VOLUME 33
NUMBER 4

WINTER 2018

CJIC

The Canadian Journal of Infection Control
Revue canadienne de prévention des infections

Official Publication of
ipac Infection Prevention and Control Canada
pci Prévention et contrôle des infections Canada
ISSN - 1183 - 5702

INSIDE

196 Position paper: Electronic devices practice recommendations

198 Understanding infection control professionals' educational practice: There is more to it than meets the eye

204 Risk analysis of respiratory infections in facilities for patients with severe motor and intellectual disabilities in Japan

209 Susceptibility of catheter-related *Klebsiella pneumoniae* strains to quaternary ammonium compounds under biofilm and planktonic conditions

216 Prevalence and risk factors of healthcare-associated infections in a Moroccan teaching hospital

220 Improvement of hospital environmental cleaning and disinfection practices following an eight-month outbreak

223 Facultative anaerobic bacteria on dentistry students' gutta-percha points: The importance of disinfection

227 Orthopaedic surgical site infections: A prospective cohort study

PM# 40065075 Return undeliverable Canadian addresses to lauren@kelman.ca

Deliberately® Different.

Accelerated Hydrogen Peroxide®/AHP® is the
first & only disinfectant technology formulated for:

Hands · Surfaces · Devices

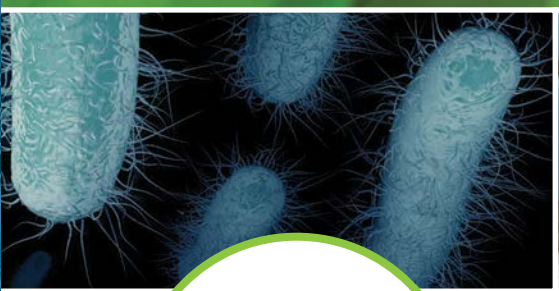
Now that's a *Deliberately Different™* way of thinking.

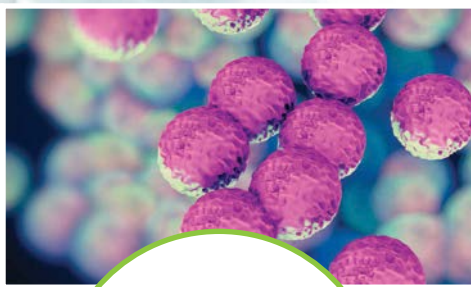
virox.com

ACCELERATED® HYDROGEN PEROXIDE® Patented

VIROX® TECHNOLOGIES INC.

Prevent nosocomial infections caused by BODY FLUIDS





100%
guarantee to reduce HAIs

65
single-patient use products

1200
hospitals adopted our products around the world

ipac Infection Prevention and Control Canada
Silver Corporate Member

Made in Canada

Hy21® Bedpan Support
One of the products offered to control HAIs at the source

FOR MORE INFORMATION, DOWNLOAD OUR DOCUMENTS:

- Hôtel-Dieu de Lévis' study: hygie.com/cjic
- Real & calculable savings: hygie.com/calculate
- Test the Hygie method: hygie.com/en/free-sample

HYGIE.COM

hygie®
One move to protect™

NEW EASYPOINT®

retractable needle

AUTOMATED
RETRACTION
NOW WITH ADDED
VERSATILITY

WHEN ACTIVATED,
NEEDLE RETRACTS
AUTOMATICALLY

RETRACTABLE NEEDLES
(50 per box/400 per case)

Needle Size	Catalog #
25G x 5/8"	82091
25G x 1"	82011
23G x 1"	82031

RETRACTABLE TECHNOLOGIES, INC.
www.retractable.com

511 LOBO LANE, LITTLE ELM, TX 75068-5295 • PHONE 972-294-1770 • TOLL FREE 1-888-703-1010 • FAX 972-294-4400 • RTISERVICE@VANISHPOINT.COM

Diversey™

ADDED ASSURANCE WITH THE POWER OF
A 1-2 PUNCH!

Oxivir® Tb Wipes
One-step, one-wipe, one-minute
cleaning and disinfection of hard surfaces.

MoonBeam™3 UV-C Disinfection
Fast. Effective. Portable. Affordable.

SOLUTIONS DESIGNED FOR HEALTHCARE™

Because every patient deserves a safe environment.

Learn more at sdfhc.com

sdfhc.com

Fast + Effective

A Fast and Effective Equipment Washer...

Medco Equipment, Inc.'s multipurpose portable equipment washer provides dramatic bacteria reduction. Independent lab tests have documented an impressive 99.9% reduction in bacteria ***after one wash***! This machine washes and sanitizes two wheelchairs in five minutes. It also cleans commode chairs, shower chairs, walkers, carts, window screens etc. **2,000 customers worldwide are now sanitizing more than 3.4 million wheelchairs yearly!** Free 30 day trial and delivery. Rent, lease-purchase or purchase. It's a portable dishwasher for wheelchairs and equipment! All stainless steel. CE.UL and CUL listed, 5 year wall to wall warranty. Seven day delivery.

Medco® EQUIPMENT

For more information call (800) 717-3626 or visit
www.medcoequipment.com

Vernacare

We Have Reinvented the Bedbath Wipe!

As the world leader in infection prevention and human waste management, Vernacare is pleased to introduce our newest innovative product – **Oasis Maceratable Bedbath Wipes**.

Vernacare's Oasis Bedbath Wipes are **MACERATABLE** and complement our human waste disposal system.

Vernacare continues to revolutionize the management of hospital human waste with over 60 years of experience.

For more information:

1-800-268-2422
www.vernacare.com

Vernacare

Bleach reinvented

A low-residue, low-odour, surface-friendly innovation

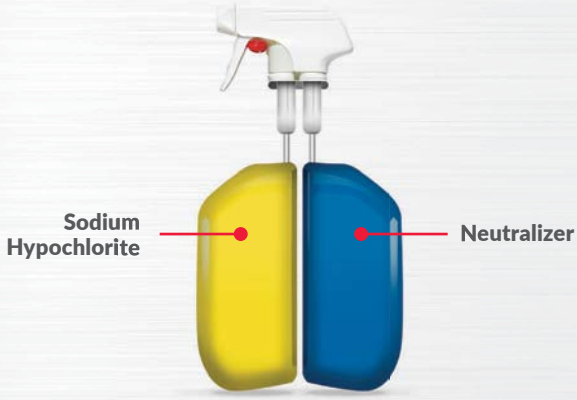
There's no denying the power of bleach to kill pathogens. But its efficacy can become overshadowed by user concerns about odour, residue and surface damage. The future of bleach tells a different story combining the proven power of bleach with excellent aesthetics for broad use throughout the facility.

Meet Clorox Healthcare® Fuzion™ Cleaner Disinfectant

Fuzion™ merges efficacy with user-friendliness to enable users to get that bleach clean – without compromise – while easing concerns about odour and residue.

Clorox Healthcare® Fuzion™ Cleaner Disinfectant

- Kills *C. difficile* in just 60 seconds
- Kills 36 additional pathogens in 60 seconds – including TB & fungi
- Low residue, low odour
- Easy on surfaces
- No protective equipment required



How it works

Inside the bottle, two chambers hold sodium hypochlorite and a neutralizer separately. When the two liquids mix upon spraying, hypochlorous acid is formed to kill pathogens quickly.[1]

The neutralizer then breaks down the bleach to leave only water and a small amount of salt on the surface, minimizing odour, residue and surface damage.[1]

Use next-gen bleach in more places

With this new advanced formulation, you can leverage the efficacy of bleach for everyday use in more places than ever before, including:[1]

- Emergency rooms (ER)
- Patient & waiting rooms
- Nurse stations
- Public restrooms
- IV/Dialysis
- And more

Rethink bleach

Most user concerns about bleach are addressed by today's formulations.

- **Better surface compatibility:** Today's bleach formats are engineered to be compatible with more surfaces and leave less residue behind.[2]
- **Improved compliance:** Ready-to-use formats like Clorox Healthcare® Fuzion™ Cleaner Disinfectant deliver the correct amount of bleach every time (versus dilutable formats whose use can be prone to human error).
- **Less odour:** The active ingredient in bleach has no actual odour and isn't volatile. A scent may occur as it interacts with pathogens, but Clorox Healthcare® Fuzion™ Cleaner Disinfectant is a low-odour formulation.

It's a new day in disinfection with Clorox Healthcare® Fuzion™ Cleaner Disinfectant.

References: 1. Clorox Professional. Clorox Healthcare® Fuzion™ Cleaner Disinfectant (DIN 02459744). https://bit.ly/2QgNDhq. Accessed October 1, 2018. **2.** Clorox Professional Products Company. Clorox Healthcare® Bleach Germicidal Wipes (DIN 02465671). https://bit.ly/2cMNINX. Accessed October 1, 2018.

Get your product trial

Get in touch to arrange for a product trial of Clorox Healthcare® Fuzion™ Cleaner Disinfectant at your facility. Our representative will help optimize your practices and leverage the innovation of this next-gen bleach.

CloroxHealthcare.ca | Healthcare@Clorox.com

Next-level clean.

With next-gen bleach.

Clorox Healthcare® Fuzion™ Cleaner Disinfectant

- Kills *C. difficile*, TB and 35 other pathogens in just 60 seconds
- Low residue, low odour
- Easy on surfaces
- No personal protective equipment required

Use as directed on hard non-porous surfaces.

CloroxHealthcare.ca | healthcare@clorox.com

Rethink disinfection.

Tap into digital record keeping

trophon®2

Simply Smarter

High Level Disinfection for Ultrasound Probes

The latest innovation in ultrasound probe high level disinfection.
Features an enhanced design, simple and fast workflows, plus all new AcuTrace™ for digital record keeping and seamless integration with your hospital IT system.

To learn more visit www.nanosonics.us or www.trophon.com/ca or call 1-844-TROPHON (1-844-876-7466)

Nanosonics Limited (Manufacturer), 14 Mars Road,
Lane Cove NSW 2066, Australia MM00805-US-AD V01

nanosonics
Infection Prevention. For Life.

EDITORIAL OFFICE
Chingiz Amirov, MPH, MSc QIPS, CIC, FAPIC
Director, Infection Prevention and Control
Baycrest Health Sciences
3560 Bathurst Street
Toronto, Ontario M6A 2E1
Tel: 416-785-2500 Ext. 2981 Fax: 416-785-2503
Email: editor-in-chief@ipac-canada.org

POSTING EMPLOYMENT OPPORTUNITIES/OTHER INFORMATION
IPAC Canada Membership Services Office
info@ipac-canada.org

PUBLISHER
Craig Kelman & Associates

3rd Floor, 2020 Portage Avenue
Winnipeg, MB R3J 0K4
Tel: (204) 985-9780 Fax: (204) 985-9795
www.kelman.ca E-mail: info@kelman.ca

EDITOR - Andrée-Anne Boisvert
DESIGN/PRODUCTION - Tracy Toutant
MARKETING MANAGER - Al Whalen
ADVERTISING COORDINATOR - Stefanie Hagidiakow

Send change of address to:
IPAC Canada
P.O. Box 46125, RPO Westdale,
Winnipeg, MB R3R 3S3
info@ipac-canada.org

Publications Mail Agreement #**40065075**
Return undeliverable Canadian addresses to: lauren@kelman.ca

SUBSCRIPTIONS
Subscriptions are available from the publisher at the following rates: All Canadian prices include GST.
Prices are listed as personal/institutional.
Canada: $30/$38 (GST # 100761253); USA (in US funds): $28/$36;
Other countries: $45/$60.
Subscriptions do not include online access to the journal. Members have online access to the current issue.

VISION
IPAC Canada – a national and international infection prevention and control leader.

MISSION
IPAC Canada is a multidisciplinary member-based association committed to public wellness and safety by advocating for best practices in infection prevention and control in all settings.

IPAC CANADA is now on FACEBOOK, TWITTER and LINKED IN

facebook twitter LinkedIn

WINTER 2018

VOLUME 33
NUMBER 4

CJIC
The Canadian Journal of Infection Control
Revue canadienne de prévention des infections

FEATURES

196 Position paper: Electronic devices practice recommendations

198 Understanding infection control professionals' educational practice: There is more to it than meets the eye

204 Risk analysis of respiratory infections in facilities for patients with severe motor and intellectual disabilities in Japan

209 Susceptibility of catheter-related *Klebsiella pneumoniae* strains to quaternary ammonium compounds under biofilm and planktonic conditions

216 Prevalence and risk factors of healthcare-associated infections in a Moroccan teaching hospital

220 Improvement of hospital environmental cleaning and disinfection practices following an eight-month outbreak

223 Facultative anaerobic bacteria on dentistry students' gutta-percha points: The importance of disinfection

227 Orthopaedic surgical site infections: A prospective cohort study

The *Canadian Journal of Infection Control* is the official publication of Infection Prevention and Control Canada (IPAC Canada). The Journal is published four times a year by Craig Kelman & Associates, Ltd. and is printed in Canada on recycled paper. Circulation: 3,000.

ISSN 1183-5702

Indexed/abstracted by the Cumulative Index to Nursing and Allied Health Literature (CINAHL)/EBSCO and SilverPlatter Information, Inc.

The *Canadian Journal of Infection Control* is a Canadian periodical as defined by section 19 of the Canadian Income Tax Act. The deduction of advertising costs for advertising in this periodical is therefore not restricted.

ipac Infection Prevention and Control Canada
pci Prévention et contrôle des infections Canada

www.ipac-canada.org

IPAC CANADA
2018 - 2019 Board of Directors

Executive Officers

President
Molly Blake, BN, MHS, GNC(C), CIC
Infection Control Professional
Winnipeg Regional Health Authority
232A North Pavilion, 2109 Portage Avenue
Winnipeg, MB R3J 0L3
Phone: 204-833-1742 Fax: 204-940-2182
president@ipac-canada.org

President-elect
Barbara Catt, RN, BScN, MEd, CIC
Manager IPAC Response and Support
Public Health Ontario
480 University Ave, Ste. 300
Toronto, ON M5G 1V2
Phone: 647-260-7100
barbara.catt@oahpp.ca

Secretary
Jennifer Happe, BSc, MSc
Infection Control Professional
Alberta Health Services
3942 50 A Avenue, Red Deer, AB T4N 6R2
Phone: 403-343-4702 Fax: 403-356-4209
jennifer.happe@ahs.ca

Treasurer
Michael Rotstein, RN, BScN, MHSc, CIC, CHE
Manager Infection Prevention and Control
St. Joseph's Health Centre
30 The Queensway
Toronto, ON M6R 1B5
Phone: 416-530-6486
mrotstein@stjoestoronto.ca

The term of Past President is one year.
IPAC Canada thanks Suzanne Rhodenizer Rose for her service to the Association.

Directors

Kim Allain, BScN, RN, MHS, CIC
Quality Improvement and IPAC Safety Lead
Nova Scotia Health Authority
902 Bethune Bldg, 1276 South Park St.
Halifax NS B3H 2Y9
Phone: 902-473-8806
kim.allain@nshealth.ca

Mandy Deeves, RN, MPH, CIC
Team Lead, Regional IPAC Team - Central
Public Health Ontario | Santé publique Ontario
480 University Avenue, Suite 300
480 avenue University, bureau 300
Toronto, ON M5G 1V2
Phone: 647-260-7234 Fax: 647-260-7600
mandy.deeves@oahpp.ca

Tara Donovan, BHSc, MSc
Network Director
BC Provincial Infection Control Network
504-1001 W. Broadway
Vancouver BC V6H 4B1
Phone: 604-875-4844
tara.donovan@phsa.ca

Joseph Kim, MD, FRCPC
Infectious Disease Consultant
Alberta Health Services
7007 14 Street SW
Calgary AB T2V 1P9
Phone: 403-943-3255 Fax: 403-212-1235
joseph.kim@ahs.ca

Ramona Rodrigues, RN, BSc, MSc(A), CIC, ICS-PCI, FAPIC
McGill University Health Centre
Montréal General Hospital
1650 Cedar Avenue
Montréal, QC H3G 1A4
Phone: 514-934-1934 ext: 42047
Fax: 514-934-8427
ramona.rodrigues@muhc.mcgill.ca

Public Representative
Stephen Palmer
79 Amberview Drive
Keswick ON L4P 3Y3
Phone: 416-938-6125
sdpalmer@rogers.com

Other Positions

Editor-in-Chief – Canadian Journal of Infection Control
Chingiz Amirov, MPH, MSc QIPS, CIC, FAPIC
Director, Infection Prevention and Control
Baycrest Health Sciences
3560 Bathurst Street
Toronto, ON M6A 2E1
editor-in-chief@ipac-canada.org

Web Communications Manager
Tanya Denich, MSc, CIC
webcommunications@ipac-canada.org

Webmaster
Pamela Chalmers
webmaster@ipac-canada.org

Online Novice IP&C Course Coordinators
Heather Candon, BSc, MSc, CIC
Jane Van Toen, MLT, BSc, CIC
basicde@ipac-canada.org

Social Media Manager
Helen Evans, MA
socialmedia@ipac-canada.org

Social Media Assistant
Philippe Fournier, BSc IT, CIC
socialmedia@ipac-canada.org

Professional Agents

Legal Counsel
Terrance Carter/Theresa Man
Carters Professional Corporation
211 Broadway
Orangeville, ON L9W 1K4
Phone: 519-942-0001
tcarter@carters.ca

Auditor
Philip Romaniuk, CPA, CA
Grant Thornton LLP
94 Commerce Drive
Winnipeg MB R3P 0Z3
Phone: 204-272-4631
phil.romaniuk@ca.gt.com

Membership Services Office

Executive Director
Gerry Hansen, BA
PO Box 46125 RPO Westdale,
Winnipeg, MB R3R 3S3
Phone: 204-897-5990/866-999-7111
Fax: 204-895-9595
executivedirector@ipac-canada.org

Deliveries only:
67 Bergman Crescent, Winnipeg, MB R3R 1Y9

Administrative Assistant
Kelli Wagner
Phone: 204-488-5027 Fax: 204-488-5028
Toll-Free: 1-855-488-5027
admin@ipac-canada.org

Conference Coordinator
Pascale Daigneault
Phone: 780-436-0983 ext. 223
Fax: 780-437-5984
pascale@buksa.com

General Information
info@ipac-canada.org

IPAC CANADA CORPORATE MEMBERS

PLATINUM:
- **GOJO Industries**
(800) 321-9647 ext. 6829, *www.gojo.com*
- **Diversey Inc.**
(262) 631-4132, *www.diversey.com*
- **Virox Technologies**
(800) 387-7578 (905) 813-0110
www.virox.com
- **The Clorox Company of Canada**
(866) 789-4973, *www.cloroxofcanada.ca*

GOLD:
- **Wood Wyant**
(800) 361-7691, *www.woodwyant.com*

SILVER:
- **3M Healthcare**
(651) 250-4821, *www.3mcanada.ca*
- **BD Canada**
(905) 288-6152, *www.hd.com/ca*
- **Class 1 Inc.**
(519) 650-2355, *www.class1inc.com*
- **DebMed**
(519) 443-8697, *www.debmed.com*
- **Ecolab Healthcare**
(651) 293-2914 (800) 352-5326
www.ecolab.com
- **HandyMetrics Corporation**
(416) 800-1743, *www.handyaudit.com*
- **Hygie Canada**
(450) 444-6777, *www.hygiecanada.com*
- **Sage Products**
(815) 455-4700, *www.sageproducts.ca*
- **Vernacare**
(416) 661-5552 ext. 232 Cell: (416) 580-9301
www.vernacare.ca
- **Webber Training**
(613) 962-0437, *www.webbertraining.com*

BRONZE:
- **Arjo Canada Inc.**
(800) 665-4831, *www.arjo.com*
- **Chem-Aqua**
(905) 457-2434, *www.chemaqua.com*
Email: *subrotoc@nch.com*
- **Citrón Hygiene**
(905) 464-0281/(800) 643-6922
www.citronhygiene.com
- **CSA Group**
www.csagroup.org
- **IPAC Consulting**
(226) 228-5550, *www.ipacconsulting.com*
Email: *contact@ipacconsulting.com*
- **Medela Canada**
(905) 608-7272 ext. 229, (800) 435-8316
www.medela.ca
- **Nosotech Inc.**
(418) 723-0862, *www.nosotech.com*
- **SciCan**
(416) 446-2757, *www.scicancanada.ca*
- **Steris Corporation**
(905) 677-0863, *www.steris.com*
- **The Stevens Company**
(905) 791-8600, *www.stevens.ca*

POSITION PAPER: Electronic devices practice recommendations

This position statement was developed by IPAC Canada's Standards and Guidelines Committee:

Chair: Madeleine J. Ashcroft
Principal authors: Madeleine J. Ashcroft, RN, BScN, MHS, CIC;[1] Erin Roberts, RN, BScN, CIC;[2] Lisa Young, BA (Hons)[3]
Affiliations: [1] Public Health Ontario, ON, Canada
[2] Grey Nuns Community Hospital, Edmonton, AB, Canada
[3] BC Emergency Health Services, BC, Canada
Corresponding author: Madeleine J. Ashcroft *madeleine.ashcroft@oahpp.ca*
Original date: October 1, 2012
Reviewed/revised: January 15, 2018

Electronic devices (for example, cellular phones, tablets, portable computers) are increasingly important in healthcare for myriad functions, some of which result in their classification as non-critical medical devices. Most are at risk of becoming fomites for the transmission of microorganisms. Standards and regulations addressing infection prevention and control (IPAC) considerations for electronic devices have been lacking or generally lagged behind their use.

The best practices in this document are based on the assumption that healthcare settings in Canada already have basic IPAC systems and programs in place, including Routine Practices and Additional Precautions; adequate resources for their IPAC program; hand hygiene; disinfection and sterilization of used medical equipment; environmental services/housekeeping (cleaning and disinfection of rooms and equipment); and education and training (including orientation and continuing education).

This document focuses on electronic devices used for Information Technology (IT) purposes, including personal devices and accessories that:

- Stay with the healthcare worker (HCW) in clinical areas (e.g., smartphone);
- Are used for patient teaching and may stay with the patient in clinical areas (e.g., tablet); and
- Move from patient to patient in clinical areas (e.g., computer/workstation on wheels).

STAKEHOLDERS

All HCWs who use portable electronic devices as part of their duties; electronic device manufacturers; and infection control professionals.

INFECTION PREVENTION AND CONTROL PRACTICE RECOMMENDATIONS FOR ELECTRONIC (IT) DEVICES

1. Hand hygiene is the most important factor in the prevention of transmission of microorganisms. IT devices should be approached with clean hands. Hand hygiene should be performed between patient contact and before and after accessing a device. [1-4]
2. Gloves inhibit hand hygiene and therefore should not be routinely worn when using IT equipment. [1, 2]
3. Electronic (IT) devices should be cleanable: Prior to selection and purchase of electronic devices, manufacturer's guidelines for use, cleaning/disinfection, and maintenance should be reviewed to ensure these guidelines meet the standards for cleaning and low-level disinfection that are necessary to disinfect devices of all pathogens of epidemiological significance. [1-3, 5-8]

   Items that cannot be adequately cleaned should not be used OR accessed in patient rooms OR be touched by patients.
4. Cover: If an item cannot be adequately cleaned and will be accessed in a patient room or touched by patients, it requires a cleanable cover. Impervious keyboard or tablet covers, skins, or solid, fluid-resistant keyboards that can be cleaned and disinfected are recommended.
5. Risk Assessment: If an item cannot be cleaned with a low-level disinfectant and is necessary for patient care, a risk assessment should be done with IPAC to determine the best approach to mitigate the risk of transmission of microorganisms.
6. Cleaning: All touch surfaces of IT devices used at or near point-of-care must be cleaned and disinfected with a low-level disinfectant (per manufacturer's instructions) if used or touched during the encounter with the patient. Where manufacturer's recommendations are not sufficient to adequately meet national standards for cleaning and disinfection of the item and products are not in keeping with the manufacturer's recommendations, review cleaning/disinfection processes and consider establishing a policy and protocol based on the best evidence available, including published evidence in recent peer-reviewed journals. Alternatives for safe use should also be considered (e.g., plastic sealable bags, screen covers).
   - Use soft, non-absorbent, lint-free cloths for cleaning as damage to equipment can compromise cleaning.
   - The surface of telephone components, pagers, and computer mice should be cleaned in a

Return to TABLE OF CONTENTS

manner that prevents damage to internal systems from excessive fluid. LCD screens in non-clinical areas should only be cleaned with item's manufacturer-approved screen cleaning products.
- Do not use compressed air to clean IT equipment such as keyboards, as this aerosolizes debris and microorganisms. [2]

7. Responsibility: The user/owner of the device is responsible for routine cleaning and disinfection of the device and that responsibility must be clearly communicated. The identified staff must follow facility protocols for cleaning and disinfection after each patient encounter in which the device is potentially contaminated.
8. Frequency: If the device remains with the patient or is in a public area, it should be cleaned at least daily. [2]
9. Policy and procedure must be in writing and staff education provided and documented.

GLOSSARY/DEFINITIONS

As per the Canadian Standard Association:

"SHALL" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard;

"SHOULD" is used to express a recommendation or that which is advised but not required; and

"MAY" is used to express an option or that which is permissible within the limits of the standard, an advisory or optional statement.

Low-level disinfectants: Disinfectants suitable for processing non-invasive medical equipment (i.e., non-critical equipment) and some environmental surfaces after thorough cleaning. Low-level disinfectants kill most vegetative bacteria (e.g., MRSA) and some fungi as well as enveloped (lipid) viruses (e.g., Hepatitis B and C, hantavirus, and HIV). Low-level disinfectants do not kill mycobacteria (e.g., TB) or bacterial spores (e.g., *C. difficile*). A low-level disinfectant has a drug identification number from Health Canada indicating its approval for use in Canadian hospitals.

REFERENCES

1. Public Health Ontario. (2013). *Best practices for cleaning, disinfection and sterilization of medical equipment/devices in all health care settings*. 3rd ed. Toronto, ON: Queen's Printer for Ontario. Retrieved from http://www.publichealthontario.ca/en/eRepository/PIDAC_Cleaning_Disinfection_and_Sterilization_2013.pdf
2. Public Health Ontario. (2012). *Best practices for environmental cleaning in all health care settings*. 2nd ed. Toronto, ON: Queen's Printer for Ontario. Retrieved from http://www.publichealthontario.ca/en/eRepository/Best_Practices_Environmental_Cleaning_2012.pdf
3. Alberta Health Services. (2016). *Cleaning and disinfection of information technology (IT) equipment*. Retrieved from http://www.albertahealthservices.ca/assets/healthinfo/ipc/if-hp-ipc-cleaning-disinfection-info.pdf
4. Alberta Health Services. (2016). *Cleaning and disinfection of telehealth and peripheral devices*. Retrieved from http://www.albertahealthservices.ca/assets/healthinfo/ipc/if-hp-telehealth-equipment-cleaning-disinfection-bpg.pdf
5. Alberta Health Services. (2016). *Steps for disinfecting telehealth and peripheral devices*. Retrieved from http://www.albertahealthservices.ca/assets/healthinfo/ipc/if-hp-telehealth-equipment-cleaning-disinfection-poster.pdf
6. Howell, V., Thoppil, A, Mariyaselvam, M., Jones, R., Young, H., Sharma, S., Blunt M., & Young, P. (2014). Disinfecting the iPad: Evaluating effective methods. *Journal of Hospital Infection, 87*(2), 77-83. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/24746231
7. Kiedrowski, L. M., Perisetti, A., Loock, M. H., Khaitsa, M. L., & Guerrero, D. M. (2013). Disinfecting of iPad to reduce contamination with *Clostridium difficile* and methicillin-resistant *Staphylococcus aureus*. *American Journal of Infection Control, 41*(11), 1136-1137. Retrieved from http://www.ajicjournal.org/article/S0196-6553(13)00193-4/abstract
8. Albrecht, U. V., von Jan, U., Sedlacek, L., Groos, S., Suerbaum, S., & Vonberg, R. P. (2013). Standardized, app-based disinfection of iPads in a clinical and nonclinical setting: Comparative analysis. *Journal of Medical Internet Research, 15*(8), 176. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/23945468

ORIGINAL ARTICLE

Understanding infection control professionals' educational practice: There is more to it than meets the eye

Gwyneth L. Meyers, PhD;[1] Michele Jacobsen, PhD;[2] Elizabeth Henderson, PhD[3]

[1] *Senior Clinical Practice Coordinator, Infection Prevention and Control, Alberta Health Services, Calgary, AB, Canada*
[2] *Professor and Vice Dean, Werklund School of Education, University of Calgary, Calgary, AB, Canada*
[3] *Professor Emeritus, Department of Community Health Sciences, University of Calgary, Calgary, AB, Canada*

Corresponding author:
Gwyneth L. Meyers
Infection Prevention and Control
Alberta Health Services
Room 3683A Peter Lougheed Centre
3500 26 Ave N.E., Calgary, AB T1Y 6J4, Canada
Tel.: 403-943-4157
gwyneth.meyers@ahs.ca

ABSTRACT

Background: There is a paucity of research exploring infection control professionals' (ICPs) educational practice and the daily challenges they face in providing education to change healthcare worker (HCW) behaviour and promote patient safety. Without closer examination of educational practice, ICPs cannot critically reflect on what, how, or why their educational approaches need to be improved or changed.

Methods: This research was conducted as part of a larger Design-Based Research study that looked at building ICP educational practice and culture within the Alberta Health Services (AHS) Infection Prevention and Control (IPAC) program. AHS ICP educational practice was explored using an online survey questionnaire, a focus group interview, and field observations of ICP educational practice. A qualitative systematic methodology was used to identify interconnected themes regarding ICP educational practice.

Results: Education is considered important and central to ICPs' professional practice. Despite its importance, ICPs are frustrated with the quality and effectiveness of the education they provide and seek ways to build their educational expertise. Four themes emerged in this study: the ICP's role as educator, circumstances influencing educational practice, educational strategies, and educational outcomes. These themes, along with their associated influences and challenges, illustrate the multifaceted nature of ICP educational practice in the AHS IPAC program.

Discussion: ICP educational practice is more complex than the IPAC educational research literature suggests. This study provides a detailed understanding of that practice and the multiple issues and processes involved in it. Making the complexity of ICP educational practice explicit validates ICPs in their role as educators and provides a foundation from which to build their educational expertise. Although ICPs are frustrated with the quality and outcomes of their education, their insights into their educational practice challenges indicate they are primed for change. ICPs seek innovative professional development experiences to change and build their educational expertise.

KEYWORDS

Infection prevention and control; education; teaching and learning; professional

INTRODUCTION

This paper is the third in a series of four discussing education in the field of infection prevention and control (IPAC). There is a paucity of research studying infection control professional (ICP) educational practice and the teaching and learning processes involved in providing effective education to facilitate healthcare workers' (HCW) behaviour change. Without an examination of that practice, we in the IPAC profession cannot critically reflect on what, how, or why our educational approaches need to be improved or changed.

IPAC educational intervention research focuses predominantly on formal information-giving strategies to improve HCW practice [1]. Such strategies do not necessarily prepare HCWs for translating knowledge into practice because the relationship between HCW knowledge acquisition and actual practice involves a complex interaction between knowledge, skills, and other social and cognitive psychological determinants [2-7].

Acknowledgements: This research would not have been possible without the ongoing support of the Alberta Health Services IPAC program and the participation of the infection control professionals in that program.

Conflicts of interest: None.

Funding: There was no formal funding for this research. Alberta Health Services provided Group Learning Initiatives Funding and funds from competitive Alberta Health Services Learning and Professional Development Awards in 2012, 2013, and 2014, which addressed some of the costs associated with this research.

Ethics approval: This research was conducted as part of a larger doctoral research study that received ethical approval from the Conjoint Health Research Ethics Board University of Calgary.

Focusing predominantly on educational strategies for the purpose of knowledge-giving results in a constrained view of education that undervalues and overlooks the pedagogical concepts involved in teaching and learning processes to facilitate behaviour change [1].

Educational expertise is a core competency for ICPs [8-10]. However, professional development opportunities for ICPs to cultivate their pedagogical expertise are limited [11]. This gap is not unusual, as HCWs are often responsible for planning educational experiences without prior pedagogical training [12, 13]. It is well known that, without training, most teachers will teach as they were taught [14].

In response to these challenges, the educational practices of Alberta Health Services (AHS) ICPs were explored through an ecological teaching and learning process lens to inform the design of an ICP educational professional development experience [11]. To build ICP educational expertise and practice that moved beyond conventional educational strategies, it was first important to understand the nature of their educational practices. This study identified the complexity of ICP educational practice and the continual challenges ICPs face as they educate to change HCWs' behaviour. Several recommendations regarding ICP educational practice emerged from the study.

MATERIALS AND METHODS

The research and data collection methods reported in this paper took place within the context of a more complex Design-Based Research (DBR) study described in the second paper in this series [15]. The data analyzed in this paper were collected over six months (from mid-April to mid-October 2016) within the AHS IPAC program. An online survey questionnaire, a focus group interview, and field observations of ICP education sessions were used to collect data. Study participants for the survey were recruited via email from a convenience sample of all full-time ICPs employed by AHS. Participants for the focus group and field observations consisted of a smaller subset of ICPs who were recruited separately by email from the same convenience sample to participate in a Community of Learning educational professional development experience.

The survey included a mix of demographic, structured, and closed and open-ended questions. Modifications were made to the survey based on feedback from pilot testing. The focus group was conducted with a small group of ICPs who were participating in an educational professional development experience using a guide with open-ended questions. Focus group questions were designed to align with and build upon survey questions to gain a deeper understanding of ICP educational experiences, expertise, beliefs, attitudes, and educational practices. This alignment allowed for cross-checking of ideas and interpretations of findings that emerged from the survey.

Survey and focus group data, which are based on self-report, were subject to the risk of participants under- or over-reporting issues. To address this concern, field observations of the educational activities of the subset of ICPs who participated in the focus group were conducted. Observation is a means to study actual behaviour and concepts that have not been made explicit in self-reported data [16]. An observation tool was developed based on the concept of the learning ecology, taking into account the relationships amongst instructor, learners, content, teaching strategies, technologies used, and the educational environment [17, 18].

As data were collected, they were cleaned and entered into Microsoft Excel© and QSR Nvivo10© for analysis. Descriptive statistics were used to analyze some of the survey questions and a qualitative systematic methodology was used to code and analyze the remaining data, which focused on identifying emerging themes [19]. Three cycles of a systematic analysis by the researcher occurred for this part of the DBR study. The first cycle was a preliminary analysis of data as each research activity was completed. This preliminary analysis served to iteratively inform the design of next steps in the study. The second cycle analyzed all study data in the order in which it was collected after all data collection had been completed. This systematic approach provided an organized process for making sense of the data collected from different data sources. The third analysis cycle stemmed from the second and involved a re-examination and recoding of all data under the emerging thematic categories identified in the second cycle to identify further key themes within those categories. In this way, findings from different data sources were further synthesized and integrated under common themes or newly identified themes. This facilitated the movement from descriptive analysis to more analytic explanations of the data, expanding on and refining what was observed, as well as looking at relationships and process to theorize how or why things occurred.

RESULTS

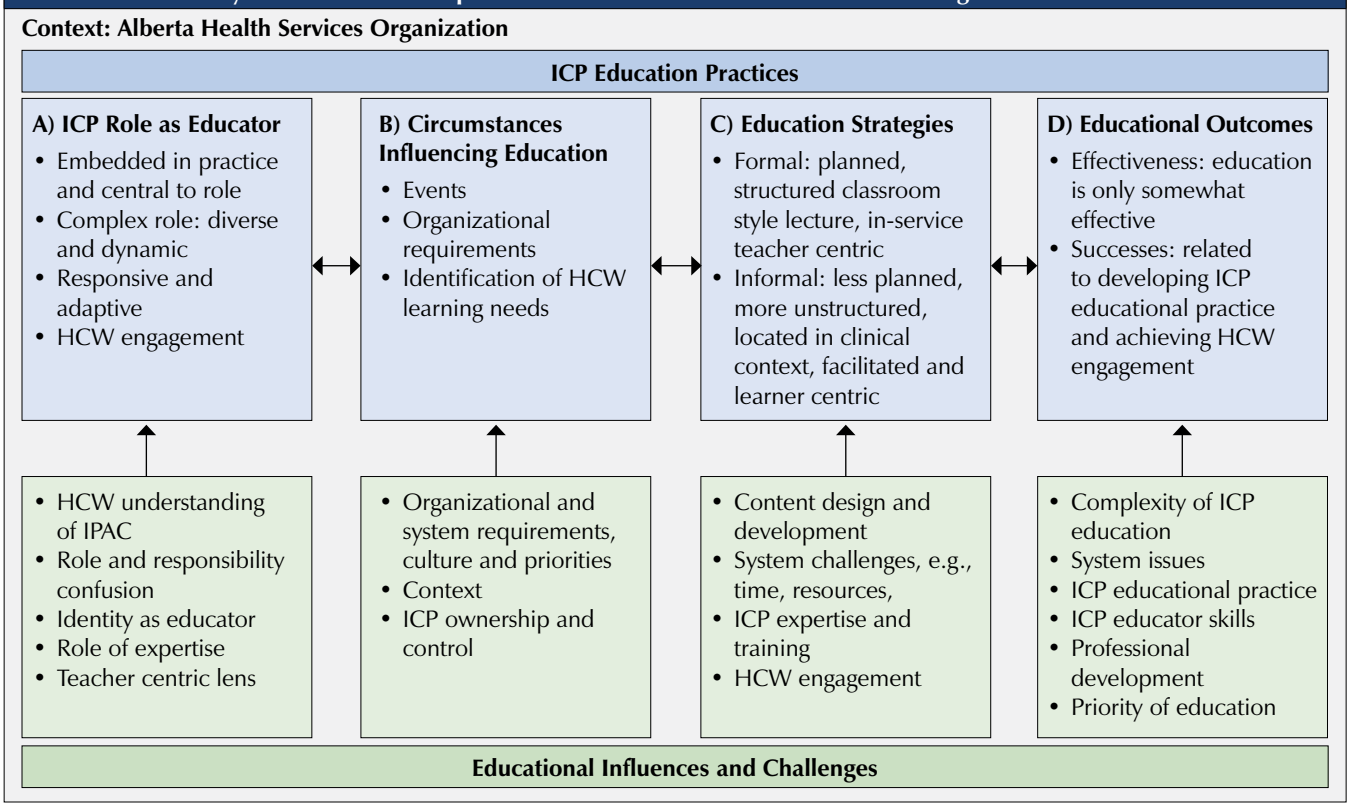
AHS IPAC is a province-wide program providing IPAC service across the continuum of care in both urban and rural healthcare settings. 48 ICPs participated in the online survey for a response rate of 55% (48/87) and eight ICPs participated in the focus group. Educational practice was observed for three of the eight ICPs in the focus group. Study participants in both the survey and focus groups were representative of the diversity of the program. ICP participants came from a variety of professional backgrounds, including microbiology, epidemiology, and nursing, and ranged in IPAC experience: 71% had less than five years' experience and 6% had over 15 years' experience.

Four main themes regarding ICP educational practice and associated influences and challenges emerged in the analysis: a) educator role, b) circumstances that influence ICP education, c) educational strategies, and d) educational outcomes. The attributes of each are summarized in Figure 1.

ICP educator role

Almost three quarters of the ICPs ranked themselves as having some educational expertise-based training that ranged from practice experience to a degree in Education. The most common type of training was obtained through conferences, workshops, and webinars. Independent of their IPAC experience, educational training, and perceived expertise, the majority of ICP respondents rated their role as educator as very important (85%, 41/48). Reasons for this importance are twofold. The first reason was

FIGURE 1: Summary of ICP educational practice and associated influences and challenges.



ICPs' perception of education as "core," "central," and "critical" to their IPAC professional practice. ICPs viewed their role as "embedded in every aspect of that practice." The second reason was the purpose of the education, that is, "the transfer of knowledge" to front-line staff and other educators, in order to "facilitate change in practice."

The ICPs discussed their role as educators in terms of complexity. They indicated a need to be "responsive and adaptive" as educators because of the "diverse and dynamic" nature of the content of that education. Reasons reported for complexity included: a) the variety of HCWs' differing roles and professions, knowledge needs, and the fact that these HCWs were always changing, with new hires and role changes; b) the variety of contexts in which IPAC education occurred and the various reasons for that education; and c) the varied experience and approaches of the ICPs themselves, influencing their ideas about how to present IPAC information.

This complexity presented several challenges for ICPs as educators. The ICPs perceived that HCWs do not understand the breadth and complexity of IPAC practice, resulting in an underestimation of the scope of content and time needed for IPAC education. Compounding this lack of understanding is what one ICP described as "the motherhood and apple pie" issue. That is, everyone can agree that IPAC principles are important but practices such as hand hygiene are so ubiquitous and generalized that everyone thinks they know about it. Consequently, the concept of IPAC is well accepted but not well practiced: "Everyone knows it; they just don't do it." The ICPs also perceived that this misunderstanding results in a lack of HCW ownership and taking responsibility for following IPAC practices. In the words of one ICP, "HCWs often want ICPs to solve their practice problems for them. I've said to a group before, 'You have to do your own infection control practice,' and then you look at me, 'You're not going to do it for me?' 'No, you have to wash your own hands.' It's really their job. We're just helping them figure out the background piece."

To address this complexity, the ICPs reported they invested time in what they described as "HCW engagement." This engagement required spending time to build collegial, collaborative relationships for the purposes of fostering credibility and trust through mutual learning and problem-solving; and to break down barriers of misunderstanding, mistrust, and negative perceptions of IPAC that could interfere with ICPs' teaching efforts. HCW engagement also meant "knowing your target audience," "knowing your learner IPAC needs," and "tailoring your education" using recognized principles of adult learning to make educational content relevant and meaningful. Although ICPs referred to the use of a variety of strategies, the pedagogical principles they apply are filtered through a conventional teacher-centric lens of information-giving as the knowledgeable expert (e.g., "I will assess and determine the type of presentation I will provide" and "What information I will give my audience?").

ICPs also struggled with their educator identity. The ICPs tended to view their educational role and subsequent practice challenges through the lens of an IPAC content expert, not through the pedagogical process lens of an educator. The ICPs reported that they did not feel prepared, supported, or confident in their educator role. This left them feeling uncertain about their

Return to TABLE OF CONTENTS

"credibility as an educator." Consequently, the ICPs struggled with feeling accepted as an IPAC expert within their educator role. Their reliance on conventional educational information-giving as a knowledgeable expert also resulted in a tension between being perceived as an expert authority and being authoritarian. The ICPs noted that conventional teacher-centric approaches have the potential to "disengage staff" if the teaching is perceived to be "dictatorial." One ICP pondered, "How does an instructor balance adult learning with not being patronizing?"

Circumstances influencing education

As educators, ICPs encounter a variety of circumstances that influence the development and delivery of education. When AHS and its IPAC program, with their respective educational cultures, responded to specific events, individual ICPs had varying degrees of control and ownership over the development of that education. The ICPs reported that it was difficult to both take ownership of and teach education prepared by others. It was easier if they were able to refine the content of the education to address local targeted HCW groups.

Administrative and legislative oversight organizations such as Accreditation Canada also influenced IPAC educational practice through mandated IPAC education and training for HCWs. To meet mandated education requirements and provide ongoing training for a large number of HCWs over a wide geographical area, the AHS IPAC program relied on the use of online education. The ICPs reported that the quality of online education was constrained by organizational system issues such as available technology, time and access to HCWs, the size of the organization, organizational branding, approval requirements, and a "one-size-fits-all" approach to education. ICPs perceived that online education favoured the provision of information over interaction and efficiency over effectiveness and they felt removed from such educational initiatives: "It doesn't even feel like yours anymore; it feels like somebody else's."

Sometimes educational circumstances were based on HCW knowledge or practice needs identified by clinical staff or by the ICPs themselves. These were recognized as the most common and rewarding educational opportunities whereby ICPs had more control over the content development and delivery of educational strategies. The ICPs indicated, however, that organizational and contextual issues tended to inform their choice of educational strategies.

Educational strategies

ICPs described the education they provided as both formal and informal. Formal education included planned, structured sessions that take place in classroom-type settings using a traditional lecture format. Within this formal education, the ICPs described using several teaching strategies, resources, and tools. Examples included using demonstration, case study, role play, and gamification. These strategies were often embedded within PowerPoint presentations to facilitate interactivity and HCW engagement. Adjunct reference materials such as information sheets and practice guides were often used to supplement content provided during the educational experience. While there was diversity and creativity in the activities and resources used by the ICPs, the formal educational strategies, including interactivity, were predominantly teacher-centric, and the responsibility and focus remained primarily with the ICP to provide meaningful information. This is in contrast to a learner-centric approach, where the focus is on HCWs taking active responsibility for and directing their learning experiences.

Informal education was described by ICPs as "just-in-time teaching," "bed huddles," or "on-the-spot, in-the-moment" education, which usually occurred in the context of the HCW practice environment and was described as "embedded" and "implicit" in their educational practice. Although informal education could be a planned teaching experience, it was often considered less structured, more responsive and HCW-driven, and involving more collaborative learning, discussion, and problem-solving. The ICPs preferred informal approaches because these were perceived as more "usable," "applicable," and "relevant" for engaging HCWs in learning experiences that were "more effective in bridging the theory-to-practice gap." In informal contexts, ICPs described their educator role as "facilitator" rather than a "sage on stage."

When describing the development and delivery of education, most ICPs' approaches could be broadly categorized into phases of the ADDIE instructional design framework: analysis, design, development, implementation, and evaluation. Primary emphasis was on analysis and development with some attention given to evaluation. Evaluation was recognized as challenging and therefore not often done. In developing their educational approaches, some ICPs referred to educational principles of creating learning objectives and attending to concepts of adult learning or different learning styles. There was limited use of pedagogical language, or reference to pedagogical concepts more generally. Implementation received limited discussion apart from the challenges they encountered in delivering their education. Notably absent was attention given to instructional design, particularly in relation to designing for teaching and learning rather than designing for content delivery. In some cases, ICPs stated they "did not have an official approach" or "just did what seemed to work."

Two central themes emerged from ICPs' responses to challenges they had in developing their education: system issues and lack of educational expertise and training. System issues included: a) competing priorities from other aspects of their work, resulting in limited time to engage HCWs to assess their educational needs and to spend on developing education; b) limited resources such as technologies to develop education; c) increased focus on online education; and d) perceived lack of priority given to education both in the IPAC program and AHS as a whole.

The ICPs indicated that their limited educational training and lack of opportunities to build their educational expertise impacted their ability to design quality education. They cited their lack of "educational knowledge, skills, and experience" as making it "difficult to be creative" and come up with "advanced educational strategies." The ICPs were cognizant of their need for improvement to design more effective, impactful education but did not "know what changes to make" or "how to move forward" to make changes.

Challenges ICPs reported in delivering their education were similar to those identified in developing their education, with the addition of HCW disengagement. The competing priorities on HCWs' time, their workload, and other educational needs resulted in change fatigue, learning burnout, and cognitive overload; these were perceived to impact HCW motivation and attention to and retention of ICP education.

Educational outcomes

While the ICPs considered education to be important, 79% (39/48) saw the education they provided as only somewhat effective. Reasons reported for lack of effectiveness included: a) the complexity of ICP domain content and of teaching and learning processes as a whole; b) insufficient time and access to HCWs to provide effective education; c) ICP educational designs not effective in motivating HCWs to learn and engage with ICP content; d) the general quality of the education ICPs provided; and e) the need for additional development of ICP teaching skills.

Although the ICPs were frustrated with their educational efforts, they did describe some areas of success. These included improvements in their teaching approaches such as "improved use of PowerPoint" or "introducing a new teaching modality." The ICPs also considered they had achieved success when they sensed they had "bridged the theory-to-practice gap," when HCWs reflected an understanding of IPAC, its relevance to them, and how to apply it to their practice (e.g., "yeah, bringing it home" and "seeing those aha moments").

Each of the four educational practice themes described above (the educator role, circumstances influencing education, educational strategies, and educational outcomes) are reflexively interconnected, each influencing the other as part of a complex ecology of ICP educational practice. For example, the effectiveness of educational outcomes is not only influenced by the choice of educational strategies, but is also influenced by an ICP's confidence and experience as an educator, as well as the professional and organizational educational culture in which the education process occurs. The horizontal arrows between the four themes in Figure 1 are designed to illustrate these reflexive linkages.

Much of the current AHS ICP educational expertise is acquired through experience: "trial and error and self-learning," "borrowing materials from more experienced ICPs," and "watching them educate" – "You learn how it's done in IPAC." The ICPs indicated that they were "interested in learning different teaching strategies," "improving the quality of their education," and "building on their educational skills and expertise." To achieve this, several suggestions were made, including: a) the development of more teaching and learning professional development experiences; b) development of peer mentoring regarding educational practice; c) access to different teaching resources and strategies; d) opportunities to work with different teaching strategies to develop a deeper understanding of and comfort with those approaches; and e) raising the profile and priority of education in ICP educational practice.

Limitations

A limitation of this study is the unique nature of the AHS organization and the provincial nature of the IPAC program within AHS. As healthcare is a provincial responsibility, the organizational and cultural contexts that impact healthcare settings and the educational practices of IPAC programs may vary from province to province. While the findings in this study are both relevant and valuable to local AHS ICP educational practice, it is important to explore IPAC educational practices in other programs across Canada to scale up this current study's findings.

DISCUSSION

This study provides an in-depth understanding of AHS ICP educational practice, making explicit multiple issues and processes involved in that practice. ICP educational practice is more complex than the IPAC educational research literature suggests; the literature focuses primarily on the formal, conventional aspects of ICP education, treating education as an interventional tool rather than a complex ecology of teaching and learning processes [1]. Many IPAC educational intervention studies focus on the delivery of planned lectures and the development of online learning for the provision of knowledge, practice change, or increased access and uptake of information by healthcare providers [20-23]. In such studies, the discussion of the complex, dynamic nature of the ICP teaching and learning process, even of formal learning, is under-explored or missing [1]. The tacit nature of informal ICP education, descibed by ICPs in this study as more effective and rewarding, is generally not visible. Consequently, the relevance and importance of IPAC informal education goes largely unrecognized and therefore is undersupported and underresearched. Making explicit the multifaceted nature of their educational practice would validate ICPs' experiences and provide a foundation from which to build their practice.

The visibility of formal IPAC education reinforces the teacher-centric lens of information-giving by a knowledgeable expert. The emphasis on knowledge acquisition supports a teaching framework focused on designing for content delivery. This is different than designing for teaching and learning using strategies that attend to engagement, motivation, and desired learning outcomes, such as changed behaviour. Research has shown that teachers' beliefs about teaching and learning constrain their teaching practices and responses to those practices [24]. Even when teachers' pedagogies align with more active and engaged learner-centric approaches to teaching, they must still confront transforming educational practices amidst the constraining influences of the systems within which they teach. Unless they develop educational expertise, ICPs will remain hindered in their approaches to teaching and how they perceive and respond to educational challenges.

Further investigation of ICP informal teaching in the context of workplace learning is warranted [25]. The workplace is increasingly becoming a place of learning and research suggests that the majority of such learning is informal and situated in the context of social practice [26, 27]. This situatedness allows workers to connect their knowledge with practice and apply it in meaningful and relevant ways. Informal education described by ICPs is more social, collaborative, and situated in the HCWs' clinical practice and aligns

Return to TABLE OF CONTENTS

with more contemporary constructivist pedagogies [28]. It is not surprising that ICPs prefer their informal teaching approaches and describe them as more effective than their formal ones. In the contextual complexity of today's healthcare, ICPs need to shift from educating principally for HCWs' knowledge acquisition and skill development to designing learning experiences that facilitate HCWs' ability to adapt what they learn to new situations, generate new knowledge, and continually improve their performance [29]. Such education must focus on process and helping HCWs take responsibility for their own learning and engage in collaborative problem-based learning tasks and activities.

Given the ICPs' frustrations with their educational practice and insights into their educational challenges, it is clear that ICPs are primed for educational professional development experiences that encompass contemporary teaching and learning strategies. ICPs struggle with their lack of pedagogical knowledge as well as with their role and identity as educators. The ICPs are asking for help in designing more effective teaching and learning strategies. In response, these study findings were used to create an innovative professional development experience to build AHS ICP pedagogical expertise. This experience was designed to faciliate a conceptual shift from commonly held, traditional understandings and approaches to education to teaching strategies that align with constructivist theories of active and engaged learning. The assumption was that with increased pedagogical knowledge and experience and a language with which to collaboratively reflect on and discuss their practices and to explore their identity as ICP educators, the ICPs would be better able to respond to the complex teaching environment in which they find themselves and modify their practices for more effective learning and professionally satisfying outcomes. The design, development, and implementation of this professional development experience will be described in the fourth and last paper in this series exploring IPAC educational practice.

REFERENCES

1. Meyers, G., Jacobsen, M., & Henderson, E. (2018). An exploration of IPAC educational intervention research: What do we mean by education? *Canadian Journal of Infection Control, 33*(2), 89-95.
2. Nichols, A. B, & Badger, B. (2008). An investigation of the division between espoused and actual practice in infection control and of the knowledge sources that may underpin this division. *British Journal of Infection Control, 9*(4), 11-15. doi: 10.1177/1469044608088621
3. Cooper, T. (2007). Putting educational theory into clinical practice. *Journal of Hospital Infection, 65*(Suppl 2), 124-127. doi: 10.1016/S0195-6701(07)60028-0
4. Pessoa-Silva, C. L., Posfay-Barbe, K., Pfister, R., Touveneau, S., Perneger, T. V., & Pittet, D. (2005). Attitudes and preceptions toward hand hygiene among healthcare workers caring for critically ill neonates. *Infection Control and Hospital Epidemiology, 26*(3), 305-311.
5. Seto, W. H. (1995). Training the work force--models for effective education in infection control. *Journal of Hospital Infection, 30*(Suppl), 241-247.
6. Illeris, K. (2003). Workplace learning and learning theory. *Journal of Workplace Learning, 15*(4), 167-178. doi:10.1108/13665620310474615
7. Hager, P., & Smith, E. (2004). The inescapability of significant contextual learning in work performance. *London Review of Education, 2*(1), 33-46. doi: 10.1080/1474846042000177465
8. Burnett, E. (2011). Outcome competences for practitioners in infection prevention and control. *Journal of Infection Prevention, 12*(2), 67-90. doi: 10.1177/1757177410395797
9. Murphy, D. M., Hanchett, M., Olmsted, R. N., Farber, M. R., Lee, T. B., Haas, J. P., & Streed, S. A. (2012). Competency in infection prevention: A conceptual approach to guide current and future practice. *American Journal of Infection Control, 40*(4), 296-303. doi: 10.1016/j.ajic.2012.03.002
10. Moralejo, D., Catt, B., Ashcroft, M., Christou, H., DeFalco, K., Dyck, B., & Rhodenizer-Rose, S. (2016). *IPAC Canada core competencies for infection control professionals*. Retrieved from https://ipac-canada.org/photos/custom/Members/pdf/2016_IPAC_Canada_CoreCompetenciesforICPs.pdf
11. Meyers, G. L. (2017). Building educational practice and culture in infection prevention and control: A design-based research study. Retrieved from https://prism.ucalgary.ca/bitstream/handle/11023/3717/ucalgary_2017_meyers_gwyneth.pdf?sequence=1
12. Kern, D. E. (2009). Introduction. In D. E. Kern, P. A. Thomas, & M. T. Hughes (Eds.), *Curriculum development for medical education. A six-step approach* (2nd ed., 1-4). Baltimore, MD: John Hopkins University Press.
13. D'Eon, M. (2004). Point. . . counterpoint. An explicit critique of McLeod et al. 2004 on tacit knowledge. *Medical Teacher*, *26*(5), 487-489.
14. Bennett, C. (1991). The teacher as decision maker program: An alternative for career-change preservice teachers. *Journal of Teacher Education*, *42*(2), 119-130. doi: 10.1177/002248719104200205
15. Meyers, G. L., Jacobsen, M., & Henderson, E. (2018). Design-based Research: Introducing an innovative research methodology to infection prevention and control. *Canadian Journal of Infection Control, 33*(3), 158-164.
16. Creswell, J. W. (2012). Collecting qualitative data. In J. W. Creswell. *Educational research: Planning, conducting and evaluating quantitative and qualitative research* (4th ed, 204-234). Boston, MA: Pearson Education.
17. Normak, P., Pata, K., & Kaipainen, M. (2012). An ecological approach to learning dynamics. *Educational Technology & Society, 15*(3), 262-274.
18. Cobb, P., Confrey, J., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher, 32*(1), 9-13.
19. Creswell, J. W. (2012). Analyzing and interpreting qualitative data. In J. W. Creswell. *Educational research: Planning, conducting and evaluating quantitative and qualitative research* (4th ed, 236-264). Boston, MA: Pearson Education.
20. Gould, D. J., & Chamberlain, A. (1997). The use of a ward-based educational teaching package to enhance nurses' compliance with infection control procedures. *Journal of Clinical Nursing, 6*(1), 55-67.
21. Atack, L., & Luke, R. (2008). Impact of an online course on infection control and prevention competencies. *Journal of Advanced Nursing, 63*(2), 175-180. doi: 10.1111/j.1365-2648.2008.04660.x
22. Bryce, E., Yassi, A., & Maultsaid, D. (2008). E-learning of infection control: It's contagious. *Canadian Journal of Infection Control, 23*(4), 228-237.
23. Koo, E., McNamara, S., Lansing, B., Olmsted, R. N., Rye, R. A., Fitzgerald, T., & Mody, L. (206). Making infection prevention education interactive can enhance knowledge and improve outcomes: Results from the Targeted Infection Prevention (TIP) Study. *American Journal of Infection Control, 44*(11), 1241-1246. doi: 10.1016/j.ajic.2016.03.016
24. Swan, M. (2007). The impact of task-based professional development on teachers' practices and beliefs: A design research study. *Journal of Mathematics Teacher Education, 10*(4-6), 217-237. doi: 10.1007/s10857-007-9038-8
25. Manuti, A., Pastore, S., Scardigno, A. F., Giancaspro, M. L., & Morciano, D. (2015). Formal and informal learning in the workplace: A research review. *International Journal of Training and Development, 19*(1), 1-17. doi: 10.1111/ijtd.12044
26. Eraut, M. (2004). Informal learning in the workplace. *Studies in Continuing Education, 26*(2), 247-273. doi: 10.1080/158037042000225245
27. Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participaiton*. New York, NY: Cambridge University Press.
28. Robinson, R., Molenda, M., & Rezabek, L. (2008). Facilitating learning. In A. Januszewski, & M. Molenda (Eds.), *Education technology: A defintition with commentary* (15-48). New York, NY: Routledge Taylor Francis.
29. Fraser, S. W., & Greenhalgh, T. (2001). Coping with complexity: Educating for capability. *British Medical Journal, 323*(7316), 799-803.

ORIGINAL ARTICLE

Risk analysis of respiratory infections in facilities for patients with severe motor and intellectual disabilities in Japan

Naoki Takayama, RN, MS;[1,2] Mayumi Aminaka, RN, PhD;[1] Namiko Mori, RN, PhD;[1] Masahiro Shirai, MD;[3] Atsushi Toyoda, MD;[4] Retsu Fujita, RN, MS;[5] Midori Nishioka, RN, PhD[1]

[1] *Graduate School of Nursing, National College of Nursing, Japan*
[2] *Department of Infection Control and Prevention, National Hospital Organization Tenryuu Hospital, Japan*
[3] *Department of Respiratory Medicine, National Hospital Organization Tenryuu Hospital, Japan*
[4] *Department of Pediatrics, National Hospital Organization Tenryuu Hospital, Japan*
[5] *Teikyo Academic Research Center, Teikyo University, Japan*

Corresponding author:
Naoki Takayama
Department of Infection Control and Prevention
National Hospital Organization Tenryuu Hospital
4201-2 Oro, Hamakita-ku, Hamamatsu-shi
Shizuoka 434-0015, Japan
Tel.: +81-53-583-3111
takayaman@d17.ncn.ac.jp

ABSTRACT

Background: The present study aimed to identify risk factors for respiratory infections in facilities for pediatric patients with severe motor and intellectual disabilities (SMID) in order to establish effective respiratory infection countermeasures.

Method: A retrospective chart review of 92 SMID patients who were admitted to a SMID facility in Japan between April 2014 and March 2015 was conducted. Stepwise multiple logistic regression analysis was performed regarding the relationship between respiratory infection and 60 patient factors, such as quadriplegia and activities of daily living, and 53 care factors, such as oral care and *ryouiku* (therapeutic education).

Results: Respiratory infection incidences were as follows: pneumonia, 39.1%; respiratory syncytial virus (RSV) infection, 26.1%; and respiratory syndrome, 31.5%. The primary risk factor for respiratory infection was movement education, a group *ryouiku* program (pneumonia: odds ratio [OR] 15.22, 95% confidence interval [CI] 2.99-77.40; RSV infection: OR 13.85, 95% CI 2.72-70.50; and respiratory syndrome: OR 10.84, 95% CI 1.78-65.93).

Conclusion: The present findings indicated that movement education sessions at SMID facilities should be promptly suspended in cases of respiratory infection outbreak. Ongoing respiratory syndrome surveillance is required to enable early recognition of an outbreak.

KEYWORDS

Infection control; patients with severe motor and intellectual disabilities (SMID); respiratory tract infections; *ryouiku*; long-term care

INTRODUCTION

In Japan, residential facilities are available for pediatric patients with severe motor and intellectual disabilities (SMID). Approximately 30% of SMID patients in these facilities receive medical interventions such as artificial respiration, oxygen administration, total parenteral nutrition, and tube feeding. They also receive *ryouiku* (therapeutic education) to maintain health, promote development, and improve social skills and quality of life. *Ryouiku* programs "combine medical interventions, nursing care, education, and childcare in order to promote all-round development and foster a strong foundation for life with the goal of helping individuals to overcome their disabilities" [1]. *Ryouiku* can be conducted individually or in groups. During group *ryouiku*, pediatric patients engage in play and exercise that involve physical contact in the form of physical interaction on the floor or therapy mats and hugs from helpers. Many activities involve sharing toys in group *ryouiku*. Patients in SMID facilities include those who have difficulty sitting upright or who move around by crawling along the floor of corridors and shared

Acknowledgements: None.

Conflicts of interest: None.

Funding: This work was supported by JSPS KAKENHI Grant Numbers JP26293458 and JP18H03079.

Ethics approval: The present study was approved by the ethics committees of the researchers' affiliated institution and the participating SMID facility (Approval Nos.: NCGM-G-001943-00 and 27-21, respectively).

rooms. There are also patients who can walk and run without difficulty despite intellectual disabilities. The risk of spread to other patients and staff from even one case of infection is high in SMID facilities due to the high frequency of interpersonal and environmental contact.

The leading cause of death in SMID patients in Japan is respiratory infection [2]. Related patient factors reportedly include neuromuscular disorders [3], bronchial asthma [3], and degree of paralysis associated with the underlying condition [4-6]. Meanwhile, the related care factors include tube feeding [7] and inadequate oral care [8]. However, no studies to date have investigated the risk of respiratory infection in SMID facilities after controlling for these potentially confounding factors. In addition, no studies have investigated the relationship between *ryouiku* programs and respiratory infection. The present study aimed to identify risk factors for respiratory infection in SMID facilities in order to establish effective respiratory infection countermeasures.

MATERIALS AND METHOD

Sample and setting

Subjects comprised 102 individuals who were admitted to one of two wards (A or B) at a standard SMID facility in Japan between April 1, 2014 and March 31, 2015. Each ward (A or B) had 55 beds. The average number of hospitalization days of both wards exceeded 1,000 days. There were no significant differences between ward A and ward B in terms of age, sex, activities of daily living, and severity.

Data collection and procedures

Survey items comprised 60 patient factors, such as degree of paralysis and activities of daily living, and 53 care factors, such as *ryouiku*, tube feeding, and oral care. Data were obtained from medical charts.

Respiratory infection

Outbreaks of the following respiratory infections occurring between April 1, 2014 and March 31, 2015 were investigated. These infections were selected for investigation based on reports of previous outbreaks at SMID facilities in Japan: respiratory syncytial virus (RSV) infection [9], human metapneumovirus (hMPV) infection [10], influenza [11], adenovirus infection [12], *Bordetella parapertussis* infection [13], and pneumonia. As unidentified causative organisms are responsible for at least half of respiratory infection outbreaks at SMID facilities [12], respiratory syndrome, which can be determined based on clinical symptoms alone, was also included in the present study.

Outbreaks that met at least one of the below criteria for identification of specific respiratory infection were included in the analysis:

1. RSV infection: positive RSV rapid antigen detection test (RADT), RSV detection on polymerase chain reaction (PCR), fourfold or greater increase or decrease in antibody titer, and/or RSV identification by viral culture [14, 15].
2. hMPV infection: positive hMPV RADT [16], hMPV detection on PCR, fourfold or greater increase or decrease in antibody titer, and/or hMPV identification by viral culture [15].
3. Influenza: positive influenza A or B virus RADT and/or influenza A or B virus detection on PCR [15].
4. Adenovirus infection: positive adenovirus RADT [17], adenovirus detection on PCR, fourfold or greater increase or decrease in antibody titer, and/or adenovirus identification by viral culture [15].
5. *B. parapertussis* infection: *B. parapertussis* identification by bacterial culture and/or *B. parapertussis* detection on PCR [15].
6. Pneumonia: new or progressive and persistent infiltrate on two or more serial chest radiographs on a single chest x-ray with i) axillary temperature ≥ 38.0° C and/or ii) white blood cell count decrease (< 4,000/mm^3) or increase (≥ 12,000/mm^3).
7. Respiratory syndrome: axillary temperature ≥ 38.0° C on two consecutive days with percutaneous arterial blood oxygen saturation ≤ 93% and/or increased oxygen demand [18-20].

Statistical analysis

Univariate and multivariate analyses were conducted regarding the relationships with respiratory infections. Univariate analysis comprised Fisher's exact test or Wilcoxon's rank sum test depending on variable type and distribution. Stepwise multiple logistic regression was performed for multivariate analysis. Patient and care factors with a relationship to respiratory infection suggested by univariate analysis ($\propto = 0.2$) were selected as independent variables. Multicollinearity between independent variables was assessed using variance inflation factor. Goodness of fit of the final models was determined using the Hosmer-Lemeshow test. Analyses were performed using SAS Studio version 3.5 (SAS Institute, Cary, NC, U.S.A.) with significance set at $\propto = 0.05$.

RESULTS

Of 102 patients, 92 patients were analyzed; ten patients who were transferred to another facility during the study period were excluded. The median age was 39 years (range: 1 to 67 years) and the number of male patients was 53 (57.6%). A total of 96.7% of patients participated in group *ryouiku*.

Respiratory infection incidences were as follows: pneumonia, 39.1% (36/92); RSV infection, 26.1% (24/92); and respiratory syndrome, 31.5% (29/92). No cases of hMPV infection, influenza, adenovirus infection, or *B. parapertussis* infection were observed.

Risk factors of respiratory infection

Independent variables selected by multiple logistic regressions for inclusion in the final model for each respiratory infection type were as follows. Pneumonia: movement education (odds ratio [OR] 15.22; 95% confidence interval [CI] 2.99-77.40), inability to wear a surgical mask (OR 4.26; 95% CI 1.27-14.35), and chest computed tomography (CT) findings of obsolete aspiration pneumonia (OR 2.81; 95% CI 1.00-7.90). RSV infection: movement education (OR 13.85; 95% CI 2.72-70.50) and ward type (OR 9.63; 95% CI 2.56-36.32). Respiratory syndrome: movement education (OR 10.84; 95% CI 1.78-

65.93), inability to roll over (OR 8.43; 95% CI 1.45-49.12), male sex (OR 4.54; 95% CI 1.43-14.40), and gastrostomy feeding (OR 3.12; 95% CI 1.06-9.22). For all models, satisfactory goodness of fit was achieved and no multicollinearity was detected (Table 1).

TABLE 1: Results of stepwise multiple logistic regression analysis regarding respiratory infection outbreaks.

	Respiratory infection		
Independent variable	Pneumonia [a)]	RSV infection[b)]	Respiratory syndrome[c)]
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Movement education (physical activity)	15.22 (2.99-77.40)	13.85 (2.72-70.50)	10.84 (1.78-65.93)
Ward type	n.s.		n.s.
A		1.00	
B		9.64 (2.56-36.32)	
Inability to wear surgical mask	4.26 (1.27-14.35)	-	-
Chest CT findings of obsolete aspiration pneumonia	2.81 (1.00-7.90)	-	-
Inability to roll over	n.s.	-	8.43 (1.45-49.12)
Sex	n.s.	-	
Female			1.00
Male			4.54 (1.43-14.40)
Gastrostomy feeding	n.s.	-	3.12 (1.06-9.22)
Variance inflation factor	1.86-5.30	4.58, 1.50	1.44-3.71
Hosmer-Lemeshow goodness-of-fit test			
x^2	0.580	0.266	5.067
Degrees of freedom	3	1	6
p-Value	0.901	0.606	0.535

Legend
RSV: respiratory syncytial virus infection
OR: odds ratio
CI: confidence interval
CT: computed tomography
n.s.: not significant (not selected in the final model)
-: variables not included as independent variables

a) Selected independent variables: age, weight, sputum suctioning, nebulizer inhalation, bronchial asthma, long-term low-dose macrolide therapy, H2 blocker use, sputum suctioning during meals, visitation from family members who live with child in nursery school/kindergarten, hugs, trunk muscle tone, inability to hold up head, tracheotomy, ward *ryouiku*, visiting education, frequency of oral care, intake of solid food, intake of liquid food, nasal feeding, swallowing training, detection of Methicillin-resistant *Staphylococcus aureus* (MRSA), detection of *H. influenzae*.
b) Excluded independent variables: age, weight, prone position, hugs, inability to hold up head, visiting education, frequency of oral care, items used for oral care, frequency of hand hygiene assistance, blood total protein, Glasgow Coma Scale score, intake of solid food, detection of *H. influenzae*, detection of *S. pneumonia*, hemiplegia, full-body wiping, entry into a room with two or four beds.
c) Excluded independent variables: age, weight, sputum suctioning, nebulizer inhalation, bronchial asthma, long-term low-dose macrolide therapy, visitations, guaranteed time in prone position, inability to hold up head, impaired mouth closure, food recognition, visiting education, length of stay, frequency of oral care, frequency of bowel movements, intake of solid food, swallowing training, motor function (bedridden), detection of MRSA, detection of gram-negative bacteria, quadriplegia.

DISCUSSION

Five patient factors (male sex, inability to wear surgical mask, chest CT findings of obsolete aspiration pneumonia, inability to roll over, and gastrostomy feeding) and two care factors (movement education and ward type) were identified as risk factors for respiratory infection in SMID facilities.

Movement education was a risk factor for pneumonia, RSV infection, and respiratory syndrome infections. Movement education, a development support program created in the United States [21], is widely incorporated into *ryouiku* programs for SMID patients in Japan [22]. In the present SMID facility, movement education was conducted jointly for two wards by three to four helpers for groups of eight to ten patients in a dedicated *ryouiku* room. Movement education included laying and sitting multiple patients on a shared therapy mat; interactive activities among two to three patients on one mat; sharing toys such as trampolines, water guns, and big drums; and activities involving close physical contact between patients and helpers such as helpers hugging patients and patients leaning against helpers. Furthermore, movement education always involves "touch time," when patients use their hands to touch each other and the helpers. The number of participants in movement education makes it difficult for helpers to ensure hand hygiene for each patient, change personal protective equipment, and wipe and disinfect shared toys and environmental surfaces. Many causative organisms of respiratory infection can survive on environmental surfaces for several hours or more [23], making it difficult to control the spread of respiratory infection during movement education. From the perspective of infection prevention, suspension of movement

Return to TABLE OF CONTENTS

education should be considered. In Japan, 56% of SMID facilities suspend *ryouiku* due to respiratory infection outbreaks each year [22]. Delayed suspension of group *ryouiku* such as movement education may allow infection to spread, ultimately prolonging the overall suspension time. There are reports of *ryouiku* suspensions lasting ≥ 4 weeks [22]. Movement education is indicated to be effective for maintaining and developing function in SMID patients [24-26] and long-term suspension is undesirable. Therefore, quickly recognizing the signs of respiratory infection outbreak and promptly changing the content of movement education to minimize contact between patients or switching to individual *ryouiku* would constitute an effective countermeasure. This approach requires the implementation of respiratory syndrome surveillance to enable early detection of the signs of an epidemic. In Japan, only 13% of SMID facilities perform respiratory syndrome surveillance [22], indicating the need for wider adoption.

The other care factor identified was ward type. The risk of RSV infection was greater in ward B than ward A. During the study period, there was an RSV infection outbreak in both wards; however, the outbreak started earlier in ward B, and ward A used the experience from ward B to rapidly implement effective RSV infection countermeasures, including hand hygiene [27], the use of gloves, gowns, and protective eyewear [28-31], and suspension of group *ryouiku*. Ward type was likely identified as a proxy variable representing these comprehensive infection countermeasures.

Since the five specified patient factors are not suitable for intervention, SMID patients who are male, unable to wear surgical mask, unable to roll over, receive gastrostomy feeding, and who present chest CT findings of obsolete aspiration pneumonia should be closely observed as a high-risk group regarding respiratory infection and efforts made to quickly recognize signs of respiratory infection.

The present findings suggested that movement education is a risk factor for respiratory infection in SMID facilities. However, as this was a retrospective study performed at a single facility, further investigation using a prospective study method at multiple facilities is required. Widespread adoption of respiratory syndrome surveillance is necessary to enable early recognition of the signs of an epidemic.

REFERENCES

1. National Association for Severe Motor and Intellectual Disabilities. (2015). *Severe motor and intellectual disabilities II: Nursing and medical care*. In Japanese.
2. Origuchi, M., Miyanomae, T., Kogo, T., Nishida, T., Imai, M., & Sugita, S. (2001). Study on the cause of death in patients with severe motor and intellectual disabilities syndrome. *IRYO, 55*(4), 175-179. In Japanese.
3. Seddon, P. C., & Khan, Y. (2003). Respiratory problems in children with neurological impairment. *Archives of Disease in Childhood, 88*(1), 75-78.
4. Torigoe, K., Sasaki, S., Hoshina, J., Torigoe, T., Hojo, M., Emura, S., Kojima, K., Onozuka, J., Isobe, M., & Numata O. (2011). Predicting factors of plural hospitalization with pneumonia in low-birthweight infants. *Pediatrics International, 53*(4), 446-453.
5. Crichton, J. U., Mackinnon, M., & White, C. P. (1995). The life-expectancy of persons with cerebral palsy. *Developmental Medicine and Child Neurology, 37*(7), 567-576.
6. Day, S. M. (2013). Proper stratification of survival curves by level of gross motor function. *Developmental Medicine and Child Neurology, 55*(5), 402-403.
7. Kanda, T., Murayama, K., Kondo, I., Kitazumi, E., Takahashi, K., Nakatani, K., Yoneyama, A., Yamori, Y., & Kanda, Y. (2005). An estimation chart for the possibility of aspiration in patients with severe motor and intellectual disabilities: Its reliability and accuracy. *No To Hattatsu, 37*(4), 307-316. In Japanese.
8. Brooks, J. C., Shavelle, R. M., & Strauss, D. J. (2012). Survival in children with severe cerebral palsy: A further international comparison. *Developmental Medicine and Child Neurology, 54*(4), 383-384.
9. Chi, H., Chang, I. S., Tsai, F. Y., Huang, L. M., Shao, P. L., Chiu, N. C., Chang, L. Y., & Huang, F. Y. (2011). Epidemiological study of hospitalization associated with respiratory syncytial virus infection in Taiwanese children between 2004 and 2007. *Journal of the Formosan Medical Association, 110*(6), 388-396.
10. Matsuda, S., Omura, T., Tsukagoshi, H., Noda, M., & Kimura, H. (2012). Prevalence of human metapneumovirus infection in hospital wards handling patients with severe motor and intellectual disabilities. *Journal of the Japanese Association for Infectious Diseases, 86*(2), 109-114. In Japanese.
11. Irie, K., Ito, M., Iwai, A., Yasunaga, R., Onari, M., & Morioka, Y. (2005). A study of an influenza epidemic and preventive measures in wards for physically and mentally handicapped patients during the 2003/2004 influenza season. *JJHM, 5*(4), 536-540. In Japanese.
12. Matsuda, S., & Noda, M. (2008). Prevalence of infectious diseases in hospital wards comprising patients with severe motor and intellectual disabilities. *IRYO, 62*(12), 679-683. In Japanese.
13. Sito, K., Miura, S., & Hosoda, N. (2011). Outbreak of *Bordetella parapertussis* in an institute for the severely handicapped. *JSMID, 36*(1), 107-111. In Japanese.
14. Popow-Kraupp, T., & Aberle, J. H. (2011). Diagnosis of respiratory syncytial virus infection. *Open Microbiology Journal, 5*, 128-134.
15. Bennett, J. E., Dolin, R., & Blaser M. J. (2014). *Mandell, Douglas, and Bennett's principles and practice of infectious diseases*. Philadelphia, PA: Elsevier.
16. Matsuzaki, Y., Takashita, E., Okamoto, M., Mizuta, K., Itagaki, T., Katsushima, F., Katsushima, Y., Nagai, Y., & Nishimura, H. (2009). Evaluation of a new rapid antigen test using immunochromatography for detection of human metapneumovirus in comparison with real-time PCR assay. *Journal of Clinical Microbiology, 47*(9), 2981-2984.
17. Tsutsumi, H., Ouchi, K., Ohsaki, M., Yamanaka, T., Kuniya, Y., Takeuchi, Y., Nakai, C., Meguro, H., & Chiba, S. (1999). Immunochromatography test for rapid diagnosis of adenovirus respiratory tract infections: Comparison with virus isolation in tissue culture. *Journal of Clinical Microbiology, 37*(6), 2007-2009.
18. Centers for Disease Control and Prevention. (2018). *CDC/NHSN surveillance definitions for specific types of infections*. Retrieved from https://www.cdc.gov/nhsn/pdfs/pscmanual/17pscnosinfdef_current.pdf
19. Mackowiak, P. A., Wasserman, S. S., & Levine, M. M. (1992). A critical appraisal of 98.6 degrees F, the upper limit of the normal body temperature, and other legacies of Carl Reinhold August Wunderlich. *JAMA, 268*(12), 1578-1580.
20. Veugelers, R., Calis, E. A. C., Penning, C., Verhagen, A., Bernsen, R., Bouquet, J., Benninga, M. A., Merkus, P. J. F. M., Arets, H. G. M., Tibboel, D., & Evenhuis, H. M. (2005). A population-based nested case control study on recurrent pneumonias in children with severe generalized cerebral palsy: Ethical considerations of the design and representativeness of the study sample. *BMC Pediatrics, 5*, 25.
21. Frostig, M. (1970). *Movement education: Theory and practice*. Westchester, IL: Follett Educational Corp.
22. Takayama, N., Aminaka, M., Mori, N., Shirai, M., Toyoda, A., Fujita R., et al. (2018). Survey on respiratory infection measures in facilities for patients with severe motor and intellectual disabilities. *Japanese Journal of Environmental Infections.* In progress. In Japanese.
23. Kramer, A., Schwebke, I., & Kampf, G. (2006). How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. *BMC*

Infectious Diseases, 6, 130. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1564025/pdf/1471-2334-6-130.pdf

24. Abe, M. (2009). Sensorimotor movement activities helped a child with severe motor and intellectual disabilities acquire calling behavior. *JSMID, 34*(1), 197-202. In Japanese.
25. Eliasson, A. C., Krumlinde-Sundholm, L., Gordon, A. M., Feys, H., Klingels, K., Aarts, P. B., Rameckers, E., Autti-Rämö, I., & Hoare, B. (2014). Guidelines for future research in constraint-induced movement therapy for children with unilateral cerebral palsy: An expert consensus. *Developmental Medicine and Child Neurology, 56*(2), 125-137.
26. Maltais, D. B., Wiart, L., Fowler, E., Verschuren, O., & Damiano, D. L. (2014). Health-related physical fitness for children with cerebral palsy. *Journal of Child Neurology, 29*(8), 1091-1100.
27. Pfeil, J., Tabatabai, J., Sander, A., Ries, M., Grulich-Henn, J., & Schnitzler, P. (2014). Screening for respiratory syncytial virus and isolation strategies in children hospitalized with acute respiratory tract infection. *Medicine (Baltimore), 93*(25), 144.
28. Leclair, J. M., Freeman, J., Sullivan, B. F., Crowley, C. M., & Goldmann, D. A. (1987). Prevention of nosocomial respiratory syncytial virus infections through compliance with glove and gown isolation precautions. *New England Journal of Medicine, 317*(6), 329-334.
29. Madge, P., Paton, J. Y., McColl, J. H., & Mackie, P. L. (1992). Prospective controlled study of four infection-control procedures to prevent nosocomial infection with respiratory syncytial virus. *Lancet, 340*(8827), 1079-1083.
30. Agah, R., Cherry, J. D., Garakian, A. J., & Chapin, M. (1987). Respiratory syncytial virus (RSV) infection rate in personnel caring for children with RSV infections. Routine isolation procedure vs routine procedure supplemented by use of masks and goggles. *American Journal of Diseases of Children, 141*(6), 695-697.
31. Gala, C. L., Hall, C. B., Schnabel, K. C., Pincus, P. H., Blossom, P., Hildreth, S. W., Betts, R. F., & Douglas, Jr., R. G. (1986). The use of eye-nose goggles to control nosocomial respiratory syncytial virus infection. *JAMA, 256*(19), 2706-2708.

ORIGINAL ARTICLE

Susceptibility of catheter-related *Klebsiella pneumoniae* strains to quaternary ammonium compounds under biofilm and planktonic conditions

Fatemeh Monirzadeh;[1] Mohammad Reza Shakibaie;[1,2,3] Melika Gholamrezazadeh;[1] Shalaleh Masoumi[1]

[1] *Department of Microbiology and Virology, Kerman University of Medical Sciences, Kerman, Iran*
[2] *Research Center for Tropical Medicine and Infectious Diseases, Kerman University of Medical Sciences, Kerman, Iran*
[3] *Environmental Health Engineering Research Center, Kerman University of Medical Sciences, Kerman, Iran*

Corresponding author:
Mohammad Reza Shakibaie
Department of Microbiology and Virology
Kerman University of Medical Sciences
Kerman, Iran
Tel.: +98 3403221660
Fax: +98 3403221671
mr_shakibaei@kmu.ac.ir

ABSTRACT

Background: The aim of this study was to evaluate the susceptibility of catheter-related *Klebsiella pneumoniae* isolates to two biocides (benzalkonium chloride and Deconex) under biofilm and planktonic conditions.

Methods: A total of 85 strains of *K. pneumoniae* were isolated from catheters of inpatients hospitalized in four hospitals in Kerman, Iran. Susceptibility to antibiotics and biocides under biofilm and planktonic growths was performed using the microdilution method. Antibiofilm activity of the biocides was determined by microtiter assay. Biofilm eradication was carried out at different periods of time. The presence of *cep*A and *qac*EΔ1 genes were detected by polymerase chain reaction (PCR).

Results: We found that 15% (n = 12) of the isolates showed strong biofilm activity, 40% (n = 35) displayed moderate activity, 30% (n = 26) demonstrated weak activity, and 15% (n = 12) showed no attachment to microtiter wells. Both the biocides had profound inhibitory activities on planktonic cells (average minimum inhibitory concentration [MIC] 0.06 ± 0.2 mg/ml for Deconex and 0.03 ± 0.1 mg/ml for benzalkonium chloride). They exerted the least antibiofilm activity at a sub-MIC concentration of 0.015 mg/ml. The isolates that formed high biofilm also harboured the *cep*A gene. Furthermore, a considerable increase in MIC to piperacillin/tazobactam, tetracycline, and cefotaxime was observed for cells grown in biofilm conditions for 24 hours, but all the isolates were sensitive to colistin and tigecycline. These differences were statistically significant, with a *p*-value of < 0.05. Most of the biofilms were eradicated from the microtiter plate within 30 minutes' exposure to these biocides.

Conclusions: As the data indicates, benzalkonium chloride and Deconex have good potential as hospital disinfectants for catheter-related infections caused by *K. pneumoniae* in planktonic conditions. Antimicrobial stewardship programs must be performed weekly in our hospitals to improve the quality of antimicrobial use, reduce the use of antibiotics, and shorten the length of hospital stay without increasing mortality rates.

KEYWORDS

Klebsiella pneumoniae; biocides; biofilm; PCR; hospital hygiene

INTRODUCTION

Klebsiella pneumoniae is a gram-negative opportunistic pathogen, which is responsible for 10% of all hospital-acquired infections [1, 2]. This bacterium causes important diseases such as pneumonia, septicemia, urinary tract infections, wounds and intensive care unit infections in immunocompromised patients, diabetic patients, and still-born infants [3]. In recent years, the emergence of *K. pneumoniae* resistant to both antibiotics as well as biocides (disinfectants) has caused serious concern for infectious diseases specialists around the world [4]. It has been reported that about 60% to 70% of *Klebsiella* infections in hospitals are resistant to more than three classes of antibiotics [5]. Studies of pneumonia in Chinese hospitals revealed a pathogen unlike any the investigators had previously seen in healthcare settings. It was hyper-virulent *K. pneumoniae* harbouring various antibiotic resistance genes, a combination that causes severe, quick-developing, and deadly infections that are nearly impossible to treat with currently available drugs [6]. Both infections and antibiotic resistances in *K. pneumoniae* are often associated with the formation of biofilm. A biofilm is broadly considered a population of microorganisms grown on a surface or interface and embedded in a matrix of extracellular polymeric substances [7]. This will provide effective resistance

Acknowledgements: We thank staff members of the Department of Microbiology at Kerman University of Medical Sciences for helping us during this research.
Conflicts of interest: None.
Funding: None.

against large molecules such as antimicrobial agents, lysozyme, and biocides [8]. It has been estimated that biofilms can tolerate antimicrobial agents (disinfectants, antibiotics, surfactants) at concentrations of ten to 1,000 times that needed to inactivate genetically equivalent planktonic bacteria [8, 9]. The presence of catheters favours biofilm formation by providing an inert surface for the attachment of bacterial cells, thereby enhancing microbial colonization and the development of biofilm [10, 11]. At present, there are few studies describing *K. pneumoniae* isolates resistant to benzalkonium chloride and Deconex through biofilm formation [12]. Reports suggest that, in the presence of benzalkonium chloride, biofilm development of *K. pneumoniae* was inhibited fourfold and the compound's MIC value was reduced by one-eighth [13].

The primary aim of this study was to evaluate the susceptibility of *K. pneumoniae* to antibiotics, benzalkonium chloride, and Deconex under biofilm and planktonic conditions. Furthermore, we studied the prevalence of quaternary ammonium compound-resistant genes (*qac*EΔ1 and *cep*A) in these isolates.

METHODS

Bacterial samples and identification

A total of 85 non-duplicate strains of *K. pneumoniae* were isolated from catheter-associated specimens of 345 patients hospitalized in four referral hospitals in Kerman (southeastern Iran). Sampling was carried out from February to November 2015. For each isolate, patient demographic data and culture site were obtained. The samples were collected from intravascular and urinary tract central catheters peripherally inserted by a trained laboratory technician that were inoculated into 5 ml Stuart transport medium (Merck Group, Darmstadt, Germany) and transferred to our lab within 24 hours of collection. The identification process was carried out based on biochemical and conventional diagnostic tests for *Enterobacteriaceae*, as described by Kilian and Bülow (1979) [14].

Compound sources and analysis

Biocides, benzalkonium chloride as standard concentrate 50% w/v solution, under trade name BC50, and Deconex were purchased from NIPCO chemical group (Tehran, Iran).

Determination of susceptibility to biocides under planktonic conditions

The MIC and minimum bactericidal concentration (MBC) of Deconex and benzalkonium chloride against isolates were determined with a broth microdilution test, explained in detail in a previous report [15]. In brief, 10 ml of 32 mg/ml stock solutions of benzalkonium chloride and Deconex were prepared and diluted to 0.015 mg/ml. 50 µl of each dilution was added to 96-well microtiter plates containing 150 µl Luria-Bertani broth. To this preparation, 50 µl of the bacterial sample at 1×10^6 colony-forming units (CFU)/ml was added. To prevent bacterial aggregations, the microtiter plates were incubated under shaking conditions (100 RPM) for 24 hours at 37° C. MIC was defined as the lowest concentration of the above compounds that inhibits bacterial growth (no visible growth). A loopful of MIC was then streaked into Muller-Hinton agar and checked for grown colonies after 24 hours' incubation at 37° C. The number of colonies formed was considered the MBC. The MBC was defined as the lowest concentration of biocides killing at least 99.9% of the initial inoculums. Simultaneously, *E. coli* ATTC 25922 was used as a control strain.

Biofilm formation under static conditions

Biofilm formation was quantified by the microtiter method, as described by O'Toole et al. (2000) [9]. In this method, 1:100 diluted *K. pneumoniae* isolates at a concentration of 1×10^6 CFU/ml were inoculated into a 96-well microtiter plate containing 100 µl of fresh Tryptic Soy Broth (TSB) (BioMérieux, Marcy-l'Étoile, France). Growths were monitored after 24 hours' incubation at 37° C. Non-adherent cells were aseptically aspirated with pasture pipettes and washed with 300 µL of phosphate-buffered saline (PBS) solution (pH 7.2) to remove any remaining suspended cells. The biofilm was subsequently stained with the addition of 150 µL of 0.2% safranin (Merck Group, Darmstadt, Germany) for 30 minutes. The stain was removed by thorough washing, once with PBS at a pH of 7.2 and then with distilled water. The wells containing biofilm matrix were kept at room temperature or at 60° C until dry. Quantification of cells in the biofilms was carried out by solubilization of dye with 300 µL of glacial acetic acid. Optical density at 480 nm was then measured for each well [15]. All mentioned experiments were performed in duplicate. *Pseudomonas aeruginosa* PAO1 was used as positive control for biofilm formation study.

MIC of antibiotics under planktonic and biofilm conditions

Susceptibility of 12 strong biofilm-forming *K. pneumoniae* isolates to different antibiotics was determined under planktonic and biofilm conditions using the microdilution method [16]. In the case of planktonic conditions, the microtiter plates were incubated under shaking at 100 RPM for 18 hours. In case of biofilm, cells attached to the wall of the microtiter wells after 24 hours were scraped in 1 ml of phosphate buffer (pH 7.2). The suspensions were then diluted to 1×10^6 CFU/ml using 5 ml of D/W. 10 µl of bacterial suspensions was added to each microtiter well containing 100 µl of sterile TSB medium and 50 µL different concentrations of antibiotics (0.5-516 µg/ml). The following antibiotics were used in this study: tigecycline, colistin, ceftazidime, imipenem, amikacin, cefotaxime, cefoxitin, gentamicin, ciprofloxacin, trimethoprim/sulfamethoxazole, piperacillin/tazobactam, tetracycline, and chloramphenicol (Mast Group Ltd., Bootle, Merseyside, UK). *E. coli* ATCC 25922 was selected as a quality control strain in this antimicrobial susceptibility study.

Biofilm inhibitory activities of Deconex and benzalkonium chloride

The antibiofilm activities of Deconex and benzalkonium chloride were evaluated as described here. Briefly, microtiter plates containing 180 µl TSB medium were prepared. 10

Return to TABLE OF CONTENTS

μL of bacterial suspension at 10 × 10^6 CFU/ml and 10 μl Deconex and benzalkonium chloride preparation at a sub-MIC concentration of 0.03 mg/ml were added to each well. The sub-MIC was defined as the highest concentration of the antimicrobial compounds that bacterial cells can grow and showing visible turbidity. The microtiter plates were kept at 37° C for 24 hours and the amount of biofilm formed in each well was measured as described above. Prior to the experiments, we measured the growth rate and viable count of each isolate in the absence and presence of biocides. The adherence efficiency was calculated as described by Stepanović et al. (2007) [17].

Determination of biofilm eradication time

To determine biofilm eradication time, we decanted the contents of a microtiter plate with 24-hour biofilm treated with biocides for contact times of five, 15, 30, and 60 minutes. Microplate wells were then rinsed gently with sterile water and stained. The bound dye was re-solubilized in 33% glacial acetic acid. Absorbance was read as described by Leary et al. (2017) [18]. The combination of benzalkonium chloride at a concentration of 0.3 mg/ml and Deconex at a concentration of 0.06 mg/ml was also used for biofilm eradication.

Detection of qacEΔ1 and cepA genes by PCR

For PCR assays, the genomic DNA of each isolate was extracted using the boiling method and subjected to phenol/chloroform treatment. The cell lysate was centrifuged at 8.000 RPM for ten minutes and used to detect quaternary ammonium compounds (QACs) (*qacE*Δ1, *cep*A) genes with the PCR technique using a set of primer sequences F: 5-GCCCTACACAAATTGGGAGA-3 and R: 5-CTGCGGTACCACTGCCACAA-3 specific for the *qac*EΔ1 gene; and primer pairs F: 5-CAACTCCTTCGCCTATCCCG-3 and R: 5-TCAGGTCAGACCAAACGGCG-3 specific for the *cep*A gene [19]. The PCR assay was carried out using a temperature gradient thermal cycler (Biometra-T300, Göottingen, Germany). The amplification program consisted of an initial denaturation at 95° C for 300 seconds, 95° C for 30 cycles for 30 seconds, annealing 60° C for 35 seconds, extension at 72° C for 40 seconds, and final extension at 72° C for 300 seconds. The 100 bp DNA Ladder was used as a molecular weight standard.

Statistical analysis

The SPSS program version 17.0 for Windows (SPSS, Chicago, IL, U.S.A.) was used for statistical analysis. Data are presented as the mean ± standard error of the mean. For all tests, a two-sided p-value < 0.05 was considered significant.

RESULTS

Biofilm quantification revealed that 15% of the isolates showed strong biofilm activity, 40% showed moderate activity, 30% showed weak activity, and 15% showed no biofilm activity. However, no significant antibiofilm activity of benzalkonium chloride and Deconex were detected after exposure of the isolates to a sub-MIC concentration of 0.05 mg/ml ($p \leq 0.05$), as shown in Figure 1. Further analysis of the susceptibility of *K. pneumoniae* to antibiotics grown under planktonic and

FIGURE 1: Biofilm formation and the effect of benzalkonium chloride and Deconex on biofilm in *K. pneumoniae* multidrug-resistant isolates. No statistical significance in the amount of biofilm masses was observed in the presence and absence of these agents.

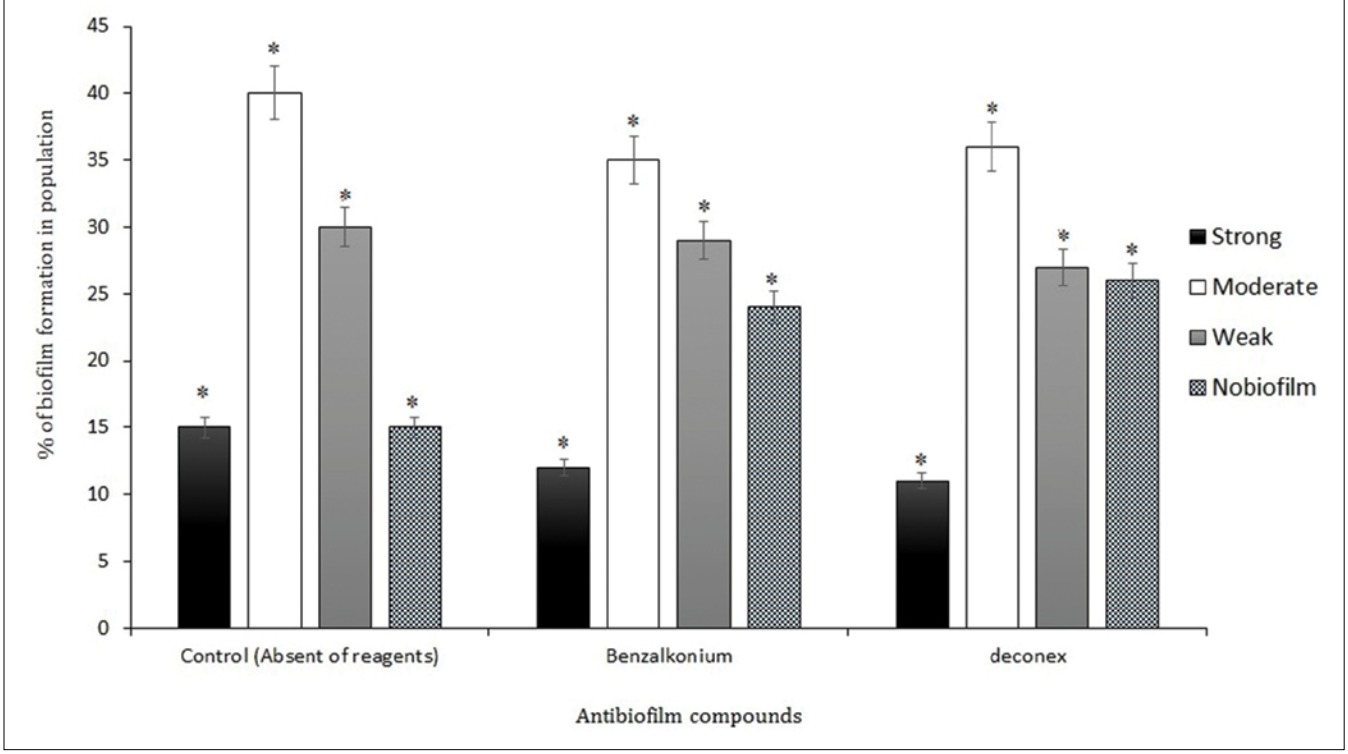
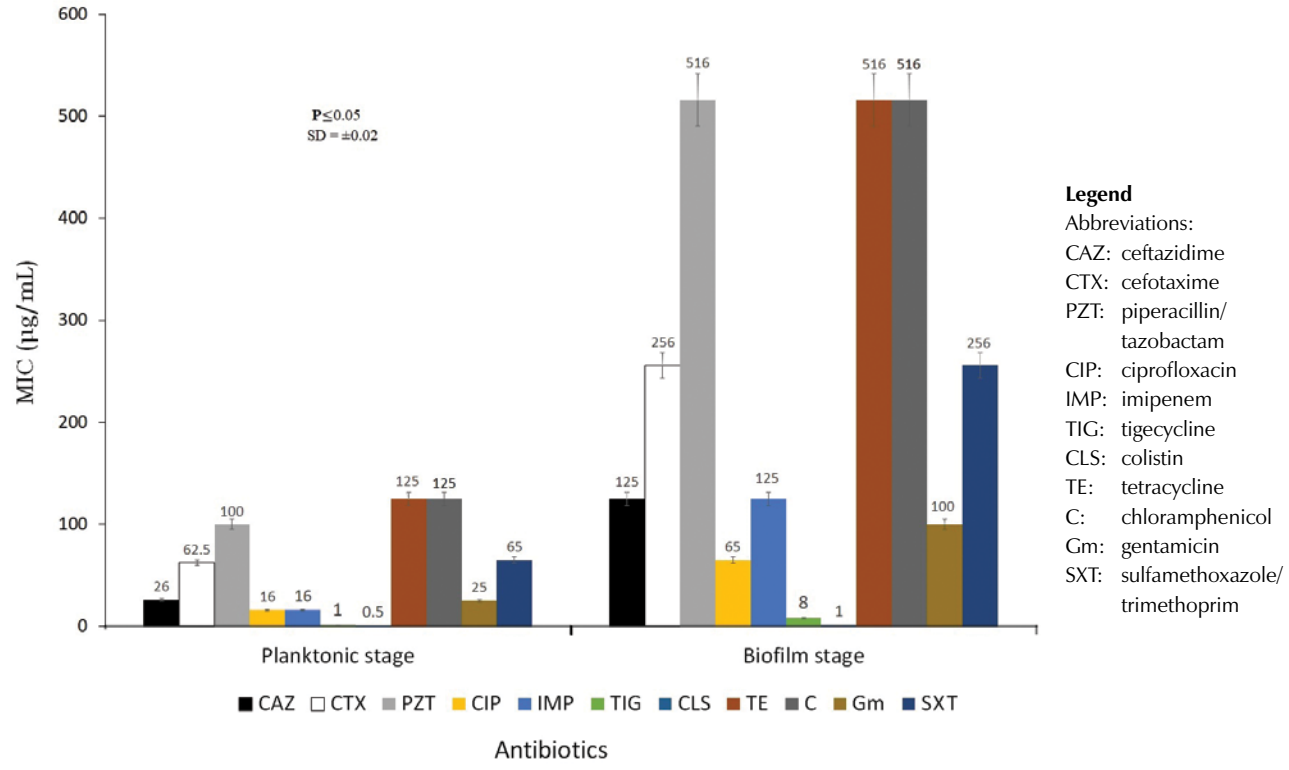


FIGURE 2: Antibiotic susceptibility of *K. pneumoniae* under biofilm and planktonic conditions. MIC was defined as the lowest concentration of antibiotics that inhibits growth (visible turbidity) after 24 hours of incubation.



biofilm conditions (Figure 2) revealed a significant increase in the MIC level for the piperacillin/tazobactam, tetracycline, chloramphenicol, trimethoprim/sulfamethoxazole, and cefotaxime antibiotics for cells taken from 24 hour biofilm. Resistance to imipenem and ceftazidime increased more than fourfold; however, in the case of tigecycline and colistin, the MIC did not differ under planktonic and biofilm growths (Figure 2). These differences were statistically significant, with a *p*-value of < 0.05. To assess the antimicrobial activity of benzalkonium chloride and Deconex, we performed MIC and MBC tests using different concentrations of the above biocides. More than 58.8% and 35.2% of the isolates exhibited an MIC of 0.015 mg/ml to benzalkonium chloride and Deconex under planktonic conditions, while 17.6% and 18.8% of the isolates showed an MIC of 0.03 mg/ml to the above compounds. We detected one isolate with an MBC of 1 mg/ml to benzalkonium chloride (isolate 53) and one isolate with an MIC of 4 mg/ml to Deconex (isolate 43), respectively.

The results of survival curves of the planktonic cells and biofilm eradication time in the presence of biocides are illustrated in Figures 3a and 3b. Here, benzalkonium chloride at a concentration of 0.03 mg/ml and Deconex at a concentration of 0.06 mg/ml reduced bacterial population to 3 log 10 units within four hours of exposure (Figure 3a). Further exposure of planktonic cells to biocides indicated a continuous drop of viable cells with no detectable CFUs after eight hours of incubation. Furthermore, we challenged biofilms with benzalkonium chloride at concentrations of 0.03 mg/ml and Deconex at concentrations of 0.06 mg/ml, respectively. A minimum biofilm eradication time assay revealed that both biocides were not effective against preformed biofilm at the recommended time of five minutes, but that they eradicated the biofilm masses from microplate wells after 30 minutes' exposure (Figure 3b). In addition, combinations of benzalkonium chloride at a concentration of 0.03 mg/ml and Deconex at a concentration of 0.06 mg/ml had a synergistic effect and removed most of the biofilm from the microtiter wells within five minutes of incubation (Figure 3b). PCR analysis showed the presence of *cep*A in 15% of the isolates showing strong biofilm, while the *qac*EΔ1 gene was absent in this study.

DISCUSSION

The U.S. Centers for Disease Control and Prevention alone records nearly 560,000 catheter-related urinary tract infections in U.S. hospitals [20]. Catheterization increases the risk of developing bacteriuria by about 3% to 6% per day. Almost 50% of short-term catheterized patients acquire infections within this period, whereas the risk of infection from long-term catheters is 100% [21].

In the present study, we selectively isolated *K. pneumoniae* strains from catheters in four hospitals and exposed them

Return to TABLE OF CONTENTS

FIGURE 3a: Survival of *K. pneumoniae* in the presence of benzalkonium chloride and Deconex. The above results are the average of two replicate experiments.

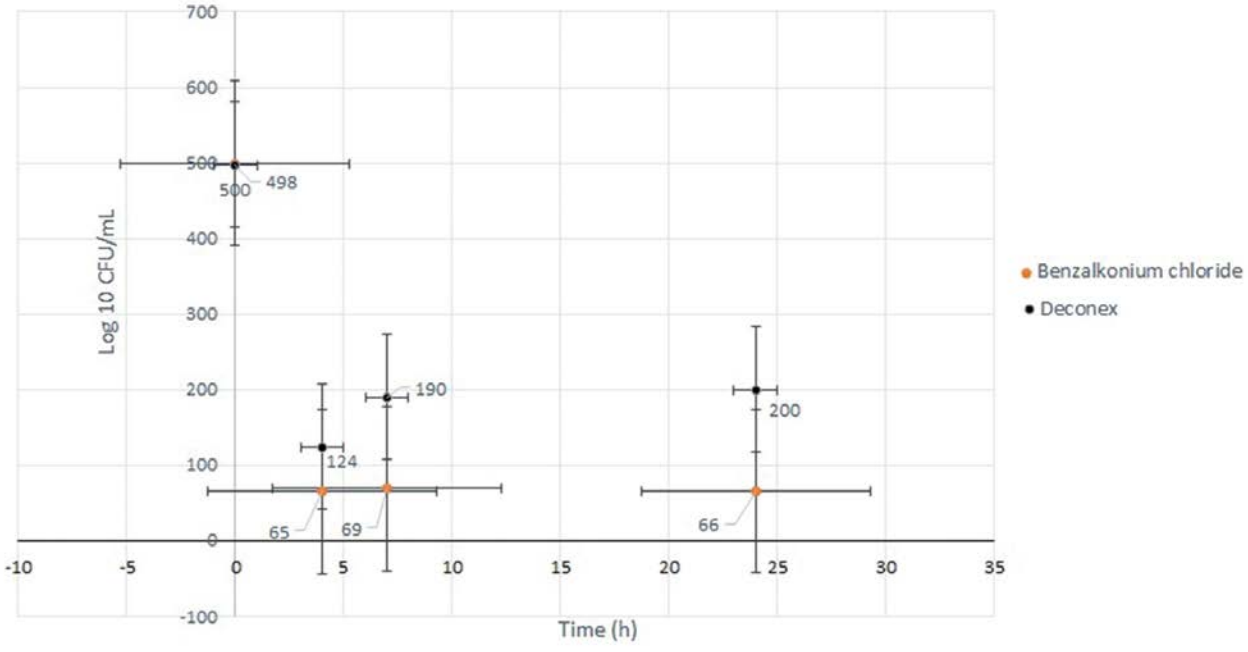
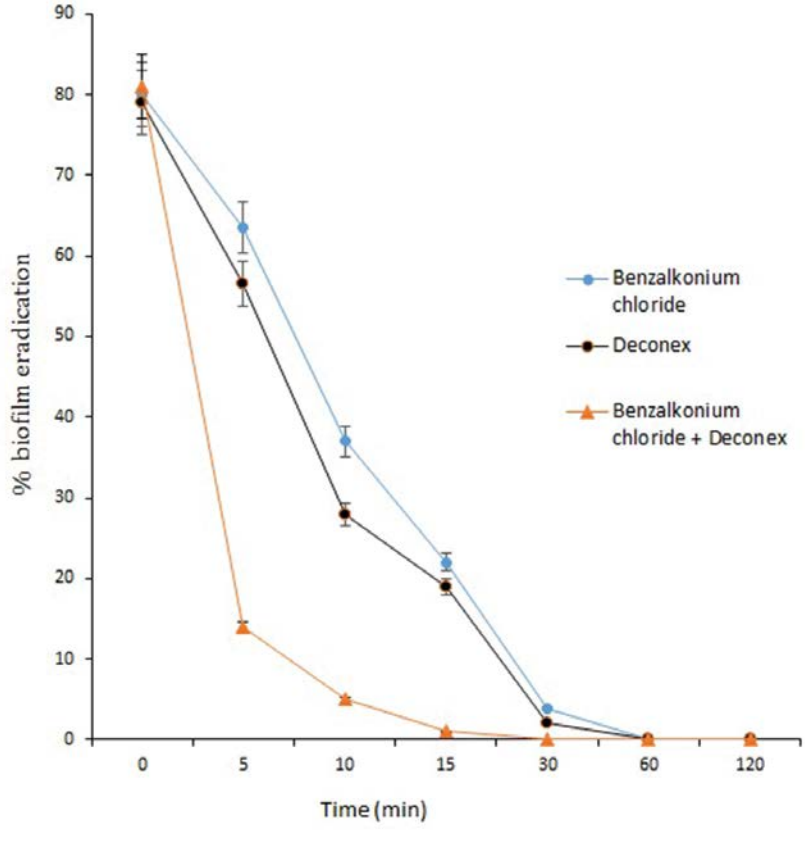


FIGURE 3b: Eradication of biofilm in the presence of benzalkonium chloride and Deconex at different time intervals. Mean values and standard deviation of the compounds are indicated by the error bar.



to different concentrations of Deconex and benzalkonium chloride. Both compounds act on the cell membrane, causing the dissociation of the bilayer membrane and the disruption of cell permeability. Our results show a high rate of sensitivity to these compounds by strains of *K. pneumoniae* (average MIC to Deconex of 0.06 ± 0.2 mg/ml and benzalkonium chloride of 0.03 ± 0.01 mg/ml). However, the compounds did not exert biofilm inhibitory activity. A recent study revealed that bacterial adherence to the benzalkonium chloride-impregnated catheters was significantly reduced compared with control catheters containing no antimicrobial agent ($p < 0.01$) [22]. Furthermore, we found a direct relationship between biofilm formation and high MIC values to antibiotics, which highlights how current planktonic-based antimicrobial susceptibility tests are often misleading [23]. This increased resistance occurs mainly in mature biofilms and is attributed to the formation of antibiotic-tolerant subpopulations in the deeper layers of biofilms in combination with impaired molecule diffusion [24]. A fourfold increase in MIC to imipenem in biofilm-grown cells was unexpected; Chen et al. (2014) [25] reported that imipenem displayed potent activity against established *K. pneumoniae* biofilms under both static and flow conditions in vitro, while Vuotto et al. (2017) [26] demonstrated that the association of biofilm production and imipenem resistance in *K. pneumoniae* was statistically significant. Recently, research has been directed at understanding why antibiotics do not effectively penetrate biofilms (specific antibiotics are required at higher dosages to treat biofilms) [27].

There was no significant relationship between antibiotic resistance and resistance to biocides in our study. On the contrary, many isolates were susceptible to biocides but resistant to antibiotics. We propose that hand hygiene, contact precautions, active patient screening, and disinfecting hospital equipment and catheter-related devices with these compounds at concentrations of 0.03 mg/ml can effectively reduce the transmission of infections caused by *K. pneumoniae* planktonic cells but not biofilm conditions. A population-based study on bloodstream infections caused by *K. pneumoniae* from 2000 to 2007 in Canada, a setting with low prevalence of antimicrobial resistance, showed an increase of the burden of disease during the last decade and a case fatality rate of 19% [28].

Our data also suggest that for resistance to QACs, the presence of both *qac*EΔ1 and *cep*A genes is essential. The absence of the *qac*EΔ1 gene led to sensitivity to these biocides. One study performed in Tehran hospitals investigated the susceptibility of 26 isolates of *K. pneumoniae* to a hospital biocide in the presence of *qac*EΔ1 and *cep*A genes [19]. The *qac*EΔ1 and *cep*A genes were detected in 26 and 19 biocide-resistant isolates. The results suggest that susceptibility to biocide in clinical isolates of *K. pneumoniae* is directly related to the presence of both *qac*EΔ1 and *cep*A genes. Similarly, it has been shown that 50%, 49%, and 53% of *K. pneumoniae* strains had reduced susceptibility to chlorhexidine and benzalkonium chloride. The antiseptic-resistant genes *cep*A and *qac*EΔ1 were found in 56, 34, and one isolates, respectively [19].

CONCLUSION

Based on the above data, we concluded that benzalkonium chloride and Deconex antiseptics are very good at controlling infections caused by *K. pneumoniae* planktonic cells and could be included in the antimicrobial stewardship program of our hospitals.

REFERENCES

1. Itokazu, G. S., Quinn, J. P., Bell-Dixon, C., Kahan, F. M., & Weinstein, R. A. (1996). Antimicrobial resistance rates among aerobic gram-negative bacilli recovered from patients in intensive care units: Evaluation of a national post marketing surveillance program. *Clinical Infectious Diseases, 23*(4), 779-84.
2. Nordmann, P., Cuzon, G., & Naas, T. (2009). The real threat of *Klebsiella pneumoniae* carbapenemase-producing bacteria. *Lancet Infectious Diseases, 9*(4), 228-236. doi: 10.1016/S1473-3099(09)70054-4
3. Podschun, R., & Ullmann. (1998). *Klebsiella spp*. as nosocomial pathogens: Epidemiology, taxonomy, typing methods, and pathogenicity factors. *Clinical Microbiology Reviews, 11*(4), 589-603.
4. Henson, S. P., Boinett, C. J., Ellington, M. J., Kagia, N., Mwarumba, S., Nyongesa, S., Mturi, N., Kariuki, S., Scott, J. A. G., Thomson, N. R., & Morpeth, S. C. (2017). Molecular epidemiology of *Klebsiella pneumoniae* invasive infections over a decade at Kilifi County Hospital in Kenya. *International Journal of Medical Microbiology, 30*(7), 422-429. doi: 10.1016/j.ijmm.2017.07.006
5. Bi, W., Liu, H., Dunstan, R. A., Li, B., Torres, V. V. L., Cao, J., Wilksch, J. J., Strugnell, R. A., Lithgow, T., & Zhou, T. (2017). Extensively drug-resistant *Klebsiella pneumoniae* causing nosocomial bloodstream infections in China: Molecular investigation of antibiotic resistance determinants, informing therapy, and clinical outcomes. *Frontiers in Microbiology, 30*(8), 1230. doi: 10.3389/fmicb.2017.01230
6. Yao, H., Qin, S., Chen, S., Shen, J., & Du, X. D. (2018). Emergence of carbapenem-resistant hypervirulent *Klebsiella pneumoniae*. *Lancet Infectious Diseases, 18*(1), 25. doi: 10.1016/S1473-3099(17)30628-X
7. Shakibaie, M. R. (2018). Bacterial biofilm and its clinical implications. *Annals of Microbiology and Research, 2*(1), 45-50.
8. Ishida, H., Ishida, Y., Kurosaka, T., Otani, T., Sato, K., & Kobayashi, H. (1998). In vitro and in vivo activities of levofloxacin against biofilm-producing *Pseudomonas aeruginosa*. *Antimicrobial Agents and Chemotherapy, 42*(7), 1641-1645.
9. O'Toole, G., Kaplan, H. B., & Kolter, R. (2000). Biofilm formation as microbial development. *Annual Review of Microbiology, 54,* 49-79. Retrieved from https://www.annualreviews.org/doi/10.1146/annurev.micro.54.1.49
10. Stahlhut, S. G., Struve, C., Krogfelt, K. A., & Reisner, A. (2012). Biofilm formation of *Klebsiella pneumoniae* on urethral catheters requires either type 1 or type 3 fimbriae. *FEMS Immunology and Medical Microbiology, 65*(2), 350-359.
11. Jefferson, K. K. (2004). What drives bacteria to produce biofilm? *FEMS Microbiology Letters, 236*(2), 163-173. Retrieved from https://academic.oup.com/femsle/article/236/2/163/535288
12. Gainor, B. J., Hockman, D. E., Anglen, J. O., Christensen, G., & Simpson, W. A. (1997). Benzalkonium chloride: A potential disinfecting irrigation solution. *Journal of Orthopaedic Trauma, 11*(2), 121-125.
13. Houari, A., & Di Martino, P. (2007). Effect of chlorhexidine and benzalkonium chloride on bacterial biofilm formation. *Letters in Applied Microbiology, 45*(6), 652-656. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/17944843
14. Kilian, M., & Bülow, P. (1979). Rapid identification of Enterobacteriaceae. II. Use of a beta-glucuronidase detecting agar medium (PGUA agar) for the identification of *E. coli* in primary cultures of urine samples. *Acta Pathologica et Microbiologica Scandinavica. Section B, Microbiology, 87*(5), 271-276.
15. Gholamrezazadeh, M., Shakibaie, M. R., Monirzadeh F., Masoumi, S., & Hashemizadeh, Z. (2018). Effect of nano-silver, nano-copper, deconex

and benzalkonium chloride on biofilm formation and expression of transcription regulatory quorum sensing gene (*rh1*R) in drug-resistance *Pseudomonas aeruginosa* burn isolates. *Burns, 44*(3), 700-708. doi: https://doi.org/10.1016/j.burns.2017.10.021

16. Andrews, J. M. (2001). Determination of minimum inhibitory concentrations. *Journal of Antimicrobial Chemotherapy, 48*(Suppl S1), 5-16.
17. Stepanović, S., Vuković, D., Hola, V., Di Bonaventura, G., Djukić, S., Ćirković, I., & Ruzicka, F. (2007). Quantification of biofilm in microtiter plates: Overview of testing conditions and practical recommendations for assessment of biofilm production by *staphylococci*. *APMIS, 115*(8), 891-899. doi: https://doi.org/10.1111/j.1600-0463.2007.apm_630.x
18. Leary, J. T., Werger, M. M., Broach, W. H., Shaw, L. N., Santoni, B.G., Bernasek, T.L., & Lyons, S. T. (2017). Complete eradication of biofilm from orthopedic materials. *Journal of Arthroplasty, 32*(8), 2513-2518. doi: 10.1016/j.arth.2017.03.050
19. Azadpour, M., Nowroozi, J., Goudarzi, G. R., & Mahmoudvand, H. (2015). Presence of *qac*EΔ1 and *cep*A genes and susceptibility to a hospital biocide in clinical isolates of *Klebsiella pneumoniae* in Iran. *Tropical Biomedicine, 32*(1), 109-115.
20. Desai, D. G., Liao, K. S., Cevallos, M. E., & Trautner, B. W. (2010). Silver or nitrofurazone impregnation of urinary catheters has a minimal effect on uropathogen adherence. *Journal of Urology, 184*(6), 2565-2571. doi: 10.1016/j.juro.2010.07.036
21. Ortega, M., Marco, F., Soriano, A., Almela, M., Martínez J. A., Pitart, C., & Mensa, J. (2013). Epidemiology and prognostic determinants of bacteraemic catheter-acquired urinary tract infection in a single institution from 1991 to 2010. *Journal of Infection, 67*(4), 282-287. doi: 10.1016/j.jinf.2013.06.003
22. Tebbs, S. E., & Elliott, T. S. (1993). A novel antimicrobial central venous catheter impregnated with benzalkonium chloride. *Journal of Antimicrobial Chemotherapy, 31*(2), 261-271.
23. Brady, A. J., Laverty, G., Gilpin, D. F., Kearney, P., & Tunney. M. (2017). Antibiotic susceptibility of planktonic- and biofilm-grown *staphylococci* isolated from implant-associated infections: Should MBEC and nature of biofilm formation replace MIC? *Journal of Medical Microbiology, 66*(4), 461-469. doi: 10.1099/jmm.0.000466
24. Ito, A., Taniuchi, A., May, T., Kawata, K., & Okabe, S. (2009). Increased antibiotic resistance of *Escherichia coli* in mature biofilms. *Applied and Environmental Microbiology, 75*(12), 4093-4100.
25. Chen, P., Seth, A. K., Abercrombie, J. J., Mustoe, T. A., & Leung, K. P. (2014). Activity of Imipenem against *Klebsiella pneumoniae* biofilms *in vitro* and *in vivo. Antimicrobial Agents and Chemotherapy, 58*(2), 1208-1213. Retrieved from https://aac.asm.org/content/aac/58/2/1208.full.pdf
26. Vuotto, C., Longo, F., Pascolini, C., Donelli, G., Balice, M. P., Libori, M. F., Tiracchia, V., Salvia. A., & Varaldo, P. E. (2017). Biofilm formation and antibiotic resistance in *Klebsiella pneumoniae* urinary strains. *Journal of Applied Microbiology, 123*(4), 1003-1018. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1111/jam.13533
27. Kostakioti, M., Hadjifrangiskou, M., & Hultgren, S. J. (2013). Bacterial biofilms: Development, dispersal, and therapeutic strategies in the dawn of the postantibiotic era. *Cold Spring Harbor Perspectives in Medicine, 3*(4), a010306. doi: 10.1101/cshperspect.a010306
28. Meatherall, B. L., Gregson, D., Ross, T., Pitout, J. D., & Laupland, K. B. (2009). Incidence, risk factors, and outcomes of *Klebsiella pneumoniae* bacteremia. *American Journal of Medicine, 122*(9), 866-873. doi: 10.1016/j.amjmed.2009.03.034

ORIGINAL ARTICLE

Prevalence and risk factors of healthcare-associated infections in a Moroccan teaching hospital

Mahfoud Chiguer;[1,2] Sanae Lamti;[3] Naima Abda, MD;[4] Zayneb Alami, PhD[1,5]
[1]Department of Pharmacy and Clinical Pharmacology, Mohammed VI University Hospital, Oujda, Morocco
[2]Department of Biochemistry and Biotechnology, Faculty of Science, Mohammed First University, Oujda, Morocco
[3]Department of Informatics, Mohammed VI University Hospital, Oujda, Morocco
[4]Department of Epidemiology, Medical School, Mohammed First University, Oujda, Morocco
[5]Department of Pharmacology, Medical School, Mohammed First University, Oujda, Morocco

Corresponding author:
Zayneb Alami, Pharmacist, Professor of Pharmacology
Department of Pharmacy and Clinical Pharmacology, Mohammed VI University Hospital, Oujda, Morocco
Tel.: (+212)667 15 87 80
z.alami@ump.ac.ma

ABSTRACT

Background: The aims of this study were to estimate the total prevalence of healthcare-associated infections (HAIs) among hospitalized patients and risk factors related to HAIs.

Materials and methods: This was a point prevalence survey conducted in a Moroccan teaching hospital from June 5 to July 19, 2017. We used version 5.3 of the European Centre for Disease Prevention and Control's protocol to collect the data. Statistical analysis was performed using SPSS (version 21.0). Multivariate analysis was conducted using simple logistic regression.

Results: Data on 207 patients were analyzed. The occupancy rate was 43.5%. The prevalence of HAIs was 22.2%, with a 95% confidence interval (CI) (17%-28%). Urinary tract infections were in the first range (17.4%). The most common pathogen causing HAIs was *Staphylococcus aureus*. Third-generation cephalosporins (38.2%) were the most common antibiotic used. Undergoing surgery (odds ratio [OR] = 7.65; 95% CI [2.72-21.51] $p < 0.001$), having a high McCabe score (OR = 1.374; 95% CI [0.417-4.531]; $p = 0.002$), and extended length of stay in the hospital (OR = 1.06; 95% CI [1.019-1.103]; $p = 0.004$) were the primary risk factors associated with HAIs.

Conclusions: The burden of HAIs in our centre is high compared to the recommendations of the World Health Organization. Further research on antibiotic use, assessment of hygiene measures, and urgent implementation of infection control policy is needed.

KEYWORDS

Healthcare-associated infections; prevention; infection control; prevalence

INTRODUCTION

Healthcare-associated infections (HAIs) are a major concern for the healthcare industry worldwide. In the U.S., one out of every 136 hospitalized patients falls seriously ill as a result of HAIs, which equates to 2 million cases and nearly 80,000 deaths each year [1].

According to a systematic review and meta-analysis published in 2011 [2, 3], the prevalence of HAIs is much higher in developing countries than in Europe and the U.S. (15.5 per 100 patients [95% confidence interval (CI); 12.6-18.9] vs. 5% or less).

Prevalence studies can be a useful part of an effective surveillance system to identify areas for further investigation [4, 5]. In Morocco, there is no national HAI surveillance program and no reportable quality indicators. Only a few teaching hospitals in Morocco have functional infection control programs. The teaching hospital in Oujda, capital of the eastern province of Morocco, was built in 2014 with a bed count of 450. The aim of this study was to estimate the prevalence of HAIs in this hospital and determine their related risk factors.

METHODS

Settings and data collection

We conducted a cross-sectional study from June 5 to July 19, 2017 at the Mohammed VI University Hospital in Oujda, Morocco. We used version 5.3 of the European Centre for Disease Prevention and Control's protocol to collect the data [6]. Only infections that were active or under antibiotic treatment on the day of the study were included. Antibiotic use was recorded according to the Anatomical Therapeutic Chemical classification of the World Health Organization [7]. Antibiotic type, route of administration, indication, and whether the indication was listed in the patient's medical record were registered.

For HAIs, we collected information on the nature of infection, onset of infection, any device relationship, and other details. The pathogens that had caused the infection were also recorded when information was available.

Acknowledgements: None.
Conflicts of interest: None.
Funding: None.

HAI definition

As per the U.S. Centers for Disease Control and Prevention, a HAI is defined as a localized or systemic condition resulting from an adverse reaction due to an infectious agent or its toxin with no evidence of infection or incubation upon admission [8].

Inclusion and exclusion criteria

We included all wards in our acute care facility. The following inclusion criteria were used: all patients admitted to the ward at or before 8 a.m. and not discharged from the ward at the time of the survey; and neonates on maternity and pediatric wards if born at or before 8 a.m. Dialysis patients (outpatients), patients in the emergency room, patients undergoing same-day treatment or surgery, and patients seen in the outpatient department were excluded from our study [6].

Statistical analysis

Categorical and continuous variables were expressed as percentages, means ± standard deviation (SD), or median and interquartile range (IQR). Statistical analysis was performed using SPSS (version 21.0). Univariate analysis was first conducted using simple logistic regression. Then, variables with $p < 0.20$ in the univariate analysis were integrated into multivariate analysis. *P*-values < 0.05 were considered to be significant.

RESULTS

Patient and hospital characteristics

We analyzed data on 207 patients, of whom 63.3% were men and 36.7% women. Mean age was 40 ± 21 years; occupational rate was 43.5%; and median length of hospital stay was seven days (IQR [5-14]).

Prevalence, sites, and HAI pathogens

46 HAIs were recorded, indicating a prevalence of 22.2 per 100 patients (95% CI [17%-28%]). In most cases, the sites of HAIs were not recorded and were unknown (21.73%). Urinary tract infections were most common (17.4%), followed by surgical wound infections (15.21%) and skin and soft tissue infections (10.87%) (Table 1).

Among the 46 infections associated with care, five microorganisms were isolated (10.86%) as follows: Staphylococcus aureus (28.58%), Klebsiella pneumoniae (28.58%), Acinetobacter baumannii (14.28%), Streptococcus agalactiae (14.28%), and MRSA (14.28%).

Antibiotic use

Among the 207 patients analyzed, 96 used antibiotics (46.4%). The most common route of administration of antibiotics was parenteral (86.7%). The five most used classes of antibiotics were third-generation cephalosporins (38.2%), penicillins with beta-lactamase inhibitors (20.1%), imidazoles (13.9%), aminosids (8.4%), and first-generation cephalosporins (3.5%).

HAI risk factors

In univariate analysis, patient characteristics and exposure to invasive devices increasing the risk of HAIs were: McCabe score, undergoing surgery, longer duration of hospital stay, and exposure to intravascular catheter (Table 2).

In the stepwise forward logistic regression, the variables found to be significantly associated with HAIs were undergoing surgery (odds ratio [OR] = 7.64; 95% CI [2.72-21.51]; $p < 0.001$), longer duration of hospital stay (OR = 1.06; 95% CI [1.019-1.103]), and McCabe score (ultimately fatal disease OR = 1.374; 95% CI [0.417-4.531], $p = 0.002$).

TABLE 1: Types of HAIs.

Type of Infection	Number	Prevalence (%)	Cumulative Percentage
Unknown infection	10	21.73	21.73
Urinary tract infection	8	17.39	39.12
Surgical wound infection	7	15.21	54.33
Skin and soft tissue infection	5	10.87	65.20
Lower respiratory tract infection	4	8.70	73.90
Central nervous system infection	4	8.70	82.60
Systemic infection	4	8.70	91.30
Prolonged fever	2	4.35	95.65
Eye, ear, nose, or mouth infection	1	2.17	97.82
Other gastrointestinal infection	1	2.18	100
Total	**46**	**100**	

DISCUSSION

One limitation of this study was a low patient occupancy rate of 43.5% attributed to Ramadan, a religious month. During Ramadan, patients prefer to be at home with their families and there is only skeletal staffing in the facility. Hence the data reported is partly biased, as it represents only the patients who had to remain in the hospital due to serious illness, or who had no family members to care for them at home. Another limitation was that the diagnosis of infections associated with care was based on the clinical criteria alone.

The prevalence of infections associated with care in our hospital was high in comparison to the prevalence of several similar studies at national (University Hospital of Rabat, Morocco in 2007; 17.8% [9]) and international (Tunisia, 17.9% [10]; Malaysia, 13.9% [11]; Senegal, 10.9% [12]; and Cuba, 7.3% [13]) healthcare centres. The prevalence of HAIs is lower in developed countries, such as Switzerland (7.2%) [14], The Netherlands (7.2%) [15], France (5.4%) [16], Norway (5.4%) [17], Germany (5.1%) [18], and Italy (4.9%) [19]. According to Allegranzi et al., HAIs are more severe and higher in prevalence in developing countries than in developed countries [2].

Patients in our intensive care unit were at the highest risk of HAIs, which is in line with findings of other studies [19, 20].

This can be explained by the large number of admissions with serious diseases, broad-spectrum antibiotic therapy, and the frequent use of invasive medical devices.

Zaidi et al. [21] reported rates of neonatal infection three to 20 times higher in resource-limited countries than those in industrialized countries. In our case, four out of five newborns hospitalized in neonatal intensive care on the day of the survey were infected.

Due to substandard documentation practices, 21.7% of infections were of unknown type. Although the number of isolated cases was small because of the high percentage of unknown and undocumented information in patient records, our study identified two main types of HAIs: urinary tract infection and surgical wound infection. These sites are the most frequently reported in prevalence surveys [9, 19, 16, 22].

Antibiotic prescription in the patients surveyed was particularly alarming, with 46.4% of the patients taking antibiotics. This high antibiotic prescription rate has been reported in the majority of studies in developing countries [23, 24]. Third-generation cephalosporins were the most commonly administered antibiotics (38.2%), which is in contrast with other studies: Germany in 2011 [18] and Malaysia in 2005 [11] reported using second-generation cephalosporins, and penicillins were more often used in another university medical centre in Rabat, Morocco in 2012 [9]. Rational antibiotic use can reduce selective pressure for the development of resistance to antibiotics [25].

In our investigation, risk factors associated with HAIs were longer duration of hospital stay, higher McCabe score, recent surgery, and exposure to an intravascular catheter. Identical risk factors were reported by other studies [12, 26, 27].

TABLE 2: Univariate and multivariate analysis for risk factors of HAIs.

Risk Factors	Univariate Analysis			Multivariate Analysis		
	OR	CI 95%	*p*-Value	OR	CI 95%	*p*-Value
Age (mean ± SD)	1.01	[1.00-1.03]	0.023			
Gender	1.01	[0.51-1.99]	0.969			
Ward						
Medical						
Surgical	6.37	[2.82-14.37]	<0.0001			
Intensive care unit	6.53	[1.93-22.14]	0.003			
Surgery						
Yes	4.70	[2.35-9.39]	<0.0001	7.64	[2.72-21.50]	<0.001
No						
McCabe score						
Non-fatal disease						
Ultimately fatal disease	1.80	[0.64-5.08]	0.261	1.37	[0.41-4.53]	0.002
Rapidly fatal disease	0.22	[0.077-0.66]	0.007	0.21	[0.05-0.85]	
Length of stay	1.05	[1.01-1.08]	0.007	1.06	[1.01-1.10]	0.004
Central intravascular catheter						
Yes	3.30	[1.05-10.36]	0.041			
No						
Peripheral intravascular catheter						
Yes	16.92	[3.96-72.20]	<0.0001			
No						
Urinary catheter						
Yes	1.708	[0.61-4.77]	0.308			
No						
Intubation						
Yes	3.67	[0.71-18.8]	0.119			
No						

Return to TABLE OF CONTENTS

HAIs are a major risk in our hospital. The results of this study provided us a complete picture of the risk factors for HAIs. An action plan of infection control and improving hygiene is urgently recommended with the participation of all stakeholders: pharmacists, doctors, nurses, the hygiene team, and administration. More efforts should be made to improve surgical procedures and reduce patients' length of stay in the hospital.

REFERENCES

1. Klevens, R. M., Edwards, J. R., Richards, Jr., C. L., Horan, T. C., Gaynes, R. P., Pollock, D. A., & Cardo, D. M. (2007). Estimating health care-associated infections and deaths in U.S. hospitals, 2002. *Public Health Reports, 122*(2), 160-166.
2. Allegranzi, B., Nejad, S. B., Combescure, C., Graafmans, W., Attar, H., Donaldson, L., & Pittet, D. (2011). Burden of endemic health-care-associated infection in developing countries: Systematic review and meta-analysis. *Lancet, 377*(9761), 228-241.
3. Hansen, S., Zingg, W., Ahmad, R., Kyratsis, Y., Behnke, M., Schwab, F., Pittet, D., & Gastmeier, P. (2015). Organization of infection control in European hospitals. *Journal of Hospital Infection, 91*(4), 338-345.
4. Freeman, J., & Hutchison, G. B. (1980). Prevalence, incidence and duration. *American Journal of Epidemiology, 112*(5), 707-723.
5. Gastmeier, P., Kampf, G., Wischnewski, N., Hauer, T., Schulgen, G., Schumacher, M., Daschner, F., & Rüden, H. (1998). Prevalence of nosocomial infections in representative German hospitals. *Journal of Hospital Infection, 38*(1), 37-49.
6. European Centre for Disease Prevention and Control. (2016). Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals. Protocol version 5.3. Stockholm: ECDC. Retrieved from https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/PPS-HAI-antimicrobial-use-EU-acute-care-hospitals-V5-3.pdf
7. World Health Organization Collaborating Centre for Drug Statistics Methodology. (2018, October 17). International language for drug utilization research. Retrieved from https://www.whocc.no/
8. Horan, T. C., Andrus, M., & Dudeck, M. A. (2008). CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. *American Journal of Infection Control, 36*(5), 309-332.
9. Jroundi, I., Khoudri, I., Azzouzi, A., Zeggwagh, A. A., Benbrahim, N. F., Hassouni, F., Oualine, M., & Abouqal, R. (2007). Prevalence of hospital-acquired infection in a Moroccan university hospital. *American Journal of Infection Control, 35*(6), 412-416.
10. Kallel, H., Bahoul, M., Ksibi, H., Dammak, H., Chelly, H., Hamida, C. B., Chaari, A., Rekik, N., & Bouaziz, M. (2005). Prevalence of hospital-acquired infection in a Tunisian hospital. *Journal of Hospital Infection, 59*(4), 343-347.
11. Hughes, A. J. (2005). Prevalence of nosocomial infection and antibiotic use at a university medical center in Malaysia. *Infection Control and Hospital Epidemiology, 26*(1), 100-104.
12. Dia, N. M., Ka, R., Dieng, C., Diagne, R., Dia, M. L., Fortes, L., Diop, B. M., Sow, A. I., & Sow, P. S. (2008). Prevalence of nosocomial infections in a university hospital (Dakar, Senegal). *Médecine et maladies infectieuses, 38*(5), 270-274.
13. Izquierdo-Cubas, F., Zambrano, A., Frómeta, I., Gutiérrez, A., Bastanzuri, M., Guanche, H., & Rodríguez, D. National prevalence of nosocomial infections. Cuba 2004. *Journal of Hospital Infection, 68*(3), 234-240.
14. Sax, H., & Pittet, D. (2005). Résultats de l'enquête nationale de prévalence des infections nosocomiales de 2004 (snip04). *Swiss-NOSO, 12*(1), 1-4. Retrieved from https://www.swissnoso.ch/fileadmin/swissnoso/Dokumente/6_Publikationen/Bulletin_Artikel_F/v12_1_2005-03_Swissnoso_Bulletin_fr.pdf
15. van der Kooi, T. I., Manniën, J., Wille, J. C., & van Benthem, B. H. (2010). Prevalence of nosocomial infections in The Netherlands, 2007-2008: Results of the first four national studies. *Journal of Hospital Infection, 75*(3), 168-172.
16. Lietard, C., Lejeune, B., Rothan-Tondeur, M., Metzger, M. H., Thiolet, J.-M., & Coignard, B. (2009). Enquête nationale de prévalence des infections nosocomiales. Résultats dans la population des sujets de 65 ans et plus, France, 2006. *Bulletin épidémiologique hebdomadaire, 31-32*, 344-348. Retrieved from http://opac.invs.sante.fr/doc_num.php?explnum_id=645
17. Eriksen, H. M., Iversen, B. G., & Aavitsland, P. (2005). Prevalence of nosocomial infections in hospitals in Norway, 2002 and 2003. *Journal of Hospital Infection, 60*(1), 40-45.
18. Behnke, M., Hansen, S., Leistner, R., Diaz, L. A., Gropmann, A., Sohr, D., Gastmeier, P., & Piening, B. (2013). Nosocomial infection and antibiotic use: A second national prevalence study in Germany. *Deutsches Arzteblatt International, 110*(38), 627-633. doi: 10.3238/arztebl.2013.0627
19. Lizioli, A., Privitera, G., Alliata, E., Antonietta Banfi, E. M., Boselli, L., Panceri, M.L., Perna, M. C., Porretta, A. D., Santini, M. G., & Carreri, V. (2003). Prevalence of nosocomial infections in Italy: Result from the Lombardy survey in 2000. *Journal of Hospital Infection, 54*(2), 141-148.
20. Datta, P., Rani, H., Chauhan, R., Gombar, S., & Chander, J. (2010). Device-associated nosocomial infection in the intensive care units of a tertiary care hospital in northern India. *Journal of Hospital Infection, 76*(2), 184-185.
21. Zaidi, A. K., Huskins, W. C., Thaver, D., Bhutta, Z. A., Abbas, Z., & Goldmann, D. A. (2005). Hospital-acquired neonatal infections in developing countries. *Lancet, 365*(9465), 1175-1188.
22. Barbut, F., & Coignard, B. (2006). Nosocomial infections. *Revue du praticien, 56*(18), 2065-2071.
23. Gikas, A., Roumbelaki, M., Pediaditis, J., Nikolaidis, P., Levidiotou, S., Kartali, S., Kioumis, J., Maltezos, E., Metalidis, S., Anevlavis, E., Haliotis, G., Kolibiris, H., & Tselentis, Y. (2004). Prevalence of nosocomial infections after surgery in Greek hospitals: Results of two nationwide surveys. *Infection Control and Hospital Epidemiology, 25*(4), 319-324.
24. Gikas, A., Pediaditis, I., Roumbelaki, M., Troulakis, G., Romanos, J., & Tselentis, Y. (1999). Repeated multi-centre prevalence surveys of hospital-acquired infection in Greek hospitals. *Journal of Hospital Infection, 41*(1), 11-18.
25. Carlet, J., Jarlier, V., Harbarth, S., Voss, A., Goossens, H., & Pittet, D. (2011). Ready for a world without antibiotics? The Pensières Antibiotic Resistance Call to Action. *Antimicrobial Resistance and Infection Control, 1*, 11.
26. Amazian, K., Rossello, J., Castella, A., Sekkat, S., Terzaki, S., Dhidah, L., Abdelmoumène, T., & Fabry, J. (2010). Prévalence des infections nosocomiales dans 27 hôpitaux de la région méditerranéenne. *Eastern Mediterranean Health Journal, 16*(10), 1070-1078. Retrieved from http://applications.emro.who.int/emhj/V16/10/16_10_2010_1070_1078.pdf?ua=1
27. de Oliveira, A. C., Ciosak, S. I., Ferraz, E. M., & Guinbaum, R. S. (2006). Surgical site infection in patients submitted to digestive surgery: Risk prediction and the NNIS risk index. *American Journal of Infection Control, 34*(4), 201-207. doi:10.1016/j.ajic.2005.12.011

OUTBREAK MANAGEMENT

Improvement of hospital environmental cleaning and disinfection practices following an eight-month outbreak

Meredith C. Faires, DVM, MSc, PhD;[1] Terrence Shaw;[2] Corey Weisgerber;[3] Treena Cross;[4] Ashley Dwyer;[5] Kateri Singer, ACP[1]

[1] *Department of Infection Prevention and Control, Regina General Hospital, Regina, Saskatchewan, Canada*
[2] *Environmental Services Department, Pasqua Hospital, Regina, Saskatchewan, Canada*
[3] *Environmental Services Department, Regina General Hospital, Regina, Saskatchewan, Canada*
[4] *Environmental Services Department, Wascana Rehabilitation Centre, Regina, Saskatchewan, Canada*
[5] *Environmental Services Department, Regina Pioneer Village, Regina, Saskatchewan, Canada*

Corresponding author:
Dr. Meredith C. Faires
Senior Hospital Epidemiologist
Regional Infection Prevention & Control
Regina General Hospital
1440-14th Ave.
Regina, SK S4P 0W5
Canada
Tel.: 306-766-4675
meredith.faires@saskhealthauthority.ca

ABSTRACT

Background: Following an eight-month vancomycin-resistant *Enterococcus* outbreak on an inpatient medical unit, the Environmental Services Department re-examined their cleaning and disinfection protocols.

Methods: Cleaning and disinfection policies and best practice recommendations were analyzed and staff and patient surveys were conducted to identify quality improvement projects.

Results: Four projects were implemented, including standardizing procedures, updating cleaning products, and introducing auditing and seasonal cleaning programs in patient care areas.

Conclusions: Engaging staff and patients and reviewing best practices resulted in the successful implementation of improvement projects to enhance cleaning and disinfection practices and improve patient safety in an acute care hospital.

KEYWORDS

Auditing; hospital; improvement projects; seasonal cleaning

INTRODUCTION

In 2013, a 35-bed inpatient medical unit experienced an eight-month vancomycin-resistant *Enterococcus* (VRE) outbreak. Three weeks after the outbreak was declared, 11 patients were newly identified as VRE-colonized despite the implementation of several outbreak measures, including adherence to hand hygiene and additional precautions, closure of overcapacity beds, double cleaning of patient rooms, cohorting of nursing staff and VRE-positive patients, and limiting patient movement. As there is increasing evidence that the environment may play a significant role in the transmission of healthcare-associated pathogens [1, 2], environmental sampling was conducted to identify high-touch surfaces contaminated with VRE in both the general ward environment and VRE-positive and -negative patient rooms and bathrooms. Results of environment sampling indicated extensive VRE contamination throughout the unit, including the nursing station, cleaning storage room, hand rails, medical charts, patient kitchen, inside and outside the automated medication dispensing machine, the staff room, as well as VRE-positive and -negative patient rooms and bathrooms. In response, increased cleaning of all equipment and high-touch surfaces was conducted. Following the outbreak, the Environmental Services (EVS) Department decided to embark on a quality improvement program to

Acknowledgements: The authors wish to thank patients, Environmental Services staff, Support Services, Patient Flow, clinical staff, Facilities Management, Clinical Engineering, Infection Prevention and Control, and the former Regina Qu'Appelle Health Region Senior Leadership Team for their support and contributions to the improvement projects.

Conflicts of interest: None.

Funding: None.

upgrade and enhance its cleaning and disinfection practices and protocols with the goal of preventing future outbreaks within the hospital.

METHODS

In 2014, the EVS Department, in partnership with the Infection Prevention and Control (IPAC) Department, analyzed the current state of practices, procedures, and products related to cleaning and disinfection at a 420-bed teaching affiliated hospital. In addition, an environmental cleaning document from the Provincial Infectious Diseases Advisory Committee [3] in Ontario was evaluated to determine if the hospital's procedures aligned with best practice recommendations.

To determine areas and environmental surfaces that were cleaned and disinfected and the healthcare provider responsible, a sticky note exercise was conducted. This activity involved nurses (working different shifts), personnel responsible for stocking the supply room, and EVS and unit support staff each receiving a specific colour of sticky note. Over a four-to-six-hour period, staff placed a coloured sticky note on the area or equipment they were currently responsible for cleaning.

To evaluate the engagement and performance of the EVS Department, surveys were completed by EVS staff, internal clients (e.g., department managers, clinical staff), and patients (Table 1). Surveys for EVS staff and internal clients were completed online and responses were based on a five-point Likert scale. Patient surveys were conducted by EVS supervisors through face-to-face discussions after the patient's room was cleaned. Survey questions for patients were open-ended.

RESULTS

Analysis of cleaning and disinfection protocols, best practices, sticky note exercises, and patient and staff surveys resulted in targeting several key areas for improvement, including standardizing procedures, replacing cleaning products, utilizing technological tools, and increasing staff accountability. Patient safety was identified as the key priority and it was decided that enhancements in cleaning and disinfection procedures should be dedicated to all patient care areas. Subsequently, four quality improvement projects were developed and implemented from 2015 to 2017.

Project 1: Standardizing cleaning procedures

Results from the sticky note exercises identified areas and equipment that were not cleaned and/or were cleaned by multiple staff. To ensure consistency in cleaning and disinfection processes and procedures by the appropriate healthcare provider, standard work was created, including procedures for floors, bathtubs, showers, furniture, medical equipment, and patient rooms. The standard work also included a script to assist EVS staff in communicating the cleaning process of a patient's room to patients and visitors.

TABLE 1: Survey questions for EVS staff, internal clients, and patients.

EVS Staff Engagement Questions	
1.	My manager is approachable and easy to talk to.
2.	In the past six months, someone has talked to me about my progress and performance.
3.	My co-workers are committed to doing quality work.
4.	The people I work with treat each other with respect.
5.	I have the right tools and materials to do my work.
6.	I have enough time to do my work.
7.	The facility where I work provides a safe work environment.
8.	I know what is expected of me at work and understand the importance of my job.
9.	At work, my opinion counts.
10.	The clients/patients count on me and the work I do.
11.	I enjoy my job.
Internal Client Questions	
1.	The Environmental Services staff are courteous and collaborative.
2.	How satisfied are you with the overall service provided?
3.	The level of cleaning in your area meets your requirements.
4.	I am able to reach an Environmental Services supervisor or manager when required.
5.	Environmental Services are integral to the operations of your department.
Patient Questions	
1.	Do you have any comments related to the cleanliness of the room?
2.	Is there anything that you need to be cleaned?

Project 2: Changing cleaning products

Initially, the EVS Department used cotton cloths and a quaternary ammonium compound to clean and disinfect surfaces. However, research indicates that cotton towels exposed to disinfectants containing quaternary ammonium compounds resulted in a substantial loss in disinfectant activity and concentration [4]. Based on this research and best practice recommendations [3], the EVS Department changed to an accelerated hydrogen peroxide disinfectant as well as microfibre cleaning materials, including cloths and mops.

Project 3: Incorporating technological tools

To enhance cleaning and disinfection practices within the hospital, two technological tools were utilized by the EVS Department. The first, an auditing system utilizing fluorescent marking gel, was introduced to assist in identifying high-touch surfaces in patient rooms and bathrooms that were consistently cleaned and disinfected. Results from the auditing system were used for trending and benchmarking. Overall, results indicated that the percentage of high-touch surfaces that are regularly cleaned and disinfected in patient rooms and bathrooms steadily increased from 70% in 2015 to 90% in 2018. Despite this overall increase, results also identified specific environmental surfaces that were not routinely cleaned and disinfected. The audit results were regularly reported at departmental huddles and were used to coach and train EVS staff. Results were also posted on the hospital's intranet website for all healthcare providers to view.

The second technological tool, a portable hydrogen peroxide disinfection system, was purchased by the EVS Department. This technology was specifically utilized during outbreaks (i.e., patient rooms, staff rooms, cleaning service rooms, tub and shower rooms) or during seasonal cleaning (i.e., patient rooms).

Project 4: Focusing cleaning and disinfection procedures in patient care areas

In 2017, a seasonal cleaning program was introduced for all inpatient units. This program was developed by internal partners during brainstorming sessions to prevent future outbreaks. The seasonal cleaning program consisted of a patient room being closed for a minimum of 24 hours. During this time, unit staff decanted the room, repairs (e.g., walls patched, puck board applied, electrical and plumbing problems repaired, walls painted) were completed by the Facilities Department, preventative maintenance of equipment (e.g., lifts, beds) was performed by the Clinical Engineering Department, and EVS staff polished the floors. Lastly, furnishings were moved back into the patient room and the room was terminally cleaned and disinfected and then fogged using the portable hydrogen peroxide disinfection system.

DISCUSSION

Understanding the current procedures and activities of the EVS Department identified several opportunities for improving cleaning and disinfection practices as well as patient safety within an acute care hospital. Engaging patients and staff resulted in clear and consistent cleaning and disinfection processes that were successfully implemented and maintained in patient care areas. Conducting sticky note exercises, which had high visual impact using little technology, resources, or cost, ensured equipment was cleaned by dedicated healthcare providers. Furthermore, by utilizing an audit and feedback system, cleaning and disinfection of high-touch environmental surfaces was easily monitored and addressed with EVS staff in addition to promoting and sustaining EVS staff accountability. Overall, the success of the various quality improvement projects was largely due in part to collaborations, partnerships, and communication strategies established between departments that included Nursing, Patient Flow, Facilities, Clinical Engineering, EVS, and IPAC.

REFERENCES

1. Dancer, S. J. (1999). Mopping up hospital infection. *Journal of Hospital Infection, 43*(2), 85-100.
2. Boyce, J. M. (2007). Environmental contamination makes an important contribution to hospital infection. *Journal of Hospital Infection, 65*(Suppl 2), 50-54.
3. Provincial Infectious Diseases Advisory Committee, Ontario Agency for Health Protection and Promotion. (2012). *Best practices for environmental cleaning for prevention and control of infections in all health care settings*. 2nd ed. Toronto, ON: Queen's Printer for Ontario. Retrieved from https://www.publichealthontario.ca/fr/eRepository/Best_Practices_Environmental_Cleaning_2012.pdf
4. Engelbrecht, K., Ambrose, D., Sifuentes, L., Gerba, C., Weart, I., & Koenig, D. (2013). Decreased activity of commercially available disinfectants containing quaternary ammonium compounds when exposed to cotton towels. *American Journal of Infection Control, 41*(10), 908-911.

CONCISE REPORT

Facultative anaerobic bacteria on dentistry students' gutta-percha points: The importance of disinfection

María del Pilar Angarita;[1] Diana Carolina Rozo;[1] Diana Forero;[1] Andrea Isabel Arias;[1] Alvaro Imbachi;[1] Laidy Johanna Sandoval[1]
[1] Faculty of Dentistry, Universidad Cooperativa de Colombia, Villavicencio, Colombia

Corresponding author:
Dr. María del Pilar Angarita
Carrera 35 #36-99 Barrio Barzal
Facultad Ciencias de la Salud
Programa de Odontología
Universidad Cooperativa de Colombia
C.P. 500001. Villavicencio (Meta)
Colombia
maria.angaritad@campusucc.edu.co

ABSTRACT

Background: During endodontic treatment in dentistry, if the gutta-percha points contain microorganisms that are resistant to the conditions in the root canal once it is sealed, they can lead to new infections. The purpose of this study was to determine the presence and quantification of facultative anaerobic bacteria in students' gutta-percha points.

Methods: A representative sample of dentistry students' gutta-percha points were collected, together with information on their characteristics. The points were placed in saline solution for inoculation in blood agar followed by anaerobic incubation for five days. Bacteria presence and type were determined, quantified, and identified. Following this, the X^2 test was used to verify whether there were any significant differences in the contamination found in the points between the characteristics studied.

Results: The results of the microbiological analysis revealed that 32.1% of the points appeared to be contaminated by facultative anaerobic bacteria. The most common types of microorganisms were gram-positive bacilli, followed by gram-positive coccus. *Staphylococcus epidermidis* was among the microorganisms identified. No relationship was observed between the presence of cone contamination and the characteristics, but a statistically significant difference was detected within the group defined by package opening date. Significant differences were also found in terms of the presence of spore-forming bacilli within the group defined by package opening and expiry date.

Conclusions: The presence of facultative anaerobic bacteria of clinical interest in the gutta-percha points used by dentistry students was identified and quantified. Among the bacteria identified, some are of clinical importance, such as *Staphylococcus epidermidis* and *Streptococcus mitis*. The establishment of disinfection protocols for such materials is recommended.

KEYWORDS

Gutta-percha; root canal obturation; contamination; bacteria

INTRODUCTION

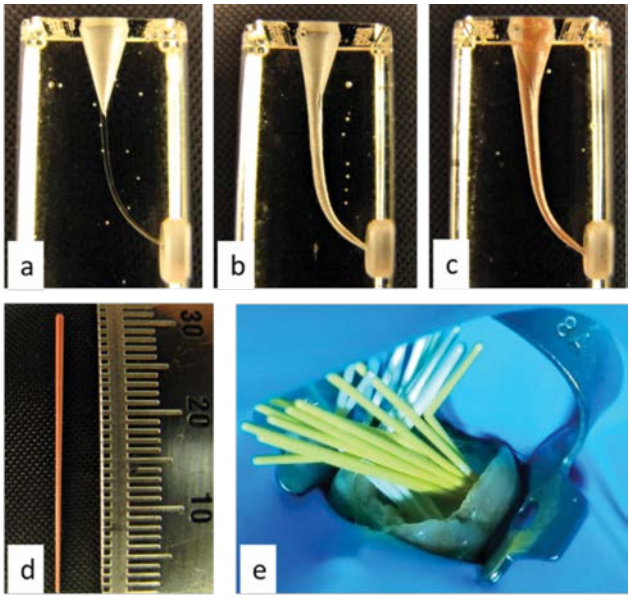
During endodontic therapy, the dentist seeks to remove the microorganisms present in the root canal and prevent new microorganisms from accessing the area by establishing inhospitable conditions [1], including the insufficient or almost null quantity of nutrients, limited space, the alteration of the redox potential (physiological state based on oxidation-reduction reactions in biological systems), low oxygen concentration, and the presence of antimicrobial substances [2]. However, it has been revealed that some of the microorganisms involved in endodontic infectious processes are able to adapt to such conditions [2, 3]. Thus, if the gutta-percha points contain microorganisms that are resistant to the conditions in the root canal once it is sealed (obturated) (Figure 1), and if they possess virulence factors and the appropriate infective dose [4], they can lead to new infections.

Acknowledgements: The findings of this study were reported at the International Conference on Environmental Microbiology and Microbial Ecology held in Toronto, Ontario, Canada on September 18-20, 2017.

Conflicts of interest: None.

Funding: Universidad Cooperativa de Colombia.

FIGURE 1: Gutta-percha points.



Legend:
(a-c) Acrylic representation of root canal preparation.
a) Untreated root canal.
b) Cleaned and shaped root canal.
c) Obturated root canal with gutta-percha points.
d) Gutta-percha point No. 25.
e) Obturation of root canal with gutta-percha points No. 15 and No. 20.

Microbiological analyses of endodontic failure reveal that the microorganisms present in the secondary infection differ from those found in the initial infection [5]. The secondary infection reveals a predominance of facultative anaerobic and gram-positive bacteria [6, 7] given the entrance of microorganisms during or after the treatment [8]. Facultative anaerobic bacteria are versatile in adapting to conditions with or without oxygen, they are able to occupy a variety of environments, and many of the species in the group can lead to infection [9]. These factors make them interesting to analyze in terms of their presence on gutta-percha points.

Given the fact that gutta-percha points (Figure 1) are made with a component that prevents the proliferation of microorganisms (zinc oxide), that some are sold in sterile conditions, and that their quality can be affected by sterilization or disinfection, there is no firm requirement to subject them to high-level disinfection or sterilization [10, 11]. However, many studies have revealed that the points become contaminated during storage and manipulation even in recently opened packages [10, 12, 13].

The aim of this study was to determine the presence and quantity of facultative anaerobic bacteria on dentistry students' gutta-percha points and to determine whether there is a relationship between the presence of the bacteria and the students' use of the instruments.

METHODS

The study complied with ethical principles and voluntary and confidential participation through the completion of informed consent forms by the participating students. This study was approved by the ethics subcommittee of the Universidad Cooperativa de Colombia.

Points collection

A representative sample of students' gutta-percha points at the Universidad Cooperativa de Colombia's Faculty of Dentistry, Villavicencio with a confidence interval of 95% (n = 81), was collected. As well as the point samples, information was gathered on the type of storage, point diameter, point brand, package opening date, and expiry date. The points were taken directly from their packages under aseptic conditions.

Microbiological analysis

For this analysis, the points were placed inside Eppendorf tubes with sterile saline solution and were shaken by hand for a minute in order to release the bacteria present in the materials. Subsequently, 200 μl of the solution was plated in duplicate in blood agar and incubated for five days at 35° C in anaerobiosis jars with AnaeroGen Thermo Scientific sachets. After the incubation process, the presence of bacteria colonies in the points was determined and the colony-forming units (CFU) were quantified. The morphology of the colonies was described, and a gram stain along with observation of the cell morphology was carried out using culturing in aerobic conditions to confirm whether the colonies were of facultative anaerobic organisms. Finally, a catalase test was carried out and colonies to be identified were selected in a microbiology-certified laboratory using the VITEK system.

Statistical analysis

The SPSS program (version 22.0) was used to determine the median value and interquartile range of the total CFUs present in the points. The X^2 test was used to verify whether there were any significant differences in the contamination found in the points between the groups defined by the characteristics studied.

RESULTS

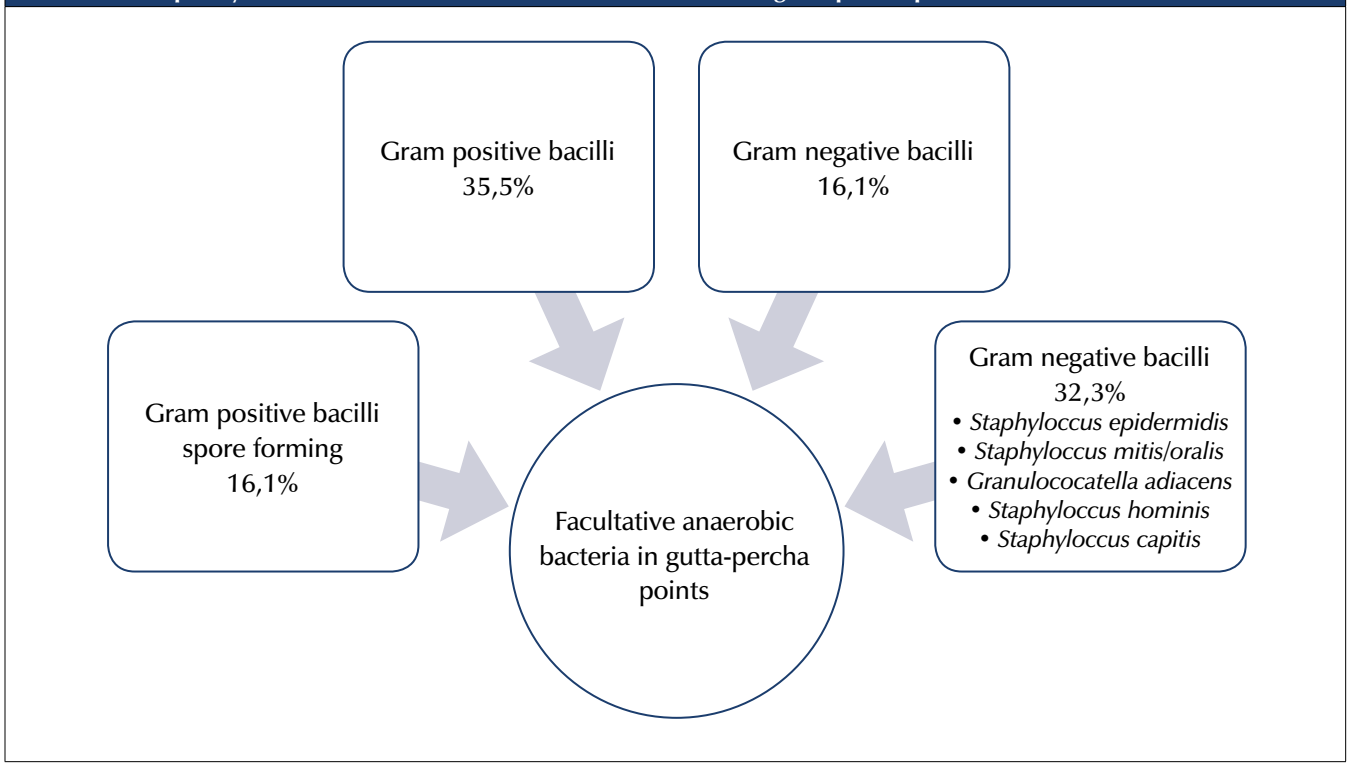
Microbiological analysis

The microbiological analysis revealed that 32.1% (n = 26) of the points were contaminated by facultative anaerobic bacteria, with a median value of 5 CFU/ml (interquartile range [IQR] 5-15). The CFU/ml range found in the contaminated points was 5 CFU/ml to 40 CFU/ml.

The study revealed different types of colony morphology and bacterial cells. It confirmed that all the isolates were of facultative anaerobic bacteria. Among the types of bacteria found in the contaminated points, gram-positive bacilli presented the highest percentage, with a median of 5 CFU/ml (IQR 5-5); followed by gram-positive coccus, with a median of 8.8 CFU/ml (IQR 5-16.9); gram-negative bacilli, with a median of 5 CFU/ml (IQR 5-7.5); and gram-positive spore-forming bacilli, with a median of 5 CFU/ml (IQR 5-22.5) (Figure 2).

Return to TABLE OF CONTENTS

FIGURE 2: Frequency of facultative anaerobic bacteria in contaminated gutta-percha points.



The influence of point characteristics on the presence of facultative anaerobic bacteria

This study found that most of the points were of the same brand (87.7%), that 36% of the points were stored in locations outside the clinic (students' houses or lockers), and that 21% of the points were past their expiry date. It was also detected that 24.6% of the points came from packages that had been opened over 12 months prior, and 1.2% were not packaged at the time of collection.

In the microbiological analysis, a greater frequency of contaminated points was observed in the groups defined by characteristics such as the type of storage (clinic), point brand (No. 3), package opening date (six to 12 months), expiry date (for over 12 months), and point diameter (No. 80). The only statistically significant difference found ($p < 0.05$) was related to the package opening date, although not in a linear relationship. With respect to the different types of microorganisms detected in the points, statistically significant differences were found ($p < 0.05$) insofar as spore-forming gram-positive bacilli were present within the groups defined by package opening date and expiry date.

DISCUSSION

The main causes of endodontic failure are attributed to microbial factors, the persistence of infectious microorganisms in the root canal, microfiltration, or to inadequate control in the aseptic chain [5, 6]. This study found that 32.1% of the dentistry students' gutta-percha points were contaminated by facultative anaerobic bacteria. Other studies have reported percentages of aerobic bacteria contamination in 5% to 40% of points from different sources (new and recently opened, stored, in use, etc.) [10, 13]. Few studies have examined the presence of facultative anaerobic bacteria only. Gomes et al. [12], for example, report contamination by this type of bacteria in 5.5% of the points.

The microflora present in endodontic failure is different from those present in the primary infection given that it is facultative anaerobic bacteria and gram-positive bacteria [6, 7] that predominate. Most of the species found belong to the Firmicutes phylum [7], which includes bacteria of the genera *Bacillus*, *Staphylococcus*, and *Streptococcus*, among others. In this study, the types of microorganisms were gram-positive bacilli, gram-positive coccus, and gram-negative bacilli. Bacteria of the genera *Staphylococcus*, such as *S. epidermidis*, *S. capitis*, and *S. hominis*, were identified. Other studies have also reported the presence of these microorganisms in the points [10, 12]. A clinically-important species frequently found in these materials is the *S. epidermidis*, which has been associated with dental abscesses [14], endocarditis [15], bacteremia [16], and other types of infection. These bacteria share certain features with *E. faecalis*, which is frequently associated with endodontic failure [17] given its ability to form biofilms [18] and for being resistant to several antimicrobials [19].

Other clinically interesting microorganisms identified are the *Streptococcus mitis*, involved in endodontic infections [8], endocarditis, septicemia, and bacteremia, among others [20]; and *Granulococatella adiacens*, associated with cases of endodontic infections [21], endocarditis [22], and bacteremia [23], among other infections.

Bacteria in the *Bacillus* genera were also identified. Some of these had spore-forming characteristics, making them resistant to physical (heat, cold, radiation, drying) and chemical (disinfectants) conditions and, as such, hard to eliminate from medical equipment. This highlights the importance of determining the most effective medium for their destruction [24]. Different *Bacillus* species have been progressively implicated in a broad range of infections, including abscesses, bacteremia, septicemia, wounds, endocarditis, and meningitis, among others. Many of these occur as secondary or mixed infections in immunosuppressed patients, but a significant proportion lead to primary infections in healthy individuals [24].

According to the scientific literature, some of the microorganisms identified in this study may lead to infection; for this to happen, however, they have to survive inhospitable conditions [1, 3], and possess the appropriate virulence factors and infective dose [4]. The microorganisms in the points analyzed were found in low doses, but susceptibility to infection in immunocompromised individuals is different [25].

With respect to the relationship between the presence and quantification of facultative anaerobic bacteria and the characteristics of the points used by the students, the only significant differences found were between the groups defined by package opening date, but there was no linear relationship. Other studies have not found significant differences between the properties studied and the contaminated points [12, 13].

CONCLUSIONS

In this study, facultative anaerobic bacteria were found in 32.1% of the points used by the dentistry students. Among the bacteria identified, some are of clinical importance, such as *Staphylococcus epidermidis* and *Streptococcus mitis*. No relationship was found between the presence of this type of bacteria and the point properties, indicating that contamination is random more than it is conditioned by opening and expiry date, brand, and diameter. As such, disinfection before use is essential.

Recommendations

We recommend the development of studies to establish appropriate disinfection protocols that do not alter the points' physical and chemical properties. The protocol must consider contamination by highly resistant bacteria structures such as spores and establish compulsory disinfection of the points before use in order to maintain the aseptic chain during treatment.

REFERENCES

1. Abbott, P. V., & Salgado, J. C. (2009). Strategies for the endodontic management of concurrent endodontic and periodontal diseases. *Australian Dental Journal, 54*(Suppl 1), S70-S85.
2. Farber, P. A., & Seltzer, S. (1988). Endodontic microbiology. I. Etiology. *Journal of Endodontics, 14*(7), 363-371.
3. Baumgartner, J. C., Bakland, L. K., & Sugita, E. I. (2002). Microbiology of endodontics and asepsis in endodontic practice. In J. I. Ingle, & C. Baumgartner (Eds.), *Ingle's endodontics* (63-88). London, UK: BC Decker.
4. Leggett, H. C., Cornwallis, C. K., & West, S. A. (2012). Mechanisms of pathogenesis, infective dose and virulence in human parasites. *PLoS Pathogens, 8*(2), 10-12.
5. Shailaja, S., & Suresh, B. S. (2014). Endodontic microflora – A review. *Journal of Oral Health and Community Dentistry, 8*(3), 160-165.
6. Siqueira, Jr., J. F. (2001). Aetiology of root canal treatment failure: Why well-treated teeth can bail. *International Endodontic Journal, 34*(1), 1-10.
7. Anderson, A. C., Hellwig, E., Vespermann, R., Wittmer, A., Schmid, M., Karygianni, L., & Al-Ahmad, A. (2012). Comprehensive analysis of secondary dental root canal infections: A combination of culture and culture-independent approaches reveals new insights. *PLoS One, 7*(11), e49576.
8. Pandey, V., Choudhary, I., Kumar, V., Tripathi, P., Misra, A., & Bagde, H. (2016). Assessment of correlation between clinical parameters and pulp canal pathogens in endodontic pathologies: A microbiological study. *Journal of Contemporary Dental Practice, 17*(8), 654-658.
9. Hentges, D. J. (1996). Anaerobes: General characteristics. In S. Baron (Ed.), *Medical microbiology* (4th ed.). Galveston, TX: University of Texas Medical Branch. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK7638/
10. Pang, N. S., Jung, I. Y., Bae, K. S., Baek, S. H., Lee, W. C., & Kum, K. Y. (2007). Effects of short-term chemical disinfection of gutta-percha cones: Identification of affected microbes and alterations in surface texture and physical properties. *Journal of Endodontics, 33*(5), 594-598.
11. Nabeshima, C. K., de Lima Machado, M. E., Borges Britto, M. L., & Pallotta, R. C. (2011). Effectiveness of different chemical agents for disinfection of gutta-percha cones. *Australian Endodontic Journal, 37*(3), 118-121.
12. Gomes, B. P., Vianna, M. E., Matsumoto, C. U., Rossi, V. de P., Zaia, A. A., Ferraz, C. C., & Souza, F. J. (2005). Disinfection of gutta-percha cones with chlorhexidine and sodium hypochlorite. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics, 100*(4), 512-517.
13. Kayaoglu, G., Gürel, M., Omürlü, H., Bek, Z. G., & Sadik, B. (2009). Examination of gutta-percha cones for microbial contamination during chemical use. *Journal of Applied Oral Science, 17*(3), 244-247.
14. Shweta, S. K. P., & Prakash, S. K. (2013). Dental abscess: A microbiological review. *Dental Research Journal, 10*(5), 585-591.
15. Otto, M. (2009). *Staphylococcus epidermidis* – the "accidental" pathogen. *Nature Reviews Microbiology, 7*(8), 555-567.
16. Blum, R. A., & Rodvold, K. A. (1987). Recognition and importance of *Staphylococcus epidermidis* infections. *Clinical Pharmacy, 6*(6), 464-475.
17. Rôças, I. N., & Siqueira, Jr., J. F. (2012). Characterization of microbiota of root canal-treated teeth with posttreatment disease. *Journal of Clinical Microbiology, 50*(5), 1721-1724.
18. O'Gara, J. P., & Humphreys, H. (2001). *Staphylococcus epidermidis* biofilms: Importance and implications. *Journal of Medical Microbiology, 50*(7), 582-587.
19. Otto, M. (2014). *Staphylococcus epidermidis* pathogenesis. *Methods in Molecular Biology, 1106*, 17-31.
20. Mitchell, J. (2011). *Streptococcus mitis*: Walking the line between commensalism and pathogenesis. *Molecular Oral Microbiology, 26*(2), 89-98.
21. Siqueira, Jr., J. F., & Rôças, I. N. (2006). *Catonella morbi* and *Granulicatella adiacens*: New species in endodontic infections. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics, 102*(2), 259-264.
22. Shailaja, T. S., Sathiavathy, K. A., & Unni, G. (2013). Infective endocarditis caused by *Granulicatella adiacens*. *Indian Heart Journal, 65*(4), 447-449.
23. Cargill, J. S., Scott, K. S., Gascoyne-Binzi, D., & Sandoe, J. A. T. (2012). *Granulicatella* infection: Diagnosis and management. *Journal of Medical Microbiology, 61*(6), 755-761.
24. Turnbull, P. C. B. (1996). *Bacillus*. In S. Baron (Ed.), *Medical microbiology* (4th ed.). Galveston, TX: University of Texas Medical Branch. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/21413260
25. Pan, J., Zhao, J., & Jiang, N. (2014). Oral cavity infection: An adverse effect after the treatment of oral cancer in aged individuals. *Journal of Applied Oral Science, 22*(4), 261-267.

CONCISE REPORT

Orthopaedic surgical site infections: A prospective cohort study

Anil K. Bhat, MS; Nachiketa Kamleshbhai Parikh, MS; Ashwath Acharya, MS

Corresponding author:
Nachiketa Kamleshbhai Parikh, MS
Kasturba Medical College
Manipal, India

ABSTRACT

Background: Orthopaedic surgical site infections (SSIs) are among the most common hospital-acquired infections, leading to serious health complications, hospital readmissions, and extended hospitalizations.

Objective: This study aimed to evaluate outcomes and assess the epidemiology of orthopaedic SSIs six months post-operation in patients with preoperatively intact sites of surgery.

Methods: The prospective cohort study was conducted in a tertiary hospital over two years. All patients with previously intact surgical sites were included (n = 9,318). The U.S. Centers for Disease Control and Prevention criteria for SSI diagnosis were used. Six-month post-surgery patients were assessed by orthopaedic medical residents. In questionable cases, wound inspections were validated by the investigating team.

Results: The incidence of SSIs was 0.91%. Diabetes, smoking, alcoholism, and prolonged retention of a drainage tube, along with implant-related surgeries, oncologic surgeries, and surgeries on areas with deep-seated infection had significantly higher rates of SSIs ($p < 0.05$). *S. aureus* was the most commonly detected bacteria, followed by gram-negative bacilli. At the six-month follow-up, 13 of 85 SSI patients had persistent infection and 39 were lost to follow-up.

Conclusion: Our study detected a 0.91% incidence of SSIs and statistically significant risk factors with significant morbidity at six months post-surgery.

KEYWORDS

Surgical site infections; orthopaedic infections; India; antibiotic resistance

INTRODUCTION

Surgical site infections (SSIs) are a serious complication in orthopaedic surgery. The problems faced by patients include but are not limited to prolonged hospital stay, multiple hospital visits, delay in functional recovery, increased mental stress, and a poor quality of life overall. A literature review indicates that a significant variability in the incidence of orthopaedic SSIs was noted between different studies, with reported rates as low as 1.9% in a study by Mabit et al. (2012) [1] to 22.7% in a study by Maksimović et al. (2008) [2]. The literature on orthopaedic SSIs in developing countries is neither extensive nor uniform. In our tertiary care hospital, we prospectively followed a cohort of orthopaedic patients for six months post-surgery, assessing incidence, risk status, risk factors, and outcomes.

METHODS

This prospective, single-centre cohort study was carried out in a tertiary care hospital in south-western India between September 2015 and September 2017. Orthopaedic surgery patients with preoperatively intact surgery sites were included in the study. Patients having open wounds at the site of surgery or having an American Society of Anesthesiologists (ASA) [3] score of five were excluded. The study was approved by the hospital's Institutional Ethics Committee and informed written consent was obtained from all study participants.

Of the 11,253 surgeries performed in the given time frame, 9,318 cases met the inclusion criteria. Their case files were reviewed and their preoperative details, demographic data, pre-morbidities, pre-anaesthetic workup chart, and diagnosis were recorded. For surgery details, the procedure notes and the anaesthetist charts were reviewed. Based on this data, the U.S. Centers for Disease Control and Prevention's (CDC) National Health and Safety Network's SSI risk index [4] was calculated for all patients. The 75th percentile cut-off value of time was established as 180 minutes for spine and arthroplasty, 90 minutes for amputation, and 120 minutes for fracture surgeries

Acknowledgements: None

Conflicts of interest: None.

Funding: None.

[4]. The wound class was based on the wound contamination classification as described by Altemeier et al. (1984) [5]. The site of surgery grade was as per the ASA.

Post-operatively, all patients were monitored for development of SSIs as per CDC criteria [6] at every wound inspection and the follow-up was performed by the operating surgeon. In the wards, the wounds would be regularly monitored by orthopaedic medical residents. If an SSI was suspected, the principal investigators were informed and a wound swab was collected for gram staining and culture, followed by antibiotic sensitivity. The details of the wound were recorded in the case file.

Culture and sensitivity reports were monitored and antibiotic therapy was initiated or modified based on the microbiology reports. SSI patients were again followed up at six months and were asked to attend an in-person assessment. If they were unable to attend, patients were evaluated remotely based on:

1. An evaluation report of their wounds by their local primary healthcare physician.
2. An over-the-phone questionnaire inquiring about fever, swelling, erythema, warmth, extent of wound involvement, edges of the wound, discolouration, foul smell, discharge from the wound, and induration.
3. Photographs of the wounds obtained over the phone.
4. Documentation of the patient's return to their preoperative functional status.

To compare risk factors, a control subset group of 87 non-infected surgical patients was randomly selected. The two groups were compared for pre-existing diabetes mellitus, history of alcoholism, body mass index (BMI), presence and duration of retention of a drainage tube, as well as the wound class.

To understand the strength of association between two categorical variables, a chi-squared test was carried out. For the scale parameters such as mean value, comparison was carried out using independent t-test analysis. A *p*-value of less than 0.05 was considered to be significant with a 95% confidence interval. To understand the variation in SSIs due to risk factors, a regression analysis was carried out.

RESULTS

At the end of the study period, a total of 11,253 surgeries were performed, of which 9,318 cases met the inclusion criteria and hence were followed up for development of SSIs. We detected 85 cases of SSIs, an incidence of 0.91%. The SSI incidence rate was 0.94% (n = 63) in males and 0.84% (n = 22) in females.

The highest number of surgeries was in the 31 to 45 age bracket, whereas the highest incidence of SSIs was in the 46 to 60 age bracket. In our study, deep incisional SSIs were the most common (56.5%), followed by organ/space infections (28.2%) and superficial incisional infections (15.3%). Of the 85 infected cases, 16 were upper limb surgeries (18.8%), 55 were lower limb surgeries (64.7%), and 14 were spinal surgeries (16.5%). The random sampling of the non-infected cases (n = 87), however, revealed 22 surgeries on upper limbs (25.3%), 50 surgeries on lower limbs (57.5%), and 15 spinal surgeries (17.2%).

The incidence of pre-existing diabetes mellitus type 2 was 24.7% in the 85 SSI cases, whereas in the non-infected cases (n = 87), the incidence was 12.6% ($p = 0.04$). A history of alcoholism ($p < 0.001$) and smoking ($p < 0.001$) pre-disposed patients to SSIs. However, our study did not find a significant correlation between the nature of the surgery (emergency vs. elective) or the BMI of the patient. Open reduction and internal fixation of a fracture was significantly associated with a higher risk of developing an SSI ($p < 0.001$) compared to closed reduction, internal fixation, and soft tissue surgeries. The mere presence of a post-operative drainage tube was not a statistically significant factor for increasing the risk of SSI occurrence. However, the duration of post-operative drainage tube retention was found to be significantly more important ($p = 0.008$). The presence of a pre-existing focus of infection at the surgical site was significantly associated with an increased risk of an SSI ($p < 0.05$).

The most common organism detected was *S. aureus* (24%) and 55% of the isolates were methicillin-resistant *S. aureus* (MRSA). The next most common organisms were gram-negative bacilli (*P. aeruginosa* and *E. coli* were the most common). Antibiotic sensitivity and resistance patterns were studied for all the detected bacteria. All MRSA were found to be sensitive to linezolid, vancomycin, and teicoplanin, whereas clindamycin sensitivity was noted in only half of the isolates. The gram-negative bacteria were noted to have two sensitivity patterns and almost half of the isolates were multidrug-resistant.

Mean duration of hospitalization was 30 days and 13 days in patients with and without SSIs, respectively ($p < 0.001$). Of the 85 SSI cases, 12 patients did not return for assessment and hence the wound status could not be assessed by us. Of these, four patients' medical records documented control of infection at the last follow-up, which meant that the patient would not need further interventions. In the remaining 73 patients (out of 85), it was found that 13 patients had a persisting infection.

DISCUSSION

Our study revealed an incidence rate of 0.9% for SSIs in preoperatively closed cases – a rate only slightly higher than those reported in studies carried out in developed parts of the world [1]. Our study's relatively lower incidence rate when compared to that of other studies conducted in developing countries can be attributed to the exclusion of open wounds and seemingly low detection of superficial SSIs.

The results of our study show a significantly increasing trend in the rate of SSI occurrence as the patient's age increases. Published literature stands divided with respect to advancing age and the risk of SSIs. Several authors have reported statistically significant association between an increase in age and higher SSI risk [7-9]. At the same time, some studies could not prove a significant association [10, 11]. The general trend, including our study, shows an increase in the rate of SSIs with patients aged up to and around 60 years old, following which there is a small decline in the incidence rate. There may be three possible reasons for these results:

Return to TABLE OF CONTENTS

1. The hardy survivor effect [9], wherein it is hypothesized that the elderly population has already survived long and may have a physiological advantage over the younger population, which leads to a lower SSI risk.
2. Selection bias.
3. Patients' increased amount of vehicular travel and work-load up to their retirement age are followed by accidental falls at home and other such low-energy mechanisms of injury, which take over as the leading cause of trauma requiring fixation.

The patients undergoing orthopaedic oncology surgeries showed the highest proportion of SSIs (4.7%) in our study. It has been reported by Gradl et al. (2014) [12] that increasing age, total number of preceding procedures, pre-existing implants, infection at another site on the date of surgery, malignant disease, a hip region that is affected, and duration of the procedure were significantly associated with increased SSI risk. Orthopaedic oncology patients in our study who developed an SSI were noted to have prolonged procedure duration, malignant disease, and a hip region that was more often involved, with the use of mega-prosthesis in many instances.

There is a general consensus that implant-related surgeries are majorly affected by SSIs and soft tissue surgeries do not get infected as easily as the implant-associated ones. The presence of a post-operative drainage tube has also been touted as a risk factor for development of an SSI because the tube serves as a foreign body [13]. Our results could not confirm this association significantly. However, the presence of a drainage tube for more than 3.5 days post-operatively as well as whether any implant was used for the surgery were significant risk factors.

The depth and, correspondingly, the severity of SSIs in orthopaedic settings in the U.S. [14], Brazil [15], and Poland [16] show a pattern of deep > superficial > organ SSIs, whereas China [17] and England [18] show a pattern of superficial > deep > organ level SSIs. Our study showed a pattern of deep>organ>superficial incisional SSIs.

Our study had limitations. Specifically, this was a single-centre study with a small sample of SSI cases studied and a portion of the sample was lost to follow-up.

REFERENCES

1. Mabit, C., Marcheix, P. S., Mounier, M., Dijoux, P., Pestourie, N., Bonnevialle, P., & Bonnomet, F. (2012). Impact of a surgical site infection (SSI) surveillance program in orthopedics and traumatology. *Orthopaedics & Traumatology: Surgery & Research, 98*(6), 690-695. Retrieved from https://www.sciencedirect.com/science/article/pii/S1877056812001594
2. Maksimović, J., Marković-Denić, L., Bumbasirević, M., Marinković, J., & Vlajinac, H. (2008). Surgical site infections in orthopedic patients: Prospective cohort study. *Croatian Medical Journal, 49*(1), 58-65. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/18293458
3. American Society of Anesthesiologists (ASA). (2014). *ASA physical status classification system*. Retrieved from https://www.asahq.org/standards-and-guidelines/asa-physical-status-classification-system
4. Culver, D. H., Horan, T. C., Gaynes, R. P., Martone, W. J., Jarvis, W. R., Emori, T. G., Banerjee, S. N., Edwards, J. R., Tolson, J. S., Henderson, T. S., et al. (1991). Surgical wound infection rates by wound class, operative procedure, and patient risk index. National Nosocomial Infections Surveillance System. *American Journal of Medicine, 91*(3B), 152S-157S. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/1656747
5. Altemeier, W. A., Burke, J. F., Pruitt, Jr., B. A., & Sandusky, W. R. (1984). *Manual on control of infection in surgical patients* (2nd ed.). Philadelphia, PA: J. B. Lippincott.
6. U.S. Centers for Disease Control and Prevention (CDC). (2018, January). *Surgical site infection (SSI) event*. Retrieved from http://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.pdf
7. Geubbels, E. L., Nagelkerke, N. J., Mintjes-De Groot, A. J., Vandenbroucke-grauls, C. M., Grobbee, D. E., & De Boer, A. S. (2006). Reduced risk of surgical site infections through surveillance in a network. *International Journal for Quality in Health Care, 18*(2), 127-133. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/16484315
8. Scott, J. D., Forrest, A., Feuerstein, S., Fitzpatrick, P., & Schentag, J. J. (2001). Factors associated with postoperative infection. *Infection Control & Hospital Epidemiology, 22*(6), 347-351. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/11519911
9. Lee, J., Singletary, R., Schmader, K., Anderson, D. J., Bolognesi, M., & Kaye, K. S. (2006). Surgical site infection in the elderly following orthopaedic surgery: Risk factors and outcomes. *Journal of Bone & Joint Surgery, 88*(8), 1705-1712. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/16882891
10. Namba, R. S., Inacio, M. C. S., & Paxton, E. W. (2013). Risk factors associated with deep surgical site infections after primary total knee arthroplasty: An analysis of 56,216 knees. *Journal of Bone & Joint Surgery, 95*(9), 775-782. doi: 10.2106/JBJS.L.00211
11. Malone, D. L., Genuit, T., Tracy, J. K., Gannon, C., & Napolitano, L. M. (2002). Surgical site infections: Reanalysis of risk factors. *Journal of Surgical Research, 103*(1), 89-95. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/11855922
12. Gradl, G., De Witte, P. B., Evans, B. T., Hornicek, F., Raskin, K., & Ring, D. (2014). Surgical site infections in orthopaedic oncology. *Journal of Bone & Joint Surgery, 96*(3), 223-230. doi: 10.2106/JBJS.L.01514
13. Zimmerli, W., & Moser, C. (2012). Pathogenesis and treatment concepts of orthopaedic biofilm infections. *FEMS Immunology and Medical Microbiology, 65*(2), 158-168. doi: 10.1111/j.1574-695X.2012.00938.x
14. Olsen, M. A., Nepple, J. J., Riew, K. D., Lenke, L. G., Bridwell, K. H., Mayfield, J., & Fraser, V. J. (2008). Risk factors for surgical site infections following orthopaedic spinal operations. *Journal of Bone & Joint Surgery, 90*(1), 62-69. doi: 10.2106/JBJS.F.01515
15. Ercole, F. F., Franco, L. M. C., Macieira, T. G. R., Wenceslau, L. C. C., de Resende, H. I. N., & Chianca, T. C. M. (2011). Risk of surgical site infection in patients undergoing orthopedic surgery. *Revista Latino-Americana de Enfermagem, 19*(6), 1362-1368. Retrieved from http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0104-11692011000600012&lng=en. http://dx.doi.org/10.1590/S0104-11692011000600012
16. Walaszek, M., Zieńczuk, W., Wolak, Z., & Dobroń W. (2013). Surgical site infections in patients of orthopedic-trauma unit in district hospital in 2008-2012. *Przeglad Epidemiologiczny, 67*(3), 439-444, 543-546. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/24340557
17. Li, G. Q., Guo, F. F., Ou, Y., Dong, G. W., & Zhou, W. (2013). Epidemiology and outcomes of surgical site infections following orthopedic surgery. *American Journal of Infection Control, 41*(12), 1268-1271. doi: 10.1016/j.ajic.2013.03.305
18. Coello, R., Charlett, A., Wilson, J., Ward, V., Pearson, A., & Borriello, P. (2005). Adverse impact of surgical site infections in English hospitals. *Journal of Hospital Infection, 60*(2), 93-103. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/15866006

PCS QCT 3-9 VALIDATED CLEANING PROCESS

Reduces hospital pathogenic organic soil more effectively than most currently used hospital cleaning and disinfecting processes.

SAFE

- Neutral pH low concentration product safer for equipment and staff.
- Endorsed and certified by the Envirodesic™ Certification Program for Maximum Indoor Air Quality™ and minimum environmental health impact.

EFFECTIVE

- Cleaning to a scientifically validated standard.
- PCS validates its recommended environmental surface decontamination processes with CREM Co Labs newly developed third tier of the Quantitative Carrier Test Method (QCT-3) to assess decontamination of high-touch environmental surfaces (HITES) with the incorporation of field-relevant wiping.
- Maximize physical removal by wiping and use the minimum amount of chemical.

ENVIRONMENTALLY RESPONSIBLE

- PCS Neutral pH solutions form equilibrium of 50% hypochlorous acid and sodium hypochlorite which are effective at very low concentrations.
- When combined with our validated wiping process health care facilities can reduce staff and environmental exposure of cleaning and disinfecting chemicals in many cases by 95%. This also reduces health care, institutions and most public facilities discharge of toxic chemicals into the environment through the release of waste water.
- Removal of hospital pathogens does not require high concentrations of chemicals with high alkali or acid pH values.
- Easy to use process that saves time.

MATERIALS REQUIRED

- PCS microfibre cloths laundered with PCS Oxidizing Laundry Detergent.
- PCS 7548 pump sprayer filled with PCS 7000 diluted Neutral pH Oxidizing Cleaning and Sanitizing Solution.

PCS QCT- 3- 9 VALIDATED CLEANING PROCESS

- Lightly spray surfaces to be cleaned, apply from cleanest to dirtiest.
- Take clean dry folded PCS microfibre cloth and wipe surfaces dry moving from cleanest surfaces to dirtiest.
- Suitable for use as instructed on hard non porous surfaces not damaged by water including windows mirrors and commonly touched surfaces. When cleaning around patients or electronic equipment dampen PCS microfibre cloth by spraying solution on cloth before wiping surface.
- Once PCS microfibre cloth becomes saturated replace with dry cloth.

Vegetative Bacteria (S. aureus and S. marcescens)
Average CFU per square centimetre

	CFU/cm2			Percent		Average Percent	
Product	Control	After Wiping	Transfer	Reduction	Transfer	Reduction	Transfer
Spray+Wipe Test 1	27,000	0	0	100	0	100	0
Spray+Wipe Test 2	35,000	0	0	100	0		

C. difficile spores
Average CFU per square centimetre

	CFU/cm2			Percent		Average Percent	
Product	Control	After Wiping	Transfer	Reduction	Transfer	Reduction	Transfer
Spray+Wipe Test 1	27,000	3.57	0	99.99	0	99.95	0
Spray+Wipe Test 2	9,240	8.15	0	99.91	0		

Request a copy of QCT-3-9 CREM Co study

Cleaning with pre-moistened disinfecting wipes or cloths transfer bacteria, viruses and C. difficile spores to clean surfaces.

Pre-moistened disinfectant wipes or microfibre cloths are the most common method of cleaning the health care environment. Cleaning the areas around patients, noncritical patient care equipment and washrooms with pre-moistened wipes or microfibre cloths remove soil bacteria, viruses and C. difficile spores.

What is not common knowledge is in the process of wiping surfaces with pre-moistened wipe or cloth in addition to removing pathogens the process inherently transfers bacteria, viruses and C. difficile spores to surfaces being cleaned.

Many published papers have reported the transfer of Norovirus from wiping surfaces with pre-moistened cloths.

PCS testing using CREM.Co Quantitative Carrier Test Method number three QCT-3 also demonstrated transferring viruses to clean surfaces by wiping with pre-moistened wipes or cloths.

PCS CREM Co Quantitative Carrier Test QCT-3 Murine Norovirus

Product Used	Transfer PFU/cm2
Saline T Detergent MF transfer of Murine Norovirus to clean surface	7.67
Saline T Detergent MF transfer of Murine Norovirus to clean surface	8.49
PCS NPH 250 MF transfer of Murine Norovirus to clean surface	9.34
PCS NPH 250 MF transfer of Murine Norovirus to clean surface	7.64
Hydrogen Peroxide 0.5% Wipe transfer of Murine Norovirus to clean surface	8.49

PCS testing using CREM.Co Quantitative Carrier Test Method number three QCT-3 in seven separate studies report the transfer of C. difficile spores to clean surfaces when wiped with pre-moistened disinfectant wipes or wiped with a pre-dampened microfibre cloth. All test where conducted with surfaces being wiped with two separate pre-moistened wipes or cloths.

PCS CREM Co Quantitative Carrier Test QCT-3 C. difficile

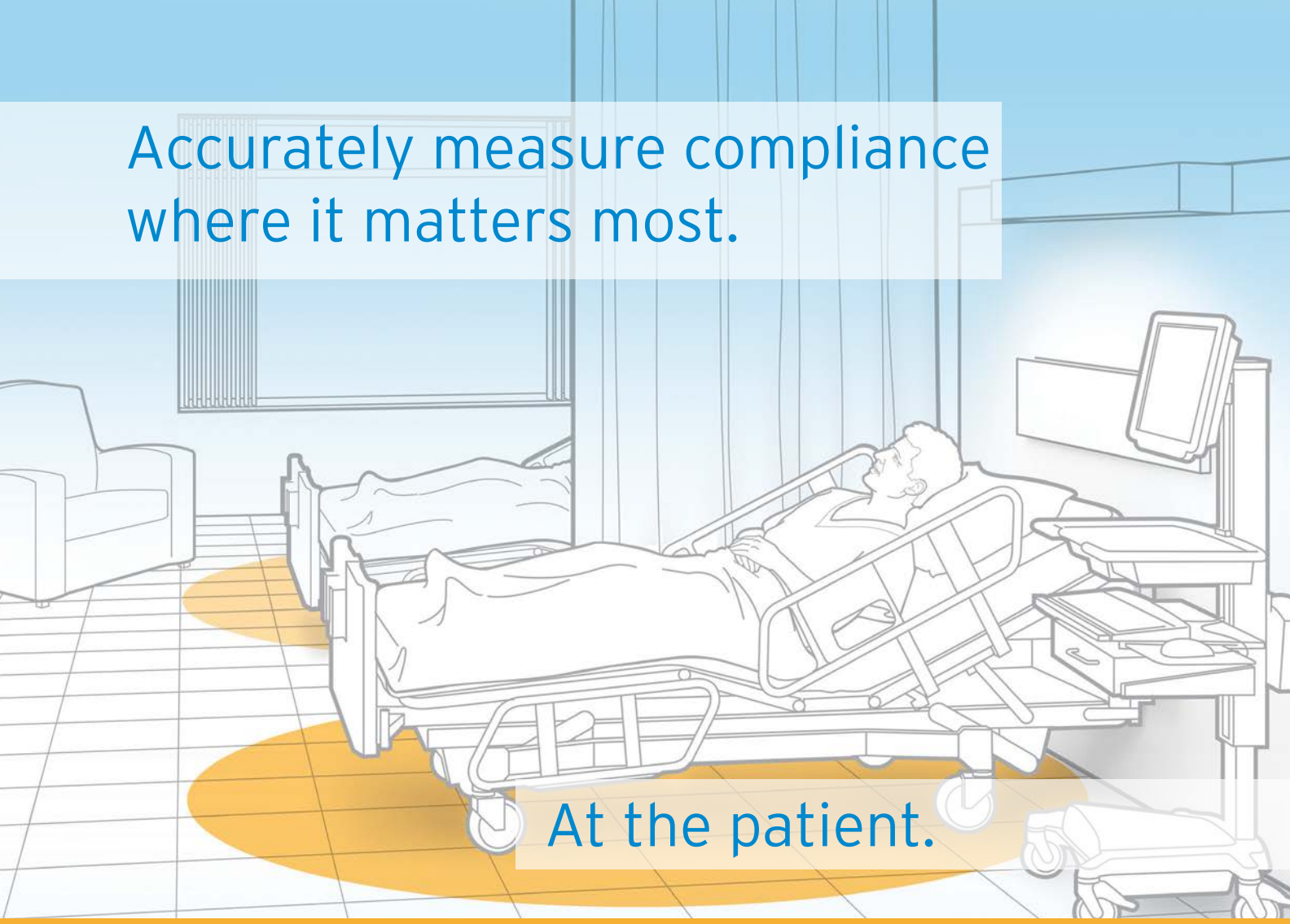
Product Used	Transfer CFU/cm2
Saline T Detergent transfer of C. difficile to clean surfaces MF	296
PCS 7000 transfer of C. difficile to clean surfaces MF	0.31
Hydrogen Peroxide 1.4% Wipe transfer of C. difficile to clean surface	15.3
Quaternary Alcohol Wipe transfer of C. difficile to clean surface	161
PCS MicroClean transfer of C. difficile to clean surface MF	116
PCS MicroClean followed by NPH 250 transfer of C. difficile to clean surface MF	14.7
PCS NPH 250 transfer of C. difficile to clean surface MF	2.33

PCS QCT-3-9 Cleaning Process

PCS 7000 diluted Neutral pH Oxidizing Cleaning and Sanitizing Solution

Spray and Wipe Dry with PCS microfibre cloth	Transfer CFU/cm2
Transfer of C. difficile to clean surface	0

Accurately measure compliance where it matters most.



The Ecolab® Hand Hygiene Compliance Monitoring System ensures that healthcare workers are washing or sanitizing before and after every patient interaction. **And we help ensure that protection for each and every patient.**

Learn more at www.ecolab.com/compliancemonitoring

ECOLAB®

Immuno-compromised patients require the best air quality.

PLASMAIR™ prevents airborne contaminant exposure in high risk areas.

PLASMAIR™
Guardian
Mobile Air Decontamination Unit

IMMUNAIR™
Protected Environment connected to PLASMAIR™

Fast and Efficient air decontamination

PLASMAIR™ mobile air decontamination units significantly reduce the incidence of Invasive Aspergillosis in hematology[1] and increase the level of safety for immunocompromised patients.

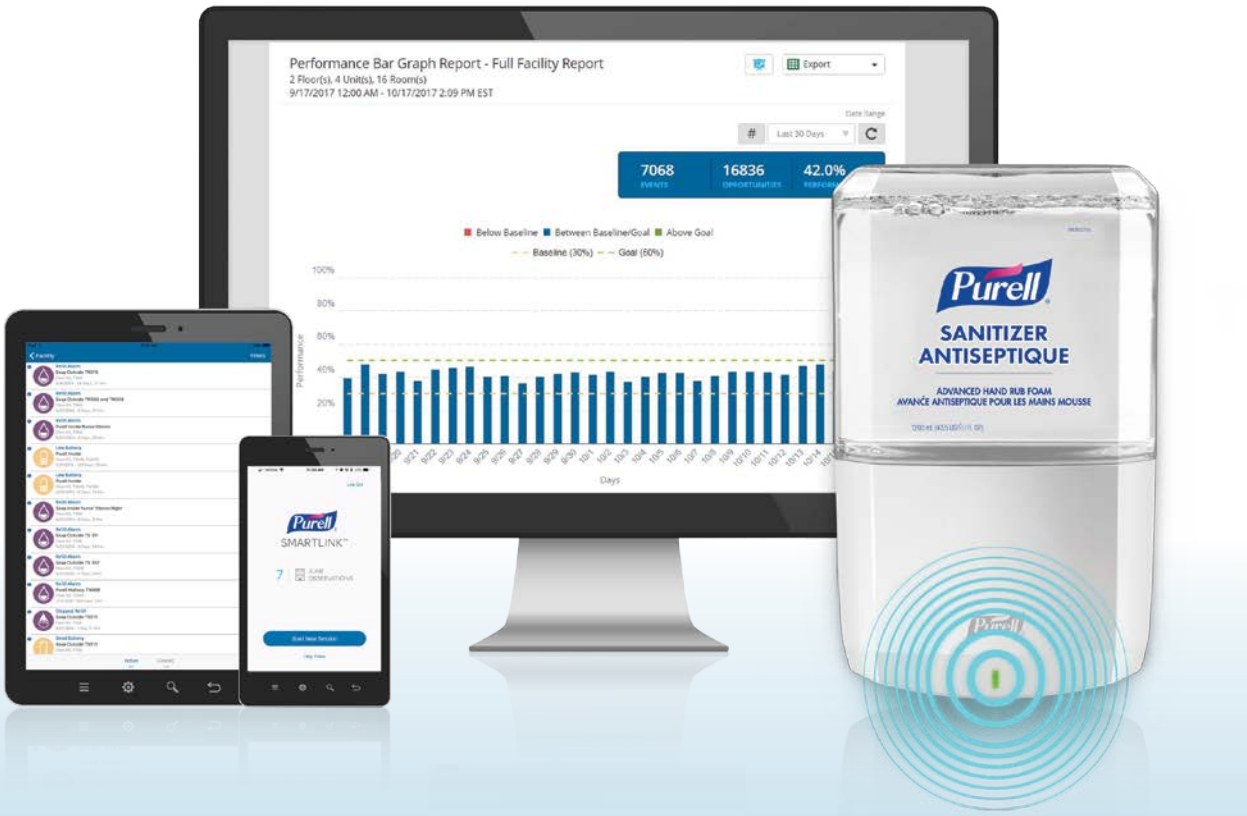
HEPA-MD™ technology uniquely combines HEPA filtration and plasma microbial destruction (MD) to quietly filter large volumes of room air from ISO9 to ISO7/6 in a few minutes or ISO 5 M1 when used with IMMUNAIR® protective environment.

PLASMAIR™ is the best solution to support or replace, deficient or inappropriate air treatment systems in hospitals' high risk areas, such as bone marrow transplant, hematology, oncology, ICU, burn units, and operating rooms.

Learn more at www.scicanmedical.ca/plasmair

SciCan | Your Infection Control Specialist™

[1] The PLASMAIR™ Decontamination System Is Protective Against Invasive Aspergillosis in Neutropenic Patients Fernandez-Gerlinger MP, et al. Infect Control & Hosp Epidemiol 2016, Vol 37, N°7. 845-851.



PURELL SMARTLINK™ Hand Hygiene Solutions

The PURELL SOLUTION™ is a complete set of products, technologies and support designed to work together to help improve patient safety. It includes advanced monitoring technologies, expert Clinical Specialists, and an already robust portfolio of efficacious products to more holistically fight against the spread of germs. Help your facility improve patient outcomes with PURELL SMARTLINK™ Monitoring Technologies and PURELL™ Clinician-Based Support.

If you're ready to discuss your hand hygiene compliance goals, contact us at Healthcare@GOJO.com or visit our website at GOJOCanada.ca/SMARTLINK to learn more.

Purell®

SMARTLINK™

Diversey*

Doesn't every patient deserve a dose of added assurance?

Accel®

The first choice for effective disinfection with a choice of dwell times

Accel® INTERvention™
1 min. dwell time

Accel® PREvention™
3-5 min. dwell time

Accel® TB
5 min. dwell time

Accel® Wipes deliver one-step cleaning and disinfection with a choice of dwell times. These pre-wetted disinfectant cleaner wipes are based on proprietary AHP® - Accelerated Hydrogen Peroxide technology to deliver fast, effective, responsible cleaning performance. After use the key ingredient breaks down into oxygen and water. These wipes are effective against key pathogens – including MRSA, VRE, TB, and Norovirus. Compatible with most hard, non-porous surfaces.

MoonBeam™3

Added assurance with fast, effective UV-C disinfection

MoonBeam™3 destroys pathogens that cause HAIs in as little as 3 minutes. MoonBeam3 adds assurance to manual cleaning and disinfection, reducing the risk for patients and staff. Individually adjustable light arms deliver a powerful UV-C light dose straight and close to disinfect high-touch surfaces. MoonBeam3 is portable and affordable, facilitating use in more places. Its fast, targeted dosing reduces labor and operation costs.

SOLUTIONS DESIGNED FOR HEALTHCARE™

Because every patient deserves a safe environment.

Learn more at sdfhc.com

This journal would not be possible without the advertising support of the following companies and organizations. Please think of them when you require a product or service. You can also access the electronic version at *www.ipac-canada.org*.

Company	Page	Phone	Web Site
AMG Medical, Inc.	IBC	800-363-2381	www.amgmedical.com
Class 1, Inc.	236	800-242 9723	www.class1inc.com
Clorox Healthcare	190-191	866-789-4973	www.cloroxhealthcare.ca
Diversey	187, 235		www.diversey.com
ECOLAB USA, Inc.	232	800-352-5326	www.ecolab.com/healthcare
Glo Germ Company	195	435-259-5931	www.glogerm.com
GOJO Canada, Inc.	234	800-321-9647	www.gojocanada.ca
Hygie Canada	185	866-588-2221	www.hygie.com
Medco Equipment	188	800-717-3626	www.medcoequipment.com
Nanosonics	192	844-876-7466	www.trophon.com/ca
Process Cleaning Solutions	230-231	877-745-7277	www.processcleaningsolutions.com
Retractable Technologies, Inc.	186	888-703-1010	www.retractable.com
SciCan Ltd.	233	800-667-7733	www.scicanmedical.ca
SC Johnson Professional CA, Inc.	OBC	519-443-8697	www.debmed.ca
Vernacare Canada, Inc.	189	800-268-2422	www.vernacare.com
Virox Technologies, Inc.	IFC	800-387-7578	www.virox.com
Wood Wyant	197	877-726-4627	www.woodwyant.com

MED EXPRESS

CANADIAN EDITION

HAVE YOU SEEN THESE MACHINES?

Not sure if your machine is a HAIGH? Our team can help you indentifying it! Call your A.M.G. Medical representative today!

IMPORTANT ANNOUNCEMENT

NOW THE ONLY ONE IN CANADA!

MedPro Defense is now the only source for all HAIGH macerator parts, service and support in Canada including the 400 Series, Multi and Solo. For more information about what we can do for you, contact us.

SOLO2®
coming soon

Introducing the New
QUATTRO® Vanguard

Call 1-800-393-2381
or visit www.medprodefense.com

See our insert included with this magazine

HAIGH by MedPro DEFENSE®

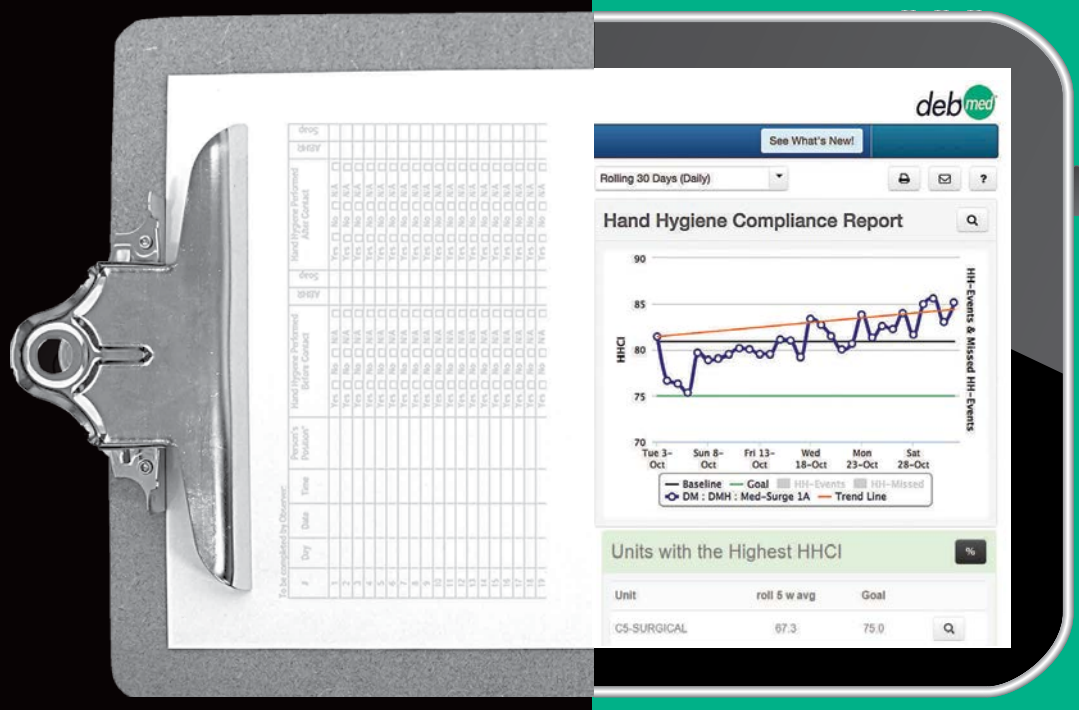
AMG MEDICAL

Montréal, QC H4T 1V5 • **1-800-363-2381**
West Chazy, NY 12992 • **1-888-412-4992**
www.amgmedical.com

A.M.G. Medical Inc. – Exclusive Canadian distributor of Haigh products

SC Johnson PROFESSIONAL
A family company™

Yesterday Today

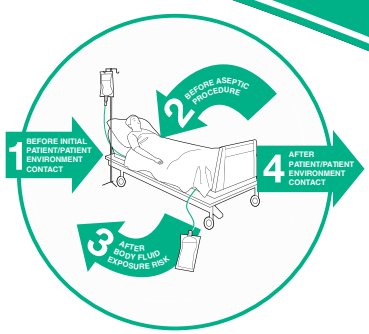


Manual monitoring of hand hygiene is so outdated.

It's time to upgrade to the clinically proven system more and more hospitals rely on.

The DebMed® Electronic Hand Hygiene Monitoring System:

- Only system proven in a peer-reviewed study to significantly reduce MRSA and C. diff HAIs[1,2].
- Easy to install with no badges or complicated equipment.
- Able to capture 100% of hand hygiene events, based on the 4 Moments for Hand Hygiene[3].
- Sustained performance improvement in as few a 90 days.



Request a demo today @ www.debmed.ca

[1], Kelly J, Blackhurst D, McAtee W, Steed C. Electronic hand hygiene monitoring as a tool for reducing healthcare-associated methicillin-resistant Staphylococcus aureus infection. Am J Infect Control 2016;44:956-7. [2]. Robinson N, Boeker S, Steed C, Kelly W. Innovative use of electronic hand hygiene monitoring to control a clostridium difficile cluster on a hematopoietic stem cell tranplant unit. Poster presentation: Association of Professionals in Infection Control (APIC) Annual Conference; June 2014; Anaheim, CA. [3]. 4 Moments for Hand Hygiene, adapted by Public Health Ontario from the World Health Organization WHO Guidelines for Hand Hygiene in Health Care Geneva World Health Organization 2009. DebMed® is the healthcare division of Deb Group. In 2015, Deb Group was acquired by SC Johnson, a privately held, family company and one of the world's leading manufacturers of household cleaning products and products for home storage, air care, pest control and shoe care. GD1641/0918