Author's response to reviews

Title: Hand disinfection in a neonatal intensive care unit: Continuous electronic monitoring over a one-year period.

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Dear Editor,

We are grateful to have been given the opportunity to submit a revised version of our paper “Hand disinfection in a neonatal intensive care unit: Continuous electronic monitoring over a one-year period”. We revised the manuscript in accordance with the reviewers’ recommendations. Below, we address the reviewers’ questions and comments.

We hope that the revised manuscript is now acceptable for publication in your Journal.

Yours faithfully,

Onno Helder, on behalf of all authors
Response to the Reviewers

Reviewer 1#: C. Reichardt,

1. Question posed by authors is well defined.

2. Methods are appropriate and well defined. The observation methods should be described more detailed:
   a. Why were only two of the 5 WHO moments observed?

   In the original manuscript we observed compliance with hand hygiene prior to starting patient care and after finishing patient care. However, in the initial manuscript we described the compliance with hand hygiene only in order to emphasize the results of the used electronic dispenser. We apologize for creating confusion on the number of observed hand hygiene moments. Actually, three of the five moments were observed during this study: hand hygiene prior to starting patient care also included hand hygiene prior to invasive procedures such as insertion of devices and administration of intra venous medication. However, this study was performed prior to the publication of ‘My five moments for hygiene’ approach, which we now clarified in the Methods and the Discussion sections. Methods section (page 3, line 9-10): ‘The currently used ‘My five moments for hand hygiene’ approach was not yet been published at the time.’

   Discussion section (page 8, line 17-24): “Second, this study was designed and performed before the ‘My five moments for hand hygiene’ approach was published (7). Three of the five hand hygiene indications were measured: before patient contact, before invasive procedures, and after patient contact. The ‘My five moments for hand hygiene’ approach is nowadays considered the “gold standard” method to monitor hand hygiene compliance. We missed the 3rd and 5th moments: ‘after touching patient surroundings’ and after body fluid exposure risk. However, our hand hygiene protocol dictates that healthcare workers must wear gloves when at risk of exposure to a patient’s body fluid. They are also required to disinfect hands before and after glove use.”

   b. Were all shifts observed and how long was one observation period?

   Night shifts and weekend shifts were not observed; one observation was 60 minutes long. We added to the Methods section (page 4, line 10-11): “Data were collected during thirty 60-minute observation sessions in each sub-unit, from 8:00 a.m. to 10:00 p.m. on weekdays.”

   c. During one observation period, was observed per HCW or per care sequence?

   Observation was per care sequence. We added to the Methods section (page 4, line 11-13): “Hygienic performance starts at each new patient contact, so in theory a healthcare worker can perform more than one care sequence during an observation period..”

   d. When during the study period were observations carried out?

   Additional information concerning the observation period is provided (page 4, line 13-14): “Observations were carried out from January to February 2008 and from May to June 2008, simultaneously with hand dispenser recordings.”
e. Was there recording of HCW groups?

*Professional category was not recorded. This is clarified in the Methods section (page 3, line 23-24): “The system does not allow distinguishing between categories of healthcare workers; data are collected anonymously.”*

f. Moreover, it would be important to state whether other than wall mounted dispensers were available

*No, there was no other than wall mounted dispensers available.*

3. Data are sound in general
   a. Data on alcohol-based hand rub (AHR) consumption should also be expressed as Milliliter per patient day in order to be comparable to other findings in literature (e.g. Pessoa-Silva et al.).

   *We did not measure the amount of hand alcohol used. It could be assessed from the actuation frequency. The average number of dispenser actuations per hand-rub session was 2.8; this is theoretically equivalent to 4.9 ml, given that one complete actuation delivered 1.8 ml. However, this is not an accurate method, since we do not know actuations were complete. They may have delivered less than 1.8 ml. We therefore cannot express hand alcohol consumption as Milliliter per patient day.*

   b. The number of hand hygiene actions (HHA) should also be given per patient day, which also allows comparison with literature (McArdle et al and Scheithauer et al.).

   *In the previous version of this paper we presented the median (interquartile range) number of hand disinfections per patient day (page 5, line 15). We now compared the results of Scheithauer et al. 2011 to our findings (page 6, line 10-11): “Another study performed in a general pediatric ward measured the amount of used hand alcohol and translated this into 47 hand rubs per patient-day (9).” McArdle et al. 2006 performed an observational study in an adult ICU setting and found an average of 350 patient contacts per patient day. However, the number of hand hygiene actions per patient day was not described.*

   c. Number of HHA should also be stratified by shift and correlated with the number of dispenser uses.

   *Table 1 (page 12) in the previous version showed the median (IQR) distribution of hand disinfection events per shift.*

   d. Based on both data sets (compliance and AHR use) it would be interesting to calculate a “reference value” for AHR consumption.

   *As explained in the response to question 3b, we did not measure the amount of consumed hand alcohol. Therefore, we cannot generate a reference value.*

4. Manuscript adheres to the relevant standards for reporting data and data deposition

   1. Discussion and conclusions are well balanced and supported by the data.
a. Why were only two moments observed?

*We clarified this point above at comment 2a. We explain that actually three moments were observed.*

b. Compliance rates vary considerably depending on the observed hand hygiene opportunity (HHO).

*We calculated the compliance rates between different observation days. We added information on the variations between the separate observation days (page 5, line 17-18): “The inter-quartile range of compliance with hand hygiene determined at the separate observation days varied from 50% to 71.5%.”*

c. The lower number of HHA per HCW in the night shift could also be explained by less HHO’s

*We added at the Discussion section (page 7, line 4-5): “Additionally, in the night shifts there are fewer hand disinfection opportunities as healthcare workers only perform routine patient care and unavoidable interventions.”*

d. It should be discussed, that only observation allows a statement whether HHA occurs at the right moment. Electronic measuring systems, as the authors correctly declared, are unable to define non-compliance. But they are also unable to detect, whether the use of the dispenser correlates with a defined HHO.

*We added at the Discussion section (page 7, line 17-18): “The used type of dispenser is unable to detect whether dispenser use correlates with a defined hand disinfection opportunity.”*

6. Limitations of study are cleared stated
7. Authors clearly acknowledge any published work upon which they are building
8. Title and abstract accurately convey what has been found
9. Language needs some minor corrections

A professional editor reviewed the manuscript.

**Reviewer 2#: H. Sax**

Summary

1. Report on assessing hand hygiene compliance through electronically counting hand hygiene actions and simultaneous direct observations during one year in a neonatal intensive care unit.

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   **Major strengths:**

2. The authors apparently possess parallel data on observation on one hand and hand hygiene actions measured by dispensers on the other. This could be interesting data to compare the two methods.

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Major challenges:

3. Some questions remain regarding the objective, the setting, the study method, and the figure (see detailed comments).

4. Unclear relation between direct hand hygiene observations and electronically counted hand hygiene actions.

5. The conclusions are not really supported by the results.

Detailed comments; compulsory:

6. Pages and lines are not numbered, which makes references more difficult.

   Page numbers and lines have been added. However, the BMC Infectious Diseases guideline did not suggest using these.

7. Page 1, Abstract: The study question is not entirely clear. Because the two methods of assessment are set in parallel, one could assume that the scope was to compare the results. Else, what do authors imply with the term ‘complementary’?

   Both methods were used parallel to each other, but we did not intend to compare results. The term ‘complementary’ implied that while observation covered only a short time, the total potential observation window is much larger and is covered by the additional method. Perhaps we should have used another term. We changed the word “complementary” with “supplementary” (page 1, line 21). The supplementary monitoring could capture a trend in hand hygiene habits. This trend is another quantity than measuring compliance with hand hygiene. We suggest that using these two data collection methods supplementary to each other creates a more balanced picture.

8. Page 1: The conclusions are not really supported by the results in this abstract.
   a. In what way is the information produced by the electronic appropriate in detail?

      We re-worded this sentence (page 1, line 18-19): “We conclude that the electronic devices provide useful information on frequency, time, and location of its use, and also reveal trends in hand disinfection events over time.”

   b. In what way do direct observations supplement electronic devices?

      The electronically counted hand hygiene events represented an underestimation of the required full compliance with hand hygiene, since the observed hand hygiene was sub-optimal. To enhance clarity we rephrased the message as follows (page 1, line 19-22): “Direct observations offer essential data on compliance with the hand hygiene protocol. In future research, data generated by the electronic devices can be supplementary used to evaluate the effectiveness of hand hygiene promotion campaigns.”

      At the Discussion section we added (page 6, line 17-22): “Combining the electronically collected data and the observational data allows generating an additional tool to monitor
hand hygiene practices. The calculated number of required hand disinfection events per
day could be an incentive for healthcare workers to strive for and reach 100%
compliance. However, this calculated number is ward-specific and may be only adhered
to if conditions such as case mix, number of patient days, and patient-healthcare worker
ratio, are comparable to conditions of the initial study period."

c. In what way do they play together to evaluate the effectiveness of a promotional
campaign?

We clarified this point above at our response to comment 8b.

9. Page 2: How does the incidence of bloodstream infections relate to hand hygiene reported in the
first paragraph?

Better hand hygiene can potentially prevent infections. We added this underlying concept
of hand hygiene to the background section (page 2, line 6-7) as follows: “There is
evidence that improved hand hygiene in NICU settings results in infection reduction (3).”

10. Page 2: Are there not more studies on the topic of comparison between direct observations and
electronically counted hand hygiene actions?

Yes, there are, but all but one do not make use of bedside dispensers.
A recently published study (Cheng et al. 2011) counted hand hygiene at bedside level.
This study is added now (page 2, line 10-12): “Cheng et al. and Marra et al. concluded
that unobtrusive measurement by electronic devices results in more objective data since
direct observations might influence hand hygiene compliance behaviour (4, 6).”

11. Page 2: The listing of the objectives of this study lets one wonder why the two methods were
done in parallel without comparing their results, especially after citing the literature on this
question and declaring direct observations as expensive.

We refer to our response to comment 7.

12. Page 4: “Electronic dispensers provided suitable data on the frequency of hand disinfection
events in a clinical setting over an extended period of time.” On what basis do the authors
conclude that data provided by dispensers were suitable?

In accordance with our response to comment 7 we argue that data collected by dispensers
offered valuable data trends. The used electronic devices capture clock round all hand
hygiene events during an extended period of time. We re-worded the sentence and
replaced “suitable data” (page 6, line 3) by “data trends”.

13. Page 4: “This likely reflects the fact that the patient comes into contact with twice as many
healthcare workers during day shifts compared to evening shifts.” How has this been assessed?

We should explain that in hindsight this sentence was awkwardly phrased. We only know
that the number of healthcare workers active during day shifts is twice as high as during
evening shifts. Therefore, we re-worded this sentence (page 6-7, line 25-1): “This is
probably caused by the fact that the work floor during day shifts counts twice as many
healthcare workers than during evening shifts; the number of patient contacts is likely not doubled.”

14. Page 5: “Hence, direct observations as recommended by the World Health Organization are still needed [9].” In the argumentation for or against electronic hand hygiene monitoring -and central to the scope of this article- the question arises on why to use electronic monitoring if direct observations have still to be undertaken?

We discussed this issue in the Discussion section (page 7, line 16-21): “Combining the electronically collected data and the observational data allows generating an additional tool to monitor hand hygiene practices. The calculated number of required hand disinfection events per day could be an incentive for healthcare workers to strive for and reach 100% compliance. However, this calculated number is ward-specific and may be only adhered to if conditions such as case mix, number of patient days, and patient-healthcare worker ratio, are comparable to conditions of the initial study period.” In addition, we supported our idea on the next page (page 7, line 9-11): “Furthermore, senior staff can motivate members of the healthcare team to improve their hand hygiene practices by relating the recorded number of hand hygiene events to the calculated number required for 100% compliance.”

15. Page 5: “We conclude that the tested dispenser provides detailed information and can be complementary used to evaluate hand hygiene promotion campaigns over an extended period of time.” Was there only one disperser or are the authors referring to a specific dispenser type? I don’t think that this statement is really supported by the results. No promotion campaign is tested in this work, nor was the detail of information a subject of scrutiny, nor quality of hand hygiene.

We thank the reviewer for pointing out this error; we changed the word ‘dispenser’ (page 8, line 6) into “type of dispenser”. Furthermore, we re-phrased the sentence (page 8, line 6-7) as follows: “We conclude that the tested type of dispenser provides useful trend data that can be evaluated supplementary to the data obtained from direct observations. Although not tested as such in this study, we believe that electronic devices could be useful to evaluate the long-term effect of hand hygiene promotion campaigns.”

16. Page 5: The Methods section is usually placed between the Introduction / Background and the Results section.

During the on-line submission process it was suggested to put the Methods section at the end. We moved the Methods section back between the Background and the Results sections.

17. Page 5: “This prospective observational study was performed in a 27-bed level III NICU at a university hospital in The Netherlands.” The paragraph on the setting should provide more details on hand hygiene culture and history; promotion, dispenser location, and the established hand hygiene protocol (hand hygiene indications) that healthcare workers in this institution are meant to apply, etc. This is important to be able to read the results in comparison to other reports.

We provide the following details on the setting section (page 3, line 4-21): “The NICU is organized into three identical sub-units with nine beds each.

Appropriate hand hygiene is considered an important safety issue which is dealt with in education programs since June 2005 (2). The institutional hand hygiene protocol used during the study period dictated that hand hygiene had to be applied before patient contact, after patient contact, and before invasive procedures. The currently used ‘My five moments for hand hygiene’ approach had not yet been published at the time (7). Hand alcohol is generally preferred to soap.
The only exceptions are visible soiling of the hands, bathroom visits, and the presence of pathogens that are immune for hand alcohol, such as Clostridium and some gastroenteritis viruses. At least 3 ml of hand alcohol should be applied to rub hands for at least 30 seconds. Hand alcohol dispensers are available at each bedside. Furthermore, non-sterile gloves must be worn when there is a risk of exposure to a patient’s body fluid. Then, hand disinfection is applied before and after glove use. In addition, two sinks with soap dispensers are located next to the nurses’ station. One of these also has a hand alcohol with chlorhexidine dispenser (Sterillium, Bode Chemie GmbH & Co., Hamburg, Germany) exclusively used for surgical hand disinfection. The latter is not provided with an electronic counting device.

18. Page 6: “The median interquartile range daily number of healthcare workers who provided patient care was 44 (42-45)…” These are probably results from this study. If this is the case, they should be report in the Results section.

   Yes, this is a result from the study. We moved this information to the Results section (page 4, line 3-6).

19. Page 6: “The median numbers of nurses vs. physicians (including nurse practitioners) …”.
   Probably nurse practitioners were included with nurses not physicians.

   No, we indeed included nurse practitioners into the group of physicians

20. Page 6: “Additionally, we randomly observed healthcare workers’ hand hygiene practices by direct observations to determine compliance, the observation tool was described in a previous study [2].” When exactly did these observations take place during the entire study period?

   These observations were performed during two periods in 2008. We added this at the Methods section (page 4, line 13-14): “Observations were carried out from January to February 2008 and from May to June 2008, simultaneously with hand dispenser recordings.”

21. Page 6: “Indications for hand disinfection were before, and after patient contact. Failure to disinfect hands was recorded as non-compliance. Interventions which needed immediate life saving action were excluded from analysis [2].” Do these indications correspond to all indications that healthcare workers are meant to respect? Usually, additional hand hygiene action is needed immediately before an invasive task and after body fluid exposure even after initial hand hygiene when approaching the patient. If this is the case it should be explained. In that case observations included only a fraction of all hand hygiene opportunities.

   We added at the Methods section details of the former institutional hand hygiene protocol (page 3, line 7-9): “The institutional hand hygiene protocol used during the study period indicated that hand hygiene had to be applied before patient contact, after patient contact, and before invasive procedures.”

22. Page 6: “Trained researchers performed observations of hand hygiene events after showing sufficient high interobserver reliability (Kappa > 0.70).” In what way was inter-observer reliability determined?

   We computed Cohen’s Kappa by comparing the results of three observations performed by the expert and each researcher in training (page 4, line 15-16): “Three trained researchers and the prevention expert (OH) independently observed hand hygiene events. Interobserver reliability assessed by Cohen’s Kappa was high (κ > 0.70).”
23. Page 6: IQR probably means inter-quartile range

   Yes indeed, and we now introduce this acronym an earlier stage.

24. Page 11: I am not sure to understand the legend to this figure, since healthcare workers do not work over 24 hours. How was this median exactly calculated?

   Healthcare workers indeed do not work in 24-hour shifts as explained, but in three shifts of eight hours (page 4, line 6-7). Furthermore, at the y-axes the median (inter-quartile range) hand disinfection per day per HCW should be expressed as the median (inter-quartile range) hand disinfection per hour per HCW. We changed this in the y-axis’ figure and the figure title: “FIGURE 1. Median (IQR) number of hand disinfection events per healthcare worker plotted for each hour of the day, calculated over the one-year study period.”