

Technical Brief Disposition of Comments Report

Research Review Title: Environmental Cleaning for the Prevention of Healthcare-Associated Infections

Draft review available for public comment from December 16, 2014 to January 12, 2015.

Research Review Citation: Leas BF, Sullivan N, Han JH, Pegues DA, Kaczmarek J, Umscheid CA. Environmental Cleaning for the Prevention of Healthcare-Associated Infections. Technical Brief No. 22. (Prepared by the ECRI Institute – Penn Medicine Evidence-based Practice Center under Contract No. 290-2012-00011-I.) AHRQ Publication No. 15-EHC020-EF. Rockville, MD: Agency for Healthcare Research and Quality; August 2015. www.effectivehealthcare.ahrq.gov/reports/final/cfm.

Comments to Research Review

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The tables below include the responses by the authors of the review to each comment that was submitted for this draft review. The responses to comments in this disposition report are those of the authors, who are responsible for its contents, and do not necessarily represent the views of the Agency for Healthcare Research and Quality.

Commentator & Affiliation	Section	Comment	Response
Peer Reviewer 1	General Comments	This report is well written, organized, and easy to read. It will be a valuable resource for Infection Preventionists, Environmental Services personnel, and others.	Thank you for this comment.
Peer Reviewer 2	General Comments	<p>Interesting read. I agree with the comments of the KIs, which are on-target regarding the nuances and qualitative aspects of the topic; KI sections may be the key elements of this Brief.</p> <p>Viral activity of EPA-approved products are noted, but a very common environmental risk, norovirus, is not addressed further. Similarly, fungi are addressed only to extent of activity of products. This is likely intentional but not adequately explained (or I missed the explanation).</p>	<p>We agree that the feedback from the Key Informants (KIs) is a key component of this technical brief. For this report, the KIs included 12 individuals with expertise in infection control, infectious diseases, and hospital epidemiology (n=7); environmental cleaning processes, hospital operations and key personnel (n=3); the topic nominator (n=1); and a representative from the Centers for Medicare and Medicaid Services (CMS).</p> <p>Several KIs provided insight on what “dangerous pathogens” to address in the report; the decision was made to limit the pathogens of interest to <i>Clostridium difficile</i> (<i>C difficile</i>), and the antibiotic-resistant organisms methicillin-resistant <i>Staphylococcus aureus</i> (MRSA), and vancomycin-resistant enterococci (VRE). This decision was mainly based on the high prevalence of the pathogens, the high priority placed on preventing these pathogens by institutional leaders, and the fact that the pathogens are well studied. We mentioned the fungicidal property of cleaning agents, when applicable, to give a fuller overview of these products. However, we focused the report on the three pathogens of interest as discussed above.</p>

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Peer Reviewer 3	General Comments	The issue of environmental cleaning is an important one. While it has been mostly neglected in the past, recent greater interest in prevention of healthcare associated infections (HAIs) and the availability of new automated systems has brought environmental cleaning to the forefront. While it is true that data are meager, the issue remains important since the occurrence of preventable infections is difficult to justify. For those who are familiar with the topic, this technical brief may not add a great deal to the discussion. It should be noted, however, that decisions are often made by those who are less expert, and this document should provide a good basic knowledge to enhance local decision making. Perhaps more importantly, this document sets a rudimentary pathway for future investigation so that decisions can be made based on hard evidence.	Thank you for your comment. We hope that the technical brief will be informative for a broad audience from front line staff to institutional leaders, and that local decision makers and researchers will also find it useful.
Peer Reviewer 4	General Comments	excellent report on this topic	Thank you for your comment.
Peer Reviewer 5	General Comments	Overall this is a rich and informative document. It provides a thorough overview of the available evidence, knowledge gaps, and challenges related to optimizing cleaning and disinfection of solid surfaces in health care facilities that serve adults. It provides a similarly thorough discussion of methods to measure cleanliness. The technical brief is timely given the recent rapid increase in new cleaning, disinfection and monitoring technologies.	Thank you for your comment. We appreciate your review of the report.
Peer Reviewer 6	General Comments	General Comments: An excellent, directed review of the state of the science centered on some very pertinent guiding questions. I consider myself fairly knowledgeable about both the state of the science and where the field needs to move to achieve greater clinical and public health relevance and I felt like it struck that perspective fairly well. I think there are certainly different perspectives that might evaluate this report differently. For example, it could be critiqued for not being detailed enough in technical details of disinfectant certification by EPA (and I think it could still be improved in that area) and modes of disinfectant action along with such issues as contact time,	We agree that the EPA plays a vital role in setting standards for disinfectants, and have added text to the External Factors section of Guiding Question 2 and the Next Steps section to emphasize their role. We endeavored to clearly identify whether products were EPA certified, and provided a link to information describing their regulatory processes. We also attempted to include a representative from the EPA among our KIs, but our efforts to recruit a participant were unsuccessful.

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		<p>interaction of disinfectants with organic load, and their interaction with manual cleaning methods. I think another valid critique would be the general context of evidentiary hierarchy with rather strict adherence to the randomized control trial (RCT) as the pinnacle of evidence. Is such a hierarchy and target of RCTs even practical and realistic for many infection control interventions, especially those with a rather modest effect size? Perhaps a future TB could focus on surrogate or intermediate steps in the ‘pathogenesis’ of patient-to-patient transmission and how the field could turn its attention to better estimation of parameters that would inform models, in this case models that would link patient-centered outcomes to environmental contamination (EC). Even this TB could benefit from some discussion of what is currently known about the likely etiologic fraction of all healthcare-associated infections(HAIs) or even multidrug-resistant organism (MDRO) transmission events that involve environmental surface contamination events. The EIC-related events that are most protected from confounder effects, namely contamination of high-touch, stationary, room surfaces that ‘carry’ an MDRO from a previous patient room occupant to a subsequent patient room occupant--these probably account for ~5-10% of all MDRO transmission events. In turn, all MDRO transmission events (or even including non-MDR organism transmission events) have probably a small etiologic impact (~20%?) on hospital-onset HAIs compared to such issues as hand hygiene, device use, patient underlying illness and how those illnesses are managed, including antibiotic use. Thus the impact of terminal room cleaning and disinfection on pathogen ‘carryover’ as effective as new ‘NTD’ method may be in stopping this (e.g close to 100% efficacy?), is likely to translate into a very small effect size in an HAI outcome (e.g. 10% x 20%=2%). As good as this TB is in what it sets out to achieve, and does achieve, it is still a bit plebian in its failure to broach such issues that, ultimately, call into question the current adaption of evidentiary</p>	<p>We agree that RCTs are often impractical for examining the effect of disinfection and monitoring strategies. Thus, we included all controlled study designs in our brief, not just RCTs. Ultimately, few of the studies we included were RCTs. It is also important to note the limitations of non-randomized or non-controlled studies, and throughout the Brief we have identified those limitations.</p> <p>We also added text to the Background discussing the role of surface contamination in the chain of pathogen transmission and patient infection, and included references to recent articles addressing this topic.</p> <p>.</p>

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		hierarchies to areas outside of drug effectiveness evaluations (where the RCT rightly reigns supreme). In all of patient safety we need more rigorous conceptual frameworks that translate into models with real investments in parameter estimation. Infection control, and especially EC, is no exception.	
KI Reviewer 1	General Comments	Thorough and clearly written report overall. It seems odd, however, that for the grey literature review conference abstracts were excluded; much of the most current literature is first published as abstracts.	Our search of the gray literature did include conference abstracts published by the Society for Healthcare Epidemiology of America (SHEA) and Infectious Disease Society of America (IDSA) from 2012 to September 2014. We did not, however, identify any abstracts that met our pre-defined inclusion criteria.
KI Reviewer 2	General Comments	This report is very well written and provides an excellent review of the existing literature and provides input on what next steps are needed.	Thank you for your comment.
KI Reviewer 3	General Comments	Excellent report. See attached file.	Thank you for your careful review of the report. See response to comments below.
KI Reviewer 4	General Comments	Page numbers in comments below refer to numbering on top of manuscript, not the page bottom.	Thank you for your comment.
KI Reviewer 5	General Comments	Thank you for the opportunity to review this technical brief. The brief is well written, timely, and it summarizes a great deal of information in an organized fashion, clearly identifying the key issues, gaps in information, and next steps. The report is well balanced without any clear bias. My only major comment is that I was disappointed Gram negative agents were excluded from the systematic review and that fact should be addressed as a major limitation throughout. Also I feel the sections on antimicrobial surfaces need significant expansion as they are superficial at this point.	A technical brief is intended to serve as an inventory of the existing evidence and help to identify gaps in existing research. It is not a systematic review in that no appraisal, grading or quantitative synthesis of the evidence is performed and we do not draw conclusions. However, we agree that restricting the pathogens to <i>C difficile</i> , MRSA, and vancomycin-resistant enterococci (VRE) is a limitation of the brief. We have added text describing this limitation. We have also added text to the section Self-disinfection Surfaces in Guiding Question 2 as requested.

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KI Reviewer 6	General Comments	It appears from the comments the KI's are primarily IP's, ID Docs and researchers. Comments and opinions swayed heavily to academia and clinicians with little emphasis on the competencies of environmental services professionals as a management entity with required skill sets and competencies similar to their clinical counterparts. As is the case with IP's and ID docs, there is a certification program for environmental services and on going available education and training through the professional organization. However, there is widely accepted opinion that use of the words housekeeping, EVS or ES while common, diminish the importance of the science of cleaning and surface disinfection and of environmental services as a profession. Recommend replacing these terms and using environmental services spelled out every time.	Thank you for your suggestion. We sought to select a panel of KIs that was balanced in its' members expertise in the fields relevant to this Technical Brief. One quarter of the KIs are professionals in environmental services and related management of hospital services; the remainder are evenly distributed across the fields of hospital infection prevention, infectious diseases, and research. The KIs uniformly praised the training, expertise, and professionalism of environmental services personnel, and emphasized their central role in patient safety. They also advised us not to use terms like "housekeeping" or "cleaners" for the reasons you suggest, and we avoided those and similar terms except when directly citing studies, or as components of our literature search strategy. We utilized the familiar and widely used abbreviation for environmental services ("EVS") throughout the Technical Brief in order to increase the brevity and readability of the text.
KI Reviewer 6	General Comments	Lines 45-51 Suggesting inclusion of IP's in environmental services leadership supports the notion of a lack of a knowledge base, education, resources and certification. Rooting environmental services into another discipline will not improve outcomes. Who or how environmental services reports up is not the problem, time, resources and process are. Suggesting this in the paper has the potential to create more problems than it may solve.	Thank you for your comment. Several of the KIs suggested that including infection preventionists in leadership roles could lead to more integrated processes, greater resources, and a better feedback and improvement loop.
Russell Olmstead Trinity Health	General Comments	Very helpful resource. Thanks and appreciation are in order for the authors and AHRQ in supporting this important report.	Thank you for your comment and careful review of the report.
Peer Reviewer 1	Background	The background correctly summarizes both the current issues & concerns associated with environmental cleaning. It identifies the scope of the report.	Thank you for this comment.

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Peer Reviewer 1	Background	Guiding Questions: The guiding questions are appropriate, detailed, and thorough. The guiding questions and the responses address broader aspects of EC beyond choosing a product by cost. They serve as a template for facilities to use when reviewing current and proposed EC practices & products. They also address factors associated with monitoring & ensuring sustainability.	Thank you for your comment.
Peer Reviewer 2	Background	I would favor a brief paragraph noting that the perceived role of the environment in infection control has been on a pendulum: In the 1940s-1960s, infection control was all about the environment with room fogging after patient discharge a common approach. Then in the 1970s-1980/90s, the environment was relegated to an esthetic but not infection control issue. Now, the environment, especially as noted in this report for C difficile, MRSA, VRE, and other pathogens, is recognized as an infection control issue.	Thank you for your suggestion. We agree that the historical trends of research in infection control are important, but we feel a description of such trends is outside the scope of this Technical Brief.
Peer Reviewer 2	Background	Guiding Questions: Re questions to address, the hierarchy of evidence proposed by McDonald and Arduino (Clin Infect Dis. (2013) 56 (1): 36-39) is worth citing.	The feasibility of different study designs is an important consideration that we now address in the Summary and Implications, but we are unable to change the focus of the Guiding Questions at this stage in the process.
Peer Reviewer 2	Background	Re Question 1, any role for microbiome-type studies?	Thank you for your question; however, we are unable to change the scope of the report at this time.
Peer Reviewer 3	Background	The background section seems reasonable, but warrants some comments. While line 13 of page 1 indicates the importance of carbapenem resistant Enterobacteriaceae, they are not part of the technical brief. While this may or may not be appropriate, it may be useful to have a brief statement of why they were excluded (page 3, lines 8 and 9, noted).	As described above, the decision to limit the pathogens of interest to <i>C Difficile</i> , MRSA and VRE was mostly based on the high prevalence of the pathogens, the high priority that institutional leaders are placing to prevent these pathogens, and the fact that the pathogens are well studied. We have added text to the Methods Section prior to Table 1 to address this.

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Peer Reviewer 3	Background	In lines 17 and 18 on page 2, the authors indicate that there is a threshold below which pathogen transmission is minimized and can be considered safe. While this does seem to be intuitive, it is not clear that there is a "safe" level of contamination, but rather there may be a level of contamination where risk assessment would consider the organisms to be a negligible threat. This may be related to both the number of organisms, type of organism, and patient host at risk.	We have added the following text to address your concerns: "Establishing an evidence-based benchmark for defining a surface as clean will depend on the patient population, current cleaning and disinfection processes, and specific pathogen(s) being targeted."
Peer Reviewer 3	Background	In lines 29 and 30 of page 2, the issue of sustaining long-term improvement is noted. While it almost seems an afterthought in this part of the document, it may be the critical element for HAI prevention.	We agree that sustainability is a critical element for HAI prevention and describe it as such in the background section: "Finally, sustaining long-term improvement is a critical but challenging goal." There is a section in the Summary and Implications section titled "Implementation and Process Research" that describes sustainability of HAI preventive strategies to be an important component but not well studied. Please note that the evidence for sustainability can be found under Guiding Question 2 (Implementation).
Peer Reviewer 3	Background	c. Guiding Questions: The guiding questions seemed reasonable and appropriately comprehensive.	Thank you for your comment.
Peer Reviewer 4	Background	Background: p 1 may want to include mention of patient privacy curtains even though limited to hard surfaces and objects	On page 2, we now include "patient privacy curtains" as another vector for disease transmission.
Peer Reviewer 4	Background	p 2 consider mention of some common surface disinfectants affecting ATP readings (enhance or interrupt ATP signal) Shama G, Malik DJ. The uses and abuses of rapid bioluminescence-based ATP assays. Int J Hyg Environ Health 2013;216:115-25.	We now cite the Shama study, and added the following text: "Lastly, some studies have shown that certain disinfectants can interfere with ATP readings."
Peer Reviewer 4	Background	Guiding Questions: no additional comments	Thank you for your comment.

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Peer Reviewer 5	Background	The authors might consider defining “cleaning” and “disinfection” early in the Background section, stating how they plan to use the terms, and then taking care to use them consistently throughout the document. In some places, the terms appear to be used interchangeably. For example, p 1 line 51, “Assessing Disinfection Following Environmental Cleaning” versus p. 2 line 13-14, “...the need for identifying standardized criteria for determining that surfaces are “clean”...	We have now defined these terms in the Background, as follows: “In this report, we use “cleaning” to refer to removal of general surface debris, and “disinfection” to refer to use of agents or technologies designed to kill microbial organisms.”
Peer Reviewer 5	Background	The authors do a good job of defining the scope of the brief, e.g. solid surfaces in rooms of adult hospital patients.	Thank you for your comment.
Peer Reviewer 5	Background	Guiding Questions: The questions are appropriate and well thought out.	Thank you for your comment.

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Peer Reviewer 6	Background	<p>I think this could benefit from a brief discussion of how contaminated environmental surfaces can play a role in the epidemiology of HAIs and specifically MDRO transmission. This would of course require a conceptual model—I would recommend you look at the figure in Otter JA et al. <i>Infect Control Hosp Epidemiol</i> 2011;32(7):687-699 although I am sure you could find variations of something like this elsewhere—it basically shows that environmental surfaces become contaminated from patients and this contamination can either pass to the next patient directly (i.e. same room carryover or reusable patient care equipment that goes from room to room) or indirectly via contamination of the hands of healthcare personnel. In such a discussion the important confounders in the relationship between EC efficacy and patient-centered effectiveness could be mentioned including hand hygiene, single vs. multiple patient rooms, and factors that increase/increase/decrease both the susceptibility of patients to colonization/infection but also contagiousness (i.e. device and procedures, antibiotics, other clinical factors). Although some of these points are brought up later in the discussion of Guiding Question #3 results, it would be helpful to discuss these in the background as such a contextual framework is key for understanding. Also, there is a major omission throughout this document and that is the important role of EPA in the regulation of all disinfectants as well as the NTDs. The only place the role of EPA certification of disinfectants and cleaning technologies (they do indirectly certify these through the disinfectants and how they are allowed to be used) is even mentioned is a brief mention of FIFRA in the last row of Table 2. Yet the EPA/FIFRA regulatory role is the major regulatory framework that in any way addresses effectiveness.</p>	<p>We added text to the Background discussing the role of surface contamination in the chain of pathogen transmission and patient infection, and included references to recent articles addressing this topic.</p> <p>We agree that the EPA plays a vital role in setting standards for disinfectants, and have added text to the External Factors section of Guiding Question 2 and the Next Steps section to emphasize their role. We endeavored to clearly identify whether products were EPA certified, and provided a link to information describing their regulatory processes. We also attempted to include a representative from the EPA among our KIs, but our efforts to recruit a participant were unsuccessful.</p> <p>We also recognize that there are many other key interventions besides disinfection of the environment that are important for reducing HAIs (hand hygiene, decolonization, modifying patient-related risk factors), but these are beyond the scope of our brief, which focuses on the environment itself.</p>

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Peer Reviewer 6	Background	Guiding Questions: Again, I think these are very pertinent questions and appropriately limited. However, I hope that the prominent mention of the US FDA in regards to environmental disinfection, alongside OSHA (Guiding Question 2, bullet 5) is just a typo and that this was supposed to list FDA. Still, as mentioned above, EPA regulatory approval, including their testing standards deserves a MUCH bigger role in the discussion of this brief.	We have added text in the Findings and Next Steps emphasizing the role of EPA, and included a link to EPA information on registration of microbial products We also have noted OSHA's role in addressing health care worker safety in handling cleaning and disinfecting agents..
KI Reviewer 1	Background	OK	Thank you for this comment.
KI Reviewer 1	Background	Guiding Questions: We saw these previously and gave feedback; I don't think these have changed much. They seem comprehensive and clear.	Thank you for this comment.
KI Reviewer 2	Background	This section does a great job of describing the problem and how it relates to spread of HAIs. However, in the background section there is no over-viewing content indicating that the physical action of cleaning alone is NOT sufficient to adequately reduce or eliminate HAI causing microorganisms from a high-touch surface and that is why a "disinfectant" component is also needed. This may be achieved by using a disinfectant-cleaner or by cleaning with a cleaning agent only followed by a disinfectant step (either a liquid disinfectant such as bleach or by "no – touch" disinfectant methods).	We have added this point to the overview, as follows: "Both the physical action of cleaning surfaces as well as application of a disinfectant are critical in reducing microbial burden on environmental surfaces."
KI Reviewer 2	Background	Page 9: The review indicates that use of UV-visible markers "increases cost", yet doesn't make this same statement for ATP detection methods. Suggested change: Reword the paragraph to reflect that ALL the monitoring methods increase costs to varying degrees. Conceptually, monitoring the compliance of housekeeping staff with the application of the surface disinfectant agent makes sense to ensure optimal microbial killing. However, clinical data to support the value of the additional cost of monitoring EC in preventing transmission of HAIs is lacking.	We have removed the text "but also increases costs" since all monitoring strategies increase costs other than visual observation. In addition, we have text on page 1 of the report under the section Assessing Disinfection Following Environmental Cleaning stating that "Several strategies have emerged that may improve the quality of visual assessment but introduce additional expense and other potential disadvantages."
KI Reviewer 2	Background	Page 10: There should be rewording of the last paragraph to indicate: "...removing and/or killing of these organisms."	We have reworded this sentence as suggested.

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KI Reviewer 2	Background	Guiding Questions: This section is clearly delineated. However, subsequently in the report there is data from some Australian, New Zealand and Canadian clinical studies – it might be better to modify the inclusion criteria to reflect this in the “setting” and “technology” sections of Table 1.	Thank you for pointing that out. Table 1 now includes the following text for Setting: Patient rooms and isolation rooms in acute care hospital wards in the United States, Canada, Western Europe, and Australia.
KI Reviewer 3	Background	Excellent summary. See attached file.	Thank you for your review of the report.
KI Reviewer 3	Background	Guiding Questions. These are important but, at times difficult to relate to the text of the report. See attached file.	Please see our responses to your comments below.
KI Reviewer 3	Background	P8 - The introduction presents a clear, succinct overview of the issues. The final two sentences in particular provide a brief but clear basis for the importance of the report.	Thank you for your comment.
KI Reviewer 3	Background	P8, L8 - Over the past several years the term “hygienic cleaning” has become increasingly used as a more specific and relevant synonym for “environmental cleaning”. While the use of the term “hygienic cleaning”, in my opinion, is to be preferred, the fact that the technical brief is based on literature published over twenty-four years could favor using the term “environmental cleaning” in this publication.	We agree that the more traditional term “environmental cleaning” should be used in the report.
KI Reviewer 3	Background	P8, L 20 -Since most (none in general use in endemic settings) of the disinfection technologies commercially available have not been shown to have a “benefit”, it would be more accurate to say “potential benefit” rather than just “benefit”.	We have made the adjustment as suggested.
KI Reviewer 3	Background	P8, L40 - Since the no-touch technologies all require pre-cleaning based on both laboratory studies as well as manufacturers’ recommendations, they should not be viewed as “alternatives” to “manually applied chemicals”. I would suggest deleting “an alternative” and substituting “in addition”.	We agree and have made changes as suggested.
KI Reviewer 3	Background	P8, L53 - While all hospitals would hope to “select optimal cleaning methods”, the Technical Brief clearly concludes that we are not presently able to define “optimal”. Therefore, the word “effective” substituted for “optimal” would improve the accuracy of the sentence.	We agree and have made changes as suggested.

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KI Reviewer 3	Background	P9, L7 - While different systems exist for evaluating either thoroughness of environmental cleaning and/or its effectiveness (the latter can only be directly evaluated microbiologically), it should be noted that all systems described are associated with increased costs (as noted at the bottom of p. 8). I would suggest that deleting the words “but also increased cost” from the sentence describing UV light implementation.	We agree and have made changes as suggested.
KI Reviewer 3	Background	P9, L13 - While the issue of defining cleanliness as a standard is thoroughly addressed in the body of the report, and given the fact that it is very likely that such a “standard” will not be able to be defined objectively and clinically in the foreseeable future, I would suggest that the word “need” does not reflect the nature of the subsequent discussion of this issue. In this context, the first sentence of this paragraph could be eliminated or the words “wish to identify ...” substituted for “need for identifying”.	We have made changes as suggested.
KI Reviewer 3	Background	P9, L20 - The “Managing and Monitoring Environmental Services Personnel” subheading suggests that those two activities are independent, which they are not. This issue could be clarified by using the word “Programmatic” instead of “Managing and” in the heading since all of the actions carefully and thoroughly described in the text cannot be performed appropriately, other than within a “program”.	The heading was changed as suggested.
KI Reviewer 3	Background	P10, L5 - It would appear to me that several aspects of guiding question 1 were not directly addressed, including: How do cleaning, disinfection and monitoring strategies interact? What advantages and disadvantages may be associated with each option? Are there current benchmarks for defining clean surfaces ...	We have added text in the Findings to address these subquestions more directly.
KI Reviewer 4	Background	Overall, background section clearly written and the issues are adequately described.	Thank you for your comment.
KI Reviewer 4	Background	P 8 line 9 - Background neglects nonporous surfaces such as some furniture and curtains (addressed on bottom of page 9)	We have revised the Introduction to include examples of porous (e.g., curtains, mattresses) and nonporous items (e.g., bed rails) in patient’s rooms.

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KI Reviewer 4	Background	P 8 lines 13-16 - States that surfaces play an important role in the transmission of pathogens but doesn't review data supporting this claim. There is a lot of uncertainty on the role of the environment in transmission of pathogens – suggest authors make reference to this. The statement “appropriate cleaning of these surfaces is necessary to reduce the risk of HAI “ is also a bit misleading as HAIs can be reduced by attention to other things such as hand hygiene, devices, etc.	We agree that other factors are crucial for reducing transmission of pathogens. We address the larger context in the Summary and Implications, and we have revised the Background to indicate that we focused on specific pathogens for which the clearest evidence for an association between surface disinfection and transmission has been established.
KI Reviewer 4	Background	P 9 line 14-17 - as written implies that determining a safe threshold of contamination is feasible	We have added text to page 9 indicating that there is a “desire to establish” safe thresholds of contamination.
KI Reviewer 4	Background	Guiding Questions: - P 10 line 18 – are we referring to “patient care environment or non porous surfaces only?	Thank you for pointing that out. While the guiding question more broadly refers to the “patient care environment” our inclusion criteria notes that we are specifically limiting the report to non-porous surfaces. We are unable to refine the questions further.
KI Reviewer 4	Background	Guiding Questions: P 10, line 25, 4th bullet - does each option refer to cleaning/disinfection only or to monitoring as well?	This bullet point has been rewritten to clarify the intent of the question - to address potential confounding or contextual factors that may affect the success of different approaches..
KI Reviewer 4	Background	Guiding Questions: P 10 line 35 – first bullet under guiding question 2 is confusing to me as written - not sure if elements is the correct word	The use of “elements” in this sentence is alluding to confounding factors that may impact the implementation of cleaning, disinfection or monitoring strategies. We changed the term to “contextual factors” for clarification.
KI Reviewer 4	Background	Guiding Questions: P 11 line 19 – believe the confounders are more complex than those listed – includes role of endogenous organisms in causing infection	We agree that the bulleted list is not comprehensive, but provides examples.
KI Reviewer 4	Background	Guiding Questions: P 11 line 29, not sure I understand bullet	The bullet for “combining or collapsing categories to streamline data” refers to whether and how to optimally design studies that include multiple types of pathogens, different kinds of surfaces, and/or various disinfection strategies.

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KI Reviewer 5	Background	In the introduction, i was expecting to see mention of how some organism can live for weeks or even months on some hospital surfaces. It would even be useful to have a table listing them. This section is also lacking references.	We have expanded the text in the introduction to note how the organisms of focus in this study can persist on surfaces for up to months, as well as added appropriate references.
KI Reviewer 5	Background	Page 9 ,line 8: The increase in expenses associated with uv/glo-germ seems overstated.	We have removed the text "but also increases costs" since all monitoring strategies increase costs other than visual observation.
KI Reviewer 5	Background	Page 9, lines 8-11: Would emphasize that ATP cutoffs have not been established to determine what is clean vs. what's not.	We have added the following text to address your concerns: "In addition, universal cutoffs for ATP levels and cleanliness have not been established."
KI Reviewer 5	Background	Page 10, line 5-10: I think not having included Gram negative organisms is a severe limitation that needs to be discussed here.	As described above, we have added text to the Methods and Summary and Implications sections describing this limitation.
KI Reviewer 5	Background	Guiding Questions: No comments.	Thank you for your comment.
KI Reviewer 6	Background	The background statement did not tell anything not already known. EC for the prevention of HAI's is affected by many factors and there is substantial evidence comparing many of the technologies and products. Problem is lack of agreement on the merits of the evidence and if the evidence is biased.	Thank you for your comment.
KI Reviewer 6	Background	Page 2 Line 13: Defining clean or agreeing on clean is a quest not likely to be achieved any time soon. Additionally clean for one patient is not clean for another. Clean in a bone marrow unit is very different than clean for a patient under observation. Clean is heavily dependent on time allowed to do the job and the process followed, no different than the process to properly adhere to hand hygiene.	We have added the following text to address your concerns: "Establishing an evidence-based benchmark for defining a surface as clean will depend on the patient population, current cleaning and disinfection processes, and specific pathogen(s) being targeted."
KI Reviewer 6	Background	Guiding Questions: Well written thought provoking Guiding Questions. However, it appears question 3 did not garner the level of attention the previous questions did or it was not clear to me.	Guiding Question 3 is presented in two sections. Evidence of the Effectiveness of Strategies for Environmental Cleaning can be found on pages 21-24. Evidence of the Effectiveness of Strategies for Monitoring of Cleanliness can be found on pages 25-28.

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KI Reviewer 6	Background	Page 3 Lines 38, 39 and 41 were not addressed.	We have added text in the Findings to address these subquestions.
Russell Olmstead Trinity Health	Background	<p>1 Consider adding to Introduction the category of soft surfaces e.g. cubicle curtain as this is increasingly a focus perception as another type of reservoir. Heres some recent studies involving this type of surface Mahida N et al. Outbreak of invasive group A streptococcus infection contaminated patient curtains and crossinfection on an ear nose and throat ward. J Hosp Infect. 2014 Jul8731414 Trillis F 3rd</p> <p>Eckstein EC et al. Contamination of hospital curtains with healthcareassociated pathogens. Infect Control Hosp Epidemiol. 2008 Nov291110746</p> <p>Ohl M Schweizer M Graham M Heilmann K Boyken L Diekema D. Hospital privacy curtains are frequently and rapidly contaminated with potentially pathogenic bacteria. Am J Infect Control. 2012 Dec40109046.</p> <p>While I realize that focus of this report is on hard surface but may be worth at least raising this point perhaps clarifying that this is aimed at nonporous surfaces and materials.</p>	<p>Thank you for forwarding the references. We have added text to the Background indicating the threat of contamination on both porous and nonporous surfaces and noting the focus of the brief on nonporous surfaces.</p> <p>Regarding the threat of privacy curtains in particular, we have revised the text in the Background section to read “Vectors for disease transmission may include medical instruments like endoscopes, fabric surfaces such as linens and patient privacy/room curtains, and the many people a patient encounters daily, including health care providers, ancillary services, visitors, and other patients.”</p>

Commentator & Affiliation	Section	Comment	Response
Russell Olmstead Trinity Health	Background	<p>2 Pg. 9 top of page Probably worth adding some brief content highlighting that some surface disinfectants can interfere with ATP readings see</p> <p>Omidbakhsh N Ahmadpour F Kenny N. How reliable are ATP bioluminescence meters in assessing decontamination of environmental surfaces in healthcare settings PLoS One. 2014 Jun 1896e99951</p> <p>Gold KM Hitchins VM. Cleaning assessment of disinfectant cleaning wipes on an external surface of a medical device contaminated with artificial blood or Streptococcus pneumonia. American Journal of Infection Control 41 2013 9017</p> <p>Sciortino CV Giles RA.. Validation and comparison of three adenosine triphosphate luminometers for monitoring hospital surface sanitization a Rosetta Stone for adenosine triphosphate testing. Am J Infect Control. 2012 Oct408e2339</p>	<p>We have added the following text to address your comments, and included the relevant citations:</p> <p>“Lastly, some studies have shown that certain disinfectants can interfere with ATP readings.”</p>
Peer Reviewer 1	Methods	Methods were clearly stated with inclusion and exclusion parameters defined.	Thank you for this comment.
Peer Reviewer 2	Methods	Use of "tabled" to denote making a table sounds like jargon (pg 7).	We have revised the text to read “detailed in tables.”
Peer Reviewer 2	Methods	Appear adequate for this type of report.	Thank you for this comment.
Peer Reviewer 3	Methods	The methods also seemed reasonable. Since the data are meager regarding environmental cleaning and methodology, the document does discuss the issues of key informants, gray literature search, and properly published significant literature. Table 1 also seems clear.	Thank you for this comment.
Peer Reviewer 4	Methods	p 6 Consider some comment on quality of research reviewed... There are a variety of tools used to score, such as those used by HICPAC Umscheid CA et al Am J infect Control May 2010	Thank you for your comment. Please note that a technical brief is a narrative report and does not critically appraise or grade evidence or synthesize outcome data.

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Peer Reviewer 5	Methods	The section clearly and concisely describes how the data for the brief were collected and integrated. Engagement with Key Informants is described.	Thank you for this comment.
Peer Reviewer 6	Methods	Seem appropriate, standard and 'grey' literature searches seem comprehensive.	Thank you for your comment.
KI Reviewer 1	Methods	p 5, line 38 and throughout this section. 'Gray' literature is misspelled. In addition, I would suggest a very clear definition of grey literature.	The use of "gray" conforms to the U.S. Government Printing Office style manual. The following text has also been added to the Gray Literature Search of the Methods section: Gray literature includes reports, studies, articles, and monographs produced by federal and local government agencies, private organizations, educational facilities, consulting firms, and corporations that typically do not appear in the peer-reviewed journal literature.
KI Reviewer 2	Methods	This section is clearly delineated.	Thank you for this comment.
KI Reviewer 3	Methods	Well described.	Thank you for this comment.
KI Reviewer 4	Methods	P 13 line 43 – Table 1, Inclusion and exclusion criteria, under Literature – none of the included study types accurately describe quasi-experimental before and after or interrupted time series studies that are included in the review. this needs to be amended	Thank you for calling attention to this. We have modified the table to include these types of study designs.
KI Reviewer 5	Methods	Again, would like to see justification as of having excluded Gram negatives and this fact discussed as a limitation.	As noted earlier, we have added text to the Summary and Implications section describing this limitation.
KI Reviewer 6	Methods	Search methods are consistent with other compendium type work and on balance the studies are sound. However, it is the opinion of environmental services leaders that future research needs to be funded in a manner that avoids conflicts of corporate interest or bias, they be performed in field and include environmental services leaders. Many of these studies lack active engagement and were more directive of staff activities.	Thank you for pointing this out. We have added a section on Funding to the Summary and Implications section alluding to the need for quality unbiased research.
Russell Olmstead, Trinity Health	Methods	none excellent job to all who developed this report.	Thank you for your comment.

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Peer Reviewer 1	Findings	<p>The findings were presented in a concise and easy to read manner. The findings were well organized in a format that followed the guiding questions. Evidence based studies were well summarized. Key Informant feedback was integrated into the findings; the KI feedback is a critical addition to the findings as the feedback introduces broader & sometimes less tangible aspects to why interventions succeed or seem to fail. The KI feedback related to how products are used (p.13), staff training (p 14), individual hospital patient safety culture (p 14-16), and how clinical staff view the role of Environmental Services staff (p. 14) are very valuable aspects for facilities to consider when looking at their programs. Implementation and management tools noted in the report (p 17-18) are also valuable.</p> <p>Reference list is extensive. Tables and figures summarizing details from the references were clear & helpful.</p>	Thank you for your comment. We agree that the addition of KI feedback is a key component of the report.
Peer Reviewer 2	Findings	Good use of the Analytic Framework and institutional issues in Question 2.	Thank you for this comment.
Peer Reviewer 2	Findings	AHP is used in text several times but only defined in Table C-3.	Thank you for pointing that out. We have chosen to write out “accelerated hydrogen peroxide” in the body of the report.
Peer Reviewer 2	Findings	Microfiber and ultramicrofiber are used repeatedly in text and tables. A brief definition would help readers.	We added definitions to Table C-3 where both terms are used.
Peer Reviewer 2	Findings	Table 4 appears to be a sub-set of Table 3, though some of the numbers don't match and it is not clear to me why that is.	We have removed Table 4 from the final report. It was intended to highlight the pathogens.
Peer Reviewer 3	Findings	Figure 1 on page 8, has an empty box in the left column. It is not clear if something is missing or not.	Thank you for pointing that out. We corrected the omission of “874.”
Peer Reviewer 3	Findings	The discussion of the modalities for routine disinfection of surfaces in patient rooms, while brief, is clear and does note the pros and cons of each item. This clarity regarding cleaning modalities with references should be most useful to many readers. The section on monitoring modalities is in a similar format and should be similarly useful.	Thank you for your careful review of the report.

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Peer Reviewer 3	Findings	The section on context (page 13 and following) is more difficult. While there is a good deal of information and much musing on the issue of training, particularly from key informants, training has not been successful in such obvious areas as hand washing and consistent use of personal protective equipment. Part of this is discussed in the section on patient safety culture (page 16 and following), but a key element in infection prevention may be to have systems in place where it is not dependent on individual training because of all of the problems noted in the context section. This also affects issues of sustainability as noted on page 19 lines 31 and following.	Thank you for that suggestion. We have added the following text to the section Key Informant Feedback: "Institutions may also want to consider using simulation to map workflow and design systems that are less user dependent and more intuitive."
Peer Reviewer 3	Findings	The section on evidence of the effectiveness of strategies for environmental cleaning is reasonable. It does point out, however, the paucity of data of clinical outcome studies on this topic. This is also true for the effectiveness of monitoring of cleanliness.	We hope the text describing the limitations of studies evaluating both cleaning and monitoring in the Summary and Implications section help address these points.
Peer Reviewer 4	Findings	P 10 copper...would not use term "Not considered standard of care" line 50. Current research is ongoing...and even if efficacy data are available ...and it is a useful method, it still might not be a standard of care	We removed text noting that copper was "not considered standard of care."
Peer Reviewer 4	Findings	p 11 fogging...suggest this report mention fogging somewhere.....Suggest a review of CDC HICPAC statement on this which recommends against fogging...nad then an additional clarification statement in the CDC norovirus guideline on fogging and newer technology...but still an unresolved issue. see CDC website at http://www.cdc.gov/hicpac/Disinfection_Sterilization/17_00_Recommendations.html#a8	Thank you for pointing that out. In Table D-1 we include all the relevant clinical practice guidelines we identified that address this issue. However, the scope of the technical brief precludes the inclusion of specific recommendations for any modalities.
Peer Reviewer 4	Findings	p 13 line 8 Regarding ATP would repeat here a key statement made in background line 12-13 about presence of ATP does not necessarily indicate viable pathogens	The text notes that "the presence of ATP does not necessarily indicate viable pathogens on the tested surface."
Peer Reviewer 5	Findings	There appears to be an omission in Figure 1. Per the figure legend, frame 2 should indicate that 874 studies remained after excluding studies at the title level. Instead, frame 2 is blank..	Thank you for pointing out the omission of "874."

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Peer Reviewer 5	Findings	The discussion of chemical disinfectants is excellent. While the authors do mention that the effectiveness of disinfectants is significantly affected by how they are used in real-world settings (p. 9, lines 27-28) they might consider expanding a bit more on the issue of contact or dwell time. That is, the authors might want to comment on the problem of unrealistically long label dwell time claims and the problems that ensue.	We have added the following text to address your concerns: “For example, manufacturer-recommended dwell times are established in the laboratory setting, but in the hospital environment, where there is often pressure to turn rooms around quickly, allowing for appropriate dwell times can be challenging.”
Peer Reviewer 5	Findings	The discussion of no-touch modalities is also very good. The authors may want to mention the use of nanoparticle-infused paint to aid UV light diffusion.	We have added the following text to address your concerns: “A recent study utilizing a UV-reflective wall coating resulted in significantly decreased decontamination times, from ~ 25 minutes to ~ 3 minutes for MRSA, and from ~ 43 minutes to ~ 9 minutes for <i>C. difficile</i> spores.”
Peer Reviewer 5	Findings	The authors provide a thorough overview of monitoring modalities (pp. 12-13.)	Thank you for your comment.
Peer Reviewer 5	Findings	P. 18 line 55. The study cited in reference 47 was conducted in the United States, not in the Netherlands.	We have revised the text to indicate that the study was conducted in the United States.
Peer Reviewer 5	Findings	P. 19 and 20: Study Outcomes. The authors sometimes conflate colonization and infection. E.g., p. 19 line 47, references 41 and 47 reported primary outcomes of colonization, not infection as stated in the brief.	We have revised the text to indicate that Hayden et al. did not report infection rate (did report VRE colonization) as a primary outcome. Datta et al. however did report incidence rate of <i>C. difficile</i> infection.
Peer Reviewer 5	Findings	P. 20 lines 16-17: I don't understand this phrase: ...”with an exception that the decrease in environmental contamination would help control spread of ...(MDROs).”	The text reads “with an expectation that the decrease in environmental contamination would help control spread of multiple-drug-resistant organisms (MDROs).”
Peer Reviewer 5	Findings	P. 23 lines 42-47. Could the authors please provide citations for the 27 studies that used surface contamination as a primary outcome, the 16 studies that used infection rate, etc?	Thank you for catching this oversight. We have added references to the Study Outcomes section.

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Peer Reviewer 5	Findings	Also, in Table C-4, it would be helpful if the authors specified the outcomes more clearly. For example, in Table C-4 on p. C-12, do all of the following refer to contamination of environmental surfaces? If so, perhaps the authors could add that information to the outcome cell. "Sites positive for culture" (line 23), "VRE positive samples" (line 37), and "CFU" (line 31).	Thank you for that suggestion. We have categorized all primary outcomes as focusing on surface cleaning (a), infection rate (b), colonization (c) or other (d).
Peer Reviewer 5	Findings	P. 26, Table 5. Could the authors provide reference numbers for the studies cited?	Thank you for the suggestion; however, we have cited the studies in the text describing the table, and just used the table to illustrate the landscape of the evidence. We believe it would compromise the readability to fit the citation numbers into each cell of the table.
Peer Reviewer 5	Findings	Table C-8: Reference 47 and 42 represent duplicate populations. Also, the study cited in reference 47 was conducted in the United States.	While Hayden et al. (reference 47) and Hota et al. (reference 42) may be duplicate populations, the studies are reporting on dissimilar outcomes (VRE colonization, percent of targets cleaned) so will remain included studies. Regarding the incorrect citing of reference 47, we have revised the text indicating that the study was conducted in the United States.

Commentator & Affiliation	Section	Comment	Response
Peer Reviewer 6	Findings	<p>Guiding Question 1. The discussion of activities (e.g. bactericidal, virucidal, etc) should be in the context of EPA-approved label claims. I think there should be some mention of the ‘augmented’ Quats (with alcohol). Where are the peracetic acid preparations in the surface disinfectant discussion? While the ‘cidal’ activity of each of the surface disinfectants is discussed, this isn’t addressed with regard to copper and silver surfaces (i.e. what activity are they expected to have).</p> <p>Regarding monitoring modalities, it would be helpful for the reader to know something about the recovery of organism bioburden using either swabs (used with culture, PCR, or ATPase), Rodac plates, or slide cultures. Specifically, what percent recovery do these sampling modalities attain in vitro and what is the usual surface area that may be sampled using these modalities? What is known about the limitations of sampling relatively small areas relative to the potential high touch surface area? Specifically what is known about the heterogeneity of high touch surface area contamination and the impact of such heterogeneity on sampling efficiency or accuracy?</p>	<p>We have added text in Guiding Question 1 describing peracetic acid preparations and the bactericidal properties of silver and copper surfaces. We did not identify any studies describing “augmented” QAC compounds. We also added text describing sampling areas for Rodac plates, and included a reference to a study that compared Rodac plates with swabs for detection of specific organisms.</p> <p>Our systematic searches did not identify any studies that specifically examined or discussed the percent recovery of organism bioburden, or the other potential sampling limitations you describe. In addition, our searches did not identify information on the potential heterogeneity of high touch surface area contamination. This Technical Brief was limited to clinical studies of cleaning, disinfection, and monitoring modalities, and it is likely that in-vitro studies are necessary to address these questions. This may be an important area for future review.</p>
Peer Reviewer 6	Findings	<p>Guiding Question 2. See previous general comments about the major omission of EPA approval and label claim context to EC.</p>	<p>We agree that the EPA plays a vital role in setting standards for disinfectants, and have added text to the External Factors section of Guiding Question 2 and the Next Steps section to emphasize their role. We endeavored to clearly identify whether products were EPA certified, and provided a link to information describing their regulatory processes. We also attempted to include a representative from the EPA among our KIs, but our efforts to recruit a participant were unsuccessful.</p>

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Peer Reviewer 6	Findings	Guiding Question 3. See previous general comments about the appropriateness of traditional evidentiary hierarchies applied to patient safety and IC/EIC in particular, also needed epidemiologic context regarding usual transmission pathways and etiologic fraction of EC-related transmission. Tables 3, 4, 5 (as well as figures 3-6) should be useful.	We agree that RCTs are often impractical for examining the effect of disinfection and monitoring strategies. Thus, we included all controlled study designs in our brief, not just RCTs. Ultimately, few of the studies we included were RCTs. It is also important to note the limitations of non-randomized or non-controlled studies, and throughout the Brief we have identified those limitations We have also added text discussing the role of surface contamination in the chain of pathogen transmission and patient infection.
KI Reviewer 1	Findings	p. 8, Figure has missing/blank box. It might be useful in this section to differentiate between literature found in peer-reviewed, published literature and grey literature. Products can readily be referred to generically.	Thank you for pointing out the omission of “874.” We have added text to the Findings section to distinguish between documentation identified in peer-reviewed, published literature versus gray literature. Lastly, we have removed brand names from the body of the report.
KI Reviewer 1	Findings	p.9, line 33 and 15, line 12 (as examples). It is poor form to start a sentence with an abbreviation (QAC, CMS).	Although it is true that some publishing-house style rules refrain from starting a sentence with an acronym, many publishers, now allow an acronym to start a sentence.
KI Reviewer 1	Findings	p. 13, line 7 (ATP Assays). The problems with ATP assays are clearly discussed, but it would be worth a sentence noting that although they do not indicate viable pathogens, they can serve as a general measure of cleanliness and may be useful as teaching as well as monitoring tools.	We have added the following text to address your concerns: “Nevertheless, ATP assay measurements can serve as a general measure of cleanliness, and given their ease of use, have utility as teaching and monitoring tools.”
KI Reviewer 1	Findings	p. 21, line 18. Whenever possible the report should avoid using brand names. I would recommend removing the brand BioQuell name. Ditto on p.24, line 8 and anywhere else. Products can readily be referred to generically.	Again, we thank you for this recommendation and have removed brand names in the report.

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KI Reviewer 1	Findings	p. 28, Evidence Gaps. This bulleted list is too brief and could be fleshed out a bit, say a little more. For example, what about PCR or patient infection rates, etc? Also see comment below about this section under Next Steps.	We have provided introductory text to the Evidence Gaps and expanded the Summary and Implications. We hope this addresses your concerns.
KI Reviewer 2	Findings	Figure 1: should the second box in the left column of the PRISMA diagram state: “Study Abstracts assessed (n=874)”? Also need to check the numbers in each box. The numbers in the final box do add up however the numbers in the other boxes in this figure don’t “add up” properly.	Thank you for pointing out the omission of “874.” We have also revised information in Figure 1.
KI Reviewer 2	Findings	Some studies included in this Technical Report assess “cleaning” only whereas others assess “cleaning-disinfection”. Therefore, the authors should define the following two terms: “cleaning” (i.e. the physical action of using an agent with no microbial killing label claims to remove debris and micro-organisms from a hard non-porous surface). “cleaning-disinfection” (i.e. the use of an agent with microbial killing label claims that removes debris and micro-organisms through physical action and in addition kills microorganisms during contact time due to the disinfectant action). Then the authors should use these two terms appropriately throughout the document.	We have now defined these terms in the Background, as follows: “In this report, we use “cleaning” to refer to removal of general surface debris, and “disinfection” to refer to use of agents or technologies designed to kill microbial organisms.”
KI Reviewer 2	Findings	Page 19: Visual observation to assess a housekeeper’s compliance may be done by covert direct observation of the housekeeper during cleaning, however, it is also frequently done by inspection AFTER the housekeeper has completed the room cleaning. The latter does not allow adequate determination of whether all high-touch surfaces were wiped or not (i.e. if the surface looked clean to the housekeeper – they may not have wiped this surface. The inspection AFTER the housekeeper leaves the room would not be capable of differentiating this aspect). These two different approaches to visual inspection should be described.	We have added text to the section on Visual Observation to differentiate between these two approaches. “Visual inspection can also occur following completion of room cleaning and disinfection by EVS staff; while assessing the subjective cleanliness of surfaces, this method precludes the ability to determine whether these surfaces were actually cleaned.”

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KI Reviewer 2	Findings	Page 19: Aerobic Colony Counts: Aerobic culture (with or without enumeration of the cfu/cm ²) is the only method that can provide information about viable specific pathogens of interest (e.g. MRSA, VRE, NDM-E.coli, etc). This aspect should be described as it is the biggest advantage of this method.	We have revised the text as follows: “Importantly, the use of aerobic culture (with or without enumerating colony counts) is the only method that can provide information about the viability of our pathogens of interest (e.g. MRSA, VRE).”
KI Reviewer 2	Findings	Page 19: UV-light Inspection: The key component of this section is the application of a UV-visible marker. As such the section name should be changed to: “UV-visible surface Marker”. A distinct advantage of this system is the simplicity (ease of implementation) and low cost of this method. These aspects should be included.	We have changed this section to address your concerns. We have specifically added: “Advantages of UV-visible surface markers include relative low cost of use and ease of implementation, including as a feedback tool for EVS staff.”
KI Reviewer 2	Findings	Page 20: PCR based technology: A key disadvantage of the PCR-based method is that currently there is no way to differentiate the presence of dead versus viable specific microorganisms. This aspect should be added to this section.	We have added the following text to address this: “However, these assays currently do not differentiate between the presence of viable versus nonviable microorganisms.”
KI Reviewer 2	Findings	The concept of improving EC for routine daily cleaning-disinfection versus ICU rooms, versus isolation rooms, versus discharge rooms has not been clearly delineated in this review. In other words – should healthcare facilities target monitoring for specific types of rooms (e.g. ICU, Isolation), or rooms at discharge (i.e. before the next patient is admitted) or routine daily rooms (e.g. including all types of rooms including all rooms where patients are admitted as well as ICU, isolation and discharge rooms)? If the clinical data obtained is from a discharge room – is this truly applicable to a regular non-discharge room (since the cleaning used for discharge rooms usually has additional aspects not included in routine daily cleaning of non-discharge rooms)?	These considerations are now addressed in the Additional Considerations section of the Summary and Implications.
KI Reviewer 3	Findings	Overwhelming! See attached file.	We will address the issues that you have brought up.
KI Reviewer 3	Findings	P16, L18 - Would recommend adding “textile or microfiber cloth” after “moistened paper towels”. Indeed, I do not believe paper towels are used more than for spot cleaning in the hospitals I am familiar with.	We have added text as suggested.

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KI Reviewer 3	Findings	P18, L34 - Would recommend adding “and disinfection cleaned” before the word “before” since these no touch modalities are used to augment routine terminal cleaning, not replace it.	We have added text to reflect the adjunctive use of these technologies.
KI Reviewer 3	Findings	P18, L52 - Ditto before the word “decontamination”.	We added text to the first paragraph under “No-Touch Modalities” to allude to this fact.
KI Reviewer 3	Findings	P19, L20 - While the discussion of the use of microbiologic methods to evaluate microbial contamination of environmental surfaces is both accurate and thorough, the first sentence of the discussion is somewhat confusing in as much as aerobic colony counts relate only to Rodac plates and agar slide culture systems. While a few reports have used an estimation of microbial growth on blood agar plates directly inoculated by cotton swabs, this method has never been viewed as quantitative. I would recommend modifying the first sentence to simply state, “Microbiologic methods have been used to evaluate microbial contamination of environmental surfaces” and changing the heading to “Microbiologic Methods”.	Thank you for this clarification. We have revised the section as suggested, and moved the sentence describing ACCs to the end of the paragraph on Rodac plates and slides.
KI Reviewer 3	Findings	P19, L46 – Pathogen acquisition, probably the most accurate and sensitive outcome measure in clinical studies on the impact of environmental cleaning, should be noted before commenting on those studies reporting an impact on infections. The two landmark studies in this regard are Hayden (Clinical Infectious Diseases 2006) and Datta (Archives of Internal Medicine 2011). These are actually the only studies which objectively document an outcome measure in an endemic setting.	We have added the outcome of pathogen acquisition, including the Hayden and Datta references, and expanded on the Hayden study demonstrating reduction in acquisition of VRE.
KI Reviewer 3	Findings	P20, L4 – P20, L32 - While it is absolutely correct to point out that a fluorescent gel cannot be used to detect the presence of specific organisms and its utility for use in investigating “a pathogen specific outbreak” has not been evaluated, I would suggest it would be more accurate to use the word “adjunctive” instead of “limited”.	We have changed “limited” to “adjunctive” in the section discussing fluorescent markers.

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Commentator & Affiliation	Section	Comment	Response
KI Reviewer 3	Findings	<p>P25, L20 - The review of the studies related to “monitoring cleanliness” represents a mixture of reports which relate to both cleanliness (measured by culture with its limitations and ATP with substantial limitations) and cleaning practice (thoroughness of cleaning). As noted in the 2010 CDC guidance (Ref 53) and the AJIC review article (Ref 54), monitoring of cleaning practice may be done with either fluorescent gel or pre/post cleaning evaluation of individual objects using agar slides or ATP (Figure 5). If the difference between assessing cleaning practice and cleanliness were summarized sequentially, it would improve the clarity of this section.</p> <p>Furthermore, it is important to distinguish between random assessment of “cleanliness” of patient zone surfaces and the use of monitoring tools as part of structured process improvement programs. Since, in my opinion, the former reports (more numerous) merely point to the “problem” while the latter offer insights into actual environmental cleaning process improvement interventions, the latter are much more relevant to the purpose of the Technical Brief and, as such, might be more clearly emphasized.</p> <p>In discussing the use of ATP in healthcare settings, the authors may wish to reference the report published by the National Health Council in Great Britain in 2007(reference below). It remains the most in-depth independent (nonmanufacturer sponsored) evaluation of the ATP tool (an independent study comparing the lack of accuracy of four ATP systems is currently in-press). It clearly and appropriately emphasizes the potential educational role that ATP can provide when a “bad” result is recognized while clearly illustrating the overall challenge of the sensitivity and specificity of the ATP tool. Department of Health. Evaluation of ATP bioluminescence swabbing as a monitoring and training tool for effective hospital cleaning. London: DoH;2007 at: http://195.92.246.148/knowledge_network/documents/Bioluminescence_20070620104921.pdf</p>	<p>Thank you for your comments. We addressed the distinction between modalities that measure cleanliness and those that monitor practice in the Study Outcomes and Summary and Implications sections of the report.</p> <p>As you suggest, we focused our discussion of the monitoring studies on specific tools that are used as interventions, rather than unstructured evaluation of surface cleanliness.</p> <p>Thank you for pointing us to the National Health Council report. We have discussed the use of ATP in assessing cleanliness earlier in the document: “Bioluminescence-based adenosine triphosphate (ATP) assays have been developed as another alternative that offers direct, rapid feedback and provides a quantitative measure of cleanliness. However, the detected presence of ATP does not necessarily indicate viable pathogens on the tested surface. In addition, universal cutoffs for ATP levels and “cleanliness” have not been established. Lastly, some studies have shown that certain disinfectants can interfere with ATP readings.²⁰⁻²²”</p> <p>In the Findings section, we have reiterated these concerns, but added “Nevertheless, ATP assay measurements can serve as a general measure of cleanliness, and given their ease of use, have utility as teaching and monitoring tools.”</p>

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KI Reviewer 3	Findings	P20, L32 - The subheading “Key Informant Feedback” represents a superb summary of many critically important aspects of these issues central to the basic premise for developing this Technical Brief. I would concur with each and every opinion summary stated.	Thank you for your comment.
KI Reviewer 3	Findings	P23, L25 - The contents under the subheading “Patient Safety Culture” provide an excellent overview of these critically important issues. As noted this is an area not well addressed in the current literature. Fortunately, it is well summarized and thoughtfully explained here. Figure 2 represents an excellent and innovative simplification of the basic elements of the CDC guidance.	Thank you for your comment.
KI Reviewer 3	Findings	P24, L43 - After the word “staff”, it might be helpful to add the words “competency and performance” and delete the word “competency” on L44 for clarification.	We have made the revisions as suggested.
KI Reviewer 3	Findings	P25, L9 - The discussion of reference 62 is incomplete. While UV powder was initially used at the hospital, the principal investigator believed that the environmental services staff were able to easily clean the glogerm powder targets because they were visible in normal light. Subsequently this suspicion was confirmed by concomitantly monitoring with UV gel which was not able to be detected under ambient light. A clear improvement in the thoroughness of environmental cleaning as a result of objective performance feedback to the staff was then documented when using the UV gel. This study retracted the findings in reference 62. Munoz-Price LS1, Fajardo-Aquino Y, Arheart KL. Ultraviolet powder versus ultraviolet gel for assessing environmental cleaning. Infect Control Hosp Epidemiol. 2012 Feb;33(2):192-5.	Thank you for highlighting this issue. We have added a reference to the follow up study in the Findings.

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KI Reviewer 3	Findings	<p>P25, L45 - Although the heading Evidence of the Effectiveness of Strategies for Implementing Cleaning and Monitoring Modalities (guiding question 2) is followed by a detailed analysis of “studies focused specifically on implementing infection control interventions and contextual factors”, it is not clear how this heading relates to the subsequent subheadings under question 2 on p. 10. This reviewer would suggest that the authors modify the subheadings and the questions outlined on pp. 10 and 11 to more clearly fit the body of the Research Brief.</p>	<p>The subquestions listed on pages 10 and 11 were developed as part of the research protocol prior to beginning the review of the literature. They were designed to guide the overall focus of the research. The presentation of the Findings was reorganized to make the report more readable, but reflects the review of the literature that was guided by the “Guiding” questions in the protocol.</p>
KI Reviewer 3	Findings	<p>Pp 28 - 31 - The staff and authors of the Technical Brief undertook a monumental task that resulted in the literature summary contained on pp. 28 to 31 of the report. Unfortunately, these studies of strategies used for environmental cleaning almost exclusively represent reports related to control of outbreaks. Furthermore, essentially none of the studies actually measured the thoroughness of the cleaning process while attempting to evaluate the role of the “target intervention”. These two limitations substantially preclude any sound assessment of the validity or general applicability of the observations and conclusions made by the authors. Indeed, many of the studies were carried out before the two major limitations noted above were widely appreciated. Only now (the past two year) has it become clearly appreciated that these studies cannot objectively guide practice. While not wishing to be self-serving, these limitations led to the development of a new paradigm for clinically comparing surface disinfectants which was initially presented as an abstract at Infectious Diseases Week in 2013 and recently published.</p> <p>Carling PC, Perkins J, Ferguson JA, Thomasser A. Evaluating a new paradigm for comparing surface disinfection in clinical practice. <i>Infect Control Hosp Epidemiol.</i> 2014 35 (11):1349-1366.</p>	<p>We appreciate your comment on these challenges. We have added a discussion of these limitations to the Summary and Implications.</p>

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KI Reviewer 3	Findings	P32, L30 – Although the statement “Findings from seven clinical trials to evaluate fluorescent markers indicate a frequent lack of attention to high risk surfaces in the near patient zone”, is intrinsically correct, it is not clear how this statement relates to the introduction to Line 26 which notes that “Drawbacks were described for all monitoring methods”. Identifying the lack of thorough cleaning was the purpose of the pre-intervention phases of these studies using fluorescent markers and as such cannot be considered a drawback to their use.	We have removed the sentence describing these as drawbacks. Thank you for clarifying the context in which these indicators were used.
KI Reviewer 3	Findings	Pp34 - 35 – It is not clear how the information on these two pages relates to the body of the report.	The Evidence Map and Evidence Gaps are intended to present concise, visual overviews of the published literature and areas for future research. We have added brief introductory text to highlight the context of these sections.
KI Reviewer 3	Findings	P36, L22 – The text related to the heading “Cleaning Modalities” provides an excellent and succinct overview of the issues discussed.	Thank you for your comment.
KI Reviewer 3	Findings	P37, L33 – The term “UV bioluminescence” is incorrect. “ATP and fluorescent markers” should be substituted.	We have made the revisions as suggested under Monitoring Modalities in the Summary and Implications Section.
KI Reviewer 3	Findings	P37, L34 – As discussed previously, the word “cleanliness” is incorrect in relationship to the previous sentence. Since a longer explanation would be redundant, I would suggest ending the sentence after the word “year”.	We have reworded the text under Monitoring Modalities in the Summary and Implications Section to avoid referring to “cleanliness.”
KI Reviewer 3	Findings	P37, L46 – It is not that benchmarks for RL use “are not well established”. It really is that they have “not been established”, as previously discussed.	We have revised the text to “have not been established.”
KI Reviewer 3	Findings	P37, L48 – “Colonization” can only be evaluated as “acquisition”, which is the more accurate term in the context of research in this area.	Thank you for this clarification. We have revised the terminology accordingly.
KI Reviewer 3	Findings	P37, L50 – Ditto	Thank you for this clarification.
KI Reviewer 3	Findings	P38, L24; P38, L44; P39, L7 and P39, L15 – Absolutely concur with these points.	Thank you for your careful review of the report.
KI Reviewer 3	Findings	P39, L4 – See comment above for P38, L48.	Thank you for this clarification. We have revised the terminology accordingly.

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KI Reviewer 4	Findings	P 16 line 23 – perhaps implied by “characteristics of a specific disinfectant”, but it may be worth mentioning compatibility/effect of the disinfectant on surfaces	Thank you for that suggestion. We have made the following revisions to the text: “For an effective disinfection protocol, consideration should be given to the microorganisms being targeted, type of surface, the characteristics of a specific disinfectant (e.g., compatibility on various surfaces/materials), cost and ease of use, and safety of EVS personnel.”
KI Reviewer 4	Findings	P 17, line 50 ? mention cost	We recognize that cost can be an important factor. We cite a study in the Background that addresses the costs associated with copper surfaces, and we expanded the discussion of copper coatings in the Findings.
KI Reviewer 4	Findings	P 18, line 11 - ? topography not typography	Thank you for catching that error. We have corrected it.
KI Reviewer 4	Findings	P 18 – for both UV and HP sections, should mention need to mechanically remove debris before use - may be best to mention the need for surface cleaning in the overview of cleaning modalities on P 16 and that failure to remove organic material can reduce efficacy of self disinfecting surfaces or no-touch technologies	We have added the clarifying text to the section on No-Touch Modalities.
KI Reviewer 4	Findings	P 19 line 7 – visual inspection might help with patient satisfaction,	Feedback from KIs indicates that this may be true. We’ve added the following text to address your comment: “Furthermore, adequacy of cleaning and disinfection as assessed by visual inspection may increase patients’ perceptions of cleanliness and therefore satisfaction levels.”
KI Reviewer 4	Findings	P 19 line 11 - If there are data on lack of correlation with visual inspection and microbial decontamination, would mention it.	We have added appropriate references to support this text.

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KI Reviewer 4	Findings	P 21, line 14, an important aspect of instilling a sense of the safety culture is making sure EVS personnel realize that they are key components of the infection prevention team including feeding back HAI rates to EVS departments (not discussed here)	Thank you for that suggestion. We have added your example of sharing HAI rates with staff to the text.
KI Reviewer 4	Findings	P 22 line 18 – relevance of the study cited unclear –	We have revisited inserting the external quality control process [Mitchell et al. study 2014] as an accurate example of external influencers. We have removed this example from the report.
KI Reviewer 4	Findings	P 22, line 21 – Table – ? relevance of discussion of sterilants not used for surface disinfection?	We have removed information regarding ethylene oxide from Table 2.
KI Reviewer 4	Findings	P 23, Figure 2 – not sure if figure is helpful (content could be in text)	We have removed the figure.
KI Reviewer 4	Findings	P 25, line 24 – is outsourcing “important”? based on the discussion in the 3rd and 4th paragraphs, it appears that there is no consensus on the value of outsourcing.	We agree that there is a lack of consensus on the value of outsourcing, but we needed to address the use of outside contractors or outsourcing as posed in Guiding Question 2: “What role do outside contractors serve in the selection and implementation of strategies, and staff training and monitoring?” Information on the services available from two environmental support services companies and evidence from one study [Brakovich et al. 2013] reporting employing outside contractors were described in the report.

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KI Reviewer 4	Findings	P 26 – 27. I think the discussions of study characteristics and outcomes can be more clearly written.	We have recently added Key Points to Guiding Question 2 and Guiding Question 3 to orient the reader to the most important information presented in these sections. We put considerable thought into how the Findings would be presented in both Guiding Question 2 and Guiding Question 3 and chose the format we felt was the most readable to our end-users. In the Study Characteristics section for both these questions, we introduce study design, then setting, pathogen type, and general information on modalities covered under that topic (e.g., cleaning or monitoring). For the Study Outcomes section, we present primary/secondary outcomes, and study findings grouping information on similar modalities together.
KI Reviewer 4	Findings	P 28, line 27-29. Isn't hydrogen peroxide vapor/mist always "adjunctive" and use in addition to conventional surface cleaning?	We agree and have removed "as an adjunctive infection control strategy" from the sentence.
KI Reviewer 4	Findings	P 28, paragraph starting line 36 – this is confusing. The review compared studies looking at disinfectants compared to detergents for cleaning. Nowhere in this discussion is this mentioned – would mention in the first sentence of the paragraph. As a consequence, the sentence "Three studies indicated no significant differences in the rates of nosocomial infection" is confusing as it is not clear what is being compared to what.	We have changed the Introduction sentence to read: "Second, Dettenkofer et al. 2004 evaluated the effects of disinfection compared with cleaning of environmental surfaces on HAI rates."
KI Reviewer 4	Findings	P 29 Table 3 would be more clear if the columns were divided into 3 sections – pathogens, study design, outcome measured.	Table 3 has been redesigned.
KI Reviewer 4	Findings	P 29-30 – the section on study characteristics is hard to read.	We have edited the section and added "Key Points."
KI Reviewer 4	Findings	P 30, line 9-10. Why is a study that is a description of practices in the context of an outbreak included in this brief?	Environmental cleaning strategies implemented in the context of an outbreak setting were not excluded from the report.

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KI Reviewer 4	Findings	<p>P 30 study outcomes – this is also confusing to read – would try to draw clear conclusions, if and when possible and be clear if there is concordance in study findings. For example, with the 9 studies examining UV, do all 9 show decreased bioburden (this isn't clearly stated and there are 5 studies referenced. There is 1 reference to the statement that UV decreased C. diff rates? Was that the only study that looked at C. diff rates? Suggest clearly stating results – for example, that most studies of UV looked at the intermediate outcome of decreased environmental contamination and x/y studies found significantly decreased bioburden. If there was only one study that assessed C. diff rates, would clearly state that the one study that assessed C. diff rates, found a decrease with UV – but if several studies looked at this outcome, would say so.</p>	<p>The purpose of this type of report, a “Technical Brief,” is to describe the spectrum of evidence and identify gaps that could be addressed in future research. As such, we aren't drawing conclusions about the effectiveness of particular cleaning and disinfecting methods, but are describing identified studies. We examined the types of outcomes sought in the studies, and organized the text by the outcomes measured.</p> <p>Of the 9 UV or PPX-UV devices, the five studies that reported on “bacterial burden” are presented together while the one study that reported on “infection rates” (Levin et al. 2013) was reported separately. Of the five studies reporting non-significant reductions in bacterial bioburden, one reported on C difficile; one reported on MRSA, VRE and C difficile; one reported on C difficile and MRSA; and 2 reported on various pathogens including one pathogen of interest. We do reference pathogen type reported in individual studies in the Study Characteristics section.</p>
KI Reviewer 4	Findings	<p>P 32, line 20 – unsure what failure rate before cleaning means.</p>	<p>The Amodio and Dino 2013 review reported failure rates associated with three different ATP benchmarks (<100 RLU, <250 RLU, <500 RLU) with respect to cleaning procedures. Four studies monitored surfaces after cleaning. Six studies monitored surfaces both before and after cleaning.</p>

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KI Reviewer 4	Findings	Table C2 - would be nice to note which studies were industry sponsored	For this report, we considered a study to be manufacturer-funded if it reported that any sponsoring institution was granted equipment and/or monetary funding from the manufacturer for execution of the study. We have noted whether studies were manufacturer-funded or not in Table C-2 as suggested.
KI Reviewer 4	Findings	The Evidence Map section is not very helpful.	We appreciate your candor. The Evidence Map was designed to serve as a concise and visual summary of the overall evidence base and important research gaps. We have added explanatory text that we hope improves the value and relevance of this section.
KI Reviewer 4	Findings	P 35, figures 5 & 6 – do these refer to the 44 cleaning modality studies? Or to others? It is unclear. Would include the N with the figures as some of the studies look at more than one outcome or pathogen	These figures refer to all the studies we reviewed. We have changed the figure titles for clarification.
KI Reviewer 4	Findings	P36, line 18-9 –why is use of outsourcing to provide cleaning services called an “important challenge”?	While we feel that regulatory requirements and sustaining improvement over time are “important challenges” to most institutional leaders, outsourcing may not be viewed in this category. We have therefore removed the term “important” from this sentence.
KI Reviewer 4	Findings	The evidence gaps are not helpful either - and seem incomplete. There are gaps on other emerging technologies including UV and hydrogen peroxide vapor	We have added reference to “no-touch” modalities in the evidence gaps.
KI Reviewer 5	Findings	Page 16, lines 56-57: Hypochlorites are not very stable and must be freshly prepared when diluting locally. Also would mention that there is significant confusion when preparing and diluting locally, resulting in high concentrations and higher irritation issues or low concentrations which offer lower efficacy.	We have made the following revisions to the text: “Hypochlorites must be freshly prepared when diluting from higher concentrations, and proper dilution protocols must be followed to reduce chemical irritation or decreased efficacy.”

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KI Reviewer 5	Findings	The self disinfecting surfaces section seems very superficial, as it does not talk about advantages and problems and compounds beyond silver and copper.	We have expanded on the discussion of altered topography, and added a section describing light-activated antimicrobial surfaces. We hope that the revisions to this section of the report address your concerns.
KI Reviewer 5	Findings	Page 18, line 11: topography.	Thank you for catching that error. We have corrected it.
KI Reviewer 5	Findings	hydrogen peroxide systems: discuss airway and mucous membrane irritation as a safety concern. Also the need to seal all vents, doors and windows, as well as sensors to avoid triggering fire alarms. High level training is required to use these devices.	We hope that the below revisions to this section of the report address your concerns: "High-level training is required to operate these devices. Air vents, doors, and windows must be isolated and sealed, and active monitoring with sensors is necessary to monitor for leaks and ensure that the room is safe for personnel to enter. A safety concern with improper use is airway and mucous membrane irritation."
KI Reviewer 5	Findings	Page 20, line 8: No cutoffs have been validated to indicate clean vs. not clean.	We have added text to indicate the lack of cutoffs to validate cleanliness: "Cutoffs used to classify surfaces as "clean" by ATP assays depend on the assay system used, and universal cutoffs for ATP levels and "cleanliness" have not been established."
KI Reviewer 6	Findings	Question 1: Page 9 Line 17: cloth immersion into a bucket is not mentioned as an application method and is in fact a common practice.	We have added immersion of textile cloths as an application method.
KI Reviewer 6	Findings	Page 9 Line 17 Environmental services personnel do not use paper towels with disinfectants as a general course. Paper may be the product used in a pre-moistened wipe bucket system. The use of the words paper towels is misleading and largely incorrect. Perhaps what is meant here is dry wipers used in a bucket system where the disinfectant of choice is poured into the bucket to saturate the wipers.	We have clarified this text, and replaced "moistened paper towel" with "wipes soaked in a disinfectant-filled bucket".

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KI Reviewer 6	Findings	Page 9 Line 41 recommend adding towels and cloths after the word cotton. Gauze pads are not used in general cleaning and surface disinfection unless referring to use on sensitive equipment or screens. However, disinfectants would not be used in that case. Recommend deleting the gauze pads comment.	We have revised the text as suggested.
KI Reviewer 6	Findings	Page 14 Line 19 This paper is about environmental cleaning and environmental services. Support services is too broad a term given the scope of this paper. Recommend sticking to environmental services to drive home the importance of the discipline to executive readers.	We have revised the text as suggested.
KI Reviewer 6	Findings	Page 9 Lines 36 & 37: non critical surfaces do not mention bed rails, call buttons, tray tables and TV remotes which are HTO's and in close proximity to a patient. Walls and floors are the specific examples given and while non critical, are not necessarily the vectors we should be referring to.	We have revised this to include certain HTOs as examples.
KI Reviewer 6	Findings	Page 10 Lines 50 and 51 appear to be biased statements. Copper is being used and there are case studies demonstrating the merits. While I agree it is not a standard of care, neither are the other novel technologies mentioned. Comment may be perceived as negative. Would also suggest expanding this section to include more recent information and study references.	We have removed text regarding standard of care. We have added additional text and study references as recommended.
KI Reviewer 6	Findings	Page 10 Line 55 Recommend a reference to back up the statement, (unless the end reference on page 11 line 6 covers the entire paragraph).	Narrative for the section on Silver was derived from the two references listed at the end of the paragraph.
KI Reviewer 6	Findings	Page 11 lines 38 and 53: the word significant should be somehow quantified or perhaps provide a range. i.e.; 60-180 minutes. A range will provide the reader with some context specific to the nature of the environmental services operation and turn times.	As suggested, we have added range of times to quantify use of the word "significant" in these two paragraphs.
KI Reviewer 6	Findings	Page 14 Line 27 Recommend changing infection control to infection prevention. Prevention is the more widely accepted term.	We have made the suggested revisions to the text.

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KI Reviewer 6	Findings	Page 14 Lines 50 and 51: "inclusion of infection preventionists in EVS leadership" is not steeped in evidence and is a very strong and not widely accepted sentiment. It is the opinion of one KI and could be perceived in a negative manner.	We appreciate your concerns and will keep "location of EVS in the administrative hierarchy" as an example but remove "inclusion of infection preventionists in EVS leadership."
KI Reviewer 6	Findings	Page 18 Lines 24-36: Naming contractor companies is not fair to the companies not named and they will use the paper to their advantage. Additionally, the information while potentially steeped in fact is very misleading. Contractors face the identical challenges as in house environmental services. Additionally, some of the contractors have scaled back their training programs and as a general course tell their managers NOT to leave the "account" to attend education programs or conferences. Contracting vs in house decisions need to be made on the basis of patient outcomes, consistency and culture not only on how much the contractor will save a hospital.	Thank you for your comment. We have removed company names to be fair to all environmental services contractors.
KI Reviewer 6	Findings	Page 19 Lines 34-35. While true, a fundamental reason gains may not have been sustainable is due to pressure to get the occupied rooms cleaned and the terminal rooms turned. Time and process is the real issue.	We have added text to the Introduction section that alludes to pressures that may contribute to failure of preventive strategies.
Russell Olmstead Trinity Health	Findings	Pg. 16 HYPOCHLORITE For clarity recommend the following rewording ...e.g. commercially available concentrate of between 46 sodium hypochlorite solutions are formulated as concentrated household bleach which are typically diluted by a factor of 10 with a final use concentration of 0.4 0.6... I'd not want reader or users to infer that this chemical be used off the shelf at full concentration.	We have revised the text as suggested.
Russell Olmstead Trinity Health	Findings	Pg. 17 COPPER While I tend to agree with the statement as written Copper-containing surfaces are not commonly used in the hospital setting and are not considered standard of care... There is an active research agenda by the manufacturer of this and one of their main targets is healthcare setting. Consider therefore softening this statement to read Efficacy of copper-containing surfaces to reduce risk of HAIs is under active investigation but real-world experience to date remains limited.	Text has been revised to read: "The effectiveness of copper-containing surfaces in reducing the risk of HAIs is under active investigation, and real-world experience remains limited to date." We have added references to the available literature.

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Russell Olmstead Trinity Health	Findings	<p>Pg. 18 ULTRAVIOLET While its true that the turn around time TAT for UVGI is shorter than vaporized H2O2 i.e. at a concentration of 35 the microbiocidal activity especially against spore forming microbes like <i>C. difficile</i> is approximately one half that of H2O2 vapor. Id rec. adding this as another limitation or disadvantage of UVGI.</p>	<p>Thank you for the comment. The turnaround time (TAT) disadvantage is noted in the last sentence of the section: “Finally, these units require significant time for effective disinfection and can therefore adversely affect bed turnover time.”</p> <p>TAT is also clarified: “While dependent on many factors (e.g., system being used, dose, organism being targeted), the turnaround time for these devices can range from approximately 15 to 20 minutes for vegetative bacteria to approximately 50 to 100 minutes for <i>C. difficile</i> spores.”</p>
Russell Olmstead Trinity Health	Findings	<p>Pg. 18. Fogging of disinfectants Not sure where this should go but there is a clarification from HICPAC on this topic that reflects more recent technology such as vaporized H2O2. Just might be useful sidebar or call out to include in this report. Reason is there remain manufacturers who market devices that produce a device that creates fog of disinfectant that revisits the old problems that originally led to CDCs recommendation against such approach. Heres the complete text and URL Environmental Fogging Clarification Statement CDC and HICPAC have recommendations in both 2003 Guidelines for Environmental Infection Control in HealthCare Facilities and the 2008 Guideline for Disinfection and Sterilization in Healthcare Facilities that state that the CDC does not support disinfectant fogging.</p> <p>Specifically the 2003 and 2008 Guidelines state 2003 Do not perform disinfectant fogging for routine purposes in patientcare areas. Category IB 2008 Do not perform disinfectant fogging in patientcare areas. Category II</p> <p>These recommendations refer to the spraying or fogging of chemicals e.g. formaldehyde phenolbased agents or</p>	<p>We have revised the introduction to Chemical Disinfectants to note this recommendation. “Lastly, as opposed to newer disinfection technologies such as hydrogen peroxide vapor, use of these chemical disinfectants are not recommended in preparations for spraying or fogging application.”</p> <p>In Table D-1 we include all the relevant clinical practice guidelines we identified that address this issue. However, the scope of the technical brief precludes the inclusion of specific recommendations for any modalities.</p>

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		<p>quaternary ammonium compounds as a way to decontaminate environmental surfaces or disinfect the air in patient rooms. The recommendation against fogging was based on studies in the 1970s that reported a lack of microbicidal efficacy e.g. use of quaternary ammonium compounds in mist applications but also adverse effects on healthcare workers and others in facilities where these methods were utilized. Furthermore some of these chemicals are not EPA registered for use in fogging type applications. These recommendations do not apply to newer technologies involving fogging for room decontamination e.g. ozone mists vaporized hydrogen peroxide that have become available since the 2003 and 2008 recommendations were made. These newer technologies were assessed by CDC and HICPAC in the 2011 Guideline for the Prevention and Control of Norovirus Gastroenteritis Outbreaks in Healthcare Settings which makes the recommendation More research is required to clarify the effectiveness and reliability of fogging UV irradiation and ozone mists to reduce norovirus environmental contamination. No recommendation unresolved issue The 2003 and 2008 recommendations still apply however CDC does not yet make a recommendation regarding these newer technologies. This issue will be revisited as additional evidence becomes available. source CDC. HICPAC.</p> <p>Available at http://www.cdc.gov/hicpac/DisinfectionSterilization1700Recommendations.html [http://www.cdc.gov/hicpac/Disinfection_Sterilization/17_00Recommendations.html]</p>	

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Russell Olmstead Trinity Health	Findings	Pg. 19 Aerobic Colony Counts Worth investigating this but believe theres some evidence that the correlation between ATP RLU readings and concentration of microbial bioburden on the surface tested is not real strong. Might be worth adding this here and the section that discusses ATP monitor. Another important aspect of ACC is that most Clinical microbiology laboratories do not perform quality control nor maintain certification to provide environmental microbiology testing. Therefore such testing would benefit from oversight by an environmental microbiology lab that is certified to conduct such testing.	We added the following text to address this suggestion: "In addition, clinical microbiology laboratories do not always perform quality-control assessments in the use of ACCs, including maintenance of certification for environmental microbiologic testing. As such, testing using microbiologic methods for environmental monitoring in the hospital setting could benefit from oversight by a certified environmental microbiology laboratory."
Russell Olmstead Trinity Health	Findings	Pg. 20 ATP see above. Would add in here the lack of high level correlation between RLU readings and microbial concentration and issue earlier that some surface disinfectants or perhaps even materials used to cleanapply disinfectants interfere with RLU readings.	Along these lines, a few studies have shown limited agreement between ATP readings and ACCs in regard to defining surfaces as "clean." We have noted that some disinfectants interfere with the ATP measure.
Russell Olmstead Trinity Health	Findings	Pg. 21 2nd sentence third paragraph from top consider slight rewording Almost every KI indicated that EVS staff is are often underappreciated despite playing a critical role within a facilitys the infection prevention and control program community.	"Infection control" has been replaced with the more widely used "infection prevention community".
Russell Olmstead Trinity Health	Findings	Pg. 30. Study Outcomes Recommend revisiting citation no. 63 for use at this point in the report as seems odd that one would use ATP RLU to monitor air contamination level i.e. ...Other reported primary outcomes included air contamination rates e.g. RLU63...	Thank you for noting this error. We have corrected the use of that study to refer to surface, not air, contamination.
Peer Reviewer 1	Summary and Implications	Clearly stated summary and implications are thorough, concise, and easy to read.	Thank you for your comment.

Commentator & Affiliation	Section	Comment	Response
Peer Reviewer 1	Summary and Implications	Next Steps: The report identified critical gaps in current evidence that should be investigated in greater detail. The six key areas identified (p 31-32) are critical in order to make sense of and apply the evidence associated with EC and HAI reduction. Emerging technologies (p. 31, line 24) are usually expensive to purchase & the associated evidence limited thus making it difficult for facilities to be able to make the business case for implementation. Additionally confusing for practitioners & facilities is the lack of thresholds for monitoring cleanliness (p. 31, line 44); more research in this area is truly needed. Methods for linking EC methods and products with patient-centered outcome must also be identified (p 31-32) along with guidance for controlling confounding factors (p 32). The next steps identify the critical missing pieces that are needed by IPs, Environmental Services personnel and facilities to assess the EC needs for the acute care setting & methods to implement interventions to achieve the best outcomes for patient and employee safety.	We appreciate your overview of this section.
Peer Reviewer 1	Summary and Implications	Question 4 is excellent.	Thank you for your careful review of the report.
Peer Reviewer 2	Summary and Implications	The role of the environment as a source of cross-infection versus as a marker for patients who are heavy bacterial shedders and the source of most spread in the hospital, i.e., the environment is only a marker of this risk, could be addressed, though this type of critique may not be an intent of Technical Briefs.	Thank you for raising this important issue. We agree that identifying the role of the environment versus the patient is a crucial question. However, as you note, this goes beyond the scope of a Technical Brief and would move the focus away from our Guiding Questions.

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Commentator & Affiliation	Section	Comment	Response
Peer Reviewer 2	Summary and Implications	<p>Next Steps: Question 4 is excellent and correctly reflects the state of the topic and the study needs.</p> <p>As noted above, the role of the environment as a source of cross-colonization/infection versus as a marker for patients who are heavy bacterial shedders and themselves the source of cross-colonization/infection could be addressed here. The environment is clearly a source for some cross-colonization/infection, but the pendulum may swing again, and so, good to do more to nail-down when environment is and is not the culprit.</p> <p>Include need to reconcile EPA-recommended "contact times" and those times in expert-based recommendations which are often different?</p>	<p>We agree that identifying the role of the environment versus the patient is a crucial question.</p> <p>We have added text addressing the role of EPA regulations and recommendations to the Findings and Summary and Implications.</p>
Peer Reviewer 3	Summary and Implications	<p>The Summary and Implications section, though brief, reviews what has been found in the other components of the document and seems clear and logical. It also points out fairly clearly the limitations of current information regarding environmental cleaning. It may be reasonable to emphasize a little more clearly that one of the limitations of most all of the studies is lack of clinical correlation of cleaning modalities and prevention of HAIs (decrease of HAIs rather than decreased bio-burden or organism count). Also, success of the modality may be related to the baseline health care associated infection rate. If intervention is done during high rates, it may be easier to show impact of any specific activity.</p>	<p>Thank you for your comments. We have added these points to the Additional Considerations.</p>

Commentator & Affiliation	Section	Comment	Response
Peer Reviewer 3	Summary and Implications	Next Steps: Overall this section is reasonable. Some comments may be useful, however. An important component of use of intervention is priority for use of any modality. For instance, do you emphasize “isolation rooms” for automated systems, fluorescence testing, etc.? Should all terminal cleaning of rooms be at the same level of intensity? What is the effect of baseline HAI rate in studies and how does that effect outcome? There is a need for scientific evaluation of cost for these modalities (personnel, equipment, etc.). While there may seem to be high expense, it may still be cheaper than the huge expense of an extended hospital stay and/or litigation and decrease income (Medicare or Private insurance) related to HAI. This may also alter the chance of true sustainment because of management interest.	We have addressed these issues further in the section on Additional Considerations.
Peer Reviewer 4	Summary and Implications	Although there is a general discussion on the limitations of some of the studies, eg cleaning modalities, it might be helpful to consider some type of grading of these studies, at least mention of this and inclusion of some type of grading in future reports. Consider grading used by HICPAC.	While we agree that including an assessment of study quality would add to the integrity of the report, the scope of the technical brief precludes appraising study quality, grading the evidence, and performing synthesis of included studies.
Peer Reviewer 4	Summary and Implications	Next Steps: no recommendations.	No response required.
Peer Reviewer 5	Summary and Implications	This section is excellent overall.	Thank you for your careful review of the report.
Peer Reviewer 5	Summary and Implications	Another challenge that the authors might consider including under "Additional Considerations," p. 30 are unique manufacturer specifications for cleaning and disinfecting some high-touch hard surfaces such as touch screens. Are these always necessary?	Thank you for this comment. We did not review any studies that examined touch screens, but we did add text relating to the role of manufacturer specifications in a broader context.
Peer Reviewer 5	Summary and Implications	Next Steps: The authors do an excellent job of summarizing future directions and challenges.	Thank you again for your comments.

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Peer Reviewer 5	Summary and Implications	They might want to opine about whether research into new technologies that allow for minimal human error versus interventions to change EVS worker behavior are likely to be more fruitful.	Thank you for this insight. We have addressed this in Next Steps.
Peer Reviewer 5	Summary and Implications	In addition, given that randomized controlled trials and head-to-head comparisons of products and interventions are listed under Evidence Gap (p. 28) the authors may want to comment on the likely high cost of conducting rigorous, randomized trials, especially if outcomes are patient-centered (p. 31) such as healthcare-associated infection (HAI). How realistic is it to expect these studies to be done? If they cannot be done, can next best experimental designs and surrogate outcomes be identified that will yield high-quality evidence?	These concerns have been addressed in the Next Steps.
Peer Reviewer 6	Summary and Implications	I think the interweave of KI input is most effective and helpful here. I thought these conclusions were reasonable and in line with the available data and input. As mentioned previously the absence of a 'pathogenic conceptual framework' or simply a 'conceptual model of how EC leads to HAIs' is a w [remainder of comment not available]	Thank you for your comment. We added text discussing the role of surface contamination in the chain of pathogen transmission and patient infection.
Peer Reviewer 6	Summary and Implications	Next Steps: I think these are really accurate in terms of interpreting what is most needed. Also, to the credit of these authors, the limitations of RCTs in this space are touched upon.	Thank you for your comment.
KI Reviewer 1	Summary and Implications	OK	Thank you for your comment.
KI Reviewer 1	Summary and Implications	Next Steps. p. 28, Evidence Gaps. Consider moving the Evidence Gaps to Conclusions or somehow combine and harmonize these with the Next Steps on p.31. Both of those sections refer to 'gaps', but mention different gaps.	The first section on Evidence Gaps is designed as a brief listing of major gaps as identified by the authors and KIs. The Summary and Implications provides additional narrative discussing these gaps. We have tried to better harmonize these sections.

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Commentator & Affiliation	Section	Comment	Response
KI Reviewer 2	Summary and Implications	Page 35: Evidence Gaps. The summary statement does indicate that “no touch” room decontamination approaches are recently emerging technologies, however, these are not listed in the “Evidence Gap” section as emerging technologies. Recommend including “No Touch” decontamination in the list of Evidence Gap Emerging Technologies.	We have added “no-touch room decontamination systems” to the Emerging Technologies listing under Evidence Gaps.
KI Reviewer 2	Summary and Implications	Page 37: end of first paragraph: The authors state: “Almost every KI emphasized that proper hand hygiene is the most important step in preventing HAIs and that failure to achieve good hand-hygiene practices can negate the value of any surface cleaning technique.” I would suggest that this sentence be re-worded. I believe that optimal environmental disinfection will be valuable even if optimal hand-hygiene has not been achieved (because it will reduce the risk of pathogen transmission in the event that a care-giver touches the environment and then fails to perform hand-hygiene before contact with the next patient). This is NOT to suggest that hand-hygiene should not be optimized – but rather that both hand-hygiene and environmental surface cleaning-disinfection techniques need to be optimized.	We have changed the sentence as follows: “Almost every KI emphasized that proper hand hygiene is the most important step for preventing HAIs and that failure to achieve good hand-hygiene practices can minimize the value of surface cleaning and disinfection techniques.” We hope this addresses your concern.
KI Reviewer 2	Summary and Implications	Page 37: Monitoring Modalities; last paragraph: The authors state; “An additional limitation of these studies is the lack of consensus for thresholds of cleanliness.” Although this is a true statement for the cfu/cm2 and the ATP methods, it is not true for the UV-visible marker methods. The expectation for the marker methods is clear – the marker should be totally removed. This should be clarified.	This has been clarified in the Summary.
KI Reviewer 3	Summary and Implications	Excellent in every way. See attached file.	Thank you for your comment.
KI Reviewer 3	Summary and Implications	Next Steps: Rather lacking in detail and specifics but this appears to be on purpose rather from fatigue!	We have added text to this section of the report to make it more informative.

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Commentator & Affiliation	Section	Comment	Response
KI Reviewer 4	Summary and Implications	f. Summary and Implications: This section is clearly written and states the limitations of current research and the challenges that researchers face. There are no major new insights.	A main objective of the technical brief is to provide an overview of the state of the science. While we realize that some experts may not find any new insights from the report, we hope that in general the document proves insightful to local decision makers and researchers.
KI Reviewer 4	Summary and Implications	g. Next Steps: - Suggesting additional research is an obvious next step-	While suggesting additional research may be an obvious next step, we hope the detailed recommendations provided in several key areas will help inform future research.
KI Reviewer 4	Summary and Implications	Agree with need to study implementation	Thank you for your comment.
KI Reviewer 4	Summary and Implications	Not sure next step on thresholds for cleanliness is achievable. Given paucity of clinical outcomes and the numerous factors leading to infection, I don't how measures of cleanliness can be correlated with infections as outcomes. Studies looking at colonization would be challenging as well, particularly in a clinical setting	We agree that such studies are very challenging to design, but our KIs suggested that this was an important area for further study.
KI Reviewer 4	Summary and Implications	Similarly, not sure it is feasible to design and conduct studies that can identify which high touch/high risk objects and surfaces pose the greatest risk of transmission (if the clinical endpoint is infection.	As above, we agree that this will be difficult. However, the KIs highlighted this as an important issue requiring more research.
KI Reviewer 4	Summary and Implications	Last "next step", need for innovative approaches, is true as conventional approaches haven't been very effective. That said, it would help to suggest approaches that are worth exploring	Thank you for this suggestion. This issue was raised by the KIs, however, our review of the evidence did not identify specific approaches and we note this in the Next Steps.
KI Reviewer 5	Summary and Implications	Discuss limitations of this review.	Thank you for your suggestion. We have added limitations of the review to the Summary and Implications section.
KI Reviewer 5	Summary and Implications	Next Steps: No comments.	No response required.

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KI Reviewer 6	Summary and Implications	Page 29 Line 52: Perhaps an important point to add is consistency of chemical concentration and effect of hard water on the efficacy of the chemicals.	Thank you for this suggestion. We have added text to the section Cleaning Modalities noting the influence of these factors on the efficacy of the products.
KI Reviewer 6	Summary and Implications	Page 30 Line 37 raises an important fact and perhaps we should also name the stakeholders needed to commonly agree on measures. Typically, agreement has left environmental services management out of the discussion all together. Hopefully dialogue will open by identifying the stakeholders consistently and fostering mutual trust and respect.	Thank you for your comment. We have added text to the Monitoring Modalities section to indicate the importance of including feedback from stakeholders (especially environmental services management) in outcome decision making.
KI Reviewer 6	Summary and Implications	<p>Next Steps: Face to face stakeholder meeting with equal representation by discipline. Science meeting implementation.</p> <p>Identify top 5 research gaps and discuss HOW the studies should be conducted.</p> <p>Review of all the existing education and training resources currently available and align with the gaps in current research as well as the challenges being addressed by those training tools.</p> <p>Acknowledgement that cleanliness is not a turf war or any one disciplines domain. Its about collaboration, teamwork, recognizing deficiencies, addressing them and monitoring sustainable outcomes in the interest of the patient.</p> <p>Speaking with a unified voice in the name of the patient.</p>	Thank you for your comment. You have highlighted several important process-oriented strategies for moving forward a research agenda. We did not include all of these in the Technical Brief because we focused on specific aspects of future research.

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Russell Olmstead Trinity Health	Summary and Implications	11 Pg. 36 Summary Implications Consider adding a bit of content on critique of the literature that was retrieved in this project relative to its strength and quality. There are tools that can score these studies accordingly such as GRADE used by HICPAC i.e. Umscheid CA et al. Healthcare Infection Control Practices Advisory Committee. Updating the guideline development methodology of the Healthcare Infection Control Practices Advisory Committee HICPAC. Am J Infect Control. 2010 May38426473.	While we agree that GRADE is a useful tool to assess quality of an evidence base, the technical brief is not intended to critically appraise, grade, or synthesize evidence or make recommendations, but is rather an overview of the state of the science to help identify existing gaps in evidence and future research needs.
Peer Reviewer 1	Clarity and Usability	Yes, the report is well structured and organized in a clear fashion. It will be a valuable addition to the Infection Preventionist's and Environmental Services personnel toolkit . It succinctly presents the current evidence and identifies gaps for future research. It presents topics and aspects associated with EC that are not routinely, if ever, considered by acute care facilities when addressing products, practice, or methods of EC - specifically the patient safety culture and alternative methods for measuring effectiveness of EC.	Thank you for your careful review of the brief. We hope that the report will be informative for a broad audience from front line staff to institutional leaders, and will also be useful to local decision makers and researchers.
Peer Reviewer 2	Clarity and Usability	I prefer the structure of analysis suggested by McDonald and Arduino (Clin Infect Dis. (2013) 56 (1): 36-39), but the authors approach is in keeping with the AHRQ Technical Briefs format and is clear. I find the absence of critical appraisal of shortcomings of existing studies (e.g., such as a Key Shortcomings column in some of the Table Cs) a loss but realize that not providing such an evaluation also is in keeping with the AHRQ approach for Technical Briefs.	You are correct that technical briefs do not include critical appraisal, grading or synthesis of the evidence, but rather an overview of the state of the science to help identify existing gaps in evidence and future research needs.

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Commentator & Affiliation	Section	Comment	Response
Peer Reviewer 3	Clarity and Usability	The document is clear and well organized. It will be increasingly useful based on the inverse of the readers' knowledge base. It might benefit by greater emphasis on the Next Steps section. A little more detail, some additions as noted above, and perhaps some thoughts on priorities (e.g., automated systems are being used with little data). Usability also depends on the audience. Individual readers may have different needs than decision makers. The Next Steps section will be individually useful, but might have significant impact on future research pathways including funding decisions.	We hope that the technical brief will be informative for a broad audience from front line staff to institutional leaders, and will also be useful to local decision makers and researchers. In regards to your comment on limited evidence for automated systems, we currently include the text "Relatively few studies have been published examining the effectiveness of no-touch disinfection modalities" in the Newly Emerging Technologies section under Next Steps. Also under Next Steps, we have added an additional section on Funding that addresses the need for unbiased research.
Peer Reviewer 4	Clarity and Usability	report well organized... would also consider an index to be helpful to the reader...as many topics are addressed in a variety of locations	We will forward your suggestion to the Agency for Healthcare Research and Quality who provides the outline for the technical brief.
Peer Reviewer 5	Clarity and Usability	Overall the report is well-organized and adequately structured and organized, given the limitations of the required format. The main points are clearly presented, for the most part. The conclusions are quite good and should inform future research.	Thank you for your careful review of the report.
Peer Reviewer 6	Clarity and Usability	Very clearly written, to the point, and relatively brief--- should be a great resource.	Thank you for your careful review of the report.
KI Reviewer 1	Clarity and Usability	Easy to follow. Main points clear and conclusions (with possible slight revisions as above) can inform future research. It is just a bit confusing to have one section on evidence gaps and a different set o summary next steps.	The technical brief template requires the inclusion of the sections as noted.
KI Reviewer 2	Clarity and Usability	This report is well structured and organized. The main points are clearly presented and the conclusions can be used to inform future research.	Thank you for your careful review of the report.

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KI Reviewer 3	Clarity and Usability	The report is very well structured and organized and the summary points to general research needs. Unfortunately very substantial portions of the literature is very limited by design issues in general and industry bias (new technologies) confounders, and a virtual absence of comparative studies. What is needed ultimately is a mechanism for solicitation of RFPs very specifically articulated by funding agencies in this area.	Presently we include information on the study design limitations which include a lack of comparative studies. We have since added the section "Funding" to the Summary and Implications Section which addresses the need for unbiased research.
KI Reviewer 4	Clarity and Usability	The background and summary sections are clearly written. I had difficulty with the findings section, particularly the study characteristics and outcomes sections of the evidence review. These are hard to read and synthesize.	We have edited the Findings section and added "Key Points" to orient the reader to the most important information identified. .
KI Reviewer 5	Clarity and Usability	No comments.	No response required.
KI Reviewer 6	Clarity and Usability	While the existing paper is clear and well written the areas noted above may improve the paper's multi-disciplinary shelf life and usefulness.	Thank you for your careful review of the report.
Russell Olmstead Trinity Health	Figures	N/A	No response required.
Peer Reviewer 2	References	References, # 47 is incorrectly cited as a study from the Netherlands; it is a US study.	We have revised the text to indicate that the study was conducted in the United States.
Russell Olmstead Trinity Health	References	N/A	No response required.
Peer Reviewer 2	Appendix	It is not clear why the Reference from Rutala et al (Appendix B; Rutala WA, Gergen MF, Tande BM, et al. Rapid hospital room decontamination using ultraviolet (UV) light with a nanostructured UV-reflective wall coating. Infect Control Hosp Epidemiol. 2013 May;34(5):527-9. PMID: 23571373) is excluded. That article cites use of a reflective paint surface to overcome one of the criticisms of the UV light disinfection approach and so seems germane to this report. Also, note a typo in the title (reflective is misspelled).	The Rutala et al. study was excluded because of the study setting. The study was described by two screeners (including one clinical investigator) as a "non-clinical (simulation) study of cleaning techniques." We have changed the title of the study to read "reflective."
Russell Olmstead Trinity Health	Appendix	N/A	No response required.

ACC=aerobic colony counts

ATP= adenosine triphosphate

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CDC=Centers for Disease Control and Prevention
EPA=Environmental Protection Agency
EVS=environmental services
GRADE=Grading of Recommendations Assessment, Development and Evaluation
HTO=high-touch objects
RLU=relative light unit
UV=ultraviolet