Journal of Hospital Infection 128 (2022) 92–95

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevier.com/locate/jhin

Environmental sampling of innate hospital surfaces: a survey of current practices and the need for guidelines

A.S. van der Schoor [a,†], M. Boyle [b,†], A.F. Voor in 't holt [a], M.C. Vos [a,‡], H. Humphreys [b,*,‡], on behalf of ESCMID Study Group for Nosocomial Infections

[a] *Department of Medical Microbiology and Infectious Diseases, Erasmus MC University Medical Center, Rotterdam, the Netherlands*

[b] *Department of Clinical Microbiology, Royal College of Surgeons in Ireland University of Medicine and Health Sciences, Dublin, Ireland*

ARTICLE INFO

Article history:
Received 18 May 2022
Accepted 21 July 2022
Available online 6 August 2022

Keywords:
Environmental sampling
Hospital surfaces
Surveys
Questionnaires
Surveillance

SUMMARY

Background: Surfaces in healthcare facilities can act as reservoirs of infection. Currently, no standardized protocol on when and how to sample hospital surfaces exists.
Aim: A web-based questionnaire was devised to gain insight into current sampling practices and was distributed by email to a targeted infection prevention and control (IPC) audience.
Methods: The survey consisted of 26 questions on sample collection and processing for a number of healthcare relevant bacterial species.
Findings: The majority of respondents were clinical microbiologists or IPC practitioners, and 57.3% were from either the Netherlands, the United Kingdom, or Ireland. Respondents had high self-reported knowledge, but this was not consistent with response to certain questions. There was no consensus on sample sites, either within or between countries. Indirect sampling methods were preferred for all target microorganisms, and cotton and flocked swabs were the most popular methods.
Conclusion: The results of our survey highlight the inconsistencies in environmental sampling between and within countries, and the need for guidance and consensus.

Introduction

Inanimate surfaces in hospitals may be contaminated with nosocomial pathogens, such as meticillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), carbapenemase-producing Enterobacterales (CPE), *Pseudomonas* spp., and *Acinetobacter* spp. [1]. These pathogens play an important role in the acquisition of healthcare-associated infections (HAIs) via direct or indirect contact with the contaminated surface [1,2]. Analysis of 1561 nosocomial outbreaks showed that the hospital environment was the source in almost 20% of those outbreaks, highlighting the importance of the environment [3]. Next to identifying the source of an outbreak and apart from sampling for research aims, monitoring the environment can be used to routinely determine the presence of nosocomial pathogens, or to evaluate cleaning efficacy.

* Corresponding author. Address: RCSI Education and Research Centre, Microbiology, Beaumont Hospital, Dublin D09 YD60, Ireland. Tel.: +35-31-8093708; fax: +35-31-8092871.
E-mail address: hhumphreys@rcsi.ie (H. Humphreys).
† These authors contributed equally.
‡ These authors contributed equally as senior authors.

https://doi.org/10.1016/j.jhin.2022.07.024
0195-6701/

Nevertheless, there are no national or international guidelines on when and how to perform environmental sampling [4,5]. Therefore, with this current survey study, we aimed to provide insights on current environmental sampling practices of the innate environment and the laboratory methods used to process these samples.

Methods

Study design

A web-based survey in the English language was developed and opened for responses between August 6th, 2021, and December 20th, 2021. Before releasing the survey, it was piloted in two centres. The survey was distributed digitally among members of the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) Study Group for Nosocomial Infections (ESGNI), the Healthcare Infection Society (HIS), and members of the European Network to Promote Infection Prevention for Patient Safety (EUNETIPS), who forwarded the survey to the members of their respective societies.

Survey questions

The survey consisted of three sections and asked specifically about sampling practices for MRSA, VRE, CPE, *Pseudomonas* spp., and *Acinetobacter* spp. (Supplementary Appendix). The first section focused on the respondent and their role in environmental sampling, the second section on sampling practices, and the third section on sample processing methods. A distinction was made between indirect and direct sampling methods. Indirect methods included sponges, wipes, cotton swabs, flocked swabs and cotton swabs; direct methods included contact plates, dip slides, and Petrifilm. Before proceeding to the second and third sections, respondents were asked if they could answer these questions. If they answered 'no', they were redirected to the next section of the survey. It was not mandatory to answer all questions. All questions consisted of multiple answer options from which to choose one, except for one question where the answer was in free text.

Statistical analyses

Responses to the survey were analysed in total, and within and between countries. Regarding analyses between countries, the following categories were used: (1) the Netherlands, (2) the UK and Ireland, and (3) other countries. Response rates differed for each question. Unanswered questions were categorized as 'not applicable', 'missing', or 'no' based on the question involved. For example, when a respondent reported not using direct sampling methods, any answers to questions regarding which direct methods were used were not included, as the respondent had already indicated that this method was not used. All analyses were performed in SPSS version 28 (IBM Corp., Armonk, NY, USA).

Results

Eighty-nine respondents completed at least part of the survey. Forty-six respondents (51.7%) were clinical microbiologists, and 35 respondents (39.3%) were infection prevention and control (IPC) practitioners. Eight respondents had another role. Eighty-eight respondents (98.9%) worked in an acute care or specialized hospital; one respondent (1.1%) worked in a health centre. Respondents were from 21 different countries, with a range of one to 22 respondents from any one country. The majority of respondents (57.3%) were from the Netherlands ($N = 22$, 24.7%), the UK ($N = 17$, 19.1%), and Ireland ($N = 12$, 13.5%). Six out of 89 respondents were from non-European countries (Hong Kong $N = 3$, India $N = 2$, USA $N = 1$).

Most respondents self-reported having good to excellent knowledge on sample collection (73/89, 82.0%), and questions in the section regarding sampling practices were answered by 58 (65.2%) respondents. Thirty-two of 58 (55.2%) respondents sampled the environment to find the source of an ongoing outbreak, 13/58 (22.4%) routinely sampled the environment for monitoring reasons, and 2/58 (3.4%) respondents never sampled the environment. Regarding sampling protocols, 42/56 (75.0%) respondents reported that they always or usually had a sampling protocol. Respondents reported that areas to be sampled were determined both prior to entering the area and while in the area to be sampled, instead of solely prior to or while in the area (30/56, 53.6%).

Sample locations

No sample site was universally sampled for any target micro-organism (Figure 1). However, for certain sites, there was consensus within countries not to sample certain locations for a target micro-organism. UK respondents never sampled the privacy curtain for any micro-organisms, and Dutch respondents never sampled the mattress and patient locker for *Pseudomonas* spp. Among Dutch, UK, and Irish respondents, there was consensus not to sample the showerhead, shower drain, and toilet bowl for MRSA. Other countries did report sampling these sites. Dry sites were mainly sampled for CPE, except in the Netherlands, where these sites were most frequently sampled for VRE. Wet or damp sites were mainly assessed for the presence of CPE in the UK and Ireland, and to detect both CPE and *Pseudomonas* spp. in the Netherlands and in other countries.

Sample methods

Indirect methods were preferred for all target micro-organisms but differed between countries. Dutch respondents preferred flocked swabs, and never used sponges or rayon swabs. UK and Irish respondents preferred cotton or flocked swabs and sponges, and never used rayon swabs or wipes. Other countries preferred cotton swabs. Direct methods were rarely used and only reported to detect MRSA or VRE. No respondents reported the use of dip slides.

Laboratory processing

The majority of respondents reported having good to excellent knowledge on sample processing (72/89, 81.8%). Questions on processing methods were answered by 39 (54.2%) respondents. Indirect culture methods were preferred for MRSA, VRE, and CPE, and direct culture methods for *Pseudomonas* spp. and *Acinetobacter* spp. For MRSA and VRE, selective enrichment broths were preferred; for CPE and *Pseudomonas* spp. non-selective enrichment broths were

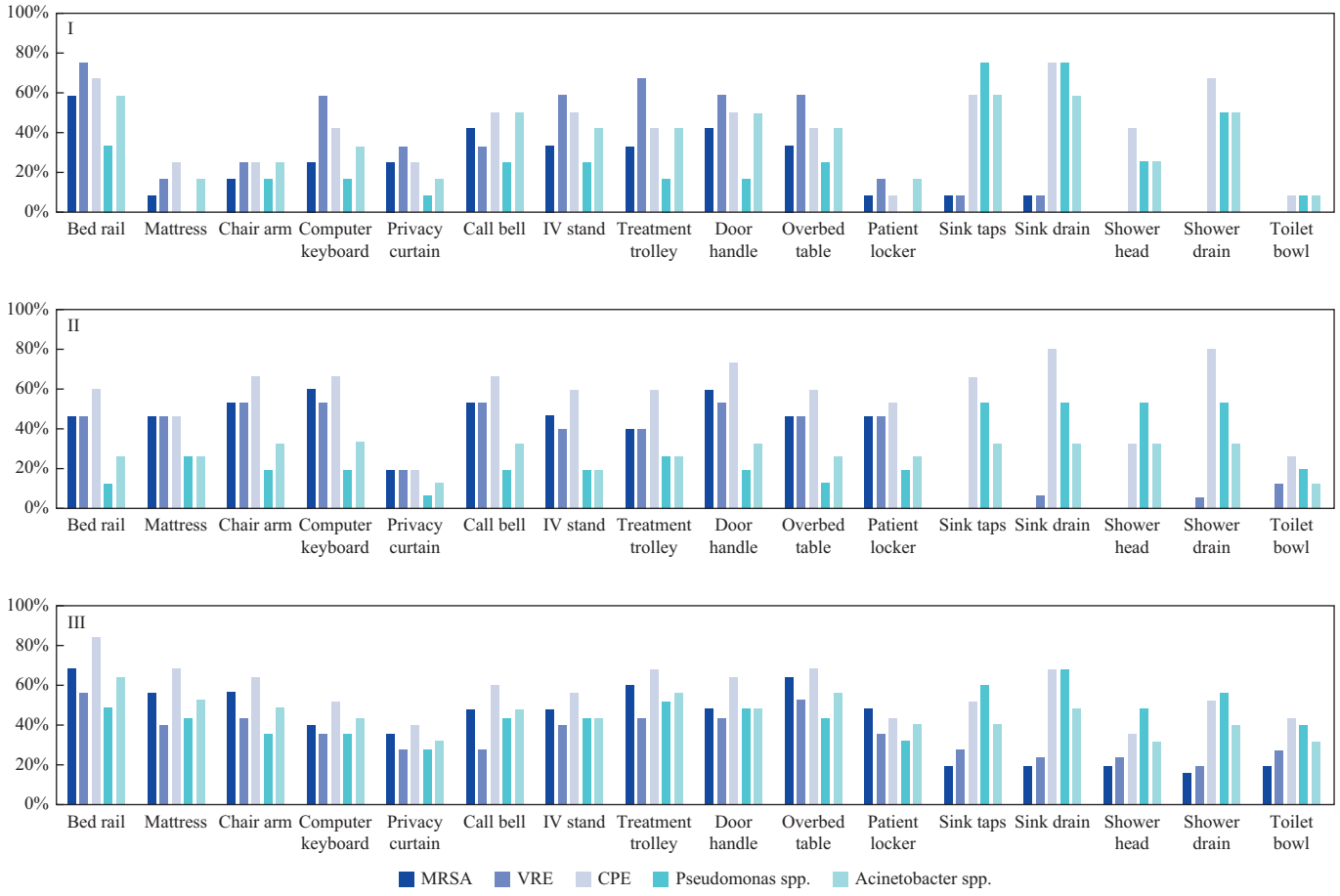

Figure 1. Percentage of respondents that sampled specific sites for the target micro-organism per country. (I) The Netherlands ($N = 12$), (II) UK and Ireland ($N = 15$), (III) other countries ($N = 25$). IV, intravenous; MRSA, meticillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant enterococci; CPE, carbapenemase-producing Enterobacterales.

preferred; and for *Acinetobacter* spp. broths were not preferred. Samples were vortexed before plating (16/38, 42.1%), and direct swabbing was the commonest plating technique (20/38, 52.6%).

Discussion

Through our survey, we sought to gain insight into current environmental sampling practices. The results indicate that there is great variability in sampling practices, both within and between countries. Whereas the literature is focused mainly on sampling to identify the source of an ongoing outbreak, specifically for outbreaks caused by multidrug-resistant micro-organisms, respondents also indicated that routine environmental sampling takes place. Eighty-nine respondents filled in the survey, but response rates differed with each question. The highest sampling rates were found for CPE, with the exception of the Netherlands, perhaps because CPE is less prevalent there than in other countries [6].

Though it was to be expected that, without current guidelines, there would be differences in sampling procedures between countries, there was still a lot of diversity even within countries, specifically for which sample sites to be assessed. Although there was some consensus within countries on which sites were never sampled (e.g. the privacy curtain), there was no consensus on which sites needed to be sampled. A possible explanation could be that the majority of respondents decided on locations to be sampled prior to entering the area, but also then changed some of these or added others while in that area. Consequently, sampling practices may differ with each sampling occasion. It may be that for this survey, respondents only reported locations that are determined prior to entering the area.

Flocked and cotton swabs were the most preferred sampling method, which is unsurprising, since they are the most frequently used sampling method in the literature [5]. This could be explained by the fact that they can be used to sample every type of surface, their affordability, and because they are readily available in most hospitals. However, standardization of sampling methods is difficult, leading to variations in recovery rates and non-comparable results [7].

Sampling was most common for CPE, and this may be explained by national epidemiology, e.g. in Ireland, a national public health emergency was declared in 2017 to address CPE and acute hospitals undertook a nationally mandated programme of extensive patient screening to prevent CPE becoming endemic [8,9]. However, sampling rates in the Netherlands were highest for VRE. This could be explained by the low prevalence of VRE in the Netherlands compared to other countries. In 2020, 0.5% of *Enterococcus faecium* isolates

were resistant to vancomycin, compared to 35.9% in Ireland [10]. Additionally, outbreaks with VRE have occurred in the Netherlands, whereas outbreaks with CPE are less common. Therefore, VRE is a greater priority for IPC measures in the Netherlands to maintain a low prevalence compared to other countries. For CPE, the prevalence throughout Europe is of concern, and consequently a priority for IPC teams [10].

We observed a distinct difference between self-reported knowledge and objective knowledge. The majority of respondents claimed good to excellent knowledge at the start of the survey, but a substantial proportion of these respondents were not able to answer the relevant questions. This could indicate that the respondents expected different questions, or that the respondents were not aware about gaps in their knowledge regarding environmental sampling processes.

An important strength of this study is that, to our knowledge, this is the first study to determine environmental sampling practices. This study has, however, several limitations. First, despite being distributed to a large network of relevant professionals, a relatively small number of respondents replied, and the majority were from three countries. Second, most respondents were either IPC practitioners or clinical microbiologists, and only one was a scientist. Third, we do not know the total number of individuals to whom the survey was sent, as it was distributed by various professional societies and groups. Furthermore, we were unable to determine variations according to professional background and the size of hospital. Therefore, the limited perspective captured by this survey may not be representative of true practices.

The results of our study highlight the diversity and lack of consensus regarding environmental sampling practices and laboratory processing, both within and between countries. There is a need for national and/or international guidelines or advice regarding environmental sampling practices, to provide some consistency in sampling. Currently, there are guidelines on surface sampling in the food industry [11]. However, there are obvious differences between the surfaces in healthcare buildings and in the food industry and the activities that occur in both settings. A standard of <5 colony-forming units/cm^2 for aerobic bacteria has been suggested for surfaces in hospitals, but this has not been universally agreed [12]. Nonetheless, guidelines might optimize the benefits of environmental sampling, including a focus on what to sample and for what purpose, and to how minimize unnecessary costs. Then environmental sampling might be more effective, and the results would be more comparable at a national and international level. However, perhaps information about environmental sampling on a larger scale is needed first. We also need to have a greater understanding of the motivation behind sampling the environment, what information is being sought by investigators, and how the results inform and shape IPC measures.

Acknowledgements

We are grateful to all those who completed the survey, those that assisted in the pilot survey, and colleagues for helpful suggestions and opinions.

Author contributions

A.S., M.B., A.V., M.C., and H.H. developed the survey. A.S. and M.B. collected and analysed the data and drafted the manuscript. All authors approved the final version of the manuscript.

Conflict of interest statement

In recent years, H.H. has received research grants from Pfizer and Astellas and has been a recipient of a consultancy fee from Pfizer. M.V. has received unrestricted research grants or support from Olympus, Pentax, and 3M for studying endoscope contamination. All other authors have no conflicts to declare.

Funding sources

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2022.07.024.

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