing (e.g. a possible approach is to use other graphical notation, such as UML diagrams).*

We agree that the figures showing the ontology concepts, particularly Figure 3 and 5, were difficult to read. We have therefore remade the figures with Microsoft Office Visio 2007. To maintain consistency amongst the various figures, Figure 4 was also remade in this tool. The new figures can be seen below:
Figure 3: Fragment of the ontology that models the context information about the staff members and patients

Figure 4: Fragment of the ontology that models the context information about the characteristics and risk factors
Figure 5: Fragment of the ontology that models the context information about the calls and tasks

2. Pag. 17 should be summarized (especially the paragraphs describing the Query Services)

We have significantly summarized the information on page 17 by mostly removing detail information about the Query Services.

With these revisions, we hope to have complied with the reviewers’ remarks and suggestions and we would like to thank them for their useful comments on our manuscript.

We sincerely hope that our revised manuscript can contribute to an issue of the BMC Health Services Research journal.

Sincere regards,

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