University of Huddersfield Repository

Assadian, Ojan, Leaper, David J., Kramer, A. and Ousey, Karen

Can the design of glove dispensing boxes influence glove contamination?

Original Citation

Assadian, Ojan, Leaper, David J., Kramer, A. and Ousey, Karen (2016) Can the design of glove dispensing boxes influence glove contamination? Journal of Hospital Infection, 94 (3). pp. 259-262. ISSN 0195-6701

This version is available at http://eprints.hud.ac.uk/id/eprint/29461/

Can the design of glove dispensing boxes influence glove contamination?

Short title: Design of glove boxes

Assadian O[1], Leaper DJ[1], Kramer A[2], Ousey KJ[1]

[1] Institute for Skin Integrity and Infection Prevention, School of Human & Health Sciences,
University of Huddersfield, UK

[2] Institute for Hygiene and Environmental Medicine, University Medicine Greifswald,
Germany

Corresponding author:

Prof. Ojan Assadian, M.D., DTMH

Institute for Skin Integrity and Infection Prevention

School of Human & Health Sciences, University of Huddersfield

Queensgate, R1/29 Ramsden Building

Huddersfield HD1 3DH, UK

E-Mail: o.assadian@hud.ac.uk

Summary

Background: Few studies have explored the microbial contamination of glove boxes in clinical settings. The objective of this observational study was to investigate whether a new glove packaging system in which gloves are dispensed one by one vertically with the cuff-end first has lower levels of contamination on the gloves and on the surface around the box aperture compared to conventional horizontally dispensed glove boxes.

Methods: Seven participating sites were provided with vertical glove dispensing systems and conventional boxes. Before opening boxes, the surface around the aperture was sampled microbiologically to establish base-line levels of superficial contamination. Once the boxes were opened, the first pair of gloves in each box were sampled for viable bacteria. Thereafter, testing sites were visited on a weekly basis over a period of six weeks and the same microbiological assessments made.

Results: The surface surrounding the aperture of the modified dispenser boxes became significantly less contaminated than the conventional boxes (P < 0.001) with an average of 46.7% less contamination around the aperture. Overall, gloves from modified boxes showed significantly less colony-forming units contamination than gloves from conventional boxes (P < 0.001). Comparing all sites over the entire six-week period, modified dispensed gloves had 88.9% less bacterial contamination.

Conclusion: This simple improvement to glove box design reduces contamination of unused gloves. Such modifications could decrease the risk of microbial cross-transmission in settings that utilise gloves. However, such advantages do not substitute for strict hand-hygiene compliance and appropriate use of non-sterile, single-use gloves.

Key words: Bacteria, nosocomial pathogens, nosocomial infection, disposable gloves, contamination, glove box, dispenser.

Introduction

Non-sterile, single-use, disposable medical gloves protect the hands of healthcare workers from contamination with blood, urine, or other body secretions. If their integrity is not compromised they can also protect hands from contamination with potentially pathogenic microorganisms and lower the risk of cross-contamination. Gloves therefore play an important role as part of contact precautions, such as caring for patients with diarrhoea or during outbreak situations,[1-3] in conjunction with strict, non-touch, hand hygiene and hand antisepsis, with soap or an antiseptic solution after glove removal. The dynamics of microbial transfer to surfaces are similar on contaminated gloved or contaminated ungloved hands. However, contaminated gloved hands make consecutive cross-transmission more likely and are a risk for pathogen transmission if used inappropriately.[4]

Although predictable, hands which remain contaminated because of poor compliance with non-touch technique may also transfer microorganisms, including pathogenic organisms, into glove boxes. The next user then may don gloves, which are already contaminated before use. Before publication of the World Health Organisation's Guidelines on Hand Hygiene,[1] one of the most comprehensive reviews on hand hygiene up to 2008, few studies had explored the microbial contamination of opened glove boxes in clinical settings. One of the notable examples is a study which identified the type, rate, burden, and pattern of contamination of boxed, clean but non-sterile medical gloves in an intensive care unit.[5] The authors found that 66% of glove pairs, removed under standard clinical working conditions, were contaminated with a mean bio-burden of 5.2 colony-forming units (CFUs); predominantly coagulase-negative staphylococci. This study, however, was unable to distinguish between extrinsic or intrinsic contamination of gloves; whether gloves had been contaminated before packaging or while the boxes were open and being used. It has been shown that unused non-sterile medical gloves, in open glove boxes on a hospital orthopaedic ward, were contaminated by contact

with unclean healthcare worker hands.[6] Significantly more skin commensals and pathogenic bacteria, including *Staphylococcus aureus* in 13% of samples, were recovered from boxes 3, 6 and 9 days after opening the boxes than from samples obtained immediately after opening glove boxes.

Curiously, the design of medical glove boxes has not changed during the last 4 decades, although the conventional "tissue box type" design used for glove dispensing may easily cause contamination of gloves inside when new gloves are taken out. To overcome these limitations, a new glove packaging system has been developed in the United Kingdom (Safedon UK Ltd). Gloves are stored in a cardboard box, which can be mounted so that after removing the lid the aperture is directed downwards. This allows gloves to be dispensed one by one from the aperture at the bottom of the box without touching the surrounding of the aperture or inside the box. In conventional, often horizontally placed packaging system, gloves come out of the boxes aperture in a more random orientation, and once opened, gloves are unprotected from environmental contamination and from bacteria possibly present on the hands of users.

The objective of this observational study was to investigate whether this new, glove-packaging system, in which gloves are dispensed one by one vertically with the cuff-end first, leads to lower levels of contamination of gloves and on the surface around the opening of the box when used, compared with conventional horizontally placed "tissue box type" glove boxes.

Methods

Seven testing sites (3 acute care hospitals, 1 dental office, 1 funeral parlour, 1 long term care facility, 1 tattoo art shop) in Yorkshire, UK, participated in this study. Each participating site was provided with the newly designed vertically mounted glove dispensing systems with nitrile medical gloves dispensed, one by one, from the bottom of the boxes (hygiene-dispenser, HD-group; SafeDon Hygiene System; Safedon Bodyguards Nitrile Examination Gloves; WRP Asia Pacific, Malaysia) and conventional horizontal boxes which dispensed nitrile gloves (tissue-box dispenser, TD-group; Bodyguards Nitrile Examination Gloves; WRP Asia Pacific, Malaysia). Each site was responsible for attaching HD-boxes to an appropriate vertical wall surface; TD-boxes were placed on a horizontal surface nearby as in their usual practice.

Before opening the boxes for the first time, the area around the cardboard lid of unopened glove boxes was sampled for a bacterial count to establish base-line background levels of contamination. Subsequently, the boxes were opened by one of the investigators under non-touch conditions, and the first pair of gloves in each box was removed through the now opened aperture using sterile forceps and placed in a sterile sampling bag. Thereafter, testing sites were visited on a weekly basis over a period of six weeks and samples of one glove pair from each packaging system were taken. The areas around the box aperture were additionally sampled after 3 and 6 weeks.

Microbiological processing and analysis

Boxes surface and gloves were tested for mould and bacteria bio-burden following BS EN ISO 11737.[7] Briefly, glove samples were automatically agitated in 100 mL sterile Ringer solution for a period of two minutes. 10 mL of the fluid was then inoculated into a Petri dish and mixed with molten Tryptone Soya Agar (TSA) and Sabouraud Dextrose Agar (SAB

plates) and allowed to set. TSA plates were incubated at 30°C +/- 2 °C for a minimum of 4 days. SAB plates were incubated at 20°C +/- 2 °C for a minimum of 7 days. Following incubation, the number of CFUs on each plate was determined and the average CFU per sample was calculated.

The surrounding of the box aperture was investigated using TSA plates and SAB plates. Box lids were removed and the agar surface was placed in contact with the packaging system, covering part of the aperture. Using uniform and steady pressure, the agar was pressed onto the surface tor approximately 10 seconds. This process was repeated for each site. TSA plates were incubated at 30° C (+/- 2° C) for a minimum of 4 days. SAB plates were incubated at 20° C (+/- 2° C) for a minimum of 7 days.

Statistical analysis

The software package ''R'' (http://www.r-project.org/) was used for statistical analysis of data. The number of microorganisms was denoted in both groups and compared against each other. The total number of macroscopically visible CFUs were counted and denoted as CFU/sample. Too numerous to count readings were counted as being >200 CFU for the purpose of processing such findings. Difference between glove dispensing systems and at each time point was calculated using an unpaired homoscedastic T-test. The statistically significance level was set at $P \leq 0.05$.

Results

Mean viable CFU counts yielded from gloves of the two different glove-dispensing systems are shown in Table I. While the mean CFU counts on gloves from the two investigated dispensing boxes did not significantly differ on opening (P = 0.999), after one week the CFU counts on gloves from the HD dispensing system were significantly fewer than from the TD boxes (P = 0.031). Although the difference was not significant during week 3, the mean CFU counts from HD boxes followed a trend to be lower than from the TD boxes (HD boxes: mean CFU per glove: 65.8, range: 10 – 319; TD boxes: mean CFU per glove: 801.0, range: 48 – 3,172). This difference was not statistically significant because of one outlier with 318 CFU per glove. However, gloves from HD boxes showed significantly less contamination overall than gloves from TD boxes (P < 0.001). Comparing all sites over the entire six-week period, HD-type dispensed gloves had 88.9% less bacterial contamination compared with TD boxed gloves.

Contact plate investigations of the box aperture (Table II) showed that the surrounding of HD dispenser apertures became significantly less contaminated than the conventional horizontal packaging system (P < 0.001). The modified design of the HD dispensing box showed on average, 46.7% less contamination around the aperture than conventional TD boxes. This was most likely related to less handling being required to remove gloves from the boxes, although some contamination with microorganisms settling from the air cannot be completely ruled out.

7

Discussion

In this study, the level of contamination on the surface area around the aperture of newly designed vertical hygiene-glove dispensing system (HD boxes) was compared with horizontally placed conventional glove dispensing boxes (TD boxes). The surface area around the aperture of the HD boxes had lower viable CFUs compared with glove boxes of TD type. However, these results must be viewed with caution since HD boxes were positioned with the aperture to the bottom, and TD boxes with the aperture to the top. Therefore, it cannot be ruled out that microorganisms also settled form the air to the surface around the aperture of the boxes. This limitation, however, does not apply to the results obtained for glove contamination itself. Again, gloves obtained from HD boxes had lower viable CFU counts compared to gloves from TD boxes.

Few studies have been published which have investigated the number of bacteria on unused gloves directly after opening glove boxes and during use in a clinical setting. Berthelot et al.[8] recovered a large variety of spore-forming and non-spore forming bacteria, including *Bacillus cereus* and *Clostridium perfringens* from unopened glove boxes. Contamination of 55% of gloves in an intensive care unit, with an average CFU of 1.8 per glove, has been reported.[5] Another study recovered bacteria from 75% of sampled gloves and measured an average of 1.7 CFU per investigated glove.[9] In our study, we obtained similar viable CFU counts on gloves but only immediately after opening glove boxes. Following one week of use, glove samples obtained from two different models of dispensing boxes showed much higher CFU counts than either of these earlier studies.[5,9,10] However, our study, in addition to acute care hospitals, also included a dental office and commercial enterprises with frequent use of gloves, including a funeral parlour and a tattoo art shop. Interestingly, the lowest mean CFU counts per glove over the 6-week observation period were found on gloves situated in a clean-room, gowning area of an operation theatre (HD boxes: 1.9 CFU/ glove; TD boxes: 4.5 CFU/

glove), and the highest CFU counts per glove in a dental office (HD boxes: 319 CFU/glove; TD boxes: 685 CFU/glove). These findings are more in agreement with those of a study which investigated the microbial contamination of gloves, before and during use, from newly opened boxes with those from boxes that had been in dental surgeries until they were nearly empty.[11] The authors reported that gloves yielded an average CFU count of 158 per used glove compared with 1.5 CFU on fresh gloves. One limitation of our study is that we did not collect data on the type of procedures at each site. It is likely that the design of glove dispensing boxes influences glove contamination as well as the type of procedures, and user awareness of the possibility that unused gloves inside a box can still be compromised by contaminated fingers. Our study has investigated a newly designed glove dispensing system which allows a single glove to be withdrawn at the cuff-end, one at a time, without touching the inside the box. As shown in our study, this design can reduce the risk of contaminating unused gloves, and hence, indirectly, the transmission of microorganisms to other surfaces or patients. However, a number of other factors may influence the contamination of boxes and gloves as well, such as exacerbation of contamination through tight packaging of boxes with large numbers of gloves, the modalities how gloves are folded and packed inside the boxes, or the possible influence of the glove material itself, which could lead to altered van-der-Waals forces around the aperture and inside the box, influencing attachment or discharge of particles in the ambient air.

In conclusion, improvements to glove withdrawal technique and dispensing glove box design have the potential to reduce contamination of remaining unused gloves. Such modifications could decrease the risk of microbial cross- transmission in settings, which require non-sterile glove use and potentially reduce the overall incidence of transmissible health care associated infections, such as wound-care clinics. However, such advantages do not substitute for strict hand-hygiene, non-touch compliance and appropriate use of non-sterile, single-use gloves.

Declaration of interest

OA has received travel compensation and speaker's honoraria in the past from Ansell Limited, B. Braun Melsungen AG, Ethicon, Maquet Medical Systems, Paul Hartmann AG, and Schulke & Mayr. AK has received travel compensation and speaker's honoraria in the past from B. Braun Melsungen AG, Ethicon, Schulke & Mayr Ltd., and Paul Hartmann AG. OA is a medical advisory board member of Hutchinson santé, Becton Dickinson UK Ltd., and Mölnlycke Health Care AB, and serves as a part-time consultant for Gerson- Lehman Group, Guidepoint Global LLC, and Quantum Management Services. All other authors have no conflicts of interest to declare.

Authors' contributions

All authors have participated in the research and preparation of the manuscript. OA designed the study and acquired data, OA, DL, AK, and KO analysed and interpreted results. All authors drafted and critically revised the content and have approved the final manuscript.

References

[1] World Health Organisation (2009). WHO Guidelines on Hand Hygiene in Health Care. First Global Patient Safety Challenge Clean Care is Safer Care. World Alliance for Patient Safety. Geneva, World Health Organisation Press.

[2] Johnson S, Gerding DN, Olson MM, *et al.* Prospective, controlled study of vinyl glove use to interrupt Clostridium difficile nosocomial transmission. *Am J Med* 1990; **88:** 137-140

[3] Centers for Disease Control and Prevention (CDC). Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. Atlanta, GA, 2007.

[4] Montville R, Schaffner DW. Inoculum size influences bacterial cross contamination between surfaces. *Appl Environ Microbiol* 2003; **69:** 7188-7193

[5] Rossoff LJ, Lam S, Hilton E, Borenstein M, Isenberg HD. Is the use of boxed gloves in an intensive care unit safe? *Am J Med* 1993; **94:** 602-607

[6] Hughes KA, Cornwall J, Theis J-C, Brooks HJL. Bacterial contamination of unused, disposable non-sterile gloves on a hospital orthopaedic ward. *Australas Med J* 2013; 6: 331-338

[7] BS EN ISO 11737-1. Sterilization of medical devices Microbiological methods - Part 1; Determination of a population of microorganisms on products. Brussels: European Committee for Standardization; 2006.

[8] Berthelot P, Dietemann J, Fascia P, Ros A, Mallaval FO, Lucht F, Pozzetto B, Grattard F. Bacterial contamination of nonsterile disposable gloves before use. *Am J Infect Control* 2006; **34**: 128-30

[9] Diaz MH, Silkaitis C, Malczynski M, Noskin GA, Warren JR, Zembower T. Contamination of examination gloves in patient rooms and implications for transmission of antimicrobial-resistant microorganisms. *Infect Control Hosp Epidemiol* 2008; **29:** 63-65

[10] Stock C, Veyrier M, Raberin H, Fascia P, Rayet I, Lavocat MP, Teyssier G, Berthelot P. Severe cutaneous aspergillosis in a premature neonate linked to nonsterile disposable glove contamination? *Am J Infect Control* 2012; **40**: 465-7

 [11] Luckey JB, Barfield RD, Eleazer PD. Bacterial count comparisons on examination gloves from freshly opened boxes versus nearly empty boxes and from examination gloves before treatment versus after dental dam isolation. *J Endod* 2006; **32:** 646-648

Table I. Mean CFU counts present on gloves after removal of boxes over time

Week	HD		TD		P	% Δ*
	CFU	Range	CFU	Range		
0	2.3	0 - 4	3.6	0 - 5	0.999	36.1
1	50.1	22 - 77	224.2	39 - 780	*0.031*	77.7
2	45.2	11 - 132	160.4	12 - 324	*0.017*	71.8
3	65.8	10 - 319	801.0	48 - 3172	0.081	91.8
4	40.0	10 - 165	650.1	26 - 1768	*0.014*	93.8
5	75.7	10 - 176	376.6	12 - 1274	*0.049*	79.9
6	45.1	10 - 110	688.7	39 - 2275	*0.050*	93.5
Overall	53.6	10 - 319	483.5	12 - 3172	< 0.001	88.9

* percentage difference (Δ) in CFU counts on gloves obtained from HD compared to TD at each site. HD = hygiene-dispenser; TD = tissue-box dispenser.

Table II. Average CFU counts present <mark>around</mark> boxes' <mark>aperture</mark> at three measure points over time

	HD		TD		P	% Δ*
Week	CFU	Range	CFU	Range		
0	14.3	10 - 55	24.7	13 - 52	0.031	42.1
3	21.5	10 - 77	61.8	12 - 169	0.004	65.2
6	39.1	1 - 99	61.2	12 - 228	0.109	36.1
Overall	26.9	1 - 99	50.5	12 - 228	< 0.001	46.7

* percentage difference (Δ) in CFU counts on gloves obtained from HD compared to TD at each site. HD = hygiene-dispenser; TD = tissue-box dispenser.