VOLUME 32
NUMBER 1

SPRING 2017

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

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

HARNESS THE POWER OF PREVENTION

When it's your job to keep patients, visitors, and hospital staff safe, every product you use has to deliver.

With the help of Clorox Healthcare®, you can safeguard the patient environment with tools that are big on power and tough on pathogens.

CLOROX
HEALTHCARE®

protection through prevention

SAME POWER. NEW FORMAT.

NEW Clorox Healthcare® Hydrogen Peroxide Cleaner Disinfectant

Now in a pull-top bottle

- Kills 38 pathogens in 60 seconds or less
- Ready-to-use, one-step disinfectant
- Use on hard and soft surfaces

Get your free sample at CloroxHealthcare.ca

CHOOSE POWER. CHOOSE CLOROX®.

Tackle HAIs with the proven power of Clorox Healthcare®.

We've got a solution for just about every surface.

Clorox Healthcare®
Professional Disinfecting Bleach Wipes & Cleaner

Kill *C. difficile* in as fast as 3 minutes and another 46 pathogens in 60 seconds or less*

Clorox Healthcare®
Hydrogen Peroxide Cleaner Disinfecting Wipes & Cleaner

Kill 38 bacteria and viruses in 60 seconds or less

Learn more at CloroxHealthcare.ca

* Wipes registered to kill *C. difficile* in 3 minutes. Pull-top bottle registered to kill *C. difficile* in 5 minutes.

CLOROX HEALTHCARE®

protection through prevention

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

WEB COMMUNICATION MANAGER
Tanya Denich, MSc, CIC webcommunications@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 - Cheryl Parisien
DESIGN/PRODUCTION - Daniel Goulet
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

SPRING 2017

VOLUME 32
NUMBER 1

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

FEATURES

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 3000.

ISSN - 1183 - 5702

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

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.

www.ipac-canada.org

VANISHpoint®

NEEDLESTICK PREVENTION THAT MEETS YOUR NEEDS

ACTIVATED VANISHPOINT SYRINGES REQUIRE LESS DISPOSAL SPACE THAN OTHER SAFETY SYRINGES & PREVENT DISPOSAL-RELATED INJURIES

automated needle retraction prevents exposure to the contaminated sharp

OTHER AVAILABLE SAFETY PRODUCTS

VanishPoint®
Blood Collection Set

VanishPoint®
Blood Collection
Tube Holder

VanishPoint®
IV Catheter

Patient Safe®
Syringe

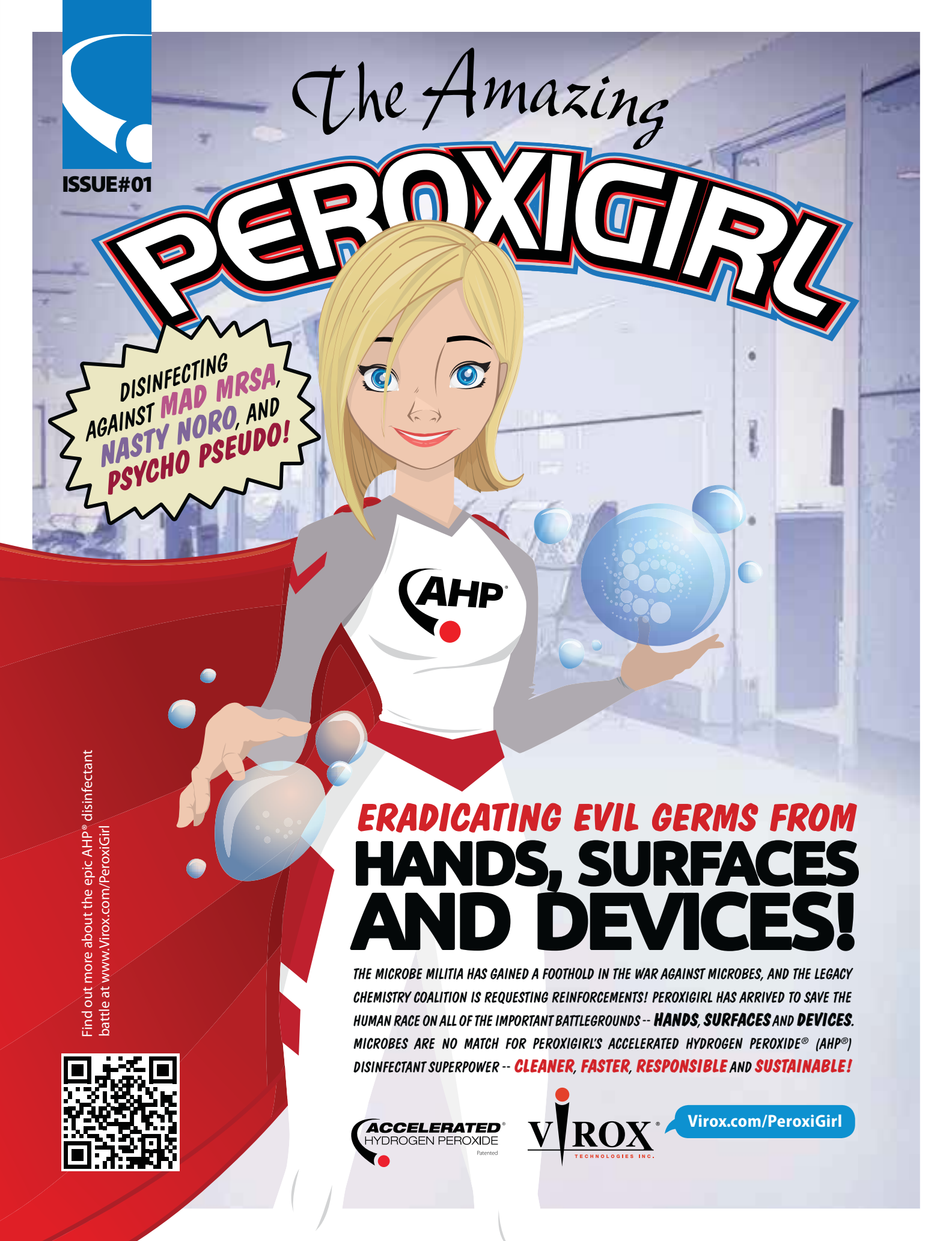
RETRACTABLE TECHNOLOGIES, INC.
www.retractable.com

P: 972.294.1770 • F: 972.294.4400
Toll Free: 1.888.703.1010
rtiservice@vanishpoint.com
511 Lobo Lane • Little Elm, Texas 75068 • USA

ISSUE#01

The Amazing PEROXIGIRL

DISINFECTING AGAINST MAD MRSA, NASTY NORO, AND PSYCHO PSEUDO!



ERADICATING EVIL GERMS FROM HANDS, SURFACES AND DEVICES!

THE MICROBE MILITIA HAS GAINED A FOOTHOLD IN THE WAR AGAINST MICROBES, AND THE LEGACY CHEMISTRY COALITION IS REQUESTING REINFORCEMENTS! PEROXIGIRL HAS ARRIVED TO SAVE THE HUMAN RACE ON ALL OF THE IMPORTANT BATTLEGROUNDS -- **HANDS**, **SURFACES** AND **DEVICES**. MICROBES ARE NO MATCH FOR PEROXIGIRL'S ACCELERATED HYDROGEN PEROXIDE® (AHP®) DISINFECTANT SUPERPOWER -- **CLEANER**, **FASTER**, **RESPONSIBLE** AND **SUSTAINABLE!**

Find out more about the epic AHP® disinfectant battle at www.Virox.com/PeroxiGirl

ACCELERATED® HYDROGEN PEROXIDE Patented

VIROX® TECHNOLOGIES INC.

Virox.com/PeroxiGirl

Sealed Air
Diversey Care

Reduce HAI risk with point of care disinfection.

Effective disinfection of high touch surfaces is everyone's job.

Make it convenient with Oxivir® Tb Wipes.

Fast, effective and safe, when and where you need it.

Tough on pathogens... Gentle on patients and surfaces.

Take the integrated approach to total disinfection.

Products that kill tough pathogens in as little as one minute, but are gentle on staff and surfaces.

Procedures that standardize processes and help ensure consistent disinfection and cleaning.

Validation system that facilitates feedback to employees and drives continuous improvement.

For more information, visit SDFHC.com/contact-us or call 800-558-2332.

sealedair.com

FIND OUT MORE ABOUT THE EPIC AHP® DISINFECTANT BATTLE AT:
WWW.VIROX.COM/PEROXIGIRL

ACCELERATED® HYDROGEN PEROXIDE Patented

VIROX® TECHNOLOGIES INC.

IPAC CANADA
2016 - 2017 Board of Directors

Executive Officers

President
Suzanne Rhodenizer Rose, RN, BScN, MHS, CIC
Health Services Manager Infection Control
Nova Scotia Health Authority
846 Bethune Building
1276 South Park Street
Halifax, NS B3H 2Y9
Phone: 902-473-4048
Fax: 902-473-3295
president@ipac-canada.org

President-elect
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
mblake@wrha.mb.ca

Secretary
Marilyn Weinmaster, RN, BScN, CIC
Infection Control Practitioner
Regina Qu'Appelle Health Region
430 Pioneer Drive
Regina, SK S4T 6L8
Phone: 306-751-5261 Fax: 306-359-1402
marilyn.weinmaster@rqhealth.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

Directors

Barbara Catt, RN BScN MEd CIC
Infection Prevention & Control Coordinator
Sunnybrook Health Sciences Centre
2075 Bayview Avenue, B112
Toronto, ON M4N 3M5
Phone: 416-480-6100 Fax: 416-480-6845
barbara.catt@sunnybrook.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
Epidemiologist
Fraser Health Authority
400-13450 102 Avenue, Central City Tower
Surrey, BC V3T 0H1
Phone: 604-587-4600 Fax: 604-587-4656
Tara.donovan@fraserhealth.ca

Camille Lemieux, BScPhm, MD, LLB, CIC
Associate Hospital Epidemiologist
University Health Network
200 Elizabeth Street
Toronto, ON M5G 2C4
Phone: 416-340-4800 Fax: 416-340-5047
Camille.lemieux@uhn.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
Barley Chironda, RPN, CIC
info@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, CA
Stefanson Lee Romaniuk
1151 Portage Avenue
Winnipeg, MB R3G 0S9
Phone: 204-775-8975
promaniuk@slrca.ca

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

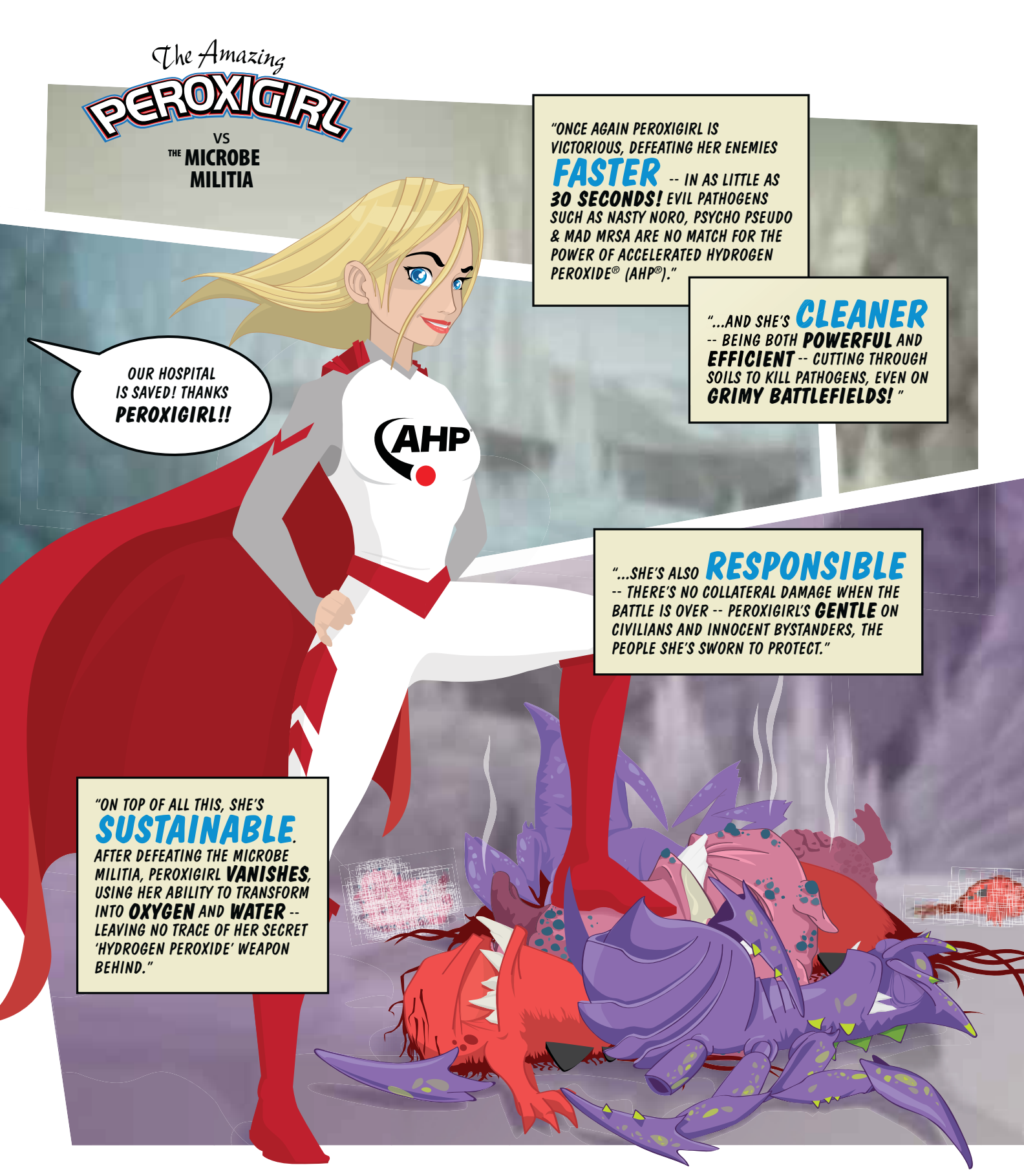
PLATINUM:
- **GOJO Industries**
Ph: (800) 321-9647 ext. 6829
Fax (330) 869-1796
- **SealedAir Diversey**
Ph: (262) 631-4132 Fax: (262) 631-4036
- **Virox Technologies**
Ph: (800) 387-7578 (905) 813-0110
Fax: (905) 813-0220
- **The Clorox Company of Canada**
Ph: (866) 789-4973

GOLD:
- **Ecolab Healthcare**
Ph: (651) 293-2914
(800) 352-5326
Fax: (651) 204-7372

SILVER:
- **3M Healthcare**
Ph: (651) 250-4821
Fax: (651) 204-2571
- **DebMed**
Ph: (519) 443-8697 Fax: (519) 443-5160
- **HandyMetrics Corporation**
Ph: (416) 800-1743
- **Hygie Canada**
Ph: (450) 444-6777 Fax: (450) 444-6222
- **Sage Products**
Ph: (815) 455-4700
- **Vernacare**
Ph: (416) 661-5552 ext. 232
Cell: (416) 580-9301
- **Webber Training**
Ph: (613) 962-0437 Fax: (613) 969-7465

BRONZE:
- **Ansell**
Ph: (450) 266-1850 Fax: (450) 266-6150
- **ArjoHuntleigh Canada**
Ph: (800) 665-4831 Fax: (800) 309-7116
- **Chem-Aqua**
Tel: 905-457-2434
Email: *subrotoc@nch.com*
Website: *www.chemaqua.com*
- **Class 1 Inc.**
Ph: (519) 650-2355
- **healthcentric**
Ph: (905) 696-6800 Fax: (905) 696-0899
- **Imperial Surgical**
Ph: (514) 631-7988 ext. 41
Fax: (514) 631-7741
- **Medela Canada**
Ph: (905) 608-7272 ext. 229
(800) 435-8316
Fax: (905) 608-8720
- **Nosotech Inc.**
Ph: 418-723-0862 Fax: 418-723-2231
- **SciCan**
Ph: (416) 446-2757 Fax: (416) 445-2727
- **Steris Corporation**
Ph: (905) 677-0863 Fax: (905) 677-0947
- **The Stevens Company**
Ph: (905) 791-8600 Fax: (905) 791-6143
- **Wood Wyant**
Ph: (800) 361-7691 Fax: (450) 680-9735

Return to TABLE OF CONTENTS



PEROXIGIRL HAS BECOME A SYMBOL OF HOPE & DISINFECTION TO ALL WHO NEED HELP BATTLING THE MICROBE MILITIA. CALL FOR HER AT:
WWW.VIROX.COM/PEROXIGIRL

ACCELERATED® HYDROGEN PEROXIDE Patented

VIROX® TECHNOLOGIES INC.

GAMMEX®

Non-Latex Underglove

DOUBLE GLOVE WITH THE WORLD'S FIRST 100% CHEMICAL ACCELERATOR-FREE UNDERGLOVE FOR OPTIMUM PEACE OF MIND

PREMIER SOUS-GANT AU MONDE 100% SANS ACCÉLÉRATEURS CHIMIQUES POUR UN DOUBLE GANTAGE EN TOUTE QUIÉTUDE

Feel the difference.
Request for samples or find out more.
Visit ansell.com/gammex.

Sentez la différence.
Demandez-nous un échantillon ou de l'information.
Visitez ansell.com/gammex (en anglais seulement)**.**

Ansell

FREE!
Find out
what's in
***your* basins**

Replace your basins with a rinse-free hygienic system

Basins may contain pathogens associated with hospital-acquired infections (HAIs).[1,2] Need more proof? We'll sample your basins for FREE!

Replace your basins now. Our comprehensive, rinse-free patient cleansing products can help standardize patient care and may address a risk factor for CAUTI through eliminating the basin.[3]

Sign up for FREE basin sampling!
Visit **sageproducts.com/Basin-Sampling**
or call **800.323.2220**

REFERENCES: 1. Marchaim D, et al., Hospital bath basins are frequently contaminated with multi-drug resistant human pathogens. Poster presented at SHEA 21st Annual Scientific Meeting, April 2011. **2.** Johnson D, Lineweaver, Maze L, Patients' bath basins as potential sources of infection: a multi center sampling study, AJCC, Vol 18, No 1, Jan 2009. **3.** Stone S, et al., Removal of bath basins to reduce catheter-associated urinary tract infections. Poster presented at APIC 2010, New Orleans, LA, July 2010.

SAGE® PRODUCTS
Now part of Stryker.

REVIEW ARTICLE

The role of copper surfaces in reducing the incidence of healthcare-associated infections: A systematic review and meta-analysis

Ignacio Pineda, MD, MSc, M.P.H,[1] **Richard Hubbard**, PhD,[2] **Francisca Rodríguez**, MSc[3]

[1] *Comite de Industrias Inteligentes, Corporación de Fomento de la Producción, Moneda 921, 8320250, Santiago, Chile. 600 586 8000*
[2] *Division of Epidemiology and Public Health, University of Nottingham, Nottingham NG5 1PB, United Kingdom*
[3] *Facultad de Medicina, Universidad San Sebastián, Lota 2465, Santiago 7510157, Chile*

Corresponding Author:
Ignacio Pineda
600 586 8000
nachopinedav@gmail.com
Fax: 780-342 0316

ABSTRACT

Background: Healthcare-associated infections are a major public health problem, with an important clinical and economic burden on health systems worldwide. In-vitro and in-vivo studies have shown that copper has the potential to kill microorganisms on contact. It has been described as the "contact killer". Despite this, the preventive role of antimicrobial copper on the reduction of healthcare-associated infections is not clear yet.

Aims & Objectives: To assess the role of copper surfaces on the reduction of healthcare-associated infections.

Methods: A systematic review of the literature with a meta-analysis. The search was carried out in five electronic databases, grey literature and reference list of included studies. Two researchers independently screened and judged the quality of the included studies. The GRADE approach was used to assess the quality of the body of evidence.

Results: Fourteen studies met the inclusion criteria. Overall, the introduction of antimicrobial copper alloys surfaces in high-touch surfaces reduced the incidence of healthcare-associated infections by around a quarter (IRR 0.74, 95% CI 0.56 to 0.97; $p = 0.03$; low quality of the evidence). Additionally, the probability of achieving the recommended concentration of less than 250 colony forming units/100cm^2 was 2.73 times higher in copper surfaces than in regular surfaces (RR 2.73, 95% CI 1.83 to 4.07; $p < 0.00001$; moderate quality of the evidence). No significant difference was observed in the mortality rate.

Conclusion: This systematic review and meta-analyses suggest that the introduction of antimicrobial copper alloys in replacement of high-touch surfaces may have a positive effect on the incidence rate of HAIs. Larger clinical trials will be needed to show an impact on mortality.

KEY WORDS:

Healthcare-associated infections, copper, cross infections, antimicrobial surfaces

INTRODUCTION

Despite current worldwide efforts, the incidence of healthcare-associated infections (HAIs) is still a significant public health problem. The prevalence of HAIs varies worldwide, with incidence in Europe at 7.1% (1), in the United Kingdom at 9%, and in the United States at 4.5% in the year 2011 (2).

In ICUs in high-income countries, nearly 30% of patients are affected by at least one episode of HAIs, significantly increasing their morbidity, length of stay, readmission rate and mortality (3, 4).

In the last decade, the contribution of the contamination of metallic or plastic surfaces in hospitals to the acquisition of HAIs has been extensively described in the literature (5-9). Most common hospital-acquired pathogens have the ability to survive on surfaces for months, and be a continuous source of transmission (10).

To prevent this phenomenon, regular cleaning and disinfection are needed. However, multiple studies reported that existing hospital-cleaning techniques alone are not sufficient to restrain the growth of microorganism for prolonged periods of time (11-13).

In response to this situation, the utilization of antimicrobial surfaces to reduce the bacterial load in the patient environment has been proposed due to their potential to inactivate the microorganisms on contact (14).

The use of a relatively cheap technology, copper, seems like an opportunity to address this problem, because of its intrinsic broad-spectrum antimicrobial activity (15-17). A series of trials have been conducted to measure the effectiveness of copper surfaces in reducing HIAs, but no good-quality systematic review has been carried out to answer this question. We performed a systematic review of the literature with a meta-analysis, to evaluate the association between the use copper surfaces and incidence of the healthcare-associated infections (HAIs).

MATERIALS AND METHODS

Type of studies and interventions

Randomized control trials (RCTs), including cluster-RCTs, observational studies, and economic evaluations were included.

We included the studies comparing antimicrobial copper versus regular surfaces in patients' environments where surface cleaning/disinfection methods otherwise remained unchanged. In ambiguous cases, study designs were discussed and consensus reached.

Outcome measures

The recommended threshold of CFU/100cm2 is max. 250 CFU/100cm^2. The outcome measured for this review is the probability of copper surfaces achieving this threshold vs. regular surfaces. Consequently, the primary outcomes used in the review were incidence rate of healthcare-associated infections (HAIs), and the probability of achieving the recommended threshold of colony forming units/100cm^2, as well as adverse events related with the utilization of antimicrobial copper.

A secondary outcome was all-cause deaths among hospitalized patients, total reduction of microbial burden and cost-effectiveness.

Literature search

We identified studies between 1 January 2000 to 30 April 2016 by searching MEDLINE, EMBASE, LILACS, Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL Plus with Full Text (EBSCO) and Epistemonikos.

Search of grey literature was performed in the following databases: TRoPHI (The Trials Register for Promoting Health Interventions); Grey Literature Report (*http://www.greylit.org/library/search*); and NHS reports.

Data extraction

Two people (IP) and (RH) independently screened titles and abstracts of all identified articles to assess the eligibility for inclusion. Decision of inclusion of articles was reached by simple consensus. A third researcher (FR) resolved possible disagreement between the two reviewers.

The following data were extracted for each eligible study: type of study, participants and setting, types of intervention, comparison and outcomes measures, and results. Additional information was extracted when appropriate: funding sources, conflicts of interest, key conclusions, and references to other relevant studies.

Quality assessment

IP and FR independently assessed the risk of bias using the Cochrane risk of bias assessment tool for RCTs, classifying it as high, unclear or low (18). The risk of bias in non-randomized controlled studies was assessed using the ROBINS-I tool (Risk Of Bias In Non-randomized Studies of Interventions) (19).

The GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) approach was used to assess the quality of evidence. The Review Manager software (20) was used to import data to GRADEpro GDT (21) to create the Summary of findings tables. The quality of evidence was downgraded or upgraded after the assessment of the following domains: risk of bias, inconsistency, indirectness, imprecision, and publication bias for the body of evidence that contributed to the report of an outcome.

Finally, the reviewer classified the quality of the body of evidence for each outcome following the guidelines recommended in the handbook published by the GRADE Working Group: the quality of evidence was classified as High, Moderate, Low or Very Low (22).

Measures of treatment effect

Studies were qualitatively assessed by the reviewers to determine whether to include them in a pooled meta-analysis. Authors stratified studies according to the outcome report for the meta-analysis and calculated rate ratio for difference in rates, risk ratio (RR) for dichotomous outcomes and when possible, hazard ratio (HR) for mortality outcomes.

The data was analyzed using Review Manager 5.3 (RevMan) (20) and results presented with 95% confidence intervals.

For rate outcomes, the incidence rates of different studies were pooled using the generic inverse variance with random effects.

For those trials where data on person-time at risk was not reported, we estimated the total person-time follow up in order to calculate the rate ratio.

RESULTS

The electronic search of databases generated a total of 1,961 potentially eligible results. After eliminating duplicates and screening by title and abstract, 110 articles were assessed full-text for eligibility. A total of 14 articles (13 full-text articles and one poster presentation) were included in the analysis. The PRISMA flow diagram with the results of the search is shown in Figure 1.

Description of studies

We included fourteen trials published between 2010 and 2016. Four studies were randomized clinical trials (23-26), one crossover study (27), eight non-randomized controlled studies (28-35), and one was an uncontrolled before/after study (36).

Twelve trials used antimicrobial copper alloys surfaces as intervention (23, 24, 26-35). One study used biocidal copper-oxide impregnated linens (36) and another study compared 50 regular pens used by ICUs nurses to 50 copper-containing pens (25). All institutions maintained their regular cleaning and disinfecting procedures in both arms during the trials. Four clinical trials measured the incidence rate of healthcare-associated infection as the primary outcome (23, 24, 42, 36), five of the studies reported the total amount of surfaces that achieved the optimal threshold of colony forming units/100cm^2 in both arms of the trial (25, 31-34), 10 studies measured the effectiveness of antimicrobial copper in reducing the total microbial burden (25-27, 29-35), three studies reported the mortality rate (23, 24, 42) and only one study reported adverse events (42). Description of all the included articles is presented in Appendix A.

Return to TABLE OF CONTENTS

FIGURE 1: PRISMA flow diagram

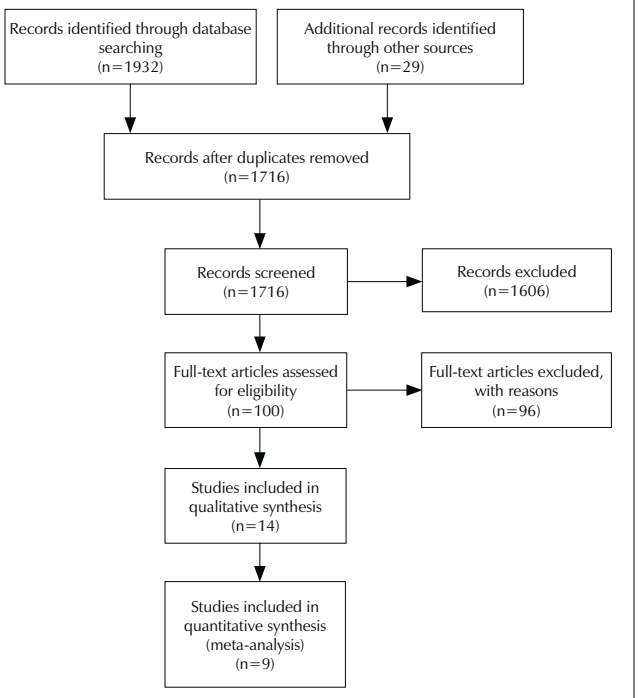
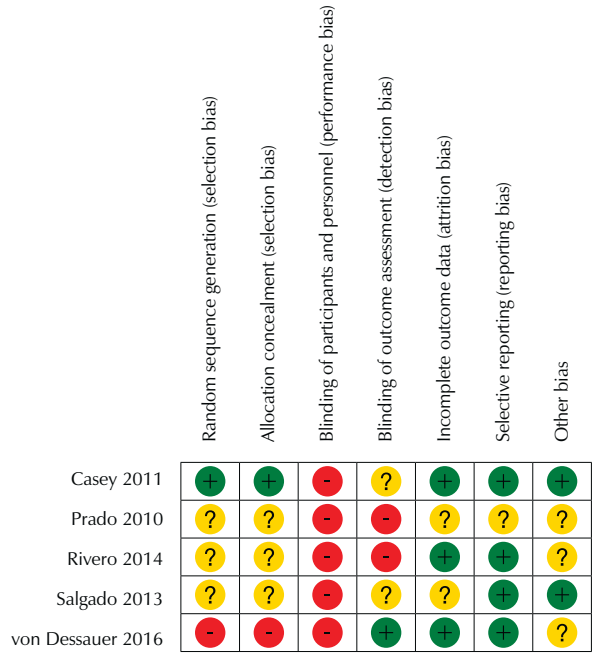


FIGURE 2: Risk of bias summary: review of authors' judgments about each risk of bias item for each included study



Risk of bias

Figure 2 shows the risk of bias summary for RCT and for one non-randomized trial with low risk of bias in the assessment with ROBINS-I tool.

Sequence generation and allocation concealment

One of the four randomized clinical trials, reported an adequate method for generating allocation sequence and allocation concealment (25). Two of them described the allocation sequence as random but did not present further details (23, 24). The allocation concealment was not evaluated in the before/after study (36). Eight studies were non randomized- controlled studies (28-35) and one was a crossover (27).

Blinding

We recognized that blinding of participants is not possible in trials using antimicrobial copper surfaces, as copper is a metal with a distinct colour and odour. Outcome evaluators could be blinded, so that was assessed. Only one study reported blinding of the outcome evaluators (28).

Incomplete outcome data

One study reported the exclusion of patients after randomization, but did not include them in the final analysis (23). Two of the studies reported a protocol deviation regarding the exposure to copper (mainly because of misplaced objects and patient movement). This lead to patients originally allocated in the intervention group to spend some hospitalization days in the control rooms and vice versa. An intention-to- treat analysis was carried out in both studies (23, 28).

Quality of non-randomized controlled studies

Eight studies were nonrandomized-controlled studies. The intervention was not blinded for hospital staff in any study. Among these eight studies, it is not clear if the outcome assessors were blinded to the intervention. Reasonable controls were used in all trials, and confounding was analyzed before the start of the trials. The surfaces included in the study were selected before the onset of the studies, and not based off the characteristics observed after the start of the intervention. The intervention groups were clearly defined in all studies. Two studies reported the introduction of the copper surfaces at least three months prior the start of the trial period (27, 29).

No major deviations from the intended intervention were observed in any trial. One study reported missing data in both intervention and control arms. Although the authors provided the reasons, loss of data was not evenly distributed between the intervention and control groups (17% vs. 11%, respectively) (31). Overall, four studies were judged as low risk of bias in all domains (28, 32-34), one study as moderate risk of bias (30), and three as serious risk of bias (29, 31, 35), including the before/after study (36).

HAI incidence

Only four studies (23, 24, 28, 36) reported the incidence rate of HAIs in both arms. Of these four, one was excluded from the meta-analysis because of the different type of intervention (copper-impregnated linen yarn) and different study design (36).

Overall, the introduction of antimicrobial copper alloys surfaces in high-touch surfaces reduced the incidence of HAIs by around a quarter (IRR 0.74, 95% CI 0.56 to 0.97; p = 0.03; three trials; 1569 participants; moderate quality of the evidence).

FIGURE 3: Forest plot of comparison: Antimicrobial copper surfaces in ICUs rooms vs. regular surfaces, Outcome Incidence of healthcare-associated infections: rate ratios

FIGURE 4: Forest plot of comparison: Antimicrobial copper surfaces vs. regular surfaces, Outcome Surfaces achieving minimum benchmark (<250 CFU/100 cm2): risk ratio

All of the studies measure the hand-washing rate in both groups to determine if any difference was present between groups. No difference was observed. To prevent the introduction of bias, cleaning staff were unaware of the study protocols or outcomes. The analysis is shown in Figure 3.

CFU threshold

Five studies reported the total of objects that achieved the recommended threshold (29, 31-34). All of them were included in the meta-analysis. Overall, the probability of achieving the recommended concentration of less than 250 CFU/100cm^2 was 2.73 times higher in copper surfaces than in regular surfaces (RR 2.73, 95% CI 1.83 to 4.07; p <0.00001; five trials; 2486 surfaces; moderate quality of the evidence). The analysis is presented in Figure 4.

Mortality rate

Three studies (23, 24, 28) reported the total number of participant's deceased in both arms and only one of them reported the HAIs-related mortality rate, founding no difference between both groups (IRR 1.17, 95% CI 0.3 to 4.36; p = 0.81) (24).

Total microbial burden reduction

Nine studies reported the total MB reduction as the main outcome. These studies could not be pooled due to methodological variability and missing data (26, 27, 29-35). All the studies reported a significant total microbial burden reduction between copper alloy surfaces and control surfaces. The percentage of reduction varies across the studies, from 37% to 100%. All of the studies were carried out in a clinical setting, with similar sample recollection between groups. The studies generally took samples in the morning, before the first cleaning and in the afternoon, after visiting hours. This was to detect any statistical difference between morning samples and night samples. Difference in hand-washing rates, room temperature, and humidity were assessed in the studies, reporting no significant difference between groups. Results for each study are presented in Table 1.

DISCUSSION

This systematic review and meta-analysis have demonstrated a reduction of about a quarter in the incidence rate of HAIs in patients hospitalized in rooms using antimicrobial copper surfaces. Also, the results presented here demonstrated that copper surfaces had an increased probability of achieving the recommended threshold of colony forming units/100cm2 than plastic/stainless steel surfaces, providing consistency in the findings

There were virtually no data available on mortality as an outcome. Due to the high number of participants needed to determine a significant difference between the two groups, it seems impractical that researchers choose mortality rate as a primary outcome in this kind of studies.

The studies included in this review were carried out in different settings: from ICUs rooms (both adult and pediatric) to a rural clinic in South Africa. Based on these results, it is clear that irrespective of the clinical setting, copper surfaces is associated with achieving the cleaning threshold of CFU/100cm^2 and reduction of total microbial burden. Furthermore, there may a benefit of introducing copper surfaces for reducing the rate of HAIs in ICUs rooms.

Based on the studies included, and in previous studies (37, 38) there were no adverse effects associated with copper alloys surfaces.

All of the studies were carried out in high-income countries, except from one. Therefore, it is unclear what would be the real impact from copper on HAI rates in low and middle-income levels (LMICs). As stated before, these countries present a higher rate of HAIs than HICs, so it is possible that the introduction of copper have a bigger benefit in those countries that the one presented here.

The follow-up duration in all included studies was relatively short (12 months the longest). It is unclear if the reduction of the incidence of HAIs would be the same after this period of time, or if the efficacy of copper surfaces would suffer damage and deteriorate from chemical cleaning and disinfection.

Based on the studies included in this review, it is clear that the use of antimicrobial copper cannot replace regular cleaning/disinfection. No study attempted replacing this process with copper. All of them added the antimicrobial copper to regular cleaning. Therefore, we are unclear what is the effectiveness of copper as an isolated intervention in reducing the rate of HAIs.

In terms of cost of the intervention, no proper economic evaluation was identified in the systematic review of the literature. A conference poster, presented by Taylor et al. of the University of York, used an economic model to answer this question (39). The cost of replacing six high-touch surfaces in 20 ICU beds with

Return to TABLE OF CONTENTS

TABLE 1: Total microbial burden reduction: Copper surfaces vs. regular surfaces

Study	Intervention	Sample Size	Colony Forming Units/100 cm²		% Reduction	p Value
			Mean	Standard Error of Mean		
Prado et al, 2010	Copper	90 rooms with 990 copper surfaces	1.851 (per room)	NR	84%	<0,0001*
	Control	90 rooms with 990 control surfaces	11.620 (per room)	NR		
Schmidt et al, 2012	Copper	501 surfaces	2.521	342	83%	<0,0001*
	Control	511 surfaces	14.813	1.812		
Casey et al, 2010	Copper	10 surfaces	No overall mean reported	NR	Between 90% and 100%	Statistical significance in nine of the ten paired analyses (and in all ten unpaired analyses)$
	Control	10 surfaces	No overall mean reported	NR		
Karpanen et al, 2012	Copper	14 surfaces	No overall mean reported	NR	8/14 surfaces had significant lower microbial counts	<0,05@
	Control	14 surfaces	No overall mean reported	NR		
Marais et al, 2010	Copper	1 room with 11 copper surfaces	59.000	NR	71%	<0,001 ^
	Control	1 room with 11 regular surfaces	200.000	NR		
Mikolay et al, 2010	Copper	144 surfaces	NR	NR	37%	>99.9%&
	Control	144 surfaces	NR	NR		
Schmidt et al, 2013	Pre-cleaning Copper (11.5 hours since last cleaning)	383 surfaces (Bed Rails)	698	368	88%	0.006$
	Pre-cleaning Control (11.5 hours since last cleaning)	455 surfaces (Bed Rails)	6.102	2.572		
	Hour 6.5 after cleaning Copper	383 surfaces (Bed Rails)	434	236	92%	<0,0001$
	Hour 6.5 after cleaning Control	455 surfaces (Bed Rails)	5.198	2.368		
Schmidt et al, 2012	Copper	668 surfaces	172	NR	88%	<0,0001*/$
	Control	652 surfaces	1.381	NR		
Seesma Rai et al, 2012	Copper	97 surfaces	NR	NR	89%	<0,0001*
	Control	53 surfaces	NR	NR		

* Kruskal-Wallis test for two groups
$ Wilcoxon signed Rank test P-value and Mann-Whitney U test
@ Mann-Whitney U test
^ Nor reported & T-test
NR: Not Reported

TABLE 2: Summary of findings (SoF)

Antimicrobial copper compared to control for reducing HAIs
Patient or population: Adults and children hospitalized in ICUs rooms/high-touch surfaces
Setting: Hospitalized patients **Intervention:** Antimicrobial copper surfaces **Comparison:** Regular surfaces

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No. of participants (studies)	Quality of the evidence (GRADE)	Comments
	Risk with Control	Risk with Antimicrobial Copper				
Healthcare-associated infections incidence rate assessed with: per 1000 patients-day follow up: range 11 months	159 per 1.000	118 per 1.000 (89 to 155)	Rate ratio 0.74 (0.56 to 0.97)	1569 (3 RCTs)	⊗⊗⊗◯ MODERATE[1, 2]	
Surfaces achieving minimum benchmark (<250 CFU/100 cm²)	325 per 1.000	887 per 1.000 (595 to 1.000)	RR 2.73 (1.83 to 4.07)	2468 (5 observational studies)	⊗⊗⊗◯ MODERATE[3]	
HAIs-related mortality rate: follow up: range 11 months to 12 months	126 per 1.000	123 per 1.000 (92 to 161)	Rate Ratio 1.17 (0.3 to 4.36)	440 (1 RCT)	⊗◯◯◯ VERY LOW[1, 4]	

Antimicrobial Copper compared to Control for reducing HAIs
Patient or population: Adults and children hospitalized in ICUs rooms/high-touch surfaces
Setting: Hospitalized patients **Intervention:** Antimicrobial copper surfaces **Comparison:** Regular surfaces

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No. of participants (studies)	Quality of the evidence (GRADE)	Comments
	Risk with Control	Risk with Antimicrobial Copper				
Adverse effects	Adverse effects were not observed among the health care workers or patients exposed to copper-surfaced items.			515 (1 RCT)	⊗⊗◯◯ LOW[1, 4]	
Total microbial burden reduction	-	-	-	(9 studies)	-	Not pooled (See Table 1)

*The risk in the intervention group **(and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).**
[1] Risk of bias
[2] CI near 1
[3] Heterogeneity
[4] Wide CI

- CI: **Confidence interval**; RR: **Risk ratio**
- GRADE Working Group grades of evidence
- High quality: **We are very confident that the true effect lies close to that of the estimate of the effect**
- Moderate quality: **We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different**
- Low quality: **Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect**
- Very low quality: **We have very little confidence in the effect estimate: The true effect is likely to be substantially different**

Return to TABLE OF CONTENTS

antimicrobial copper was calculated, based on expert opinions, to be £30,600 higher than baseline rooms (£105,000 vs. £74,400). The average cost of infection was based in a previous study (40) at £1,000 per patient-day. In conclusion, the model predicts that the cost of implementing copper in a 20 bed ICU will be recovered in two months. In a five-year breakdown, there is a potential cost saving of £1.9m associated with the introduction of copper alloys and 352 fewer infections. The cost per infection averted is calculated to be £94,10. These results must be analyzed with caution. All costs and other information used in the model are based in the United Kingdom setting, a HIC, making difficult to extrapolate the results to other settings. The cost of the intervention, and other possible costs should be described in more detail. In spite of this, these results are promising, with interesting potential use for policymakers.

One limitation of this review is that we only included studies published in Spanish or English. As the original search did not include language filters, one study in Greek and one in German were found that could have met the inclusion criteria, but were excluded (41, 42). Another potential bias of this review is that copper-related private companies funded almost all of the studies included in the analysis. It was not possible to assess the publication bias with a funnel plot. The studies that assessed the outcomes selected in this review were fairly small-sized, with two of them not being sufficiently powered according to their statistical power calculation assumptions. Because of this, is unclear if the reduction in the incidence of HAIs would be maintained in larger trials. Nevertheless, considering that there is no biologic plausibility that lower microbial burden should lead to an increase of HAIs rates, it is conceivable that better-structured RCTs and times-series experimental designs could demonstrate an even greater reduction in the HAIs rates. Additionally, all of the studies presented important protocol deviations. In some cases, patients from the control group were exposed to copper and patients from the intervention group were exposed to regular surfaces. This may have contributed to underestimating the real effectiveness of copper in reducing the HAIs rates.

The findings of this systematic review showed that additional research to assess the efficacy of antimicrobial copper in preventing HAIs in necessary. There are only three studies that reported this outcome. More high-level quality RCTs and time-series experimental studies are needed to be more certain in the positive results presented here. These future studies need to have a longer follow-up period, be sufficiently powered, and present fewer probabilities of introducing bias and confounding.

Similar studies are needed in LMICs, where actual evidence is limited. It is essential to assess the potential benefits of antimicrobial copper surfaces in countries where the rate of HAIs is significantly higher than in the rest of the world. In the same way, studies focusing in sub-groups with more risk of acquiring HAIs could be useful for policymakers in order to prioritize resources. A proper economic evaluation of the introduction of this technology is needed to determine the monetary impact of this intervention.

The increasing rate of antimicrobial resistance and high rates of HAIs, especially in LMICs, are some of the major public health concerns in the world. Different types of interventions have been proposed to tackle this problem. Copper, a safe, effective and relatively cheap technology may be considered in addition to current policies in order to deliver a safe medical care to all patients. The reduction of the incidence rate of HAIs presented in this systematic review by nearly a quarter shows that copper has the potential to revolutionize the fight against this public health issue.

REFERENCES

1. European Centre for Disease Prevention and Control. Annual epidemiological report 2014. Antimicrobial resistance and healthcare-associated infections. Stockholm: ECDC; 2015. Available from: *http://ecdc.europa.eu/en/publications/Publications/antimicrobial- resistance-annual-epidemiological-report.pdf*.
2. World Health Organization. Report on the Burden of Endemic Health Care- Associated Infection Worldwide. World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland: WHO Press; 2011. Available from: *http://apps.who.int/iris/bitstream/10665/80135/1/9789241501507_eng.pdf*.
3. Vincent JL. Nosocomial infections in adult intensive-care units. Lancet (London, England). 2003;361(9374):2068-77.
4. Martin J. The Impact of Healthcare-Associated Infections in Pennsylvania. Harrisburg, PA: Pennsylvania Health Care Cost Containment Council; 2011. Available from: *http://www.phc4.org/reports/hai/10/docs/hai2010report.pdf*.
5. Han JH, Sullivan N, Leas BF, Pegues DA, Kaczmarek JL, Umscheid CA. Cleaning Hospital Room Surfaces to Prevent Health Care-Associated Infections: A Technical Brief. Annals of internal medicine. 2015;163(8):598-607.
6. Otter JA, Yezli S, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. Infect Control Hosp Epidemiol. 2011;32(7):687-99.
7. Creamer E, Humphreys H. The contribution of beds to healthcare-associated infection: the importance of adequate decontamination. The Journal of hospital infection. 2008;69(1):8-23.
8. Dettenkofer M, Spencer RC. Importance of environmental decontamination--a critical view. The Journal of hospital infection. 2007;65 Suppl 2:55-7.
9. Weber DJ, Anderson D, Rutala WA. The role of the surface environment in healthcare-associated infections. Current opinion in infectious diseases. 2013;26(4):338-44.
10. Kramer A, Schwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. BMC infectious diseases. 2006;6:130.
11. Cooper RA, Griffith CJ, Malik RE, Obee P, Looker N. Monitoring the effectiveness of cleaning in four British hospitals. American journal of infection control. 2007;35(5):338-41.
12. Griffith CJ, Obee P, Cooper RA, Burton NF, Lewis M. The effectiveness of existing and modified cleaning regimens in a Welsh hospital. The Journal of hospital infection. 2007;66(4):352-9.
13. Dharan S, Mourouga P, Copin P, Bessmer G, Tschanz B, Pittet D. Routine disinfection of patients' environmental surfaces. Myth or reality? The Journal of hospital infection. 1999;42(2):113-7.
14. Hans M, Erbe A, Mathews S, Chen Y, Solioz M, Mucklich F. Role of copper oxides in contact killing of bacteria. Langmuir : the ACS journal of surfaces and colloids. 2013;29(52):16160-6.
15. Noyce JO, Michels H, Keevil CW. Use of Copper Cast Alloys To Control Escherichia coli O157 Cross-Contamination during Food Processing. Applied and Environmental Microbiology. 2006;72(6):4239-44.
16. Warnes SL, Keevil CW. Mechanism of copper surface toxicity in vancomycin- resistant enterococci following wet or dry surface contact. Applied and Environmental Microbiology. 2011;77(17):6049-59.
17. Jonas RB. Acute Copper and Cupric Ion Toxicity in an Estuarine Microbial Community. Applied and Environmental Microbiology. 1989;55(1):43-9.

18. Higgins J, Geen S, editors. Cochrane Handbook for Systematic Reviews of interventions. Version 5.1.0 ed. [updated March 2011]: The Cochrane Collaboration; 2011.
19. Sterne JAC, Higgins JPT, Reeves BC. on behalf of the development group for ROBINS-I: a tool for assessing Risk Of Bias In Non-randomized Studies of Intervention 2016 [Version 7 March 2016 (cited May 2016):[Available from: *http://www.riskofbias.info*
20. The Cochrane Collaboration. Review Manager (RevMan) [Computer program]. Copenhagen: The Nordic Cochrane Centre; 2014.
21. GRADEpro GDT. GRADEpro Guideline Development Tool [Software]. McMaster University (developed by Evidence Prime, Inc.); 2015. p. Available from *http://www.gradepro.org*.
22. Schünemann H, Bro ek J, Guyatt G, Oxman A, editors. GRADE handbook for grading quality of evidence and strnght of recommendations. Updated October 2013 ed: The GRADE Working Group; 2013.
23. Salgado CD, Sepkowitz KA, John JF, Robert Cantey J, Attaway HH, Freeman KD, et al. Copper surfaces reduce the rate of healthcare-acquired infections in the intensive care unit. Infection Control and Hospital Epidemiology. 2013;34(5 SPL):479- 86.
24. Rivero P, Brenner P, Nercelles P. Impact of copper in the reduction of hospital-acquired infections, mortality and antimicrobial costs in the Adult Intensive Care Unit. [Spanish]. Revista chilena de infectologia : organo oficial de la Sociedad Chilena de Infectologia. 2014;31(3):274-9.
25. Casey AL, Karpanen TJ, Adams D, Lambert PA, Nightingale P, Miruszenko L, et al. A comparative study to evaluate surface microbial contamination associated with copper- containing and stainless steel pens used by nurses in the critical care unit. American journal of infection control. 2011;39(8):e52-e4.
26. Prado V, Duran C, Crestto M, Gutierrez A, Sapiain P, Flores G, et al. Effectiveness of copper contact surfaces in reducing the microbial burden (MB) in the intensive care unit (ICU) of hospital del Cobre, Calama, Chile. International Journal of Infectious Diseases. 2010;14:e268.
27. Karpanen TJ, Casey AL, Lambert PA, Cookson BD, Nightingale P, Miruszenko L, et al. The antimicrobial efficacy of copper alloy furnishing in the clinical environment: a crossover study. Infection Control & Hospital Epidemiology. 2012;35(7):3-9 7p.
28. von Dessauer B, Navarrete MS, Benadof D, Benavente C, Schmidt MG. Potential effectiveness of copper surfaces in reducing health care-associated infection rates in a pediatric intensive and intermediate care unit: A nonrandomized controlled trial. American journal of infection control. 2016;44(8):e133-9.
29. Casey AL, Adams D, Karpanen TJ, Lambert PA, Cookson BD, Nightingale P, et al. Role of copper in reducing hospital environment contamination. Journal of Hospital Infection. 2010;74(1):72-7.
30. Mikolay A, Huggett S, Tikana L, Grass G, Braun J, Nies DH. Survival of bacteria on metallic copper surfaces in a hospital trial. Applied microbiology and biotechnology. 2010;87(5):1875-9.
31. Rai S, Hirsch BE, Attaway HH, Nadan R, Fairey S, Hardy J, et al. Evaluation of the antimicrobial properties of copper surfaces in an outpatient infectious disease practice. Infection Control & Hospital Epidemiology. 2012;33(2):200-1 2p.
32. Schmidt MG, Attaway HH, Sharpe PA, John J, Sepkowitz KA, Morgan A, et al. Sustained reduction of microbial burden on common hospital surfaces through introduction of copper. Journal of clinical microbiology. 2012;50(7):2217-23.
33. Schmidt MG, Attaway HH, Fairey SE, Steed LL, Michels HT, Salgado CD. Copper continuously limits the concentration of bacteria resident on bed rails within the intensive care unit. Infection Control and Hospital Epidemiology. 2013;34(5 SPL):530- 3.
34. Schmidt MG, von Dessauer B, Benavente C, Benadof D, Cifuentes P, Elgueta A, et al. Copper surfaces are associated with significantly lower concentrations of bacteria on selected surfaces within a pediatric intensive care unit. American journal of infection control. 2016;44(2):203-9 7p.
35. Marais F, Mehtar S, Chalkley L. Antimicrobial efficacy of copper touch surfaces in reducing environmental bioburden in a South African community healthcare facility. Journal of Hospital Infection. 2010;74(1):80-2.
36. Lazary A, Weinberg I, Vatine JJ, Jefidoff A, Bardenstein R, Borkow G, et al. Reduction of healthcare-associated infections in a long-term care brain injury ward by replacing regular linens with biocidal copper oxide impregnated linens. International journal of infectious diseases : IJID : official publication of the International Society for Infectious Diseases. 2014;24:23-9.
37. Borkow G, Zatcoff RC, Gabbay J. Reducing the risk of skin pathologies in diabetics by using copper impregnated socks. Medical hypotheses. 2009;73(6):883-6.
38. Borkow G, Okon-Levy N, Gabbay J. Copper oxide impregnated wound dressing: biocidal and safety studies. Wounds: A Compendium of Clinical Research & Practice. 2010;22(12):301-10 10p.
39. Taylor M, Chaplin S. The economic assessment of an environmental intervention: Discrete deployment of copper for infection control in ICUs. Value in Health. 2013;16 (7):A353.
40. Negrini D, Sheppard L, Mills GH, Jacobs P, Rapoport J, Bourne RS, et al. International Programme for Resource Use in Critical Care (IPOC)--a methodology and initial results of cost and provision in four European countries. Acta anaesthesiologica Scandinavica. 2006;50(1):72-9.
41. Anagnostakou M, Kouskouni E, Petropoulou C, Efstathiou P, Karageorgou K, Manolidou Z, et al. Implementation of antimicrobial copper in a neonatal intensive care unit (NICU). CONNECT: The World of Critical Care Nursing. 2014;9(2):54- 1p.
42. [In the hospital test: germicidal copper. Metal coatings on door knobs and light switches to prevent infections]. Kinderkrankenschwester: Organ der Sektion Kinderkrankenpflege / Deutsche Gesellschaft fur Sozialpadiatrie und Deutsche Gesellschaft fur Kinderheilkunde. 2008;27(12):517

APPENDIX A: Characteristic of included studies

Study	Country	Design	Population and setting	Intervention and Control	Outcome measure	Author's conclusion
Casey et al, 2010 (29)	United Kingdom	NR-C	Busy acute medical ward, which included gastroenterology patients. United Kingdom	I: Three copper-containing items; toilet seat, a set of brass tap handles and a brass door push plate C: Regular surfaces	Median CFU/cm^2	"The results of this trial clearly demonstrate that copper-containing items offer the potential to significantly reduce the numbers of micro-organisms in the clinical environment. However, the use of antimicrobial surfaces should not act as a replacement for cleaning in clinical areas, but as an adjunct in the fight against HCAI."
Casey et al 2011 (25)	United Kingdom	RCT	Two critical care units at the University Hospitals Birmingham National Health Service Foundation Trust	I: 50 copper-containing pens (CuZn15; 85% copper, 15% zinc) C: 50 stainless steel pens	Median number of CFU isolated	"Our findings clearly demonstrate that the use of copper-containing pens significantly reduces the level of microbial contamination on writing instruments. Thus, copper pens may provide a tool to prevent reinoculation of decontaminated hands. The use of copper also may be applied to other surfaces in the healthcare setting."
Karpanen et al, 2012 (27)	United Kingdom	CO	Acute care medical ward with 19 beds at a large university hospital	I: Antimicrobial copper surfaces in high-touch surfaces C: Regular surfaces	CFU reduction	"Copper furnishings may therefore be a beneficial adjunct to standard hospital cleaning and hygiene procedures in reducing environmental contamination and the risk of cross-transfer of microorganisms within the healthcare environment."
Lazary et al, 2014 (36)	Israel	B/A	108 patients hospitalized in the Head Injury Ward at The Reuth Medical Centre, Tel Aviv	I: Copper-containing linens (replacing all the regular non- biocidal linens and personnel uniforms with copper oxide impregnated biocidal products) C: Regular linens	Rate of HAIs, Rate of fever days, Total days of antibiotics, Cost reduction	"The results of this study clearly demonstrate that the use of copper oxide impregnated linens in a long-term care ward reduce HAI and antibiotic and other infection-related treatments, and can be an important addition to the arsenal of measures taken in hospitals to reduce an important source of nosocomial pathogens and the risk of HAI."

Study	Country	Design	Population and setting	Intervention and Control	Outcome measure	Author's conclusion
Mikolay et al, 2010 (30)	Germany	NR-C	144 surfaces in an oncological/pneumological and a geriatric ward at Asklepios Hospital Wandsbek, Hamburg	I: Antimicrobial copper alloys surfaces C: Aluminium and plastic surfaces	CFU reduction	"The presented data clearly indicate that use of copper alloys for touch surfaces decreases the number of living bacterial cells adhering to these surfaces. Further, these surfaces probably decreased the repopulation rate of these germs."
Prado et al, 2010 (26)	Chile	RCT	ICU rooms at Hospital del Cobre de Calama, Chile	I: Copperized surfaces (bed rails, bed lever, tray tables, chair arms, touch screen monitor pen, and IV poles) C: Regular surfaces	The mean microbial burden (mMB), determined as colony forming units (CFU)/100cm^2	"The antimicrobial effects of copper on critical contact surfaces within ICU rooms was evident and significant in this hospital located in this arid region of Chile throughout the 30 week trial. The antimicrobial properties of copper were of a broad spectrum in that a reduction in the total microbial burden was seen for each class of microbe characterized in ICU rooms containing copper."
Seema Rai 2012 (31)	United States	NR-C	Outpatient infectious disease clinic, United States	I: 134 copperized surfaces I high touch surfaces of phlebotomy chairs C: 60 noncopperized surfaces	Total CFU/100 cm^2 reduction.	"Covering high-touch surfaces with antimicrobial copper may provide an adjunctive infection control measure to minimize the spread of bacteria. The microbicidal activity of copper was effective in significantly reducing the total median burden by 90% on arm tops and by 88% on copperized trays. Deployment of copper surfaces within high-risk patient environments is warranted to enhance patient safety."
Rivero et al, 2014 (24)	Chile	RCT	440 patients hospitalized in ICU rooms at Hospital Van Buren, Valparaiso	I: Antimicrobial copper surfaces C: Regular surfaces	HAIs incidence rate, mean day average before HAIs, Total antibiotic cost, HAIs mortality rate.	"The use of copper as a surface in the ICU showed no statistically significant differences in rates of nosocomial infections during the study period, however, these results could be related to the sample size."

Return to TABLE OF CONTENTS

Study	Country	Design	Population and setting	Intervention and Control	Outcome measure	Author's conclusion
Salgado et al, 2013 (23)	United States	RCT	614 patients in the ICUs of 3 hospitals, US	I: Antimicrobial copper surfaces C: Regular surfaces	Rates of incident HAI and/or colonization with methicillin-resistant Staphylococcus aureus (MRSA) or vancomycin-resistant Enterococcus (VRE)	"Patients cared for in ICU rooms with copper alloy surfaces had a significantly lower rate of incident HAI and/or colonization with MRSA or VRE than did patients treated in standard rooms. Additional studies are needed to determine the clinical effect of copper alloy surfaces in additional patient polulations and settings."
Schmidt et al, 2012 (32)	United States	NR-C	16 rooms in ICUs in three hospitals, US	I: Copper-alloy surfaces C: Regular surfaces	The mean microbial burden (mMB), determined as colony forming units (CFU)/100cm^2	"The introduction of copper surfaces to objects formerly covered with plastic, wood, stainless steel, and other materials found in the patient care environment significantly reduced the overall MB on a continuous basis, thereby providing a potentially safer environment for hospital patients, health care workers (HCWs), and visitors."
Schmidt et al, 2013 (33)	United States	NR-C	75 beds in ICUs rooms	I: Copper surfaces in bed rails C: Regular surfaces	The mean microbial burden (mMB), determined as colony forming units (CFU)/100cm^2	"Copper-alloyed surfaces offer a continuous way to limit and/ or control the environmental burden. Hospital and environmental services need not perform additional steps, follow complex treatment algorithms, obtain "buy-in" from other providers, or require additional training or oversight."
Schmidt et al, 2016 (34)	Chile	NR-C	8 rooms from the ICU (PICU) and 8 rooms from the intermediate care unit (PIMCU), Roberto del Rio, Santiago	I: Copper surfaces in high-touch surfaces C: Regular surfaces	CFU/100 cm^2	"Copper surfaces warrant serious consideration when contemplating the introduction of no-touch disinfection technologies for reducing burden to limit acquisition of HAIs."

Study	Country	Design	Population and setting	Intervention and Control	Outcome measure	Author's conclusion
von Dessauer et al, 2016 (28)	Chile	NR-C	8 rooms from the ICU (PICU) and 8 rooms from the intermediate care unit (PIMCU), Roberto del Rio, Santiago	I: Copper surfaces in high-touch surfaces C: Regular surfaces	Diagnosis of an HAI event associated with patient stay within the PICU or PIMCU Safety	"Exposure of pediatric patients to copper-surfaced objects in the closed environment of the intensive care unit resulted in decreased HAI rates when compared with noncopper exposure; however, the RRR was not statistically significant. The clinical effect size warrants further consideration of this intervention as a component of a systems-based approach to control HAIs."
Marais et al, 2010 (35)	South Africa	NR-C	Two consulting rooms in a rural region of the Western Cape, South Africa.	I: Copper sheets on touch surfaces C: Regular surfaces	Mean CFU/100cm^2 reduction	"The study showed that the antimicrobial activity of copper touch surfaces reduced environmental bioburden to a far greater extent than standard materials and would be beneficial in the healthcare environment."

NR-C: Nonrandomized, controlled study CO: Crossover

RCT: Randomize Controlled Trial B/A: Before and after study CFU: Colony forming units

Return to TABLE OF CONTENTS

ORIGINAL ARTICLE

Aseptic techniques for labour epidurals: A survey and review of neuraxial anesthesia practice

Caitlyn Hui, BSc,* **Ramesh Varadharajan**, MD,* **Amir Yousefzadeh**, MD,* **Sharon Davies**, MD,* **Naveed T Siddiqui**, MD*

** Department of Anesthesia and Pain Management, Mount Sinai Hospital, University of Toronto, Ontario, Canada*

Address for correspondence:

Naveed T Siddiqui,
Department of Anesthesia and Pain Management, Mount Sinai Hospital, University of Toronto, 600 University Avenue, Toronto M5G1X5, Ontario, Canada.
Phone: 416-586-5270 Fax: 416-586-8664
Email: naveed.siddiqui@uhn.ca

ABSTRACT

Background: Aseptic technique is essential for the prevention of infection during labour epidural procedures. The literature suggests there is significant variability in aseptic practice among clinicians which often depends on personal beliefs rather than scientific evidence. The main objective of this survey was to determine which components of aseptic precautions in labour epidural anesthesia were considered essential by anesthesiologists.

Methods: A self-administered questionnaire regarding commonly used aseptic techniques during epidural insertion was distributed via regular mail to 1047 practicing anesthesiologists in Ontario, Canada. Questions were formulated with assistance from community and university based obstetrical anesthesiologists. The survey focused on practice demographics, methods of asepsis during preparation, and aseptic technique during epidural insertion.

Results: The response rate for this survey was 42% (40% were non-teaching and 60% academic physicians). The major findings revealed significant heterogeneity; 38% of respondents wore a sterile gown, 68% selected chlorhexidine gluconate as their ideal antiseptic, 32% used povidone iodine, and 78% did not consider the use of a filter needle essential to aseptic practice. Furthermore, while all respondents acknowledged hand-washing essential to aseptic practice, high variability regarding details of hand-washing technique was evident between individuals. Significant differences in aseptic practice were also observed between non-teaching and teaching hospitals.

Conclusion: Aseptic technique for labour epidural insertion varies among individuals and institutions.

KEY WORDS

Aseptic, labor, epidural, anesthesia

INTRODUCTION

Asepsis is critical to the performance of epidural anesthesia in the prevention of contamination and associated complications. Although obstetric complications due to labour epidurals are rare, the resulting outcomes are often catastrophic and can result in serious morbidity or mortality (1-3). In response to the severity of these complications, published standards of care for aspetic technique during insertion of an epidural catheter on the labour floor exist; however, rates of adherence to such guidelines are not well known. Furthermore, the components of sterile technique considered essential are controversial amongst physicians.

There are few published guidelines for practice of aseptic techniques during epidural placement (2). However, local practice and adherence to different components of aseptic techniques is not known. Breaches in sterile technique by the anesthesiologist during spinal or epidural placement can be a source of infection. Similarly, bacteria can be introduced into the epidural space from distant sites such as the vaginal tract via the blood stream or from patient skin or other human factors (4,5). The sources of infection related to the technical aspects of the epidural insertion include contaminated equipment or solutions before or during the initiation of the anesthetic block or tracking of organisms, such as skin contaminants, along the catheter site (6). Taken together, these facts underscore the importance of meticulous attention to aseptic technique.

In light of emerging data, several published reports have expressed concerns regarding the practice of proper aseptic technique and adherence to standardized protocols. For example, in July 2006, the American Society of Regional Anesthesia (ASRA) published guidelines for aseptic technique for neuraxial anesthesia, but recognized there was a paucity of supporting evidence at the present time (7). Recently, in 2014, the Association of Anaesthetists of Great Britain and Ireland published concise guidelines regarding skin antisepsis for central neuraxial blockade (8). Similarly, it has generally been assumed that during the teaching of invasive technical skills such as epidural insertion, improvement in aseptic technique parallels improved technical skills and manual dexterity. However, in a study conducted in our institution we found that manual skills for epidural insertion improved with increasing experience, but aseptic technique

Acknowledgement

Financial support and sponsorship: This work was supported by the Department of Anesthesia and Pain Management Mount Sinai Hospital.

Conflicts of interest: For all authors, none were declared.

did not (9). Therefore, before improvements in clinical practice can occur and standards of care are developed, we believe that there is a need to determine what physicians currently believe are the essential components of aseptic precautions during the performance of labour epidural anesthesia.

The goals of this study, therefore, were to establish which components of aseptic precautions are considered essential by physicians. With this data, we aimed to assess physician adherence to recommended aseptic technique. Furthermore, we aimed to determine whether differences in aseptic technique exist between non-teaching community and academic practice.

METHODS

Following REB approval (REB No. 08-0183-E) a survey regarding commonly used aseptic techniques during labour epidural insertion was distributed via regular mail to 1047 practicing anesthesiologists in Ontario, Canada. The participants mailing address were obtained from the College of Physicians and Surgeons of Ontario (CPSO). The survey included a pre-paid return envelope and a brief cover letter describing the purpose of the questionnaire. Participant confidentiality was maintained by coding each subject's response according to a specific number and their addresses were only used for distribution purposes.

The survey was designed in the form of a self-administered descriptive questionnaire. Items in the questionnaire were formulated with the help of experienced obstetrical anesthesiologists practicing in both community and university affiliated hospitals in Ontario. (Appendix 1). The questions aimed to highlight the experience and clinical practice of the individual anesthesiologist as well as determine the different methods used to maintain aseptic technique while performing labour epidurals.

Analysis

Completed survey results obtained from the questionnaire were analysed according to the responses. Means, proportions and percentages were calculated for the main categories. A secondary analysis comparing the practices between community and university hospitals was also completed utilizing a two-tailed Fisher's exact test with $p < 0.05$ considered as statistically significant. All statistics were calculated utilizing GraphPad Prism Software (Version 6).

RESULTS

The response rate for this survey was 42%. The respondents included 40% non-teaching community and 60% academic physicians. The majority of respondents were from academic institutions, with work experience of 5-10 years and a frequency of 1,000 to 4,000 epidural insertions at their hospitals (Table 1).

TABLE 1: Survey demographics

Responses (n=439/1047)	(Percentages)
Practice	
Community/teaching/both	40/60/0
Work Experience (<5, 5-10, >10 years)	18/46/38
Frequency of epidurals (<1000, 1-4000, >4000)	32/54/14
Preparation – Hand Cleaning	
With soap, extending up to the elbow x3 and sterile towel.	38
With soap, without extending up to elbows	60
With isopropyl alcohol	2
Don't consider hand wash at all	0
Removal of Jewelry	78
Wearing of a sterile gown	39
Wearing sterile gloves	100
Wearing a surgical hat and a fresh face mask	91
Short nails	69
Anti-septic solutions	
Chlorhexidine with alcohol	68
Povidine Iodine	32
Use a filter needle	22
Use of sterile drapes/towels	98
Number of support persons in the room	
One support person	78
More than one support person	12
No support person	10
Patient to wear an operating room hat	46

Return to TABLE OF CONTENTS

There was a heterogeneous practice with respect to the wearing of sterile gowns, the type of antiseptic preparation solution, and the use of a filter needle for drawing local anesthetic solutions (Table 1). Specifically, only 39% wore a sterile gown, 68% selected chlorhexidine gluconate as their ideal antiseptic, 32% used povidone iodine, and 78% of physicians did not consider the use of a filter needle essential to aseptic practice. Furthermore, although 100% of physicians considered hand cleaning essential, there was significant variation regarding the protocol utilized; 38% of respondents washed their hands and forearms up to the elbow with soap and dried with a sterile towel while 60% of respondents washed their hands with soap without extending up to the elbows and did not use the sterile towels. An additional 2% of respondents acknowledged washing their hands with isopropyl alcohol (Table 1). In contrast, little to no variation was observed amongst physicians in terms of using sterile gloves (100%), a surgical hat/fresh face mask (91%) and sterile drapes/towels (98%).

In addition to comparing Ontario anesthesiologists, significant differences were observed between academic and non-teaching community hospitals with respect to aseptic technique during epidural preparation and antiseptic solutions. Of the 38% of respondents that washed their hands with soap extending up to the elbow, the majority were from teaching hospitals rather than community (34% versus 4%, $p < 0.0001$). In contrast, 1.7% of the 2% of respondents that washed their hands with isopropyl alcohol were also from community hospitals ($p < 0.0001$, Table 2). Regarding antiseptics, the majority of the respondents that utilize chlorhexidine gluconate were from academic hospitals (84%), while 9% ($p < 0.0001$) of the physicians utilizing povidone iodine were from academic hospitals. Academic hospitals also had a significantly higher proportion of physicians utilizing filter needles [(18% of the 22% respondents), $p < 0.0001$].

No significant differences were observed between academic and community hospitals regarding the number of support persons in the room, removal of jewelry, short nails, and the wearing of a sterile gown, surgical hat and fresh face mask. Almost all anesthesiologists answered yes to wearing a surgical hat and fresh face mask and the use of a sterile drape; however, 31% of respondents did not consider short nails to be essential practice and 22% of respondents did not remove jewellery (Table 2).

DISCUSSION

Our study revealed significant variation in aseptic practice amongst Ontario anaesthesiologists with respect to gowning, the antiseptic solution used for skin preparation, and filter needles for local anaesthetic withdrawal. Furthermore, while all 439 respondents acknowledged sterile gloves and hand cleaning as essential aseptic practices, significant differences existed in hand cleaning techniques before performing labour epidurals.

"Aseptic precautions" is an umbrella term encompassing all aspects of aseptic technique. While this term lacks a comprehensive definition, several components of aseptic precautions are commonly considered routine within institutions (8) and typically encompass both the preparation for and performance of the procedure. We chose to survey each individual component of aseptic precautions, as a breech in sterility of any

TABLE 2: Non-teaching community versus academic institutions comparisons

Responses (n=439/1047)	Community physicians (%)	Academic physicians (%)	P Value (Fisher's Exact Test, P < 0.05)
Preparatory Antiseptic Steps			
With soap, extending to elbow x2 and sterile towel	11	89	$p < 0.0001$
With soap, without extending to elbow	60	40	
With isopropyl alcohol	85	15	$p < 0.0001$
Removal of jewelry	49	51	$p = 0.87$
Wearing of a sterile gown	41	59	$p = 0.17$
Wearing of sterile gloves	40	60	$p = 0.0071$
Wearing of surgical hat/fresh mask	43	57	$p = 0.068$
Short nails	49	51	$p = 1.00$
Anti-Septic Solutions and Procedural Antisepsis			
Chlorhexidine gluconate	16	84	$p < 0.0001$
Povidone Iodine	91	9	
Use of a filter needle	18	82	$p < 0.0001$
Use of sterile drapes/towels	39	61	$p = 0.0026$
Number of Support Persons in room			
1 support person	41	59	$p = 0.88$
> 1 support person	33	67	
No support person	40	60	

step has the potential to cause epidural catheter colonization. Our questionnaire was designed to include all the major steps of aseptic technique recommended while administering an epidural in addition to examining differences in practice between teaching and non-teaching community hospitals.

Sterile gowns are considered a method to prevent cross-contamination between patients and healthcare providers by blocking the exchange of infectious material. However, recent studies suggest that the use of gowns may not reduce infection or mortality rates (10,11). For instance, a study conducted by Siddiqui et al found no difference in epidural catheter colonization between gowned and ungowned practitioners. The researchers attributed the low incidence of colonization rates without gowns (<10%) to the overall sterile precautions undertaken, unlike previous studies that indicated a colonization rate in excess of 50% (6). In this survey, 39% (n = 171) of respondents considered gowns essential aseptic practice while performing an epidural.

Variability among responses was also observed for antibacterial skin preparation, an essential step prior to the performance of any invasive procedure. Some of the most commonly used antiseptics are 0.5-2% chlorhexidine gluconate and povidone iodine. Chlorhexidine gluconate has been shown to have a very long-term efficacy. When combined with isopropyl alcohol, clinical studies show accelerated bactericidal effects with a greater degree of potency (11). In contrast, povidone iodine has a delayed onset of action (several minutes) and limited duration in effect, often requiring reapplication every 24 hours to maintain antimicrobial activity (4,13). Consequently, a combination of chlorhexidine gluconate and isopropyl alcohol is considered a near ideal skin disinfectant. In general, the respondents of our survey reflect these views. While some variation did exist, the majority of total respondents (68%) selected chlorhexidine gluconate as their ideal antiseptic.

Regarding the use of filter needles, variation amongst respondents was observed. Bacterial filters are recommended to prevent foreign material from gaining access to the epidural space and to filter bacteria present within the perfusing solution (4). Any particulate matter injected in the epidural space can provoke an inflammatory reaction, putting the patient at risk of serious complications. Specifically, needles with a 5 μm filter at the catheter hub are recommended when withdrawing solutions from a multi dose vial through a rubber stopper (14). Despite these recommendations, only 22% of respondents acknowledged using filter needles as essential to aseptic practice. This variability amongst anesthesiologists may reflect the lack of scientific evidence supporting the use of filter needles, in addition to the problem of widespread availability of filter needles.

No significant differences were observed between Ontario anesthesiologists regarding use of sterile drapes and sterile gloves. Self-adhesive fenestrated large drapes with a centre hole for regional techniques are currently considered standard practice (9,15). Moreover, covering the skin puncture site with either a tight occlusive dressing or a fixation device before removing the drape is recommended as studies indicate that epidural catheter colonization is largely due to microbial organisms from the skin (16,17). In this survey, 98% of respondents considered sterile drapes/towels essential aseptic practice. Likewise, consistent with current recommendations, 100% of respondents acknowledged wearing sterile gloves while performing epidural anesthesia.

WHO guidelines consider proper hand hygiene the most important aspect in the prevention of cross-contamination between healthcare providers and their patients (18). Hand hygiene aseptic techniques vary, ranging from basic soap and water to alcohol-containing solutions. Antiseptic solutions combined with an alcohol compound have been shown to result in significantly slower rates of bacterial regrowth (19,20). Therefore, it is currently recommended that healthcare providers utilize an alcohol-based antiseptic solution, in addition to soap and water, for maximal bactericidal effect. Based on the survey results, 100% of respondents considered hand cleaning an essential aseptic practice. However, the majority of respondents did not partake in the use of alcohol-based antiseptic solution in addition to hand cleaning, nor did they extend the scrub up to the elbows. Central to the principle of extending hand cleaning to the elbows is the concept of bacterial fallout from the forearms as a potential source of contamination of the equipment and sterile field below. There is, however, a lack of scientific evidence regarding the best practices of handwashing, especially for short term regional anesthesia techniques, highlighting the need for further research.

The variations in the anesthesiologists responses that were observed in our survey are similar to those in an Australian survey of obstetrical anaesthesiologists. Similar to our results, Sellor et al observed wide variation in practice of what was considered essential aseptic precautions, reflecting a lack of scientific data to support the comprehensive practice of aseptic techniques as a whole (5). Although small differences were observed between the two studies, for example, Sellor found that fresh face masks were not considered aseptic practice by 29% of respondents while only 9% of our respondents did not use fresh face masks, such variation is likely due to the fact that they conducted their survey before ASRA published aseptic guidelines for epidural insertions.

Finally, significant differences were observed between institutions when comparing the aseptic practice of teaching versus non-teaching community hospitals. Notably, physicians within academic hospitals reported significantly higher rates of handwashing with soap and extending to the elbow, wearing sterile gloves, utilizing chlorhexidine gluconate as the primary antiseptic solution, employing a filter needle, and using sterile drapes. Physicians from community hospitals had a significantly greater proportion of individuals washing their hands with isopropyl alcohol and selecting povidone iodine as their antiseptic of choice.

Overall, our results reflect significant variation from published guidelines on asepsis. While the most recent guidelines suggest cap, mask, sterile gown, gloves, and a sterile drape as barrier precautions, this practice is not currently consistent amongst all antesthiologists. Furthermore, it is recommended that

chlorhexidine in alcohol be used for skin antisepsis following thorough handwashing; however, only a small percentage of respondants engage in this practice. Such deviations from current guidelines may be a reflection of the timing at which this survey took place.

One of the limitations of our study include physicians' abilities to self reflect on aseptic technique. Although items in the questionnaire were designed to accurately gauge physicians' practice, self-reporting may not reflect a true picture.

Epidural anesthesia for labour carries an increased risk of a breech in sterility during the procedure for several reasons. First, labour epidurals are performed in a delivery room on the obstetric floor – a more vulnerable environment for infectious complications compared to an operating room. Second, these procedures are often performed in urgent situations or the request for epidural occurs late in a patient's labour. Such time constrictions may result in lapses in aseptic precautions and less precise technique. Fortunately, since obstetrical patients are typically young and healthy, infectious complications are not as common in this population as compared to others. However, we cannot assume that all parturients have the immunity to protect against lapses in aseptic technique and infectious complications can result in serious, life-threatening conditions, including meningitis, permanent nerve damage, and in severe cases, death (4). Considering the variability observed in this study between both individual anesthesiologists and institutions, evidence based guidelines are necessary for all steps of epidural catheterization, starting from the preparation to the procedure itself. This will ensure more rigid aseptic technique in order to better protect the obstetric population from infectious complications. Knowing the practice among the anaesthesiologists in performing labour epidurals will not only point out the areas of concern, but also help to take vital initial steps in either formulating, updating and enforcing the much-needed aseptic guidelines.

CONCLUSION

Our results suggest the practice of aseptic technique for labour epidural insertion currently varies among individual physicians. Furthermore, there is a lack of consensus between academic and non-teaching community hospitals as to the essentials of aseptic practice.

REFERENCE

1. Moen V, Dahlgren N, Irestedt L. Severe neurological complications after central neuraxial blockades in Sweden 1990-1999. Anesthesiology 2004; 101: 950-9.
2. Siddiqui N, Friedman Z, McGeer A, Yousefzadeh A, Carvalho JC, Davies S. Optimal hand washing technique to minimize bacterial contamination for neuraxial anesthesia: a randomized control trial. Int J Obstet Anesth. DOI: *http://dx.doi.org/10.1016/j.ijoa.2016.09.006*. Accessed October 6, 2016.
3. D'Angelo R, Smiley RM, Riley ET, Segal S. Serious complications related to obstetric anesthesia: the serious complication repository project of the Society for Obstetric Anesthesia and Perinatology. Anesthesiology 2014; 120: 1505-12.
4. Hebl JR. The importance and implications of aseptic techniques during regional anesthesia. Reg Anesth Pain Med 2006; 31: 311-23.
5. Sellors JE, Cyna AM, Simmons SW. Aseptic precautions for inserting an epidural catheter: a survey of obstetric anaesthetists. Anaesthesia 2002; 57: 593-6.
6. Siddiqui NT, Davies S, McGeer A, Carvalho JC, Friedman Z. The effect of gowning on labor epidural catheter colonization rate: a randomized controlled trial. Reg Anesth Pain Med 2014; 39: 520-4.
7. Hebl JR, Neal JM. Infectious complications: a new practice advisory. Reg Anesth Pain med 2006; 31: 289-90.
8. Association of Anaesthetists of Great Britain and Ireland, Obstetric Anaesthetists' Association; Regional Anaesthesia UK; Association of Paediatric Anaesthetists of Great Britain and Ireland, Campbell JP, Plaat F, et al. Safety guideline: skin antisepsis for central neuraxial blockade. Anaesthesia 2014; 69: 1279-86.
9. Friedman Z, Siddiqui N, Katznelson R, Devito I, Davies S. Experience is not enough: repeated breaches in epidural anesthesia aseptic technique by novice operators despite improved skill. Anesthesiology 2008; 108: 914-20.
10. Pelke S, Ching D, Easa D, Melish ME. Gowning does not affect colonization or infection rates in a neonatal intensive care unit. Arch Pediatr Adolesc Med 1994; 148: 1016-20.
11. Slaughter S, Hayden MK, Nathan C, et al. A comparison of the effect of universal use of gloves and gowns with that of glove use alone on acquisition of vancomycin-resistant enterococci in a medical intensive care unit. Ann Intern Med 1996; 125: 448-56.
12. Maki DG, Ringer M, Alvarado CJ. Prospective randomised trial of povidone-iodine, alcohol, and chlorhexidine for prevention of infection associated with central venous and arterial catheters. Lancet 1991; 338: 339-43.
13. Humar A, Ostromecki A, Direnfeld J, et al. Prospective randomized trial of 10% povidone-iodine versus 0.5% tincture of chlorhexidine as cutaneous antisepsis for prevention of central venous catheter infection. Clin Infect Dis 2000; 31: 1001-7.
14. James FM, George RH, Naiem H, White GJ. Bacteriologic aspects of epidural analgesia. Anesth Analg 1976; 55: 187-90.
15. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol 1999; 20: 250-78.
16. Sato S, Sakuragi T, Dan K. Human skin flora as a potential source of epidural abscess. Anesthesiology 1996; 85: 1276-82.
17. Tumber SS, Liu H. Epidural abscess after multiple lumbar punctures for labour epidural catheter placement. J Biomed Res 2010; 24: 332-5.
18. Allegranzi B, Storr J, Dziekan G, Leotsakos A, Donaldson L, Pittet D. The First Global Patient Safety Challenge "Clean Care is Safer Care": from launch to current progress and achievements. J Hosp Infect 2007; 65: 115-23.
19. Boyce JM, Pittet D. Boyce JM, Pittet D; Healthcare Infection Control Practices Advisory Committee; HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Guideline for Hand Hygiene in Health-Care Settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee an HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Society for Healthcare Epidemiology of America/ Association for Professionals in Infection Control/Infectious Diseases Society of America. MMWR Recomm Rep 2002; 51: 1-45.
20. Silvestri L, Petros AJ, Sarginson RE, de la Cal MA, Murray AE, van Saene HK. Handwashing in the intensive care unit: a big measure with modest effects. J Hosp Infect 2005; 59: 172-9.

APPENDIX 1: The questionnaire

Section – 1 (Practice)

1. How long have you been practicing as an anesthesiologist independently?
   a) Less than 5 yrs
   b) 6-10 yrs
   c) More than 10yrs

3. How many labor epidurals do you perform/supervise in a week?
   a) Less than 10
   b) 10-20
   c) More than 20

4. Where do you practice?
   a) University teaching hospital
   b) Non-teaching community Hospital
   c) Both

5. How many epidurals are performed at your centre per year?
   a) Less than 1,000
   b) 1,000-4,000
   c) More than 4,000

Section – 2 (Preparation)

6. How do you wash your hands before performing epidurals?
   a) With soap up to elbow and pat dry with sterile towel.
   b) With soap without extending up to elbows.
   c) With Isopropyl Alcohol (prior donning sterile gloves).
   d) Don't consider hand wash at all.

7. Which of the following do you practice while performing epidural?
   a) Remove jewelry such as rings, wrist watches, bracelets, etc.
   b) Wear a sterilized gown.
   c) Wear sterile gloves.
   d) Wear a surgical hat and a fresh face mask.
   e) Keeping short nails as essential component of proper aseptic technique.

Section – 3 (Technique)

8. Which of the following is supplied in your epidural tray?
   a) Local anesthetic
   b) Sterile prep solution
   c) None

9. What do you use for skin prep?
   a) Pre-packed single application prep sticks
   b) Multiple use prep-solution bottles.

10. Which anti-septic solutions do you use?
    a) Chlorhexidine Gluconate and Isopropyl Alcohol
    b) Povidine Iodine
    c) Combination of Povidine Iodine and Chlorhexidine Gluconate.

11. Do you routinely use a filter needle for drawing local anesthetic solutions for:
    a) Epidural
    b) CSE
    c) Spinal
    d) Top ups

12. Does your kit contain sterile drapes?
    a) Yes and I apply it to patients' back to isolate the sterile field
    b) Yes, but I don't I apply it to patients' back to isolate the sterile field.
    c) No, but I make sure to create a sterile field with the help of sterile towels.
    d) No, and I don't create a sterile field with the help of sterile towels.

13. To secure and maintain the cleanliness at the insertion site, do you use:
    a) Sterile fixation device.
    b) Sterile opsite or similar dressing
    c) Sterile gauze with adhesive tape.
    d) Adhesive tape only.

14. For labor epidurals with the exception of nurses and trainees, do you have a limit for number of support person in the room?
    a) I allow only one support person in the room.
    b) I allow more than one support person in the room.
    c) I don't allow any support person in the room.

15. Do you require all support individuals present in the room to wear:
    a) OR hat
    b) Fresh facemask
    c) both
    d) neither
    e) not applicable

16. Do you require the patient to wear an operating room hat?
    a) Yes
    b) No

Return to TABLE OF CONTENTS

ORIGINAL ARTICLE

Device-associated infection rates in Intensive Care Units of five cities of the Kingdom of Saudi Arabia: International Nosocomial Infection Control Consortium (INCC) findings

Hail M. Al-Abdely,[1] **Areej Dhafer Alshehri**,[1] **Victor Daniel Rosenthal**,[2] **Weam Banjar**,[1] **Yassir Khidir Mohammed**,[1] **Abdullah Mufareh Assiri**,[1] **Analen Fabros Cabato**,[3] **Jerlie Mae Gonzales Celiz**,[3] **Mohammed Abdullah Al Raey**,[3] **Hessa Abdullah Al Enizy**,[4] **Nahla Moustafa Abedel Kader**,[5] **Diaa Abdullah Mohammed**,[6] **Duaa Khalil Al-Awadi**,[7] **Maria Wasbourne**,[1] **Randa Saliya**,[1] **Ibrahim A.M. Al-Zaydani Asiri**,[3] **Saeed Ali Aldarani**,[3] **Elizabeth Laungayan Cortez**,[3] **Nadia Lynette Demaisip**,[3] **Misbah Rehman Aziz**,[3] **Apsia Musa Molano**,[4] **Celia Flores Baldonado**,[4] **Arlu Marie Casuyon Pahilanga**,[4] **Rosita Gasmin Aromin**,[4] **Evangelina Balon Ubalde**,[4] **Sharifa Al Atawi**,[4] **Rosita Gasmin Aromin**,[5] **Evangelina Balon Ubalde**,[5] **Nahla Abdel Kader**,[5] **Modhi Abdullah Alkamaly**,[5] **Nawal Mohammed Alanazi**,[5] **Ibtesam Yahia Hassan Assiry**,[5] **Deepa Sasithran Nair**,[6] **Grace Sindayen**,[6] **Annalyn Amor Malificio**,[6] **Syed Zahid Bukhari**,[7] **Roaa Hasan Basri**,[7] **Duaa Khalil al-Awadi**,[7] **Jeyashri Jaji Mushtaq**[7]

[1]*General Directorate of Prevention and Infection Control, Ministry of Health, Riyadh, Saudi Arabia*
[2]*International Nosocomial Infection Control Consortium (INICC), Buenos Aires, Argentina*
[3]*Assir Central Hospital, Assir, Saudi Arabia*
[4]*King Khalid Hospital, Tabuk, Saudi Arabia*
[5]*King Khalid Hospital, Najran, Saudi Arabia*
[6]*King Abdulaziz Specialist Hospital, Taif, Saudi Arabia*
[7]*Hera General Hospital, Makkah, Saudi Arabia*

Corresponding author:

Victor Daniel Rosenthal
11 de Septiembre 4567, Floor 12, Apt 1201
Buenos Aires, ZIP 1429, Argentina
Phone: 54-11-4704-7227
E-mail address: victor_rosenthal@inicc.org
Website: www.inicc.org

ABSTRACT

Background: This report summarizes the results of the International Nosocomial Infection Control Consortium (INICC) study conducted in five cities of the Kingdom of Saudi Arabia from September 2013 through March 2015.

Methods: We utilized an online surveillance system in a prospective, cohort study of device-associated healthcare-associated infections (DA-HAI) in seven adult and pediatric intensive care units (ICUs) of five hospitals. The study applied CDC/NHSN criteria and definitions, using INICC Surveillance Online System.

Results: Data was collected from 4,551 ICU patients for 30,041 bed-days. In the Medical/Surgical ICUs, the central-line associated bloodstream infection (CLABSI) rate was 4.5 per 1,000 central line (CL)-days; the ventilator-associated pneumonia (VAP) rate was 7.5 per 1,000 mechanical ventilator (MV)-days; and the catheter-associated urinary tract infection (CAUTI) rate was 4.7 per 1,000 urinary catheter (UC)-days. The rates were statistically significantly higher compared to CDC/NHSN rates (0.8 [CLABSI]; 1.1 [VAP]; and 1.3 [CAUTI]), whereas in comparison with INICC rates (4.9 [CLABSI]; 5.3 [CAUTI]; 16.5 [VAP]), CLABSI and CAUTI rates did not attain statistically significant difference and VAP rate was statistically significantly lower. With the exception of CL DUR in the pediatric ICUs, device utilization ratios were higher than INICC and CDC/NHSN's. Excess length of stay was 14.8 days for patients with CLABSI, 17.5 for patients with VAP and 22.1 for patients with CAUTI. Excess mortality was 38.4% for CLABSI, 31.8% for VAP and 19.0% for CAUTI in adult and pediatric ICUs.

Conclusions: DA-HAI rates found in the study are higher than CDC/NSHN reported rates and similar to or lower than INICC's.

KEY WORDS:

Saudi Arabia; hospital infection; antibiotic resistance; ventilator-associated pneumonia; catheter-associated urinary tract infection; central line-associated bloodstream infections.

Acknowledgments

The authors thank the many healthcare professionals at each member hospital who assisted with the conduct of surveillance in their hospital; Débora López Burgardt, who works at INICC headquarters in Buenos Aires, and the INICC Advisory Board, Country Directors and Secretaries (Hail M. Alabdaley, Yassir Khidir Mohamed, Safaa Abdul Aziz AlKhawaja, Amani Ali El-Kholy, Aamer Ikram, Vineya Rai, María Isabel Villegas Mota, Souha S. Kanj, Hakan Leblebicioglu, Yatin Mehta, Bijie Hu, Lul Raka, Najiba M Abdulrazzaq, Sergio Cimerman, Alfonso J. Rodríguez-Morales, Sofía del Carmen González Collantes, Javier Eduardo Desse, Hernán Diosnel Rodríguez Enciso, Nguyen Viet Hung, Wing Hong Seto, Anucha Apisarnthanarak, Toshihiro Mitsuda, Syed Sattar, William Rutala, William R. Jarvis, Russell N. Olmsted, Carla J. Alvarado, Catherine Murphy, Dennis Maki, Nicholas Graves, Patricia Lynch and Didier Pittet), who have so generously supported this unique international infection control network.

INTRODUCTION

Device-associated healthcare-acquired infections (DA-HAIs) are considered one of the principal threats to patient safety in the intensive care settings and are among the main causes of patient morbidity and mortality, particularly in limited-resource parts of the world (1, 2).

Available evidence indicates that DA-HAI surveillance programs may have a positive impact on reducing healthcare-acquired infection rates and healthcare costs (3). Linking the DA-HAI causative microorganisms to their antimicrobial susceptibility is essential to minimize development of resistant strains (4). In the same way, it is fundamental to address the burden of antimicrobial-resistant infections and report pathogens and susceptibility to antimicrobials of DA-HAI-associated pathogens, so that informed decisions can be made to effectively prevent transmission of strain phenotypes with very few available treatments options (4).

For more than 30 years, the U.S. the Centers for Disease Control and Prevention's National Healthcare Safety Network (CDC/NHSN) has provided benchmarking U.S. intensive care unit (ICU) data on DA-HAIs, which have proven invaluable for researchers (5).

The International Nosocomial Infection Control Consortium (INICC) is an international non-profit, open, multi-centre, collaborative healthcare-associated infection control program with a surveillance system based on that of the CDC/NHSN, (5) using the INICC Surveillance Online System (ISOS) (6-8). INICC is comprised of more than 2,000 hospitals in 500 cities of 66 countries from Latin America, Europe, Eastern Mediterranean, Southeast Asia, and Western Pacific (World Health Organization regions) and is currently the only source of aggregate standardized data on the epidemiology of healthcare-associated infections (HAIs) worldwide (9). INICC goals are to create a dynamic global network of hospitals worldwide and conduct surveillance of DA-HAIs and SSIs using standardized definitions and established methodologies, and reduce DA-HAI rates worldwide (10).

This report is a summary of data on DA-HAIs collected using ISOS, between September 2013 and March 2015 in 7 ICUs in 5 hospitals in the Kingdom of Saudi Arabia (6, 7).

METHODS

Setting and study design

This prospective cohort surveillance study was conducted in 7 ICUs of 5 hospitals in five different cities of the Kingdom of Saudi Arabia, through the implementation of the INICC Multidimensional Approach (IMA), as described below.

The types of ICUs participating in this study were as follows: one coronary, five medical/surgical and one pediatric.

TABLE 1: Pooled means of rates of central line-associated bloodstream infection, ventilator-associated pneumonia, and catheter-associated urinary tract infections and utilization ratios, by type of location, adult and pediatric patients

Type of ICU	ICU, n	Patients, n	Bed days	CL days, n	DUR, CL (95% CI)	CLABSI, n	CLABSI rate	MV days, n	DUR, MV (95% CI)	VAP, n	VAP rate	UC days, n	DUR, UC (95% CI)	CAUTI, n	CAUTI rate
Coronary	1	975	4,160	339	0.08 (0.07 - 0.09)	2	5.9	198	0.05 (0.04 - 0.05)	1	5.1	927	0.22 (0.21 - 0.24)	3	3.2
Medical/ Surgical	5	3,337	24,629	17,925	0.73 (0.72 - 0.73)	81	4.5	20,776	0.84 (0.84 - 0.85)	156	7.5	20,675	0.84 (0.83 - 0.84)	98	4.7
Pediatric	1	239	1,252	506	0.40 (0.38 - 0.43)	6	11.9	731	0.58 (0.56 - 0.61)	8	10.9	494	0.39 (0.37 - 0.42)	0	0.0
Pooled	7	4,551	30,041	18,770	0.62 (0.62 - 0.63)	89	4.7	21,705	0.72 (0.72 - 0.73)	165	7.6	22,096	0.74 (0.73 - 0.74)	101	4.6

ICU, intensive care unit; CL, central line; CLABSI, central line-associated bloodstream infection; MV, mechanical ventilator; VAP, ventilator-associated pneumonia; UC, urinary catheter; CAUTI, catheter-associated urinary tract infection; * DA-HAI rates are expressed as healthcare-associated infections per 1000 device-days; DUR, device utilization ratio; CI, confidence interval.

TABLE 2: Pooled means of crude mortality, crude excess mortality, length of stay, and crude excess Length of stay, of adult and pediatric intensive care unit patients with and without device-associated healthcare-acquired infection

Patients	Patients, n	Deaths, n	Pooled crude mortality, %	Pooled crude excess mortality, % (95% CI)	LOS, total days	Pooled average LOS, days	Pooled average excess LOS, days (95% CI)
Without DA-HAI	4,289	759	17.7		23,288	5.4	1.0
With CLABSI	41	23	56.1	38.4 (23.2 - 52.7)	830	20.2	14.8 (13.5 - 16.2)
With CAUTI	49	18	36.7	19.0 (6.9 - 32.8)	1,350	27.6	22.1 (20.7 - 23.6)
With VAP	95	47	49.5	31.8 (22.5 - 41.1)	1,665	17.5	12.1 (11.3 - 12.9)

ICU, intensive care units; CI, confidence interval; DA-HAI, device-associated healthcare-acquired infection; CLABSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract infection; LOS, length of stay; CI, confidence interval.

Return to TABLE OF CONTENTS

We collected denominator data, patient-days and specific device-days to calculate DA-HAI rates per 1000 device-days. Prospective data using INICC patient detailed forms were used to calculate excess mortality and length of stay (LOS).

The infection control professionals (ICPs) had previous experience conducting surveillance of DA-HAIs.

In accordance with the INICC's Charter, the identity of all hospitals and cities is kept confidential. Due to the fact that this was an epidemiological surveillance study, which did not include tests of experimental drugs, biomedical devices or products, and that patient data were anonymized, an informed consent was not

TABLE 3: Benchmarking of device-associated healthcare-acquired infection and antimicrobial resistance rates in this report against the report of the International Nosocomial Infection Control Consortium (2007-2012) and the reports of the US Centers for Disease Control and Prevention's National Healthcare Safety Network Data (2013 and 2009-2010)

	This Report	INICC Report (2007-2012)(9)	CDC/NHSN Report (2013)(5)
Medical Surgical ICU			
CL, DUR	0.73 (0.72 – 0.73)	0.54 (0.54 – 0.54)	0.37
CLABSI rate	4.5 (3.6 – 5.6)	4.9 (4.8 – 5.1)	0.8
MV, DUR	0.84 (0.84 – 0.85)	0.36 (0.36 – 0.36)	0.24
VAP rate	7.5 (6.4 – 8.8)	16.5 (16.1 – 16.8)	1.1
UC, DUR	0.84 (0.83 – 0.84)	0.62 (0.62 – 0.62)	0.54
CAUTI rate	4.7 (3.8 – 5.8)	5.3 (5.2 – 5.8)	1.3
Pediatric ICU			
CL, DUR	0.40 (0.38 – 0.43)	0.50 (0.50 – 0.50)	0.45
CLABSI rate	11.9 (4.4 – 25.8)	6.1 (5.7 – 6.5)	1.2
MV, DUR	0.58 (0.56 – 0.61)	0.53 (0.53 – 0.53)	0.37
VAP rate	10.9 (4.7 – 21.6)	7.9 (7.4 – 8.4)	0.8
UC, DUR	0.39 (0.37 – 0.42)	0.31 (0.31 – 0.32)	0.21
CAUTI rate	0.0 (0.0 – 7.5)	5.6 (5.1 – 6.1)	2.5

Pathogen, antimicrobial	This Report Resistance %	INICC 2007-2012 Resistance % (9)	CDC/NHSN 2009-2010 Resistance % (4)
Staphylococcus aureus			
Oxacillin	60%	61.2%	54.6%
Enterococcus faecalis			
Vancomycin	0%	12.2%	9.5%
Pseudomonas aeruginosa			
Ciprofloxacine	23%	37.5%	30.5%
Piperacillin or piperacillin-tazobactam	25%	33.5%	17.4%
Amikacin	21.4%	42.8%	10.0%
Imipenem or meropenem	37.5%	42.4%	26.1%
Klebsiella pneumoniae			
Ceftriaxone or ceftazidime	60%	71.2%	28.8%
Imipenem or meropenem	30.4%	19.6%	12.8%
Acinetobacter baumanii			
Imipenem or meropenem	95.1%	66.3%	62.6%
Escherichia Coli			
Imipenem or meropenem	0%	8.5%	1.9%

ICU, intensive care unit; CLABSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract infection; DUR, device utilization ratio; INICC, International Nosocomial Infection Control Consortium; CDC/NSHN, Centers for Disease Control and Prevention National Healthcare Safety Network of the United States of America.

necessary according to the ethics committees that evaluated and approved the study.

INICC Surveillance Online System

INICC Surveillance Online System (ISOS) applies standard CDC/NSHN methods and definitions,(11) and also includes INICC methodology, collecting specific data per patient from all patients, both those with and those without HAI, collecting risk factors of HAIs, such as invasive devices, and surrogates of HAIs, which include, but are not limited to, fever, low blood pressure, results of cultures, antibiotic therapy, LOS and mortality. Collecting data on all patients in the ICU makes it possible to match patients with and without HAI by several characteristics.

Data collection and analysis

The ISOS follows the INICC protocol and ICPs and hospital epidemiologist, who collected daily data on central line-associated bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs) and ventilator-associated pneumonias (VAPs), and denominator data, patient-days and specific device-days in the ICUs. These data were uploaded to the ISOS, and were used to calculate DA-HAI rates per 1000 device-days, mortality and LOS, according to the following formulas: Device-days consisted of the total number of central line (CL)-days, urinary catheter (UC)-days, or mechanical ventilator (MV)-days. Crude excess mortality of DA-HAI equaled crude mortality of ICU patients with DA-HAI minus crude mortality of patients without DA-HAI. Crude excess LOS of DA-HAI equaled crude LOS of ICU patients with DA-HAI minus crude LOS of patients without DA-HAI. Device utilization ratio (DUR) equaled the total number of device-days divided by the total number of bed days.

Training

ICPs and hospital epidemiologists were trained by the INICC team during a two-day session in September 2013. Investigators were also provided with tutorial movies, manuals and training tools that described in detail how to perform surveillance and upload surveillance data through the ISOS. In addition, investigators assisted webinars, and had continuous access to a support team at the INICC headquarters in Buenos Aires, Argentina.

Statistical analysis

INICC Surveillance Online System (ISOS) version 2.0 (Buenos Aires, Argentina) was used to calculate HAI rates, device utilization, LOS and mortality. Relative risk (RR) ratios, 95% confidence intervals (CIs) and P-values were determined for primary and secondary outcomes using EpiInfoÒ version 6.04b (CDC, Atlanta, GA), SPSS 16.0 (SPSS Inc. an IBM company, Chicago, Illinois).

RESULTS

The length of hospitals' participation in the INICC Program was as follows: mean length of participation + SD, 17.4 + 4.6 months, range 6 to 19 months. For the Outcome Surveillance Component, DA-HAI rates, DURs ratios, crude excess mortality, crude excess LOS, by specific type of DA-HAI, microorganism profile and bacterial resistance from September 2013 through March 2015 are summarized in Tables 1 to 4.

Table 1 shows DA-HAI rates in all the participating ICUs and provides data on DURs for CL, UC and MV, and their respective confidence intervals. Central line DUR, mechanical ventilator DUR and urinary catheter DUR were statistically significantly higher in the Medical/Surgical ICUs.

Table 2 provides data on crude ICU mortality and crude LOS in patients hospitalized in each type of unit during the surveillance period, with and without DA-HAI, and crude excess mortality and crude excess LOS of adult and pediatric patients with CLABSI, CAUTI, and VAP. It was possible to calculate this data, because unlike standard CDC/NHSN methodology, which only collects data of devices and DA-HAI, by using ISOS INICC also collects LOS, mortality and several other outcomes.

Table 3 compares the results of DA-HAI rates and DURs in this report from the Kingdom of Saudi Arabia with the INICC international report for the period 2007-2012 and with the US CDC/NHSN report of 2013 (9, 12), and provides data on bacterial resistance of pathogens isolated from patients with DA-HAI in adult and pediatric ICUs, and compares the antimicrobial resistance rates of this report with the INICC international report for the period 2007-2012 and with the CDC/NHSN report of 2009-2010. Overall, CLABSI and CAUTI rates did not attain statistically significant difference in this study to the INICC data, although there was a statistically significantly lower VAP rate in this study compared to INICC. Compared to US CDC/NHSN data, all DA-HAI rates in this study were statistically significantly higher. DUR was higher in most cases as well, but the CL DUR in the pediatric ICUs was lower than the INICC and US CDC/NHSN reported data.

DISCUSSION

Scientific literature has indicated that the rates of reported DA-HAIs in Kingdom of Saudi Arabia's ICUs are higher than the rates reported by the U.S. CDC/NHSN (13). In a study published in 1995, the DA-HAI rates in Saudi Arabia were as follows: 6.4 VAP rate per 1,000 MV-days in the pediatric ICUs, 20.7 CLABSI rate per 1,000 CL-days, and 11.4 CAUTI rate per 1,000 UC-days in the medical ICU (13). Balkhy et al. showed that the most common health-care infections in Saudi Arabia were CLABSI, followed by VAP and CAUTI, while in this study the VAP was the most frequent infection. The excess LOS for health-care infection was 8 days or more in this study, which was less than the 12-22 days in this study (14). In a recent study conducted in a Pediatric ICU, the CLABSI rate was 20.1 per 1,000 CL-days, which was higher than the found 11.9 CLABSI rate in this type of ICUs (15). In another study conducted in an adult ICU from Saudi Arabia the CLABSI rate was 4.6 per 1,000 CL days, which was very similar to the 4.5 rate in this study's medical/surgical ICUs (16). The VAP rate in a different study in a pediatric ICU was 8.9 per 1,000 MV days, which was lower than this study's rate (10.9)(17).

In this study's ICUs, DA-HAI rates and pooled DU ratios did not attain statistical significance to or were statistically significantly lower than the Global INICC Report and higher than CDC/NHSN's data (5, 9). LOS and mortality were statistically significantly higher in patients with DA-HAI; it was possible to calculate this data, because unlike standard CDC/NHSN methodology, which only collects data of devices and DA-HAI, through the use of ISOS, LOS and mortality were also collected.

The percentages for *Enterococcus faecalis* as resistant to vancomycin, and *Escherichia Coli* as resistant to imipenem or meropenem, were lower in this study than in INICC and CDC/NHSN reports (4). On the other hand, the antimicrobial resistance percentages found in this study's ICUs were similar to the CDC/NHSN(4) and INICC reports (9) for *Staphyloccocus aureus* as resistant to oxacillin. By contrast, the resistance percentages for *Pseudomonas aeruginosa* were higher in this study than in U.S. CDC/NHSN's report (4), but similar to the INICC reported resistance (9).

These higher DA-HAI rates compared to CDC/NHSN may be due to the fact that even having evidence-based updated national infection control bundles, adherence of health care workers to infection control bundles might be irregular (18).

In order to reduce the hospitalized patients' risk of infection, DA-HAI surveillance and measurement of consequences, such as length of stay and mortality, are primary and essential, because it effectively describes and addresses the importance and characteristics of the threatening situation created by DA-HAIs.

The INICC program, in this particular study, focuses just on the ICUs; that is, healthcare settings with the highest HAI rates, in which patients' safety is most seriously threatened, due to their critical condition and exposure to invasive devices (18).

Through the last 12 years, INICC has undertaken a global effort in America, Asia, Africa, Middle East, and Europe to respond to the burden of DA-HAIs, and has achieved successful results, by increasing hand hygiene compliance, improving compliance with other infection control bundles and interventions as described in several INICC publications, and consequently reducing the rates of DA-HAI and mortality (11, 19-38).

To compare a hospital's DA-HAI rates with the rates identified in this report, it is required that the participating hospitals collect their data by applying the methodology described for CDC/NHSN and INICC, and then calculate infection rates and DURs for the DA-HAI Module.

The particular and primary application of these data is to serve as a guide for the implementation of prevention strategies and other quality improvement efforts locally for the reduction of DA-HAI rates to the minimum possible level.

Study limitations

The findings in this report did not consider the difference in time periods for the different data sources in the comparisons made with INICC and CDC/NHSN. Second, the member hospitals' laboratories had to be relied on to identify infecting pathogens and delineate bacterial resistance patterns, although different laboratories have varying levels of expertise and resource availability; however, similar concerns can be raised about any multi-institutional surveillance study. Third, the frequency of culturing and the use of other diagnostic tests were beyond the control of infection control programs; in hospitals where culturing and other laboratory testing is infrequent and suspected infections are treated empirically, the capacity of the surveillance program to detect most DA-HAIs is likely to be low.

CONCLUSIONS

DA-HAI continues to pose a public health threat that may affect the quality of healthcare service in the Kingdom of Saudi Arabia. There is a growing need to establish surveillance systems including monitoring compliance with intervention bundles, in order to continue reducing the burden of HAIs.

REFERENCES

1. Rosenthal VD, Lynch P, Jarvis WR, et al. Socioeconomic impact on device-associated infections in limited-resource neonatal intensive care units: findings of the INICC. Infection 2011;39:439-50.
2. Rosenthal VD, Jarvis WR, Jamulitrat S, et al. Socioeconomic impact on device-associated infections in pediatric intensive care units of 16 limited-resource countries: International Nosocomial Infection Control Consortium findings*. Pediatr Crit Care Med 2012;13:399-406.
3. Hughes JM. Study on the efficacy of nosocomial infection control (SENIC Project): results and implications for the future. Chemotherapy 1988;34:553-61.
4. Sievert DM, Ricks P, Edwards JR, et al. Antimicrobial-resistant pathogens associated with healthcare-associated infections: summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009-2010. Infect Control Hosp Epidemiol 2013;34:1-14.
5. Dudeck MA, Horan TC, Peterson KD, et al. National Healthcare Safety Network report, data summary for 2011, device-associated module. Am J Infect Control 2013;41:286-300.
6. Rasslan O, Seliem ZS, Ghazi IA, et al. Device-associated infection rates in adult and pediatric intensive care units of hospitals in Egypt. International Nosocomial Infection Control Consortium (INICC) findings. Journal of infection and public health 2012;5:394-402.
7. Rosenthal VD, Richtmann R, Singh S, et al. Surgical Site Infections, International Nosocomial Infection Control Consortium (INICC) Report, Data Summary of 30 Countries, 2005-2010. Infect Control Hosp Epidemiol 2013;34:597-604.
8. Rosenthal VD, Pawar M, Leblebicioglu H, et al. Impact of the International Nosocomial Infection Control Consortium (INICC) multidimensional hand hygiene approach over 13 years in 51 cities of 19 limited-resource countries from Latin America, Asia, the Middle East, and Europe. Infect Control Hosp Epidemiol 2013;34:415-23.
9. Rosenthal VD, Maki DG, Mehta Y, et al. International Nosocomial Infection Control Consortium (INICC) report, data summary of 43 countries for 2007-2012. Device-associated module. Am J Infect Control 2014;42:942-56.
10. Rosenthal VD. International Nosocomial Infection Control Consortium (INICC) resources: INICC multidimensional approach and INICC surveillance online system. Am J Infect Control 2016 Jun 1;44(6);e81-90.
11. Leblebicioglu H, Yalcin AN, Rosenthal VD, et al. Effectiveness of a multidimensional approach for prevention of ventilator-associated pneumonia in 11 adult intensive care units from 10 cities of Turkey: findings of the International Nosocomial Infection Control Consortium (INICC). Infection 2013;41:447-56.
12. Dudeck MA, Edwards JR, Allen-Bridson K, et al. National Healthcare Safety Network report, data summary for 2013, Device-associated Module. Am J Infect Control 2015;43:206-21.

13. Sobayo EI, Memish Z, Mofti A, Al-Mohaya S, Rotowa N. Device-day infection rates - a surveillance component system for intensive care units at Security Forces Hospital, Riyadh, Saudi Arabia. Ann Saudi Med 1995;15:602-5.
14. Balkhy HH, Cunningham G, Chew FK, et al. Hospital- and community-acquired infections: a point prevalence and risk factors survey in a tertiary care center in Saudi Arabia. Int J Infect Dis 2006;10:326-33.
15. Almuneef MA, Memish ZA, Balkhy HH, Hijazi O, Cunningham G, Francis C. Rate, risk factors and outcomes of catheter-related bloodstream infection in a paediatric intensive care unit in Saudi Arabia. J Hosp Infect 2006;62:207-13.
16. Memon JI, Rehmani RS, Venter JL, Alaithan A, Ahsan I, Khan S. Central venous catheter practice in an adult intensive care setting in the eastern province of Saudi Arabia. Saudi Med J 2010;31:803-7.
17. Almuneef M, Memish ZA, Balkhy HH, Alalem H, Abutaleb A. Ventilator-associated pneumonia in a pediatric intensive care unit in Saudi Arabia: a 30-month prospective surveillance. Infect Control Hosp Epidemiol 2004;25:753-8.
18. Rosenthal VD, Maki DG, Salomao R, et al. Device-associated nosocomial infections in 55 intensive care units of 8 developing countries. Ann Intern Med 2006;145:582-91.
19. Rosenthal VD, Guzman S, Crnich C. Impact of an infection control program on rates of ventilator-associated pneumonia in intensive care units in 2 Argentinean hospitals. Am J Infect Control 2006;34:58-63.
20. Tao L, Hu B, Rosenthal VD, Zhang Y, Gao X, He L. Impact of a multidimensional approach on ventilator-associated pneumonia rates in a hospital of Shanghai: findings of the International Nosocomial Infection Control Consortium. J Crit Care;27:440-6.
21. Guanche-Garcell H, Morales-Perez C, Rosenthal VD. Effectiveness of a multidimensional approach for the prevention of ventilator-associated pneumonia in an adult intensive care unit in Cuba: findings of the International Nosocomial Infection Control Consortium (INICC). J Infect Public Health 2013;6:98-107.
22. Mehta Y, Jaggi N, Rosenthal VD, et al. Effectiveness of a multidimensional approach for prevention of ventilator-associated pneumonia in 21 adult intensive-care units from 10 cities in India: findings of the International Nosocomial Infection Control Consortium (INICC). Epidemiol Infect 2013;141:2483-91.
23. Rosenthal VD, Alvarez-Moreno C, Villamil-Gomez W, et al. Effectiveness of a multidimensional approach to reduce ventilator-associated pneumonia in pediatric intensive care units of 5 developing countries: International Nosocomial Infection Control Consortium findings. Am J Infect Control 2012;40:497-501.
24. Rosenthal VD, Rodriguez-Calderon ME, Rodriguez-Ferrer M, et al. Findings of the International Nosocomial Infection Control Consortium (INICC), Part II: Impact of a multidimensional strategy to reduce ventilator-associated pneumonia in neonatal intensive care units in 10 developing countries. Infect Control Hosp Epidemiol 2012;33:704-10.
25. Rosenthal VD, Rodrigues C, Alvarez-Moreno C, et al. Effectiveness of a multidimensional approach for prevention of ventilator-associated pneumonia in adult intensive care units from 14 developing countries of four continents: findings of the International Nosocomial Infection Control Consortium. Crit Care Med 2012;40:3121-8.
26. Rosenthal VD, Guzman S, Pezzotto SM, Crnich CJ. Effect of an infection control program using education and performance feedback on rates of intravascular device-associated bloodstream infections in intensive care units in Argentina. Am J Infect Control 2003;31:405-9.
27. Higuera F, Rosenthal VD, Duarte P, Ruiz J, Franco G, Safdar N. The effect of process control on the incidence of central venous catheter-associated bloodstream infections and mortality in intensive care units in Mexico. Crit Care Med 2005;33:2022-7.
28. Jaggi N, Rodrigues C, Rosenthal VD, et al. Impact of an international nosocomial infection control consortium multidimensional approach on central line-associated bloodstream infection rates in adult intensive care units in eight cities in India. Int J Infect Dis 2013;17:e1218-24.
29. Leblebicioglu H, Ozturk R, Rosenthal VD, et al. Impact of a multidimensional infection control approach on central line-associated bloodstream infections rates in adult intensive care units of 8 cities of Turkey: findings of the International Nosocomial Infection Control Consortium (INICC). Ann Clin Microbiol Antimicrob 2013;12:10.
30. Rosenthal VD, Guzman S, Safdar N. Effect of education and performance feedback on rates of catheter-associated urinary tract infection in intensive care units in Argentina. Infect Control Hosp Epidemiol 2004;25:47-50.
31. Leblebicioglu H, Ersoz G, Rosenthal VD, et al. Impact of a multidimensional infection control approach on catheter-associated urinary tract infection rates in adult intensive care units in 10 cities of Turkey: International Nosocomial Infection Control Consortium findings (INICC). Am J Infect Control 2013;41:885-91.
32. Kanj SS, Zahreddine N, Rosenthal VD, Alamuddin L, Kanafani Z, Molaeb B. Impact of a multidimensional infection control approach on catheter-associated urinary tract infection rates in an adult intensive care unit in Lebanon: International Nosocomial Infection Control Consortium (INICC) findings. Int J Infect Dis 2013;17:e686-90.
33. Navoa-Ng JA, Berba R, Rosenthal VD, et al. Impact of an International Nosocomial Infection Control Consortium multidimensional approach on catheter-associated urinary tract infections in adult intensive care units in the Philippines: International Nosocomial Infection Control Consortium (INICC) findings. J Infect Public Health 2013;6:389-99.
34. Rosenthal VD, Bijie H, Maki DG, et al. International Nosocomial Infection Control Consortium (INICC) report, data summary of 36 countries, for 2004-2009. Am J Infect Control 2012;40:396-407.
35. Rosenthal VD, Maki DG, Rodrigues C, et al. Impact of International Nosocomial Infection Control Consortium (INICC) strategy on central line-associated bloodstream infection rates in the intensive care units of 15 developing countries. Infect Control Hosp Epidemiol 2010;31:1264-72.
36. Rosenthal VD, Ramachandran B, Villamil-Gomez W, et al. Impact of a multidimensional infection control strategy on central line-associated bloodstream infection rates in pediatric intensive care units of five developing countries: findings of the International Nosocomial Infection Control Consortium (INICC). Infection 2012;40:415-23.
37. Rosenthal VD, Duenas L, Sobreyra-Oropeza M, et al. Findings of the International Nosocomial Infection Control Consortium (INICC), part III: effectiveness of a multidimensional infection control approach to reduce central line-associated bloodstream infections in the neonatal intensive care units of 4 developing countries. Infect Control Hosp Epidemiol 2013;34:229-37.
38. Rosenthal VD, Ramachandran B, Duenas L, et al. Findings of the International Nosocomial Infection Control Consortium (INICC), Part I: Effectiveness of a multidimensional infection control approach on catheter-associated urinary tract infection rates in pediatric intensive care units of 6 developing countries. Infect Control Hosp Epidemiol 2012;33:696-703.

Return to TABLE OF CONTENTS

EMERGING TECHNOLOGY

Comparison of the efficacy of two airborne disinfection products in reducing the *Aspergillus fumigatus* contamination from hospital false ceiling reservoirs

Loeffert ST,[1] **Gustin MP**,[1,2] **Cassier P**,[3] **Bouché P**,[3] **Lion C**,[3] **Filoni M**,[3] **Perraud M**,[3] **Vanhems P**[1,4]

1 Emergent pathogens Laboratory - Mérieux Fondation, Centre International de Recherche en Infectiologie (CIRI), Inserm U1111, Lyon, France
2 Institut of Pharmaceutical Sciences and Biology, Claude Bernard 1 University, Lyon, France
3 Environmental Safety and Biology Laboratory, Edouard Herriot hospital, Lyon, France
4 Hospital Hygiene-Epidemology Unit, Edouard Herriot hospital, Lyon, France

Corresponding author:
Loeffert Sophie Tiphaine
sophie.loeffert01@chu-lyon.fr

ABSTRACT

Objectives: The aim of this study was to compare, in a blinded design, antifungal efficacy of two airborne disinfectants (AD) for *Aspergillus*-contaminated false ceilings of hospital rooms.

Methods: Two types of ADs containing either hydroxyacetic acid (AD#1) or peracetic acid + H2O2 (AD#2) were tested for the disinfection of *A. fumigatus* on false ceiling of four hospital rooms. Airway disinfection involves non-directed spraying of disinfectants reaching all surfaces contained in a given volume.

Results: A total of 11 different false ceiling tiles were sampled before and after disinfection in each of the four rooms tested. Product AD#2 showed a Contamination Rate (CR) of *A. fumigatus* decreasing from 7.2±6.5 colony-forming units (CFU)/m² (mean±SD) before to 2.5±3.4 after disinfection (*adjusted p*=0.05). AD#1 had CR fall from 9.4±8.5 CFU/m² to 7.9±7.3 (*adjusted p*=0.80).

Conclusions: AD#2 is significantly more effective at eradicating *A. fumigatus*, thus representing a good alternative to environmental management of this pathogen in hidden reservoirs.

KEY WORDS

Aspergillosis, airborne disinfection, environment reservoir, hospital

INTRODUCTION

Aspergillus fumigatus is a filamentous, ubiquitous saprophyte fungus that causes invasive infections in immunocompromised patients, often with severe outcomes and 50-90% mortality (1,2). Contamination occurs by inhalation of airborne conidia spores, with various consequences, from allergy to invasive aspergillosis (IA) (3,4). The species evoking IA are mostly *A. fumigatus* (>80%), *A. flavus, A. terreus* and, rarely, *A. nidulans* (3). Incidence of IA has been associated mainly with fungal exposure due to infrastructure work (5-8). Persistence of fungal spores in hospital environment creates reservoirs which directly impact IA incidence (9-11). For several decades we have known that dust above false ceiling is an environmental niche for *Aspergillus* which can be re-suspended in the air when maintenance or renovation work are carried out (12). The most effective way of decreasing IA occurrence is to eliminate those reservoirs and avoid direct patient exposure to environmental *Aspergillus* conidia by an appropriate disinfection (13-14). Airborne disinfection comprises the non-directed spraying of disinfectants onto surfaces within a determined volume, and can be ejected in dry or wet vapor forms. A fine particle aerosol is generated with particles settling onto surfaces and decontaminating them. The usual airborne disinfectant (AD) AD#1 used at our hospital include hydroxyacetic acid for false ceiling disinfection. Lately, another product comprised of hydrogen peroxide (H_2O_2) with peracetic acid has become available. In this study we evaluated the antifungal efficacies of two airborne disinfectants (AD) for decontamination of false ceilings from *A. fumigatus*.

METHODS

The study was conducted in one of the 32 blocks of an 800-bed teaching hospital in Lyon (France) in December 2014. The building was recently closed for subsequent demolition. This was an opportunity to evaluate the extent of contamination with *A. fumigatus*, and to test the technical feasibility of airborne disinfection within false ceilings of partly active medical wards.

Acknowledgements

The authors thank ANIOS Laboratories and LCB Food Safety industry, France, for their study participation by providing products free of charge. They were not involved in study design, analysis, results interpretation and discussion. Co-authors have no conflict of interest to declare.

Sampling strategy

Four similar rooms of a 24-bed medical unit were randomly selected for the study. The rooms were comparable in volume, location and exposure. Sampled false ceiling tiles were randomly assigned. Top of chosen tiles were entirely sampled with sterile wipes (Biomerieux®) before and a day after AD application (Figure 1). Tiles selected were measured in square meters (a mean of 1,65 m^2 of tiles located in center and 1,66 m^2 of tiles located at rooms corners) in order to report the *A. fumigatus* contamination measured to the surface sampled (CFU/m^2).

Application of disinfection product

AD#1 contained 4% hydroxyacetic acid (80 mg/m^3), and AD#2 contained 3% peracetic acid (~1,200 ppm) and 0.12% H_2O_2. Each AD was assigned to two different rooms out of the four rooms tested and applied by the same operator, as recommended by the supplier. Rooms were emptied and all openings were sealed during the disinfection period. In order to facilitate AD dispersion in false ceilings in the tested rooms, few tiles were slightly displaced just before AD application. Thus, chemical particles could saturate the room entirely and be active on all surfaces.

Plate incubation and reading

Sterile wipes were transferred into stomacher bags filled with buffered peptone water (200 ml) afterwards. For each sample, 1 ml was inoculated on yeast extract glucose chloramphenicol agar. Negative controls were realized with unused sterile wipes. Plates were incubated five days at 37°C and checked every 48 hours to observe *A. fumigatus* colonies growth. *A. fumigatus* colonies were counted, microscopically identified and expressed in colony-forming units per square meter (CFU/m^2). Only *A. fumigatus* colonies were considered in this study.

Statistical analysis

Before this study began, preliminary tests were conducted on false ceiling tiles of another medical unit to ascertain the best sampling technique, between sampling by sterile wipes and agar impaction, for evidencing at least 75% of decontamination with a probability of 90% between the two groups (data not shown). Continuous data were reported as mean ± standard deviation (SD) for each condition (after and before disinfection) and each AD (AD#1 vs AD#2). The similarity of contamination distribution before disinfection among the four rooms was checked by the Kruskal-Wallis test. Then, contamination distribution was compared before or after disinfection vs AD#1 or AD#2, by Wilcoxon rank test leading to four statistical tests: i) before AD#1 vs before AD#2, ii) after AD#1 vs after AD#2, iii) before AD#1 vs after AD#1, and iv) before AD#2 vs after AD#2. We reported *p* values for each single test and *p* values adjusted for multiple (i.e., 4) comparisons with the Holm method (15). For all statistical tests, the two-tailed significance level was $p \leq 0.05$.

RESULTS

A total of 11 different false ceiling tiles were sampled before and after disinfection in each of floor rooms tested leading to 22 observations per occasion and product, i.e., a total of 88 observations. All 88 environmental samples were collected and processed for isolation of *A. fumigatus* colony.

FIGURE 1: Sampling of false ceiling tiles

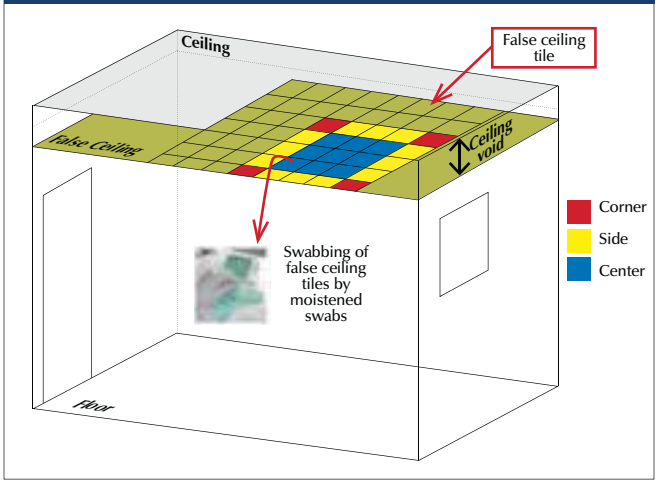
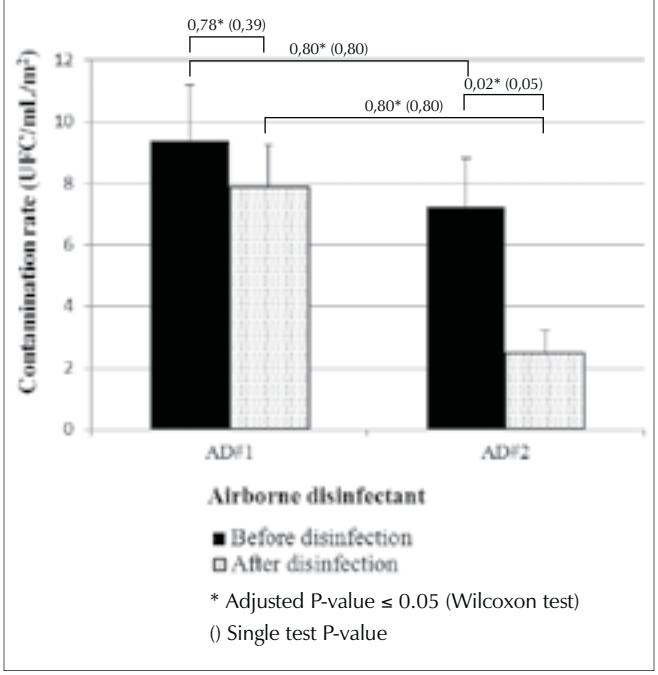


FIGURE 2: Evaluation of false ceiling tile contamination before and after disinfection with AD#1 vs AD#2



Comparison of A. fumigatus load before and after disinfection with each AD

No statistically significant difference of *A. fumigatus* contamination was found between corner tiles and center tiles in the four rooms before or after disinfection. Similarly, no difference was found across the four rooms before disinfection ($p=0.72$). Mean values (CFU/m^2) before disinfection were: AD#1 vs AD#2: 9.4±8.5 vs 7.2±6.5 ($p=0.39$, adjusted $p=0.78$). The evolution of *A. fumigatus* contamination after AD

Return to TABLE OF CONTENTS

application is shown in Figure 2. Significant differences between the two products after disinfection were found. After AD, CFU/m² values were: AD#1 vs AD#2 against *A. fumigatus*: 7.9±7.3 vs 2.5±3.4 (p=0.02, adjusted p=0.05).

Efficacy of AD products on A. fumigatus tiles load

Fungal loads of *A. fumigatus* were compared before and after disinfection with AD#1 or AD#2. In the AD#1 group, the *A. fumigatus* contamination rate was 9.4±8.5 before and 7.9±7.3 CFU/m² after disinfection (p=0.80, adjusted p=0.80), whereas in the AD#2 group, the *A. fumigatus* contamination rate was 7.2±6.5 before and 2.5±3.4 CFU/m² after disinfection (p=0.01, adjusted p=0.04) (Figure 2). Reduction rates were 16% for AD#1 and 66% for AD#2 respectively.

DISCUSSION

AD#2, the new tested product, composed of H_2O_2 and peracetic acid vapor was effective against *A. fumigatus* as it delivered 66% reduction of environmental colonization vs. 16% for AD#1. Construction, renovation and maintenance work in healthcare facilities present a challenge to the safety of immunocompromised patients by exposing them to *Aspergillus* conidia re-suspended in the air. This mold is ubiquitous both indoors and outdoors, often growing behind walls and above false ceilings. To ensure safe environment for immunocompromised patients with respect to *Aspergillus*, it is important to reduce the airborne burden of conidia. It has already been demonstrated that IA rates can be decreased by enhancing environmental management around high-risk patients (9). We consider that one of the relevant ways to prevent the spread of these airborne pathogens is to reduce environmental reservoirs by using optimal products to reach this objective. Some have investigated the efficacy of airborne systems for the disinfection of some hospital environments and for infection control, but their antifungal efficacy has not been evaluated on false ceilings which expose high-risk patients to IA during maintenance/renovation work in hospital wards (16-17). Our investigation confirmed the high homogenous presence of *A. fumigatus* on the false ceilings of hospital units. To our knowledge no other study has investigated the contamination rate of *A. fumigatus* on false ceiling of hospital rooms and evaluated disinfection methods *to prevent its* spread during renovation/maintenance. The antifungal efficacy of both of the tested products complied with the French standards for fungicide activity (NF T 72-281). The main difference between the two technologies is the emission of chemical particles. One of the products, (AD#1), ejects particles in dry vapor form, whereas the other product (AD#2) occurs in wet vapor form. These products are used in different fields of work. AD#1 typically disinfects surfaces in the food industry and canteens, whereas AD#2 is mostly confined to medical device disinfection and sterilization in the pharmaceutical industry. AD#1 appears to be the least expensive product available and more suitable for hospital food service areas rather than ward disinfection. For application of these products, rooms need to be vacated and air vents sealed for several hours, depending of the product applied and the volume of the room. While some studies have shown the effectiveness of those systems as an environmental disinfectant and infection control measure, this has still some limitations for use in real life settings, where wards are occupied by patients and rooms are rarely empty (16). In this study we tested these products in an empty ward in order to evaluate its efficacy for false ceiling disinfection before renovation work. No leakage of product was observed; so it seems that these products could be used in sealed part of wards undergoing renovation work even if the other parts of the wards remain active.

Our study has some limitations. Neither the kinetics of *Aspergillus* colonization on false ceiling tiles, nor the contribution of this source compared to other sources (surfaces, air, water) were estimated. The study focused only on one empty conventional medical ward and cost effectiveness was not assessed for both products which had different purchase prices.

CONCLUSION

This study highlighted the presence of environmental reservoir of *A. fumigatus* on hospital false ceiling. The new product, AD#2 appears to be the most efficient for *A. fumigatus* eradication from room false ceiling. Our data indicate that airborne disinfection devices can help prevent Aspergillosis risk from hidden environmental reservoirs, such as false ceilings in hospitals by lowering the *A. fumigatus* bioburden present on tiles just before removing it for infrastructure facility. Our findings also showed that this protocol seems possible in a sealed part of an active hospital ward undergoing renovation.

REFERENCES

1. Nicolle MC, Bénet T, et al. Invasive aspergillosis in patients with hematologic malignancies: incidence and description of 127 cases enrolled in a single institution prospective survey from 2004 to 2009. *Haematologica* 2011;96:1685-91.
2. Gangneux JP, Camus C, Philippe B. Epidemiology of and risk factors for invasive aspergillosis in nonneutropenic patients. *Rev Mal Respir* 2008;25:139-53.
3. Marr KA, Patterson T, Denning, D. Aspergillosis. Pathogenesis, clinical manifestations and therapy. *Infect Dis Clin North Am* 2012;16:875-94.
4. Badiee P, Hashemizadeh Z. Opportunistic invasive fungal infections: diagnosis & clinical management. *Indian J Med Res* 2014;139:195-204.
5. Pelàez T, Munõz P, Guinea J, Valerio M, Giannella M, Klaassen CHW, Bouza E. Outbreak of Invasive Aspergillosis After Major Heart Surgery Caused by Spores in the Air of the Intensive Care Unit. *Clin Infect Dis* 2012;54:24-31.
6. O'Gorman CM. Airborne Aspergillus fumigatus conidia: a risk factor for Aspergillosis. *Fungal Biology Review* 2011;25:151-157.
7. Pini G, Faggi E, Donato R, Sacco C, Fanci R. Invasive pulmonary aspergillosis in neutropenic patients and the influence of hospital renovation. *Mycoses* 2008;51:117-22.
8. Kanamori H, Rutala WA, Sickbert-Bennett EE, Weber DJ. Review of Fungal Outbreaks and Infection Prevention in Healthcare Settings During Construction and Renovation. *Healthcare Epidemiology* 2015;61:433-444.
9. Hao ZF, Ao JH, Hao F, Yang RY, Zhu H, Zhang J. Environment surveillance of filamentous fungi in two tertiary care hospitals in China. *Chin Med J* 2011;124:1970-5.
10. Bénet T, Nicolle MC , Thiebaut A, *et al*. Reduction of invasive aspergillosis incidence among immunocompromised patients after control of environmental exposure. *Clin Infect Dis* 2007;45:682-6.

11. Otter JA, Yezli S, Perl TM, Barbut F, French GL. The role of 'no-touch' automated room disinfection systems in infection prevention and control. *J Hosp Infect* 2013; 83:1-13.
12. Perraud P, Piens MA, Nicoloyannis N, Girard P, Sepetjan M, Garin JP. Invasive nosocomial pulmonary aspergillosis: risk factors and hospital building works. *Epidem. Infec* 1987;99:407-412.
13. Dancer SJ, White LF, Lamb J, Girvan EK, Robertson C. Measuring the effect of enhanced cleaning in a UK hospital: a prospective cross-over study. *BMC Medicine* 2009;7:28.
14. Arnow PM, Andersen RL, Mainous PD, Smith EJ. Pulmonary aspergillosis during hospital renovation. *Am Rev Respir Dis* 1978;118:49-53.
15. Holm SA. Simple sequentially rejective multiple test procedure. *Scand J Stat* 1979;6:65-70.
16. Falagas ME, Thomaidis PC, Kotsantis IK, Sgouros K, Samonis G, Karageorgopoulos DE. Airborne hydrogen peroxide for disinfection of the hospital environment and infection control: a systematic review. *J Hosp Infect* 2011;78:171-7.
17. Shapey S, Machin K, Levi K, Boswell T.C. Activity of a dry mist hydrogen peroxide system against environmental *Clostridium difficile* contamination in elderly cares wards. *J Hosp Infect* 2008;70:136-41.

CONCISE REPORT

Expansion of a province-wide surveillance protocol to include community onset healthcare-associated *Clostridium difficile* infection

Lesley A. McLeod,[1] MSc, CIC

1Mamawetan Churchill River Health Region, Saskatchewan, Canada

Corresponding author:
Lesley A. McLeod
3472 Elder Grove, Regina, SK. Canada S4V 2V3
Phone: 1-306-290-8746
Email: lesley.mcleod@pophealthnorthsask.ca

ABSTRACT

Objectives: To expand the CDI surveillance protocol to capture information about patients with community onset healthcare-associated *C. difficile*.

Methods: A series of consultations were held with experts in medical microbiology, infectious diseases, information technology, and infection control. Four main issues were to be addressed: database evaluation; revision of inclusion criteria; data collection evaluation; and improved access to provincial electronic health records database.

Results: The revised CDI surveillance protocol was launched on April 1, 2016. The database was revised to incorporate changes to the inclusion criteria, as well as data collection. Preliminary results indicate that one-third of the patients diagnosed with HA-CDI in Saskatchewan have symptom onset in the community.

Conclusions: Inconsistencies in surveillance definitions and access to data can negatively affect a multi-jurisdictional surveillance program. Early involvement of those performing data collection is critical for the success of the program.

KEY WORDS

Clostridium difficile; surveillance; healthcare-associated

INTRODUCTION

Clostridium difficile infection (CDI) is a virulent healthcare-associated infection that is easily spread among patients/residents in healthcare facilities (1). Its severe consequences demand a reliable surveillance protocol in order to support outbreak investigations, monitor trends, and evaluate interventions aimed at reducing incidence.

Recent studies suggest that the epidemiology of healthcare-associated CDI (HA-CDI) is changing. Although CDI continues to be predominantly a healthcare-associated infection, with 94% of all CDI being related to a recent healthcare exposure, location of onset of these infections has begun to shift from acute care hospitals to long term care (LTC) facilities or outpatient settings (2-5). Presently, there is limited Canadian surveillance information about cases presenting to these settings due to challenges obtaining timely and consistent data.

In 2012, a provincial CDI surveillance system was launched in Saskatchewan that included all patients over one year of age with CDI who were in an acute or LTC facility at the time of diagnosis. The regional Infection Control Professionals (ICPs) charged with data collection experienced various challenges obtaining notification of all cases. In 2014, CDI became reportable to public health in Saskatchewan (6). However, due to the existence of the provincial surveillance protocol, tracking of CDI was deemed to be the role of ICPs and not public health, so it became imperative that notification systems to ICPs be improved. In November 2015, ICPs began receiving all CDI toxin positive lab reports from the provincial lab directly and confidence grew that ICPs were receiving notification of most, if not all, CDI cases.

A review of the program and recent literature in late 2015 indicated that the 2012 protocol was working well to achieve the initial goal of capturing quality data on those patients diagnosed with CDI while in a healthcare facility, but it was excluding valuable information from those patients with recent healthcare admissions who were diagnosed with CDI in outpatient settings. The goal of the revised protocol was to expand the inclusion

Acknowledgments

The author thanks Dr. Jessica Minion (medical microbiologist), Dr. Lei Ang (Medical Microbiologist), and Dr. Alice Wong (Infectious Disease Physician), as well as the members of the Provincial Infection Control Network of Saskatchewan (PICNS) who provided expertise, feedback and trial testing of the revised CDI surveillance protocol.

Potential conflicts of interest

The author reports no conflicts of interest related to this article. Patient confidentiality is protected in this protocol by codifying the recorded information, making it only identifiable to the individual region's infection control team.

criteria to allow the capture of information for those patients diagnosed with HA-CDI with symptom onset in the community.

METHODS

Late in 2015, provincial Infection Control Coordinators (ICCs) within the Ministry of Health held a series of consultations with regional ICPs currently responsible for CDI data collection and reporting, as well as with experts in medical microbiology, epidemiology and information technology (IT). It was desirable to address four main issues in the new protocol:

- Evaluate existing (Epidata) database and revise or develop new as necessary.
  - Assess whether new, improved options exist for data collection and analysis.
  - Revise existing or develop new database to incorporate expanded inclusion criteria, updated facility codes and other changes as needed.
- Better align Saskatchewan's CDI surveillance protocol with the Canadian Nosocomial Infection Surveillance Program (CNISP) CDI surveillance protocol (7).
  - Update surveillance case definitions in provincial protocol to match those in most recent CNISP protocol.
  - For convenience of the acute care facilities in the province that also participate in the CNISP surveillance program: Investigate feasibility of developing one data collection form for both surveillance programs and ensure new database has ability to filter out cases meeting CNISP criteria to allow for cross-referencing.
- Identify ways for ICPs to obtain permission to access new provincial electronic health records database (eHR Viewer).
  - Access is critical for identifying if patients meet expanded inclusion criteria (i.e. had previous admission to any healthcare facility in the province in the past four weeks).
- Data collection evaluation.
  - Evaluate what data remained important to collect and what could be discontinued in an effort to balance increased workload for those doing data collection and entry.

RESULTS

Revisions to the Saskatchewan CDI Surveillance protocol for 2016-17 (8) and EpiData database for CDI data collection were completed by January 2016 and went through pilot testing in February. Data collection using the new protocol began April 1, 2016. Results from the first two quarters of fiscal year 2016-17 indicate that 27% (Q1) and 31% (Q2) of the patients diagnosed with HA-CDI had symptom onset in the community and information about treatment of those patients is proving useful in developing new antimicrobial stewardship initiatives.

In order to implement the surveillance protocol expansion, the following decisions were made and actions taken:

First, the decision was made to simply revise the programming in the existing version of EpiData (v3.1) as there was no additional cost and everyone was familiar with using it.

Second, given that the inclusion criteria for the CNISP and provincial CDI surveillance systems are different; the three participating CNISP sites in the province elected to continue use of two separate data collection forms to avoid confusion. Changes were made to the Saskatchewan data collection form to provide a more visually appealing form that is similar to that used by CNISP and the database was designed to allow regions to filter out cases meeting CNISP criteria to allow for cross-referencing. It is important to note that Saskatchewan's surveillance protocol is now aligned with CNISP in terms of case definitions for primary and recurrent CDI cases, as well as definitions for healthcare-associated (HA) and community-associated (CA) CDI. However, inclusion criteria differ in that Saskatchewan's protocol includes those patients over one year of age that have been diagnosed anywhere in the province (inpatient and outpatient), while the CNISP protocol only includes those over one year of age that were diagnosed during an acute inpatient visit.

Third, advocacy at a provincial level for the role of ICPs in this and other provincial surveillance initiatives resulted in the addition of the ICP job description to the approved access list for the new provincial electronic health records database (eHR viewer). This allows approved users to search for lab results and admissions data for a patient anywhere in the province, not only within a specific health region.

Finally, the decision was made to discontinue collection of risk factor data, including prescription of antibiotics in the previous six weeks. This was deemed to be information that was fairly labor intensive to collect, has already been well documented in the literature, and is already being used to improve patient outcomes through antimicrobial stewardship and other education initiatives.

DISCUSSION

Development of a surveillance protocol that crosses jurisdictions is always challenging. In 2012, the decision to begin a provincial surveillance program with *C. difficile* infections was due to the presumed ease of obtaining lab results and the ability to use relatively objective case definitions that were already being used by most health regions in the province. During the first three years of data collection, information was gathered that demonstrated a variety of inappropriate treatment regimens for new and recurrent cases, and identified trends in new CDI cases, as well as CDI outbreaks within regions and across the province. This information has been incorporated into the provincial CDI management guidelines (9) and education tools in an effort to educate staff and physicians about how to prevent the spread of CDI within the facilities.

Despite the wealth of information that was obtained with the 2012 version, the time had come to expand the scope of the program to incorporate those patients with CDI onset in the community. During the expansion process, several lessons were learned:

Despite the desire to streamline data collection and align with CNISP, attempts to combine data collection into one form were unsuccessful because of fundamental differences in inclusion criteria (i.e., CNISP excludes cases diagnosed in mental health, LTC, and outpatient settings). Current initiatives, such as the National Surveillance Case Definition Standardization project

Return to TABLE OF CONTENTS

(10), that are endeavoring to develop Pan-Canadian surveillance definitions for a variety of infections, including CDI, will continue to be supported and encouraged by those in Saskatchewan. In the meantime, consideration was given to a surveillance design that would allow those cases that meet the case definitions and criteria for CNISP to be easily filtered from the provincial data.

Lab and admissions data that was believed to be readily accessible by ICPs had privacy restrictions that required special permissions at the Ministry level and top level support at the regional level. Consistent access to lab and admissions information is vital to the success of a surveillance program but is often a challenge to obtain due to valid privacy concerns or other technology issues. When designing a surveillance protocol that crosses jurisdictions, it is important to consider whether or not access is available to all who will be participating. The best surveillance programs must have input by those who are collecting the data and those who will be making use of the collated information.

Finally, it takes a great deal of time and effort for staff to collect this type of surveillance data. It is vitally important that the information obtained is evaluated frequently to determine if it is useful for making improvements to patient outcomes.

Results from the first half of the 2016-17 surveillance year indicate that one-third of the patients being diagnosed with HA-CDI in Saskatchewan are having symptom onset in the community and these would not have been captured using the previous version of the provincial CDI surveillance protocol. Information gathered from this expanded surveillance is being used to develop improved management guidelines and inform additional antimicrobial stewardship initiatives.

REFERENCES

1. Association for Professionals in Infection Control & Epidemiology, Inc. (APIC), "Guide to the Elimination of *Clostridium difficile* in Healthcare Settings" (Washington, DC: APIC, 2008). [*http://www.apic.org/Resource_/EliminationGuideForm/5de5d1c1-316a-4b5e-b9b4-c3fbeac1b53e/File/APIC-Cdiff-Elimination-Guide.pdf* – retrieved Dec 2015]
2. Centres for Disease Control and Prevention. "Vital Signs: Preventing *Clostridium difficile* infections." *MMWR Morbidity and Mortality Weekly Report* 61 (March 2012): 157-162.
3. Lessa FC, Mu Y, Bamberg WM et al. "Burden of *Clostridium Difficile* Infection in the United States" *N Engl J Med* 2015;372:825-34.
4. Pawar D, Tsay R, Nelson DS, et al. Burden of *Clostridium difficile* infection in long-term care facilities in Monroe County, New York. *Infect Control Hosp Epidemiol* 2012;33:1107-12.
5. Severe *Clostridium difficile*–associated disease in populations previously at low risk – four states, 2005. *MMWR Morbidity and Mortality Weekly* Rep 2005;54:1201-5.
6. Saskatchewan Ministry of Health, "Communicable Disease Manual, Appendix Table 1: Category I Communicable Diseases" (Regina, SK: Saskatchewan Ministry of Health, Amended August 2014). [*http://www.qp.gov.sk.ca/documents/gazette/part2/2014/G2201432.pdf* – retrieved February 2015]
7. Canadian Nosocomial Infection Surveillance Program (CNISP), "2015-2017 Surveillance for *Clostridium difficile* infection (CDI)" (Ottawa, ON: Public Health Agency of Canada, Revised November 2015).
8. Saskatchewan Ministry of Health, "*Clostridium difficile* Infection (CDI) Surveillance Protocol: Saskatchewan" (Regina, SK: Saskatchewan Ministry of Health, March 2016). [*http://www.saskatchewan.ca/~/media/files/health/health%20and%20healthy%20living/health%20care%20provider%20resources/treatment%20procedures%20and%20guidelines/infection%20prevention%20and%20control%20program/cdi%20surveillance%20protocol%20march%202016.pdf* – retrieved Nov 2016]
9. Saskatchewan Ministry of Health, "Guidelines for the Management of *Clostridium difficile* Infection (CDI) in all Healthcare Settings" (Regina, SK: Saskatchewan Ministry of Health, August 2015). [*http://www.saskatchewan.ca/government/health-care-administration-and-provider-resources/treatment-procedures-and-guidelines/infection-prevention-and-control-program* – retrieved Dec 2015]
10. Canadian Patient Safety Institute (CPSI), "An Infection Prevention and Control Action Plan", July 2015. [*http://www.patientsafetyinstitute.ca/en/About/PatientSafetyForwardWith4/Documents/Infection%20Prevention%20and%20Control%20(IPAC)%20Action%20Plan.pdf* – retrieved Nov 2016]

CONCISE REPORT

Saline flush after administration of lipid emulsion reduces the risk of central line infections: A case-control study

Satoru Mitsuboshi,[1]* Bachelor of Pharmacy
*Corresponding author
Email: ccrtyo34057@gmail.com

Hitoshi Yamada,[1] Bachelor of Pharmacy
Email: hitosiyama1104@gmail.com

Kazuhiko Nagai,[1] Bachelor of Pharmacy
Email: nagai_k@niigata-min.or.jp

Yukihiro Yamaguchi,[2,3] Medical Doctor
Email: yukihiro@kenwakai.gr.jp

1 Department of Pharmacy, Kaetsu Hospital, 1459-1 Higashikanazawa, Akiha-ku, Niigata-shi, Niigata 956-0814, Japan
2 Division of Infectious Diseases, Kenwakai Otemachi Hospital, 15-1 Otemachi, Kokurakita-ku, Kitakyushu-shi, Fukuoka 803-8543, Japan
3 KRICT (Kitakyushu Regional Infection Control Team) 3-8-1, Hananoji, Wakamatsu, Kitakyushu, Fukuoka, 808-0136, Japan

*Corresponding author
Satoru Mitsuboshi
1459-1 Higashikanazawa, Akiha-ku, Niigata-shi, Niigata 956-0814, Japan
E-mail: ccrtyo34057@gmail.com
Tel: +81250224711
Fax: +81250224760

ABSTRACT

Background: Lipid emulsion (LE) may increase the occurrence of central line infections (CLI). We hypothesized that saline flush after the administration of LE (SFLE) may decrease bacterial contamination of catheters and reduce the risk of CLI.

Methods: To evaluate the effectiveness of SFLE in reducing the risk of CLI, we conducted a retrospective two-year case-control study that included all patients who received LE via a central venous catheter (CVC). Patients who were administered LE without SFLE between 1 February 2014 and 31 January 2015 (non-SFLE group), and patients who were administered SFLE between 1 February 2015 and 31 January 2016 (SFLE group) were studied. CLI was defined to include catheter-related local infection (CRLI) and central line-associated blood stream infections.

Results: The non-SFLE and SFLE groups included 58 cases (52 patients) and 52 cases (45 patients), respectively. CVCs were inserted for a total of 2,757 and 1,715 catheter days in the non-SFLE and SFLE groups, respectively. We observed 17 and 9 cases of CLI in the non-SFLE and SFLE groups, respectively, a rate of 5.8 and 5.2 per 1000 catheter days in each group. In multivariate logistic regression analyses, SFLE was associated with a decreased risk of CLI (odds ratio, 0.33, 95% confidence interval, 0.11–0.89).

Conclusion: Our results suggest that SFLE may decrease the risk of CLI.

KEY WORDS

Saline flush, lipid emulsion, central venous catheter, catheter-related infections

INTRODUCTION

Lipid emulsion (LE) infusion administered more than twice weekly is associated with central line-associated blood stream infections (CLABSI) in patients receiving home parenteral nutrition (1). Additionally, some studies have suggested that LE infusion is a risk factor for coagulase-negative staphylococcal bacteremia in very low birth weight newborns (2) and *Malassezia furfur* fungemia in infants (3). Battistella et al (4) showed that LE infusions during the early post-injury period increased susceptibility to infection, prolonged pulmonary failure, and delayed recovery in critically injured patients. These results suggest that LE may be associated with an increased risk for central line infections (CLI). Freeman et al (5) showed that catheters can be colonized within 24-48 h after insertion, and when nutrient-rich growth mediums, such as lipids,

Financial disclosure

None declared

are infused through the colonized catheter, only a few hours of rapid growth are required for the numbers of coagulase-negative staphylococci to reach levels sufficient for bloodstream invasion.

We hypothesized that saline flush after the administration of LE (SFLE) may decrease the bacterial contamination of central venous catheters (CVC) and reduce the risk of CLI. However, no studies have examined this method for reducing the risk of infection in CVCs following LE infusion. Therefore, this study aimed to clarify the relationship between SFLE and CLI in inpatients receiving LE infusion.

MATERIALS AND METHODS

This two-year case-control study included all patients who received LE via CVC in Kaetsu Hospital (Niigata, Japan), a 261-bed hospital with six wards, between 1 February 2014 and 31 January 2016. SFLE was started from 1 February 2015. Patients were administered LE without SFLE between 1 February 2014 and 31 January 2015 (non-SFLE group), while patients were administered SFLE between 1 February 2015 and 31 January 2016 (SFLE group) for improved experimental quality. The records of patients from these two groups were reviewed. This study and its protocol were approved by the Ethics Committee of Kaetsu Hospital.

The demographic and clinical characteristics of the patients were reviewed and recorded (Table 1). The frequency of LE administration was calculated as the duration of LE administration divided by the duration of catheter insertion. We excluded patients who were administered LE within three days of CVC

TABLE 1: Case characteristics: administration of lipid emulsion via CVC

	Non-SFLE (n = 58)	SFLE (n = 52)
Diagnosis, n (%)		
Respiratory disease	18 (31)	15 (22)
Gastrointestinal disease	13 (22)	16 (24)
Central nervous system disease	13 (22)	13 (19)
Cardiovascular disease	14 (24)	5 (7)
Other disease	0 (0)	3 (4)
Age, y (SD)	82 (8)	79 (15)
Body weight, kg (SD)	42 (12)	41 (12)
Insertion site, n (%)		
Subclavian	3 (5)	0 (0)
Internal jugular	11 (19)	21 (40)
Femoral	44 (76)	31 (60)
Duration of catheter insertion, day (SD)	48 (46)	33 (32)
Multi-lumen catheter, n yes (%)	3 (5)	4 (8)
Use of maximal sterile barrier precautions, n yes (%)	55 (95)	48 (92)
Use of alcohol-based hand rub, L/1000 patients (SD)	8 (2)	9 (3)
Administration of PN, n yes (%)	52 (90)	51 (98)
Duration of PN administration, day (SD)	35 (43)	24 (30)
Duration of LE administration, day (SD)	30 (24)	24 (30)
Frequency of LE administration, times (SD)	0.8 (0.4)	0.7 (0.3)
Development of CLI, n (%)	16 (28)	9 (17)
Number of CLI per 1000 catheter days	5.8	5.2

Continuous variables were reported as means and standard deviation; and categorical variables, as frequency and percentage.

Frequency of LE administration was calculated as duration of LE administration divided by the duration of catheter insertion.

In 2 patients, the body weight measurements were not available (1 patient from the non-SFLE group and SFLE group each).

CLI, central line infections; LE, lipid emulsion; PN, parenteral nutrition; SD, standard deviation SFLE, saline flush after the administration of lipid emulsion.

insertion or received another LE preparation (e.g., propofol, flurbiprofen, or alprostadil), had subcutaneous ports, had the catheter removed for at least two days, or did not undergo catheter removal (continued CVC for home parenteral nutrition or transfer to another hospital). In addition, we excluded the episodes of CLI after the second CLI during a single hospitalization, since there were several patients who experienced repeated CLI. Moreover, in the non-SFLE group, we excluded patients who had the catheter removed after starting SFLE.

The insertion site was decided by the physician. Ultrasonography was occasionally used to guide the insertion, based on the physicians' discretion. The skin at the insertion site was disinfected with 1% chlorhexidine in 70% alcohol. After CVC insertion, the area surrounding the catheter was cleaned, and an occlusive dressing was applied covering the site. The insertion area was examined daily for the presence of any abnormality by the nurse assigned to the patient. Catheter dressings were changed every seven days or sooner at the discretion of the nurse caring for the patient if the dressing was contaminated (this is the standard duration in Japan). The insertion area was disinfected with 1% chlorhexidine in 70% alcohol every time the catheter dressing was changed. The connecting lines using an in-line filter were changed every seven days. The decision to remove the catheter was made by the patient's physician. Catheters were removed when they were no longer needed; other reasons for catheter removal included occurrence of complications, accidental removal, or death. No antibiotic cream or lotion was applied around the insertion area. The catheters were not antimicrobial-coated. Removed catheter tips were not routinely cultured. For LE infusion, 100–250 mL/day of 20% LE was administered for 3–6 h piggybacked through the CVC line below the in-line filter. The line for LE was removed after administration was completed. The SFLE protocol was started on 1 February 2015. After the LE line was removed, the CVC line was flushed using 10 mL of saline.

CLI was defined as CRLI or CLABSI. CRLI was defined as the presence of any sign of local infection (induration, erythema, heat, pain, or purulent drainage). CLABSI was defined as a positive blood culture obtained from a peripheral vein and presence of signs of a systemic infection (fever, chills, and/or hypotension), with no apparent source of bacteremia except the catheter (6).

TABLE 2: Microorganisms isolated from blood culture

	Non-SFLE	SFLE
Staphylococcus epidermidis	3	2
Staphylococcus aureus	1	2
Serratia marcescens	0	1

In the non-SFLE group, all strains of Staphylococcus epidermidis and Staphylococcus aureus showed methicillin resistance.

In the SFLE group, 1 strain of Staphylococcus epidermidis and Staphylococcus aureus each showed methicillin resistance.

SFLE, saline flush after the administration of lipid emulsion.

The statistical software JMP9 (SAS Institute Inc., Cary, NC) was used for all statistical analyses. Continuous variables were reported as means and standard deviation, and categorical variables were recorded as frequency and percentage. Multivariate modeling was performed using logistic regression with a stepwise backward-forward selection ($p < 0.25$) procedure to identify the independent factors associated with CLI. For multivariate analysis, SFLE, age, sex, body weight, duration of catheter insertion, femoral CVC insertion, use of maximal sterile barrier precautions, use of a multi-lumen catheter, use of alcohol-based handrub during the month of CVC insertion in the ward, administration of PN, and frequency of LE administration were included as variables. Odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated. $P < 0.05$ was considered statistically significant.

RESULTS

The study included 96 patients (58% men), aged 22-98 years (median, 83 years) and with body weight ranging from 25 to 97 kg (median, 39 kg). A total of 110 cases (96 patients) who received LE via CVC were included in this study. Subsequently, 53 cases were excluded from the study, including 20 cases that received LE within 3 days of CVC insertion, 18 cases that received another LE preparation (15 and 3 cases who were administered flurbiprofen and alprostadil, respectively), five cases that experienced repeat CLI after the occurrence of a second CLI during a single hospitalization, one case wherein the catheter was not removed due to transfer to another hospital, and nine cases in the non-SFLE group that had the catheter removed after starting SFLE. No patients received the insertion of a tunneled catheter, subcutaneous port, or a peripherally inserted central catheter.

Case profiles are shown in Table 1. The non-SFLE and SFLE groups included 58 cases (52 patients) and 52 cases (45 patients), respectively. One patient was included in both the non-SFLE and the SFLE groups, and happened to be present in both periods of the study. CVSs were inserted for a total of 2,757 and 1,715 catheter days in the non-SFLE and SFLE groups, respectively. We observed 16 and nine cases of CLI in the non-SFLE and SFLE groups, respectively, and a rate of 5.8 and 5.2 per 1000 catheter days in each group.

TABLE 3: Multivariate logistic regression analyses of factors associated with CLI

	Odds ratio	OR (95% CI)	P
Non-SFLE	1.00		
SFLE	0.33	0.11–0.89	0.03
Sex: female	1.00		
Sex: male	5.21	1.73–19.15	< 0.01

CI, confidence interval; OR, odds ratio; SFLE, saline flush after the administration of lipid emulsion.

Return to TABLE OF CONTENTS

The microorganisms isolated from blood cultures are shown in Table 2. In the non-SFLE group, we observed four microorganisms, including three methicillin-resistant Staphylococcus epidermidis and one methicillin-resistant Staphylococcus aureus. In the SFLE group, we observed five microorganisms, including two strains of *Staphylococcus epidermidis* and *Staphylococcus aureus* each (of which one strain each showed methicillin resistance) and one strain of Serratia marcescens.

The results of multivariate logistic regression analyses of the factors associated with CLI are shown in Table 3. SFLE was associated with a decreased risk of CLI (OR, 0.33, 95% CI, 0.11-0.89). Additionally, male sex was associated with an increased risk of CLI (OR, 5.21, 95% CI, 1.73-19.15).

DISCUSSION

In this study, the rate of CLI decreased from 5.8 to 5.2 per 1000 catheter days after starting SFLE, and the use of SFLE was associated with a decreased risk of CLI in multivariate analyses. No study has previously reported the usefulness of SFLE in preventing CLI. Freeman et al (5) showed that catheters can be colonized within a few hours following LE administration. We considered that SFLE may clean the catheter following LE infusion and prevent bacterial colonization.

In some studies, CLI (including CRLI and CLABSI) occurred at a rate of 8-9 per 1000 catheter days for CVCs (6,7). The rate of CLI in our study was lower. We observed four and five strains of microorganisms isolated from blood cultures in the non-SFLE and SFLE groups, respectively. *Staphylococcus epidermidis* strains were the most common in both groups. These findings are similar to those of previous studies (7,8).

Femoral access was the most common site for CVC insertion in our study (60-70%). Because many patients were elderly and/or had dementia, femoral access was used to prevent accidental removal. Youn et al[7] showed that 5-10% of CVCs were inserted through femoral access; among patients admitted to intensive care units, femoral access has been associated with a greater risk of infectious and thrombotic complications than subclavian catheterization (8).

Male sex was associated with an increased risk of CLI in multivariate analyses. Moro et al (9) showed that the risk of skin colonization was higher among males, probably due to the presence of facial hair, which facilitates the multiplication of microorganisms. However, since femoral access was the most common site of CVC insertion in our study, the presence of facial hair may not be related to the increased risk of CLI observed in males.

Our study has some limitations. First, it used a retrospective design and had a small sample size. Second, the insertion sites were not randomly assigned. Third, femoral access for CVC insertion was the most common, in contrast to previous reports.

CONCLUSIONS

Overall, our results suggest that the administration of SFLE instead of LE infusion alone may decrease the risk of CLI. However, further prospective studies are needed to confirm these findings.

REFERENCES

1. Buchman AL, Opilla M, Kwasny M, Diamantidis TG, Okamoto R. Risk factors for the development of catheter-related bloodstream infections in patients receiving home parenteral nutrition. *JPEN J Parenter Enteral Nutr.*2014; 38: 744-749.
2. Avila-Figueroa C, Goldmann DA, Richardson DK, Gray JE, Ferrari A, Freeman J. Intravenous lipid emulsions are the major determinant of coagulase-negative staphylococcal bacteremia in very low birth weight newborns. *Pediatr Infect Dis J.* 1998; 17:10-17.
3. Weiss SJ, Schoch PE, Cunha BA. Malassezia furfur fungemia associated with central venous catheter lipid emulsion infusion. *Heart Lung.*1991; 20: 87-90.
4. Battistella FD, Widergren JT, Anderson JT, Siepler JK, Weber JC, MacColl K. A prospective, randomized trial of intravenous fat emulsion administration in trauma victims requiring total parenteral nutrition. *J Trauma.*1997; 43 :52-58.
5. Freeman J, Goldmann DA, Smith NE, Sidebottom DG, Epstein MF, Platt R. Association of intravenous lipid emulsion and coagulase-negative staphylococcal bacteremia in neonatal intensive care units. N Engl J Med. 1990; 323: 301-308.
6. Lorente L, Henry C, Martín MM, Jiménez A, Mora ML. Central venous catheter-related infection in a prospective and observational study of 2,595 catheters. *Critical Care.* 2005; 9: R631-R635.
7. Youn SH, Lee JC, Kim Y, Moon J, Choi Y, Jung K. Central Venous Catheter-Related Infection in Severe Trauma Patients. World J Surg. 2015; 39: 2400-6.
8. Merrer J, De Jonghe B, Golliot F, Lefrant JY, Raffy B, Barre E, et al. Complications of femoral and subclavian venous catheterization in critically ill patients: a randomized controlled trial. JAMA.2001; 286: 700-7.
9. Moro ML, Viganò EF, CozziLepri A. Risk factors for central venous catheter-related infections in surgical and intensive care units. The Central Venous Catheter-Related Infections Study Group. Infect Control Hosp Epidemiol. 1994; 15: 253-64.

CONCISE REPORT

Comparison of efficacy and cost of three different antimicrobial prophylaxis drugs in microsurgical transsphenoidal surgery

Halil Ulutabanca, Erciyes University, Faculty of Medicine, Department of Neurosurgery

Aysegul Ulu- Kilic*, Erciyes University, Faculty of Medicine, Department of Infectious Diseases

Emine Alp, Erciyes University, Faculty of Medicine, Department of Infectious Diseases

Tülay Orhan, Erciyes University, Faculty of Medicine, Infection Control Committee

Ahmet Selçuklu, Erciyes University, Faculty of Medicine, Department of Neurosurgery

Mehmet Doganay, Erciyes University, Faculty of Medicine, Department of Infectious Diseases

This study was presented at the 26th European Congress of Clinical Microbiology and Infectious Diseases. EV0869. 9-12 April 2016, Amsterdam, Netherlands.

* Corresponding Author

Aysegul Ulu- Kilic
Department of Infectious Diseases, Faculty of Medicine,
Erciyes University, Kayseri/ Turkey
Email: draysegululu@yahoo.co.uk

ABSTRACT

Background: While some elective neurosurgery operations, such as craniotomy, cerebrospinal fluid shunting procedures and intrathecal pumps, have clear recommendations for antimicrobial prophylaxis (AMP), no comprehensive recommendations exist for transsphenoidal surgery (TSS). The aim of this study was to compare the efficacy and cost of three different AMP drugs in TSS.

Method: A retrospective analysis of the clinical records of patients who underwent pituitary surgery between January 2012 and February 2016 was performed. TSS was performed via endonasal microsurgical approach. Patients were classified into three groups according to AMP regimen received. The cost analysis per patient was calculated in United States dollars.

Results: We identified a total of 126 patients who underwent TSS. Of these, 32 (25.3%) received chemoprophylaxis with cefazolin, 50 (39.6%) with ceftriaxone, and 44 (34.9%) with fucidic acid drops. There were no cases of peri- or post-operative meningitis or any other procedure-associated infections in these patients. Cost-comparison of the three AMP regimens showed that cefazolin was more expensive than ceftriaxone and fusidic acid regimens.

Conclusion: Three compared AMP drugs for TSS were found similarly effective with no reported infectious complication. The requirement of AMP for TSS is still controversial at hospitals where the infection rate is very low and the majority of infections are treatable.

KEY WORDS

transsphenoidal surgery, antimicrobial prophylaxis, pituitary

INTRODUCTION

The prevention of surgical site infections (SSIs) is an important public health concern. In order to reduce surgical complications, the Surgical Care Improvement Project (SCIP) in our hospital adopted the timely administration of prophylactic antibiotics as one of the important quality improvement measures (1-3). The key concepts of antibiotic prophylaxis are represented by selection, timing, duration and route of antimicrobials administration depending on the type of surgical procedure (1, 3, 4). The neurosurgery operations of elective craniotomy, cerebrospinal fluid shunting procedures and intrathecal pumps already have well-established guidelines for perioperative administration of prophylactic antibiotics (5-7). However, there are no comprehensive recommendations for transsphenoidal surgery (TSS). Previous studies reported low incidence of meningitis and sinusitis after TSS with different antimicrobial prophylaxis (AMP) regimens (2, 3, 8, 9). A comparative study was needed to determine appropriate procedure-specific AMP options. We conducted a study comparing the efficacy and cost of three different TSS AMP regimens.

Conflict of interest and source of funding

We approve its publication and confirm that there is no conflict of interest related to this article. There is no contribution from other authors and funding agencies.

METHODS

Setting

This study was conducted in the neurosurgery unit of Erciyes University Hospital, a tertiary acute care hospital with 1,300 beds. The division of neurosurgery consists of a 49-bed unit and a separate 13-bed intensive care unit.

Definitions

SSI was defined as an infection related to an operative procedure that occurs at or near the surgical incision within 30 days of the procedure or within 90 days if prosthetic material is implanted at surgery. SSI was classified as superficial incisional, deep incisional and organ/space SSI according to the revised CDC criteria (10).

Study

A retrospective analysis of the clinical records of patients (aged >18 years) who underwent pituitary surgery between January 2012 and February 2016 was performed. Patients operated upon by a single experienced neurosurgeon team (Author 1 and 5) were included into the study. TSS was performed via endonasal microsurgical approach according to the standard guidelines for the procedure. Patients who were receiving antimicrobial therapy in the preoperative period and who had a complication of large cerebrospinal fluid leakage were excluded from the analysis. Procedures and materials for preparation of the surgical site remained unchanged for all patients (povidone iodine solution for preparation of nose and nasal cavities).

Patients were classified into three groups according to the AMP regimen they received. Group 1 included patients who received chemoprophylaxis with 2g IV cefazolin (30 min. before surgery); Group 2 received a single dose of 1g IV ceftriaxone (30 min before surgery); and Group 3 received fusidic acid 1% drops (intranasal, two times daily for three days). Patients were evaluated for the development of SSIs by means of hospital and post-discharge surveillance for 30 postoperative days. The cost analysis per patient was calculated in constant 2016 US dollars. Patients were excluded from the analysis if they had a known allergy to antibiotics in the study group. The study was approved by the Research Ethics Committee of Erciyes University (2016/299).

RESULTS

A total of 126 patients who underwent TSS were included in this study. The mean age of the patients was 44.8 years (28-60), with 68 (54 %) of the patients being females. Of the 126 patients, 32 (25.3%) received chemoprophylaxis with cefazolin, 50 (39.6%) ceftriaxone, and 44 (34.9%) fucidic acid drops. Demographic and clinical characteristic of patients are presented in Table 1. The types of the lesions operated upon, surgical site preparation procedures, and the average duration of surgeries – the main risk factors for SSIs – were found similar among the groups.

There were no statistically significant differences between the three groups with respect to patients' demographic and clinical characteristics. No cases of peri- or post-operative meningitis, or any other SSI were noted in either group. Cost-comparison of the three AMP regimens showed that ceftriaxone and fusidic acid regimens were more cost-effective compared to cefazolin.

DISCUSSION

Globally, incidence of SSIs has been on decline due to the developments in surgical antisepsis methods. However, SSIs still remain one of the most important causes of hospital-acquired infections, accounting for about 30% of them (11). Such infections extend the length of hospital stay, increase the rates of morbidity and mortality, and contribute significantly to the costs of healthcare (3, 12). The efficacy of AMP in reducing SSI has been shown with previous studies (1, 6, 13). But even though multiple guidelines on AMP have been published so far, clinical practices vary significantly among countries (13-16).

TSS is a relatively safe procedure and infectious complications are rare. In a previous survey, including 958 surgeons of different experience, the rate of post-operative meningitis was reported at 1.5%, and sinusitis at 8.5% (9). More recent studies have found infections rates to be even lower (2). That said, there is no single, agreed upon AMP regimen for TSS that would specify the timing, choice of prophylactic agent, and duration of AMP (6, 17, 18). Passing through the sphenoidal sinus, the surgery may be considered as clean contaminated and so would be eligible for AMP (19).

Cefazolin is an AMP agent of choice for craniotomy due to its good safety profile and favorable duration of action. However, its appropriateness for TSS is not as well documented. Previous studies described various dosages and durations, and reported that infectious complications were extremely low (2, 4). On the other hand, cefazolin does not penetrate the cerebrospinal fluid (CSF) well. It was also found to be costlier than comparative agents in our study.

CSF-penetrating third-generation cephalosporins were found similarly effective in endonasal surgeries for pituitary tumors (2, 8, 20). Ceftriaxone is a broad spectrum antibiotic with its long serum half-life and excellent penetration into CSF. It was the cheapest alternative AMP agent with an added advantage of a single dose administration. However, in the absence of a large cerebrospinal fluid leak the need for such a broad spectrum agent is controversial.

Topical applications (polymyxin, tetracycline) may be a "non-invasive" option for AMP in TSS (2). The role of intranasal antibiotics on healing the nasal mucosa and their safety and bioavailability, compared to systemic antibiotics, is unknown. These drugs have an advantage of being administered by patient at home. Fusidic acid has good *in vitro* activity against staphylococci, including both methicillin sensitive and resistant strains. It also has useful activity against *Neisseria* spp, *Bordetella pertussis*, Corynebacterium spp and some Gram positive anaerobes. Single dose oral fusidic acid was previously found effective in neurosurgery in a randomized placebo-controlled trial (21). In this study, intranasal use of fusidic acid drops was found as effective as comparatives. However, difficulties in adherence may be a factor for patients receiving AMP at home.

Few study limitations need to be mentioned. Our study is limited by its retrospective design and is under-powered. Since meningitis is a rare event, for the study to be sufficiently powered, a much larger sample size would

be required. As well, it must be noted that TSS performed via endonasal microsurgical approach is a procedure requiring extensive experience. Our hospital is the reference center for this type of surgery, with over 50 operations performed annually by a single experienced team.

In conclusion, the three AMP regimens compared in this study were found similarly effective with no reported infectious complication. With antimicrobial efficacy being similar, cost and ease of administration favor ceftriaxone as the agent of choice. The disadvantage, of course, is the broad-spectrum activity of ceftriaxone that may contribute to the growing antibiotic resistance. Further studies with placebo controls for select cases without large cerebrospinal fluid leaks may be needed to examine the perspectives of performing TSS without AMP altogether.

REFERENCES

1. Smaill FM, Grivell RM. Antibiotic prophylaxis versus no prophylaxis for preventing infection after cesarean section. Cochrane Database Syst Rev. 2014(10):CD007482.
2. Little AS, White WL. Prophylactic antibiotic trends in transsphenoidal surgery for pituitary lesions. Pituitary. 2011;14(2):99-104.
3. Djindjian M, Lepresle E, Homs JB. Antibiotic prophylaxis during prolonged clean neurosurgery. Results of a randomized double-blind study using oxacillin. J Neurosurg. 1990;73(3):383-6.
4. Brown SM, Anand VK, Tabaee A, Schwartz TH. Role of perioperative antibiotics in endoscopic skull base surgery. Laryngoscope. 2007;117(9):1528-32.
5. Erman T, Demirhindi H, Gocer AI, Tuna M, Ildan F, Boyar B. Risk factors for surgical site infections in neurosurgery patients with antibiotic prophylaxis. Surg Neurol. 2005;63(2):107-12; discussion 12-3.

TABLE 1: Comparison of demographics, clinical features of patients who underwent TSS and per patient cost of three different AMP protocols

	Group 1 n=32 (%)	Group2 n=50 (%)	Group 3 n=44 (%)	p
Mean age ± SD	43.3±13.1	45.9±12.4	44.6±16.0	0.702
Male gender	16 (50.0)	26 (52.0)	16 (36.4)	0.276
Median length of preoperative hospital stay (days, range)	2 (1-15)	2 (0-8)	2 (0-7)	0.973
Median length of hospital stay (days, range)	6 (2-35)	6 (3-13)	6 (2-17)	0.444
Primary diagnosis				0.572
Acromegaly	9 (28.0)	17 (34.7)	16 (36.4)	
Prolactinoma	3 (8.0)	4 (8.2)	3 (6.8)	
Cushing's syndrome	4 (12.0)	9 (18.4)	4 (9.1)	
Non-functioning pituitary tumors	16 (52.0)	19 (36.7)	16 (36.4)	
Ratke's cleft	0 (0.0)	1 (2.0)	4 (9.1)	
Chordoma	0 (0.0)	0 (0.0)	1 (2.3)	
Underlying diseases				
Diabetes mellitus	6 (18.8)	9 (18.0)	10 (22.7)	0.835
COPD	1 (3.1)	3 (6.0)	0 (0.0)	0.305
Hypertension	5 (15.6)	11 (22.0)	12 (27.3)	0.501
Heart failure	0 (0.0)	1 (2.0)	1 (2.3)	1.000
Renal failure	0 (0.0)	1 (2.0)	0 (0.0)	1.000
Use of COSs	4 (12.5)	9 (18.0)	11 (25.0)	0.370
Obesity	1 (3.1)	5 (10.0)	2 (4.5)	0.463
Smoking	4 (12.5)	8 (16.0)	2 (4.5)	0.217
Cost (per patient USD)	4.10	3.73	3.20	-
Infection rate	0/32 (0.0)	0/50 (0.0)	0/44 (0.0)	-

(SD: Standart deviation, COPD: Chronic obstructive pulmonary disease, COS: corticosteroid)

Group 1: Cefazolin (two doses, 30 min. before surgery)

Group 2: Ceftriaxone (one dose, 30 min before operation)

Group 3: Fucidic acid 1 % drops (intranasal, two times daily for three days)

Return to TABLE OF CONTENTS

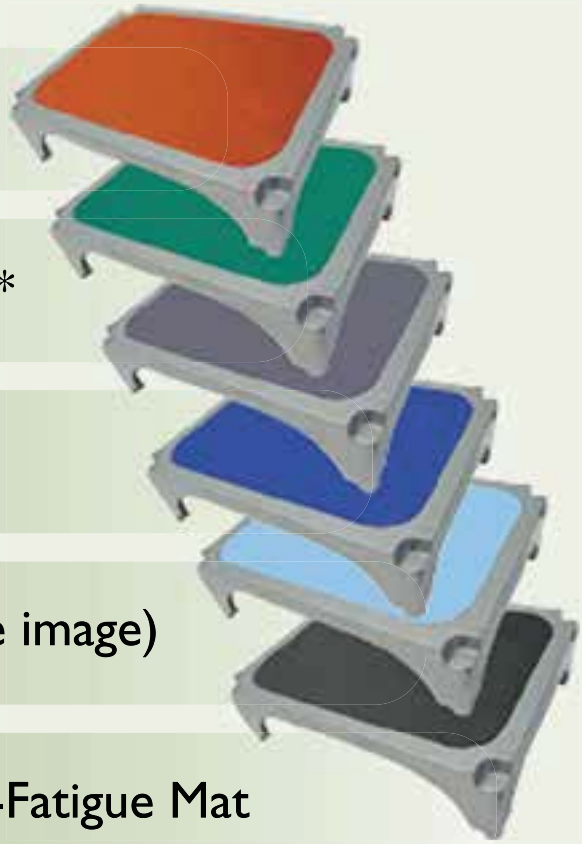
6. Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Surg Infect (Larchmt). 2013;14(1):73-156.
7. Buffet-Bataillon S, Haegelen C, Riffaud L, Bonnaure-Mallet M, Brassier G, Cormier M. Impact of surgical site infection surveillance in a neurosurgical unit. J Hosp Infect. 2011;77(4):352-5.
8. Chalkiadakis GE, Gonnianakis C, Tsatsakis A, Tsakalof A, Michalodimitrakis M. Preincisional single-dose ceftriaxone for the prophylaxis of surgical wound infection. Am J Surg. 1995;170(4):353-5.
9. Ciric I, Ragin A, Baumgartner C, Pierce D. Complications of transsphenoidal surgery: results of a national survey, review of the literature, and personal experience. Neurosurgery. 1997;40(2):225-36; discussion 36-7.
10. July 2013 CDC/NHSN Protocol Clarifications SSISE. 2013:9-23.
11. Magill SS, Hellinger W, Cohen J, Kay R, Bailey C, Boland B, et al. Prevalence of healthcare-associated infections in acute care hospitals in Jacksonville, Florida. Infect Control Hosp Epidemiol. 2012;33(3):283-91.
12. Perencevich EN, Sands KE, Cosgrove SE, Guadagnoli E, Meara E, Platt R. Health and economic impact of surgical site infections diagnosed after hospital discharge. Emerg Infect Dis. 2003;9(2):196-203.
13. Ozgun H, Ertugrul BM, Soyder A, Ozturk B, Aydemir M. Peri-operative antibiotic prophylaxis: adherence to guidelines and effects of educational intervention. Int J Surg. 2010;8(2):159-63.
14. Shibao S, Toda M, Tomita T, Ogawa K, Yoshida K. Analysis of the bacterial flora in the nasal cavity and the sphenoid sinus mucosa in patients operated on with an endoscopic endonasal transsphenoidal approach. Neurol Med Chir (Tokyo). 2014;54(12):1009-13.
15. Savitz SI, Rivlin MM, Savitz MH. The ethics of prophylactic antibiotics for neurosurgical procedures. J Med Ethics. 2002;28(6):358-63.
16. Hosoglu S, Sunbul M, Erol S, Altindis M, Caylan R, Demirdag K, et al. A national survey of surgical antibiotic prophylaxis in Turkey. Infect Control Hosp Epidemiol. 2003;24(10):758-61.
17. Little AS, White WL. Short-duration, single-agent antibiotic prophylaxis for meningitis in trans-sphenoidal surgery. Pituitary. 2011;14(4):335-9.
18. Somma T, Maraolo AE, Esposito F, Cavallo LM, Tosone G, Orlando R, et al. Efficacy of ultra-short single agent regimen antibiotic chemo-prophylaxis in reducing the risk of meningitis in patients undergoing endoscopic endonasal transsphenoidal surgery. Clin Neurol Neurosurg. 2015;139:206-9.
19. Narotam PK, van Dellen JR, du Trevou MD, Gouws E. Operative sepsis in neurosurgery: a method of classifying surgical cases. Neurosurgery. 1994;34(3):409-15; discussion 15-6.
20. Orlando R, Cappabianca P, Tosone G, Esposito F, Piazza M, de Divitiis E. Retrospective analysis of a new antibiotic chemoprophylaxis regimen in 170 patients undergoing endoscopic endonasal transsphenoidal surgery. Surg Neurol. 2007;68(2):145-8; discussion 8.
21. Mindermann T, Zimmerli W, Gratzl O. Randomized placebo-controlled trial of single-dose antibiotic prophylaxis with fusidic acid in neurosurgery. Acta Neurochir (Wien). 1993;121(1-2):9-11.

IMPERIAL SURGICAL®

STEP UP! To the Best Stacking Step Stool

The only stool with **ANTIMICROBIAL*** protection and designed with **INFECTION CONTROL** prevention as its prime objective:

- NO welds and NO hollow legs to trap debris/fluids
- Cart Washable and Sterilizable**
- Light Weight Aluminium
- Heavy Duty Capacity (see image)
- Available with an Anti-Fatigue Mat



* Patent Pending

Anti-Fatigue Mat

Available Single-Use and Reusable

1-800-661-5432

www.StackingStepStool.com

Handle Hygiene, keeps door handles clean.

No matter who touched it last.

Handle Hygiene is an easy-to-install, automatic disinfectant dispenser system suitable for most types of door handles.

Every time a door is used, the system delivers a disinfectant mist upon the handle, sanitizing it after each opening.

The system significantly reduces the risks of cross-contamination, by inactivating 99.9% of common viruses and bacteria, including MRSA.

Does not contain any kind of pressurized gas

Specific maintenance not required

Batteries not required

Contact SciCan today and we will help you determine the optimal deployment of Handle Hygiene in your hospital's high risks and high traffic areas.

Toll Free: 1-800-667-7733

www.scicanmedical.ca/HANDLEHYGIENE

Manufactured by: Clever Hygiene Solutions Ltd. 95 Ranelagh Village, Dublin. D06 V1W5

SciCan | Your Infection Control Specialist™

CaviCide1™ and CaviWipes1™ are the only low alcohol surface disinfectants with a 1 minute contact time.

- Kills all product labeled organisms in 1 minute, including Norovirus
- Allows for faster room turnover
- Same formulation in a spray and a wipe

Go to www.metrex.com/CJIC to learn more about CaviWipes1™ and CaviCide1™.

Metrex™
Protecting People

Now available

Nexa™ Point-of-Care Holder

Attaches to tray tables, bed rails or at the end of the bed

Position on the wall, bed side table or even the workstation

Secure to nurse, dialysis, anesthesiology and phlebotomy stations or carts

PROMOTE COMPLIANCE. HAND HYGIENE AVAILABLE WHERE YOU NEED IT MOST.

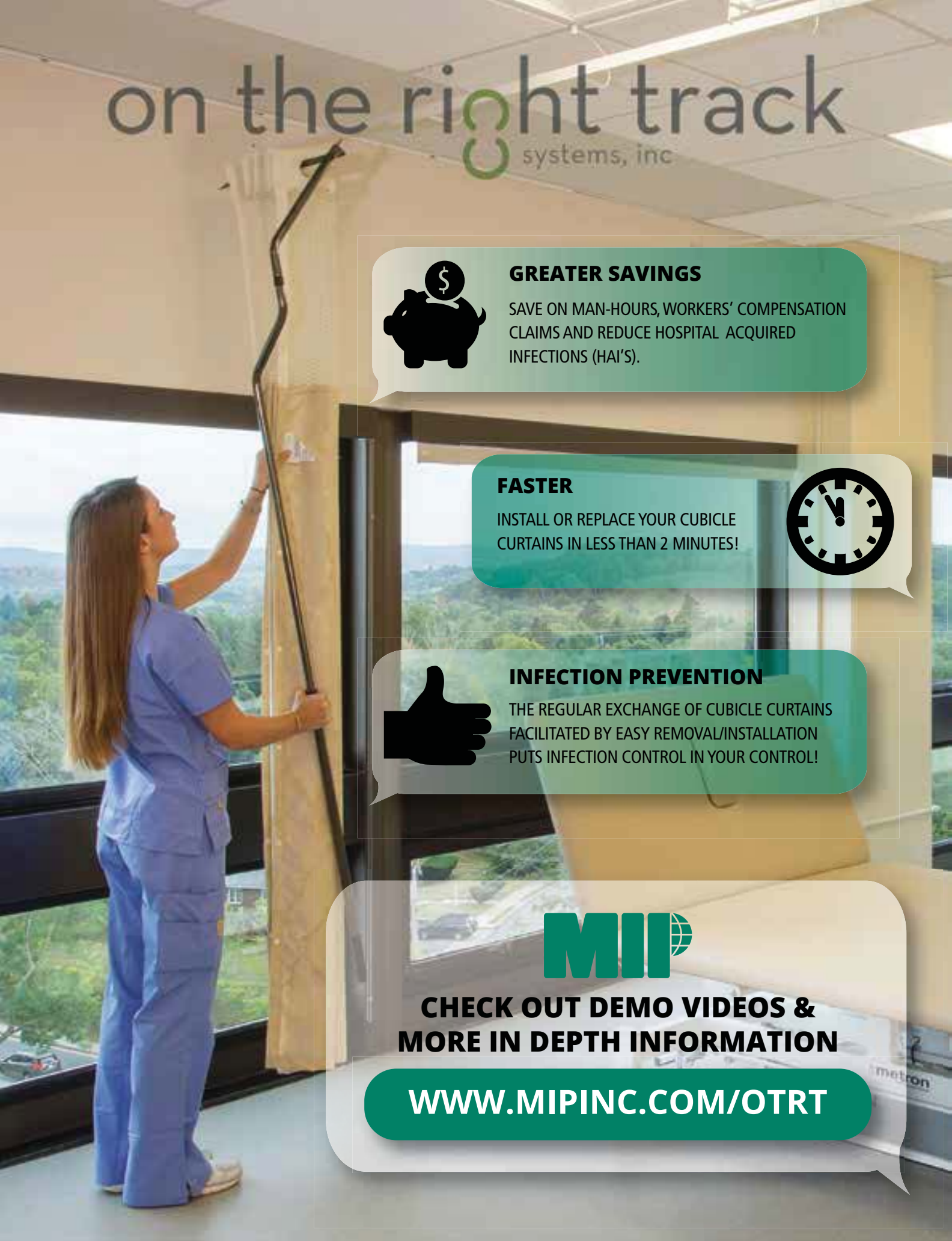
The Nexa™ Point-of-Care Holder is part of the Ecolab hand hygiene program, designed to support your goals with best-in-class products, innovative dispensing options, staff training materials and personalized service.

Revitalizing Skin Lotion Fragrance Free (540 mL)

Quik-Care™ Nourishing Foam* (535 mL)

Contact your Ecolab Healthcare Account Executive at 1 800.352.5326 or visit ecolab.com/healthcare.

ECOLAB®


on the right track
systems, inc
GREATER SAVINGS
SAVE ON MAN-HOURS, WORKERS' COMPENSATION CLAIMS AND REDUCE HOSPITAL ACQUIRED INFECTIONS (HAI'S).
FASTER
INSTALL OR REPLACE YOUR CUBICLE CURTAINS IN LESS THAN 2 MINUTES!
INFECTION PREVENTION
THE REGULAR EXCHANGE OF CUBICLE CURTAINS FACILITATED BY EASY REMOVAL/INSTALLATION PUTS INFECTION CONTROL IN YOUR CONTROL!
MIP
CHECK OUT DEMO VIDEOS & MORE IN DEPTH INFORMATION
WWW.MIPINC.COM/OTRT

Making the choice simple

For outstanding ultrasound probe HLD compliance.

trophon® is now available directly from Nanosonics in Canada (the inventor and manufacturer)

Call 1-844-TROPHON (1-844-876-7466)

www.trophon.com/ca

trophon®

nanosonics

Infection Prevention. For Life.

MM0284-CA-AD V01

PCS
PROCESS CLEANING SOLUTIONS
Bringing Science to the Art of Cleaning®

BUY 1st CANADIAN

HYPOCHLOROUS ACID

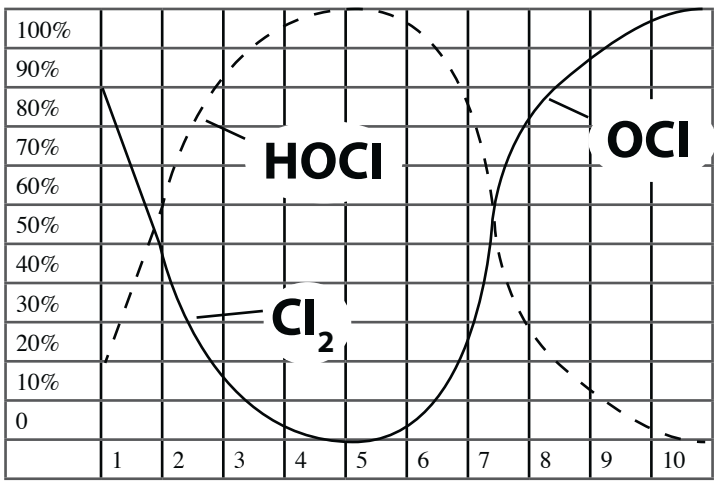
PCS SODIUM HYPOCHLORITE WITH NEUTRAL PH

- **Maximize mildness to skin.**
- **Reduce chemical residues.**
- **Improve cleaning performance.**
- **Maximize antimicrobial properties.**

Hypochlorous acid is a chemical that is normally produced in the human white blood cells in response to injury and infection. It is a chemical that is well studied and researched, it is regarded as a medical panacea as it is much more antiseptic than anything we have at present. Its wound healing capabilities and beneficial effect on inflammation are also well known.

Hypochlorous acid (HOCl) forms an equilibrium with sodium hypochlorite (OCl) in liquid solutions.

The figure below shows the effect pH has on the equilibrium.



Below pH 2 the equilibrium favors chlorine. Between pH 2 and 7.4 hypochlorous acid predominates and above pH 7.4 hypochlorite predominates.

STEVENS

"Where service is a commitment" | "Où le service est un engagement"

BREAK THE CHAIN OF INFECTION

Contact Stevens for a Customized Solution Today

Proud Partners of

MEIKO · Sealed Air Diversey Care · GOJO · 3M · icu medical · Metrex Protecting People · WIPAK · Kimberly-Clark PROFESSIONAL · PERMUL

www.stevens.ca

HALIFAX	MONTREAL	TORONTO	WINNIPEG	CALGARY	VANCOUVER
800-565-0765	855-660-7750	800-268-0184	800-665-0368	800-665-0368	800-565-8444

Eliminates 99.999% of MRSA and VRE

Eliminates 99.99% of *C. diff* spores

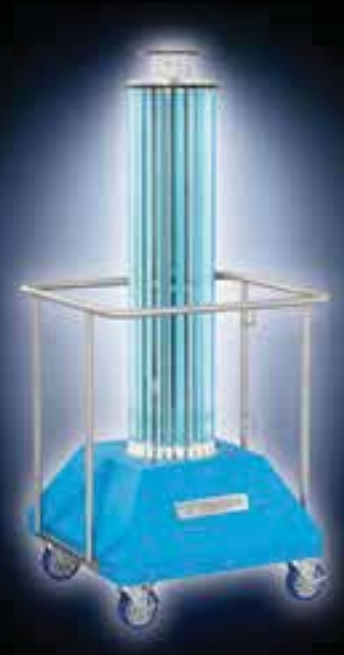
Eliminates 99.999% of Viruses

Independent studies prove PATHOGON™ UV Antimicrobial System is effective against pathogens that can cause healthcare associated infections (HAI).

Start winning the fight against invisible infectious pathogens today with STERIS's own PATHOGON UV Antimicrobial System.

PATHOGON™
UV Antimicrobial System

By STERIS, the leader in Infection Protection.



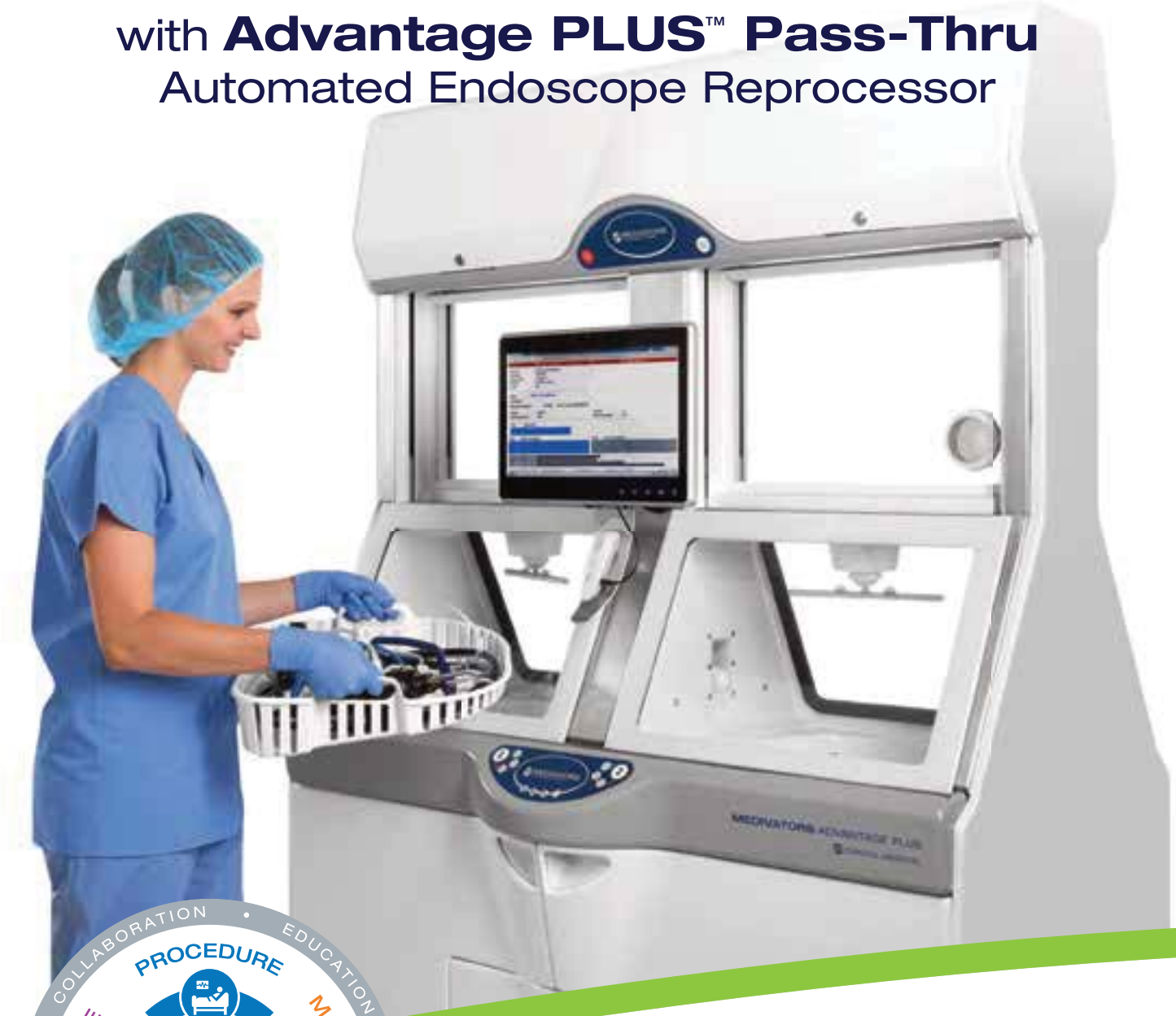
Request a quote today at www.pathogon.com!

STERIS

STERIS Canada Inc. | Healthcare
375 Britannia Road East, Unit 2
Mississauga, ON L4Z 3E2 Canada
800 661 3937
www.steris.com <http://www.steris.com>

Maximize Infection Prevention

with Advantage PLUS™ Pass-Thru Automated Endoscope Reprocessor



Our Complete Circle of Protection portfolio is a full-value, proactive partnership dedicated to helping mitigate risk and streamline operational efficiencies.

Visit Cantel Medical in Booths 34 & 35 at IPAC Canada to learn more about our innovative reprocessing technologies.

CANTEL MEDICAL

The key to infection prevention?

Introducing,
the next generation in HAI prevention

The Vernacare Compact - A space-efficient disposal unit that provides safe and effective human waste disposal at the point of care, has arrived. The Compact's hand-free operation ensures the highest hygiene standards and is equipped with Vernacare's unparalleled **SmartFlow**™ technology for effective waste disposal.

For an exclusive look at our newest innovation, visit us at booth #12 at the ***IPAC Canada 2017 National Education Conference*** in Charlottetown, PEI.

1-800-268-2422 • www.vernacare.com

Vernacare™
cleaner safer healthcare

Is capturing ONLY .02% of hand hygiene opportunities enough?

IMPROVE THE QUALITY OF CARE WITH MORE ACCURATE & ACTIONABLE DATA

GOJO SMARTLINK™ Total Solutions

ACTIVITY MONITORING SYSTEM (AMS)

- Accurately captures event & opportunity data at Moments 1 & 4, as recommended by the **Ministry of Health and Long Term Care**
- Includes PURELL® Point of Care dispenser, allowing the system to capture critical hand hygiene events at the time of patient care

CLINICIAN-BASED SUPPORT

- Expertise to help build and sustain hand hygiene improvement

SERVICE ALERTS

- Ensures product availability with dispenser alerts for low refills, batteries and operation

A recent study in a Canadian Emergency Department using the SMARTLINK Activity Monitoring System, captured **over 300,000 hand hygiene opportunities in one month**, compared to **only 60** through Direct Observation.[1]

1. Anne Bialachowski et al, "Electronic Hand Hygiene Monitoring in the Emergency Department: Charting New Territory," http://www.gojo.com/en-CA/Markets/Acute-Care/Hand-Hygiene-Education/Technical-Publications

GOJO® SMARTLINK™

To learn more call 800-321-9647 or visit GOJOCANADA.ca/SMARTLINK

REQUEST A FREE TRIAL AT SMARTLINK@GOJO.COM

#20685 (3/2017)

Sealed Air
Diversey Care

Introducing Your New HAI Risk Reduction Team.

Fast, effective disinfectant wipes everyone can use on high touch surfaces.

Bed rails/controls/surfaces

Chairs/furniture

Overbed tables

Bedside tables/phones

Easy-to-use wipes for "grab-n-go" disinfection at point of care.

INTERVention™ Wipes clean and disinfect in one minute with no PPE required.

Convenient, in-room dispensing means medical staff, visitors – even patients – can grab a wipe to help prevent the spread of pathogens like TB and norovirus.

Fast, effective, responsible, sustainable – at the right time and place!

Accel®
powered by ACCELERATED HYDROGEN PEROXIDE Patented

HELPING YOU ACHIEVE TOTAL DISINFECTION

Products

Procedures

Validation

To learn more about Accel® disinfectant cleaners, call customer service at 1-800-668-7171.

sealedair.com

hygie®

COMMITTED TO ECO-FRIENDLY PRODUCTS

THE PERFECT SOLUTION FOR BODY FLUID MANAGEMENT

It's so easy with Hygie

A 50% decrease of the incidence of nosocomial infections associated with body fluids*

Get Your Product Guide And Free Samples!
info@hygie.com | www.hygie.com

*Source: Managing excreta at the source at Levis Hospital, Qc, Canada. Catherine Roy, Nursing Care Management, The Chaudiere Appalaches Integrated Health and Social Services Centre, Qc, Canada. HYGIENES - September 2016.

ipac pci

PARADIGM

Silver Corporate Member

BOOTH 27

The Hand Hygiene Compliance and Skin Care Experts

- Full line of skin care products specifically **formulated for healthcare**
- Electronic Hand Hygiene Compliance System clinically proven to improve compliance and **reduce MRSA HAIs by 42%**
- A comprehensive range of best practice tools to **enable improved hand hygiene behaviour** by hospital staff

Learn more at debmed.com

Make Hands Matter in the Workplace

www.debmed.com | 888.DEB.SOAP

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.medprodefense.com
Ansell Canada	10	800-363-8340	www.ansell.com/gammex
BD Canada	OBC	866-979-9408	www.bd.com
Cantel Medical	62	844-348-5636	www.medivators.com
CardioMed Supplies Inc.	40	800-387-9757	www.cardiomed.com
CHAIR (Coalition for Healthcare Acquired Infection Reduction)	11		www.chaircanada.org
Class 1 Inc.	11	800-242 9723	www.class1inc.com
Clorox Healthcare	IFC, 1, 2	866-789-4973	www.cloroxprofessional.com
DDC Dolphin Canada Inc.	53	604-512-8848	www.ddcdolphin.com
DebMed	67	888-DEB-SOAP	www.debmed.com
Ecolab USA Inc.	56	800-352-5326	www.ecolab.com/healthcare
Emerald Health Information Systems	40	613-599-8178	www.emeraldhis.com
GOJO Canada, Inc.	64	800-321-9647	www.GOJOCanada.ca
Hygie	66	866-588-2221	www.hygie.com
Imperial Surgical Ltd.	52	800-661-5432	www.StackingStepStool.com
Metrex Corp.	55	800-841-1428	www.metrex.com
MIP	57	877-356-2987	www.mipinc.com/otrt
Nanosonics	58	844-876-7466	www.trophon.com/ca
Process Cleaning Solutions	59	877-745-7277	www.processcleaningsolutions.com
Retractable Technologies, Inc.	4	888-703-1010	www.retractable.com
Sage Products LLC	12	800-323-2220	www.sageproducts.com
SciCan Ltd.	54	800-667-7733	www.scicanmedical.ca
Sealed Air Diversey Care	6, 65	800-558-2332	www.sealedair.com
STERIS Canada Inc.	61	800-661-3937	www.steris.com
The Stevens Company Limited	60	800-268-0184	www.stevens.ca
Vernacare Canada Inc.	63	800-268-2422	www.vernacare.com
Virox Technologies Inc.	5, 7, 9	800-387-7578	www.virox.com

WOULD YOU LEAVE THIS BEHIND FOR THE FUTURE?

ZORBI is the ONLY human waste management system that's BIODEGRADABLE with a 5 YEAR SHELF LIFE. **GUARANTEED!**

ZORBI™
No Mess. No Odour.

Before you choose a human waste management solution call us **1-800-363-2381** or visit **www.medprodefense.com**

MedPro DEFENSE®

THE DIFFERENCE WE MUST MAKE TOGETHER

ANTIMICROBIAL RESISTANCE THREATENS GLOBAL HEALTH, STABILITY AND ECONOMIC SECURITY.

The rapid growth of antimicrobial resistance (AMR) transcends its devastating impact on human health. AMR is emerging among the world's leading global security and economic threats, demanding the attention of world leaders. Based on current trends, AMR will cause an estimated 10 million deaths annually by 2050, surpassing the number of deaths caused by cancer.[1] BD joins with industry and world leaders in calling for mobilization of a global, collaborative alliance to address the threat of AMR. We stand ready to support this vital effort with 120 years of expertise in advancing medical practice and an extensive portfolio of products and solutions that facilitate infection prevention and control, diagnosis, surveillance and reporting, including infections resistant to antimicrobial treatment.

We also bring decades of firsthand experience collaborating across the public and private sectors to advance global health in areas such as childhood immunization, HIV & AIDS, tuberculosis, sepsis and healthcare-associated infections. The threat of AMR requires full engagement and partnership among all stakeholders, including patients, clinicians, government and nongovernment agencies, academic institutions and companies. Together, we must be the first and final line of defense.

Vincent A. Forlenza
Chairman of the Board, Chief Executive Officer and President

Come visit the BD booth at IPAC

Learn more about the Difference of One at **bd.com/DO1-AMR**

BD
Advancing the world of health

1 Review on Antimicrobial Resistance. *Tackling Drug-Resistant Infections Globally: Final Report and Recommendations.* 2016.