# “Risk factors for the environmental spread of different multi drug-resistant organisms”

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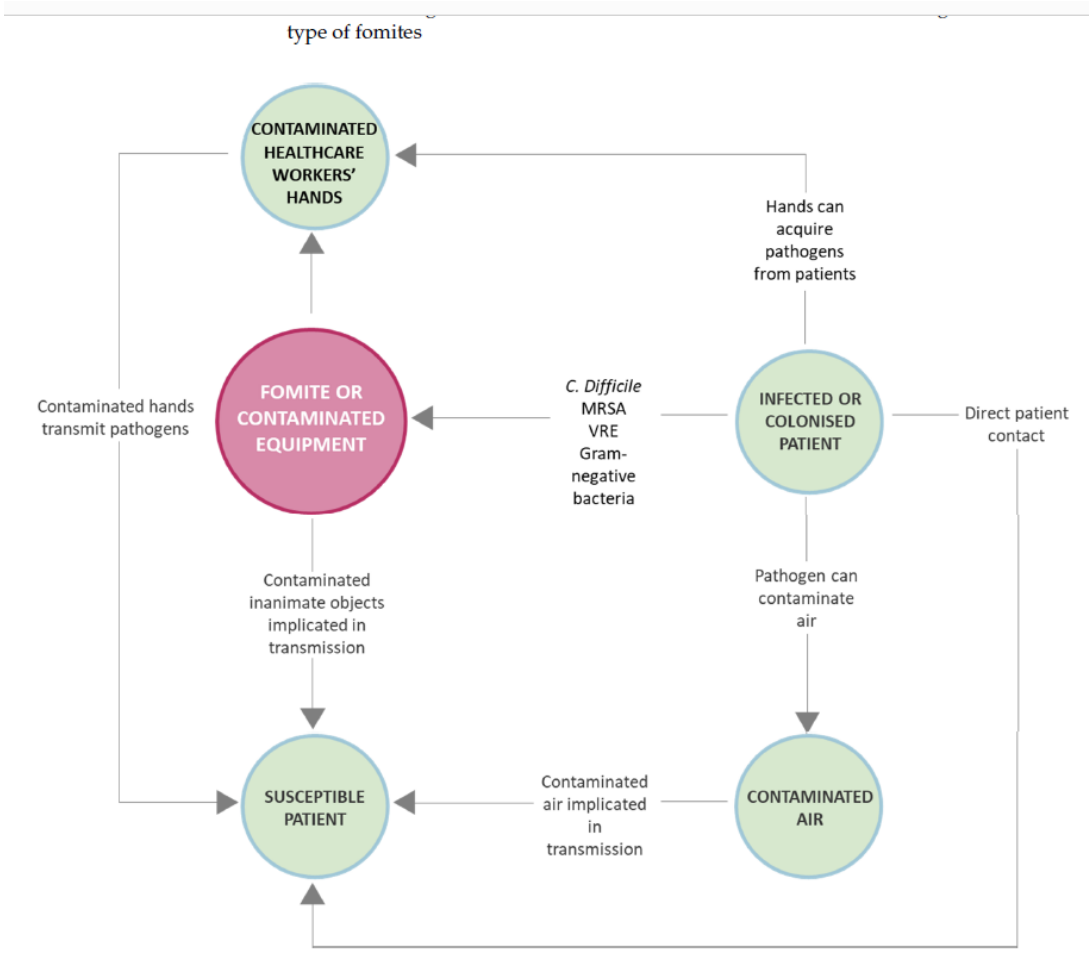
# Should we be interested in this issue?

- A definite increase in the prevalence of MDRO colonization
- Increased risk of hospital acquisition
- In case of acquisition a risk of secondary infection and a higher risk of mortality

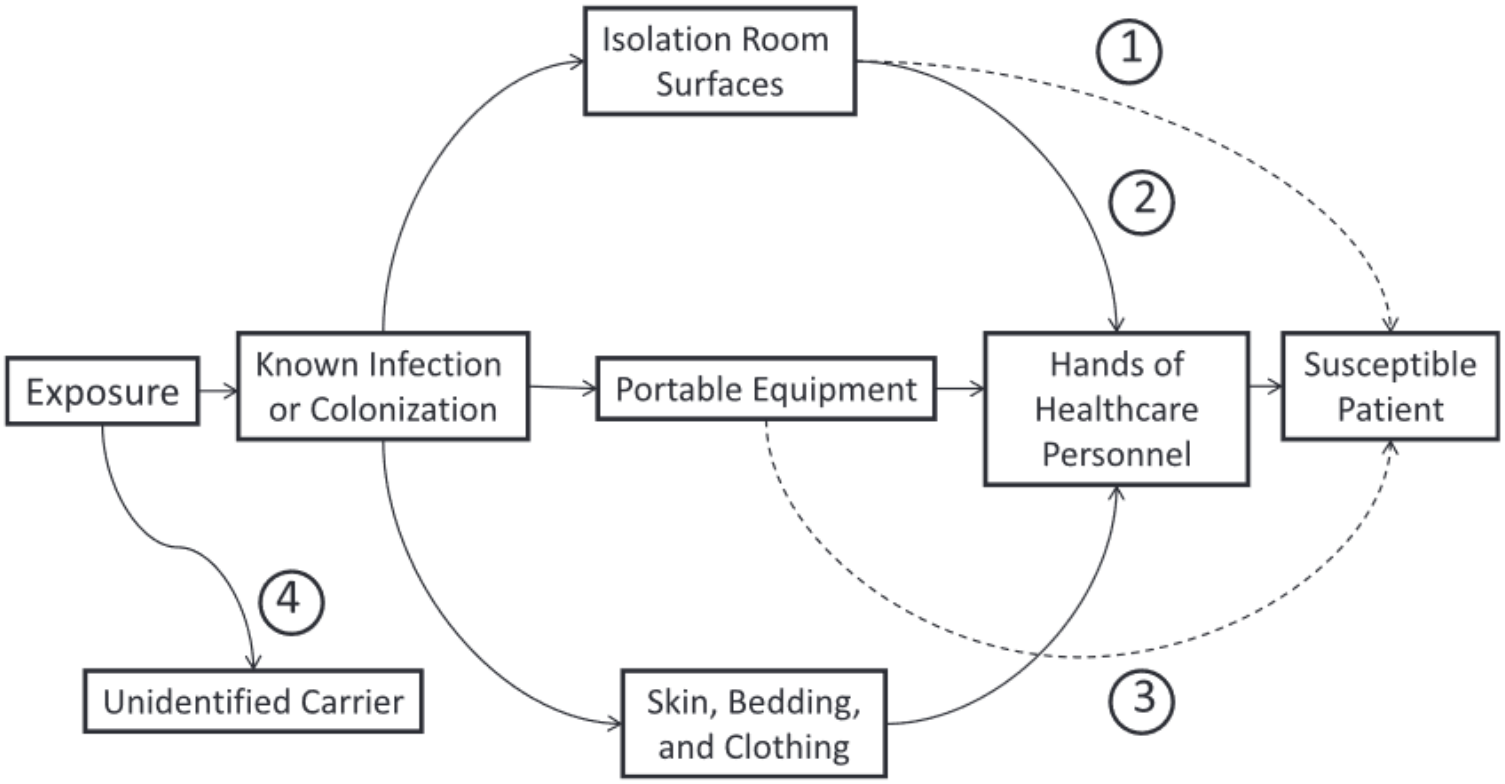
# How does the environment contribute to the acquisition of MDRO ?






Artasensi A, Mazzotta S, Fumagalli L. Back to Basics: Choosing the Appropriate Surface Disinfectant. Antibiotics (Basel). 2021 May 21;10(6):613.

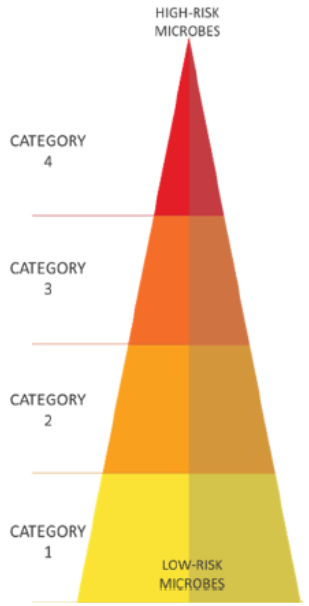
C.J. Donskey / American Journal of Infection Control 41 (2013) S12-S19



# Classification of biological agents

**Table 2.** Classification of biological agents.

| Risk Classification | Description | Examples | Heading |
|---|---|---|---|
| Category 1 | Pathogen with a low probability of developing diseases in the human organism | Nonpathogenic strains of *Escherichia* | |
| Category 2 | Pathogen that may cause pathology in humans and be a potential hazard for workers; it's unlikely that can be spread in the community; usually, there are effective treatments | Measles virus, *Salmonella, Legionella* | |
| Category 3 | Pathogen that may cause severe illness in humans and be a serious hazard for workers; the biological agent may spread in the community, but usually effective treatments are available | HIV, *Bacillus anthracis*, HBV, HCV, *Mycobacterium tuberculosis* SARS-CoV-2 | |
| Category 4 | Pathogen that may cause severe illness in humans and may be a serious hazard for workers; the biological agent can spread in the community, and usually, there are no effective treatments available. Pathogens with a low probability of developing diseases in human organisms. Pathogens that may cause pathology in humans and be a potential hazard for workers; it is unlikely that they can be spread in the community; usually, there are effective treatments | Ebola virus, Lassa virus, Smallpox virus. Nonpathogenic strains of *Escherichia* Measles virus, *Salmonella, Legionella* | |






Artasensi A, Mazzotta S, Fumagalli L. Back to Basics: Choosing the Appropriate Surface Disinfectant. Antibiotics (Basel). 2021 May 21;10(6):613.

# MDRO : what are the questions being asked?

- What is the importance or magnitude of the problem ?
- Does this problem specific to a particular situation?
- Does this problem concern all patients?

# Epidemiology of contaminated surfaces

- Surface contamination contributes to the risk of transmission both directly and indirectly

- It is difficult to predict the frequency of contamination of surfaces according to the species concerned, it depends of
    - The volume of the reservoir
    - The specificity of the species concerned its ability to survive outside its host, its ability to sporulate
    - The quality of biocleaning
    - The outbreak situation

# All patients do not spread in the same way

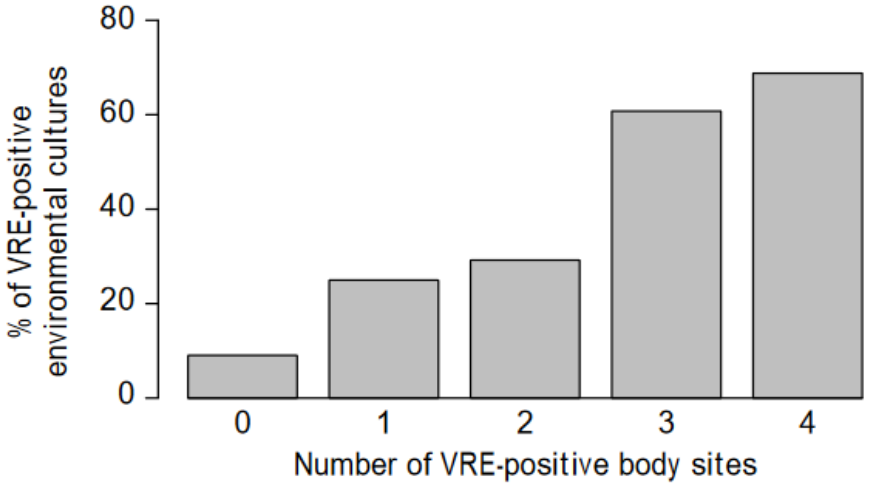
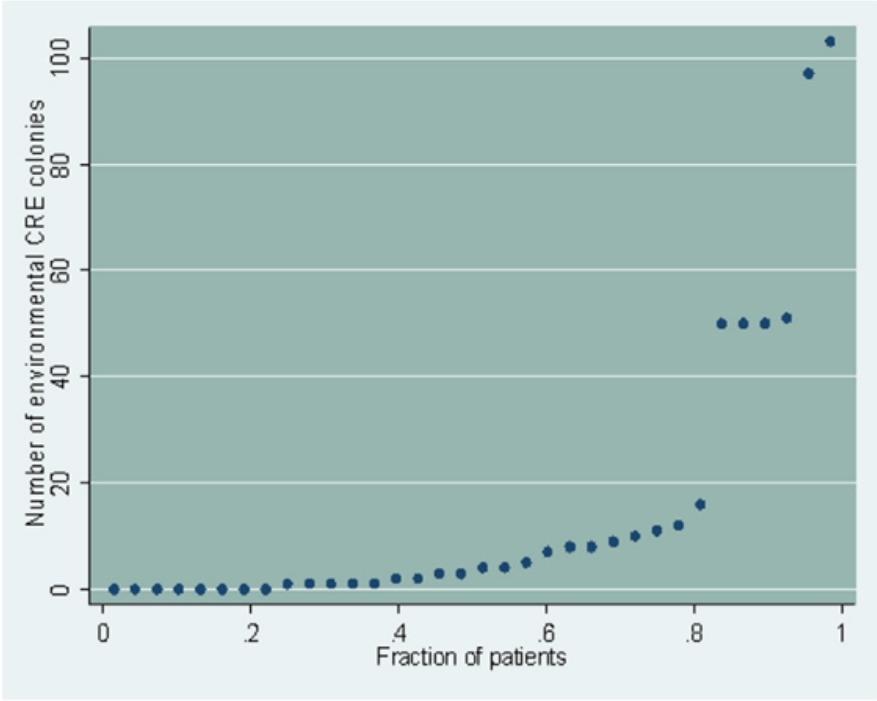



Figure: Correlation between number of body sites colonised with VRE and environmental contamination in the same room




Bonten MJ, Hayden MK, Nathan C, van Voorhis J, Matushek M, Slaughter S, Rice T, Weinstein RA. Epidemiology of colonisation of patients and environment with vancomycin-resistant enterococci. Lancet. 1996 Dec 14;348(9042):1615-9. Lerner A, Adler A, Abu-Hanna J, Cohen Percia S, Kazma Matalon M, Carmeli Y. Spread of KPC-producing carbapenem-resistant Enterobacteriaceae: the importance of super-spreaders and rectal KPC concentration. Clin Microbiol Infect. 2015 May;21(5):470.e1-7.

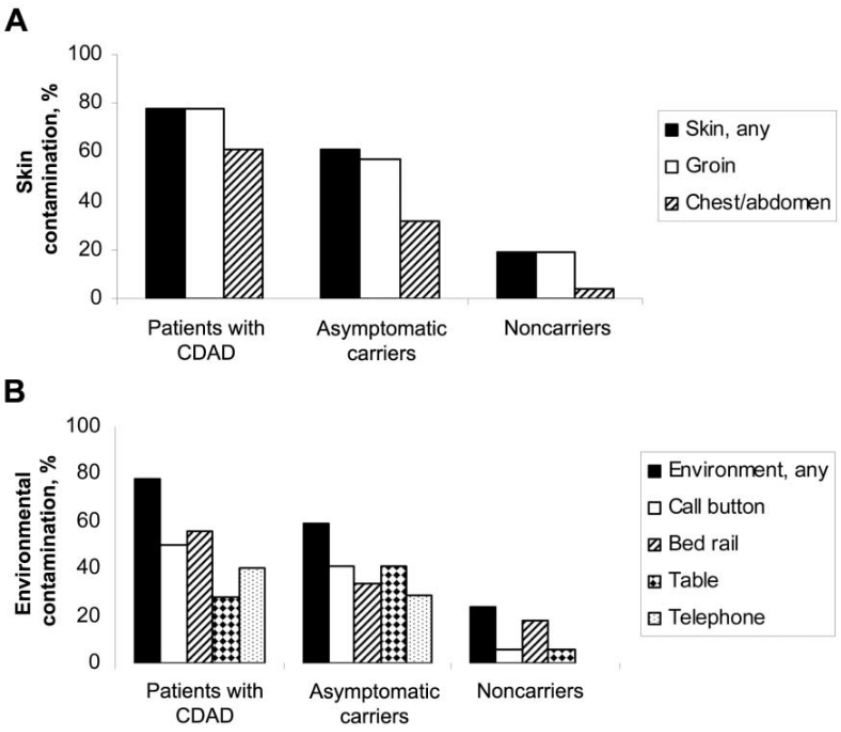
# Different species = different risk ?

**Table 2**
Univariate and multivariate analysis of risk factors for environmental contamination

| | Environmental contamination (n = 10)* | Others (n = 84)† | Univariate analysis: OR, [95% CI], *P* value | Multivariate analysis: OR, [95% CI], *P* value |
|---|---|---|---|---|
| Nosocomial/community acquisition | 4/6 | 45/39 | 0.58 [0.13-2.55], $P = .58$ | Ns |
| *E coli/Klebsiella* | 1/9 | 45/39 | 10.38 [1.24-228.58], $P = .02$ | 11.6 [1.37-97.67], $P = .02$ |
| Room cleaning before/after environmental sampling | 7/3 | 68/16 | 0.55 [0.11-3.04], $P = .69$ | Ns |
| Colonized/infected status | 8/2 | 69/15 | 0.87 [0.15-6.61], $P = .78$ | Ns |
| Antibiotics (yes/no) | 6/4 | 49/35 | 1.07 [0.24-4.94], $P = .81$ | Ns |
| Invasive device (yes/no) | 9/1 | 51/33 | 5.82 [0.69-128.39], $P = .14$ | 6.8 [0.78-59.2], $P = .08$ |
| Time elapse between acquisition and environmental sampling, mean days (SD) | 21.2 (27.75) | 14.6 (36.92) | 0.006 | 1.0 [0.98-1.017], $P = .98$ |
| Incontinence (yes/no) | 5/5 | 44/40 | 0.91, [0.21-3.98], $P = .84$ | Ns |

Guet-Revillet H, Le Monnier A, Breton N, Descamps P, Lecuyer H, Alaabouche I, Bureau C, Nassif X, Zahar JR. Environmental contamination with extended-spectrum β-lactamases: is there any difference between Escherichia coli and Klebsiella spp? Am J Infect Control. 2012 Nov;40(9):845-8.

# Which patients disseminate more (infected or colonized) ?



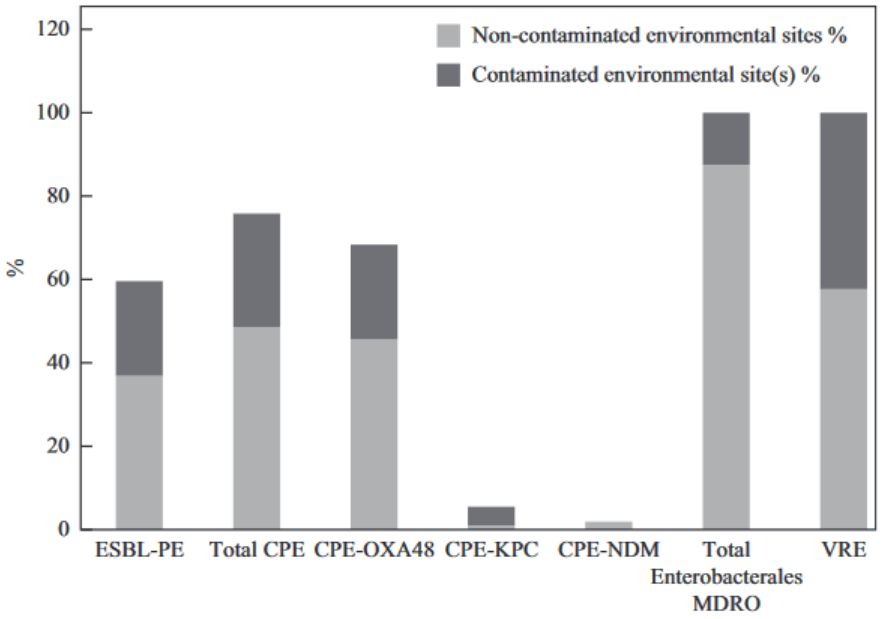

| Continence | Baseline (day 0) No. (%) |
|---|---|
| Continent (n =15) | 9/15 (60) |
| No diarrhea (9) | 6/9 (67) |
| Diarrhea (6) | 3/6 (50) |
| Incontinent (n = 15) | 11/15 (73) |
| Occasional (8) | 7/8 (88) |
| Always (7) | 4/7 (57) |
| Colostomy (n = 3) | 3/3 (100) |

Asymptomatic carriers are a potential source for transmission of epidemic and nonepidemic Clostridium difficile strains among long-term care facility residents. Clin Infect Dis. 2007 Oct 15;45(8):992-8. Mayer RA, Geha RC, Helfand MS, Hoyen CK, Salata RA, Donskey CJ. Role of fecal incontinence in contamination of the environment with vancomycin-resistant enterococci. Am J Infect Control. 2003 Jun;31(4):221-5.

# Survival in the environment is variable depending on the microbial species

| | % of site contamination | Study |
|---|---|---|
| MRSA | 24 – 89% | Otter et al, JHI 2007<br>Dryden et al, JHI 2008<br>French et al, JHI 2004 |
| *C difficile* | 25% - 75% | Barbut et al, ICGE 2009<br>Boyce et al, ICHE 2008<br>Weber et al, AJIC 2010 |
| *Serratia* (GNB) | ~8% | Bates et al, JHI 2005<br>Otter et al, JHI 2007 |
| *Acinetobacter baumannii* | ~50% | Weber et al, AJIC 2010 |
| VRE | 94% | Eckenstein et al, BMC Inf dis 2007 |

# Survival in the environment is variable depending on the microbial species




| Type of bacterium | Duration of persistence (range) |
|---|---|
| Acinetobacter spp. | 3 days to 5 months |
| *Bordetella pertussis* | 3 – 5 days |
| *Campylobacter jejuni* | up to 6 days |
| *Clostridium difficile* (spores) | 5 months |
| *Chlamydia pneumoniae, C. trachomatis* | ≤ 30 hours |
| *Chlamydia psittaci* | 15 days |
| *Corynebacterium diphtheriae* | 7 days – 6 months |
| *Corynebacterium pseudotuberculosis* | 1–8 days |
| *Escherichia coli* | 1.5 hours – 16 months |
| Enterococcus spp. including VRE and VSE | 5 days – 4 months |
| *Haemophilus influenzae* | 12 days |
| *Helicobacter pylori* | ≤ 90 minutes |
| Klebsiella spp. | 2 hours to > 30 months |
| Listeria spp. | 1 day – months |
| *Mycobacterium bovis* | > 2 months |
| *Mycobacterium tuberculosis* | 1 day – 4 months |
| *Neisseria gonorrhoeae* | 1 – 3 days |
| *Proteus vulgaris* | 1 – 2 days |
| *Pseudomonas aeruginosa* | 6 hours – 16 months; on dry floor: 5 weeks |
| *Salmonella typhi* | 6 hours – 4 weeks |
| *Salmonella typhimurium* | 10 days – 4.2 years |
| Salmonella spp. | 1 day |
| *Serratia marcescens* | 3 days – 2 months; on dry floor: 5 weeks |
| Shigella spp. | 2 days – 5 months |
| *Staphylococcus aureus*, including MRSA | 7 days – 7 months |
| *Streptococcus pneumoniae* | 1 – 20 days |
| *Streptococcus pyogenes* | 3 days – 6.5 months |
| *Vibrio cholerae* | 1 – 7 days |

Saliba R, Ghelfenstein-Ferreira T, Lomont A, Pilmis B, Carbonnelle E, Seytre D, Nasser-Ayoub E, Zahar JR, Karam-Sarkis D. Risk factors for the environmental spread of different multidrug-resistant organisms: a prospective cohort study. J Hosp Infect. 2021 May;111:155-161. Kramer A, Schwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. BMC Infect Dis. 2006 Aug 16;6:130.

# Is the frequency of contamination the same during non outbreaks period?

Environmental contamination according to selected surfaces

| | Any bacteria ≥1 cfu/cm$^2$ | *Staphylococcus aureus* | Enterobacterales |
|---|---|---|---|
| Over-bed table | 59.8% | 1.4% | 4.2% |
| Chair | 69.1% | 1.9% | 2.8% |
| Bed rails | 74.7% | 3.7% | 1% |
| Toilet seat | 82.6% | 2.6% | 11.2% |
| Door and closet knobs | 57.5% | 1.4% | 0% |

| Variable | Contaminated rooms ($N$ = 54) | Non-contaminated rooms ($N$ = 53) | Multivariate analysis $P$-value | Odds ratio |
|---|---|---|---|---|
| Patients known carrier or infected with MDRO | 6 (11.1%) | 13 (24.5%) | 0.01 | 0.25 (0.09–0.72) |
| Recent surgery | 14 (25.9%) | 20 (37.7%) | | |
| Comatose patients | 2 (3.7%) | 0 | | |
| Any invasive devices | 23 (42.6%) | 32 (60.4%) | 0.91 | |
| Urinary catheter | 1 (1.85%) | 11 (20.7%) | 0.03 | 0.19 (0.04–0.89) |
| Venous catheter | 22 (40.7%) | 30 (56.6%) | 0.17 | |
| Dependent patients | 14 (25.9%) | 17 (32%) | | |
| Antibiotic therapy | 12 (22.2%) | 19 (35.6%) | 0.12 | |
| Single room | 30 (55.5%) | 43 (81.1%) | 0.0005 | 0.3 (0.15–0.6) |
| Time elapsed between admission and sampling (days), mean value | 7.1 | 9.8 | | |

MDRO, multidrug-resistant organism.

Pilmis B, Billard-Pomares T, Martin M, Clarempuy C, Lemezo C, Saint-Marc C, Bourlon N, Seytre D, Carbonnelle E, Zahar JR. Can environmental contamination be explained by particular traits associated with patients? J Hosp Infect. 2020 Mar;104(3):293-297.

# Other factors involved in survival

- Many factors are associated with survival in the environment including
  - The initial inoculum
  - The presence of biological material
  - Sensitivity to ultraviolet light
  - Heat resistance
  - Type of surfaces

Dai R, Liu S, Li Q, Wu H, Wu L, Ji C. A systematic review and meta-analysis of indoor bioaerosols in hospitals: The influence of heating, ventilation, and air conditioning. PLoS One. 2021 Dec 23;16(12):e0259996.

# What are other variables need to be considered ?

- Are there differences depending on the ward concerned ?
- Could we define a “high risk surfaces” ?
- What about other environmental reservoirs ?

# Are there differences depending on the ward concerned ?

| Ward concerned | Risk of acquisition | Risk of sustained colonisation | Risk of secondary infection | Risk of mortality |
|---|---|---|---|---|
| ICU | ++ (workload) | ++ (Colonisation pressure) | +(invasive procedures) | ++ |
| Hematological | ++ (workload) | ++ (Colonisation pressure) | ++ (neutropenia) | +++(40%) |
| Neonatology | ++ (dependency) | +/- | ++ (immaturity) | ++ |
| LTCF | ++ (dependency) | +/- | +/- | ++ |
| Others | | | | ++ |

Huang SS, Datta R, Platt R. Risk of acquiring antibiotic-resistant bacteria from prior room occupants. Arch Intern Med. 2006 Oct 9;166(18):1945-51. Drees M, Snydman DR, Schmid CH, Barefoot L, Hansjosten K, Vue PM, Cronin M, Nasraway SA, Golan Y. Prior environmental contamination increases the risk of acquisition of vancomycin-resistant enterococci. Clin Infect Dis. 2008 Mar 1;46(5):678-85. seir S, Blazejewski C, Lubret R, Wallet F, Courcol R, Durocher A. Risk of acquiring multidrug-resistant Gram-negative bacilli from prior room occupants in the intensive care unit. Clin Microbiol Infect. 2011 Aug;17(8):1201-8.

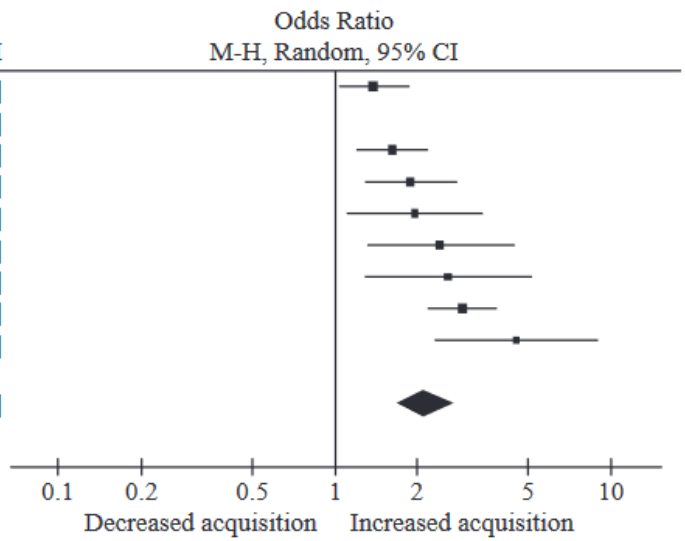
# Risk of organism acquisition from prior room occupants: a systematic review and meta-analysis

B.G. Mitchell [a,b,*], S.J. Dancer [c], M. Anderson [a], E. Dehn [a]

| Study or Subgroup | Decreased acquisition Events | Total | Control Events | Total | Weight | Odds Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| Huang (MRSA) | 57 | 1454 | 248 | 8697 | 16.2% | 1.39 [1.04, 1.86] |
| Nseir (ESBL producing Gram neg) | 8 | 50 | 50 | 461 | 0.0% | 1.57 [0.70, 3.52] |
| Huang (VRE) | 58 | 1291 | 256 | 9058 | 16.2% | 1.62 [1.21, 2.16] |
| Ajao (Klebsiella sp. or Escherichia coli) | 32 | 648 | 235 | 8723 | 14.2% | 1.88 [1.29, 2.74] |
| Nseir (Pseudomonas) | 21 | 85 | 61 | 426 | 10.4% | 1.96 [1.12, 3.45] |
| Drees (VRE) | 19 | 138 | 31 | 500 | 9.7% | 2.42 [1.32, 4.43] |
| Shaughnessy (Clostridium difficile) | 10 | 91 | 77 | 1679 | 8.3% | 2.57 [1.28, 5.15] |
| Mitchell (MRSA) | 74 | 884 | 163 | 5344 | 16.4% | 2.90 [2.18, 3.86] |
| Nseir (Acinetobacter) | 16 | 52 | 41 | 459 | 8.6% | 4.53 [2.32, 8.86] |
| Total (95% CI) | | 4643 | | 34886 | 100.0% | 2.14 [1.65, 2.77] |
| Total events | 287 | | 1112 | | | |

Heterogeneity: $Tau^2 = 0.09$; $Chi^2 = 21.32$, df = 7 (P = 0.003); $I^2 = 67\%$

Test for overall effect: Z = 5.74 (P < 0.00001)




Mitchell BG, Dancer SJ, Anderson M, Dehn E. Risk of organism acquisition from prior room occupants: a systematic review and meta-analysis. J Hosp Infect. 2015 Nov;91(3):211-7.

# Could we define a « high risk surfaces » ?

- Frequently touched items such as telephones, handles, taps, light switches, levers, knobs, buttons, keyboards, push plates

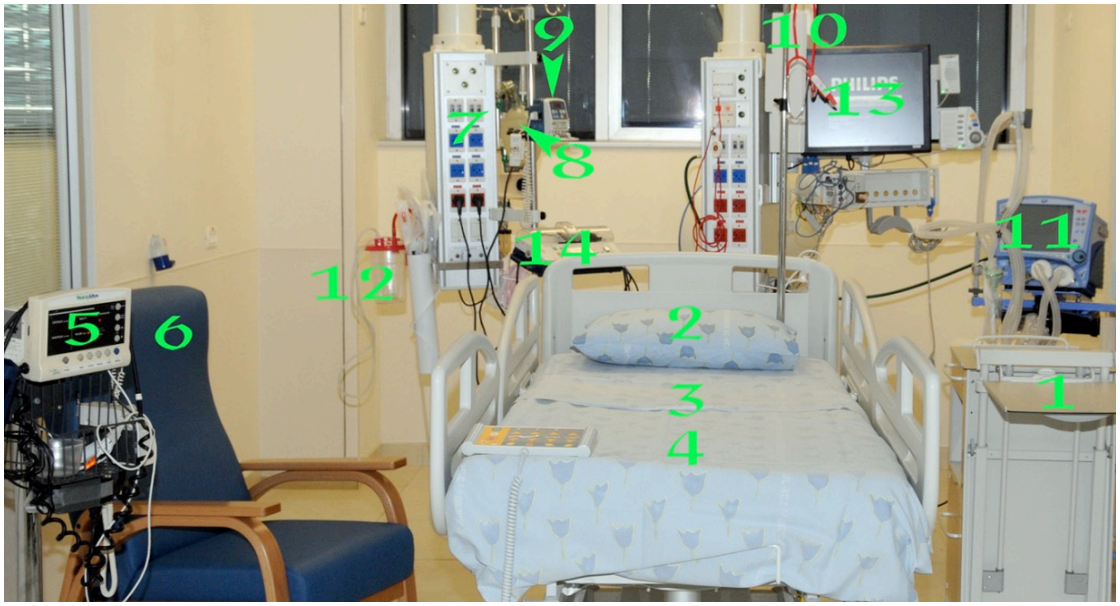
| Category of surface touched or handled during 40 × 30 min observed sessions | Site | Total no. of times touched | % touched of all sites handled |
|---|---|---|---|
| Near-patient surfaces (in room) | Patient console | 8 | 5% |
| | Notes | 37 | 22% |
| | Bed frame | 19 | 11% |
| | Locker | 4 | 2% |
| | Curtains | 6 | 4% |
| | Category total (%) | 74 | 44% |
| Clinical equipment (in room) | Hoist | 0 | 0% |
| | Commode | 4 | 2% |
| | BP stand | 10 | 6% |
| | Stethoscope | 3 | 2% |
| | IV drip | 23 | 14% |
| | Category total (%) | 40 | 24% |
| Far-patient surfaces (outside room) | Computer | 20 | 12% |
| | Filing cabinet | 0 | 0 |
| | Notes trolley | 18 | 11% |
| | Telephone | 16 | 9% |
| | Category total (%) | 54 | 32% |
| Total items touched | | 168 | 100% |

BP, blood pressure; IV, intravenous.
Total number of times handled exceeds values listed in Table I since some items were touched on multiple occasions.



Smith SJ, Young V, Robertson C, Dancer SJ. Where do hands go? An audit of sequential hand-touch events on a hospital ward. J Hosp Infect. 2012 Mar;80(3):206-11.

# Could we define a « high risk surfaces » ?



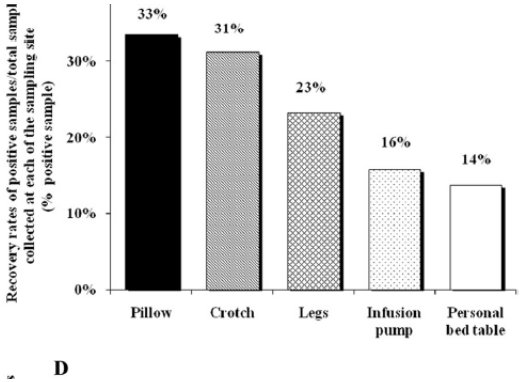




FIG 1 Locations of testing for environmental CRE (eCRE). 1, personal bedside table; 2 to 4, bed linen around the pillow (2), crotch (3), and legs (4); 5, pulse oximeter; 6, personal bedside chair; 7, electrical outlet line; 8, manual respirator bag; 9, infusion pump; 10, dedicated stethoscope; 11, ventilator; 12, suction machine; 13, cardiovascular monitor screen; 14, enteral feeding pump.

Lerner A, Adler A, Abu-Hanna J, Meitus I, Navon-Venezia S, Carmeli Y. Environmental contamination by carbapenem-resistant Enterobacteriaceae. J Clin Microbiol. 2013 Jan;51(1):177-81.

# What about other environmental reservoirs ?

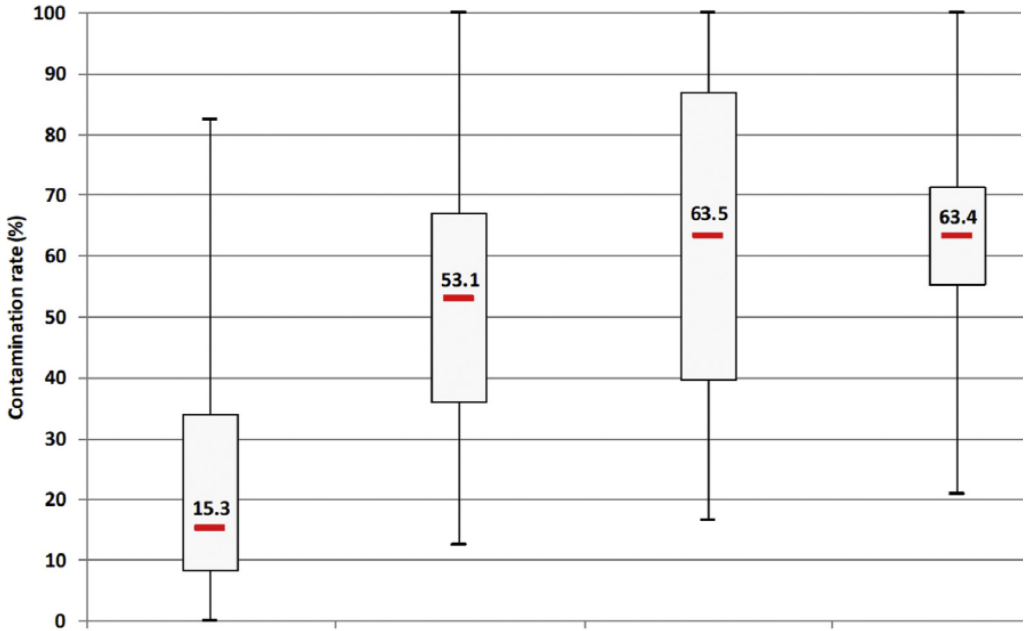
- Several studies suggested a high rate of tap water and sink contamination

- Several studies suggested the role of contaminated sink as the source of outbreak

Leitner E, Zarfel G, Luxner J, Herzog K, Pekard-Amenitsch S, Hoenigl M, Valentin T, Feierl G, Grisold AJ, Högenauer C, Sill H, Krause R, Zollner-Schwetz I. Contaminated handwashing sinks as the source of a clonal outbreak of KPC-2-producing Klebsiella oxytoca on a hematology ward. Antimicrob Agents Chemother. 2015 Jan;59(1):714-6. Umezawa K, Asai S, Ohshima T, Iwashita H, Ohashi M, Sasaki M, Kaneko A, Inokuchi S, Miyachi H. Outbreak of drug-resistant Acinetobacter baumannii ST219 caused by oral care using tap water from contaminated hand hygiene sinks as a reservoir. Am J Infect Control. 2015 Nov;43(11):1249-51. Clarivet B, Grau D, Jumas-Bilak E, Jean-Pierre H, Pantel A, Parer S, Lotthé A. Persisting transmission of carbapenemase-producing Klebsiella pneumoniae due to an environmental reservoir in a university hospital, France, 2012 to 2014. Euro Surveill. 2016 Apr 28;21(17).

# Risk related to sink

73 ICUs
3 months follow-up
51% contaminated sink
Ris k of acquisition associated with :
- Frequency of contamination
- Proximity to the patient
- Frequency of the cleaning
- Frequency of "splachs”




| | Bleach Daily 2,6% | QAC Daily RTU | QAC Daily conc. | No treatment |
|---|---|---|---|---|
| Median value | 15.3 | 53.1 | 63.5 | 63.4 |
| 1st quartile | 8.4 | 36.0 | 39.8 | 55.4 |
| 3rd quartile | 33.9 | 67.1 | 86.9 | 71.3 |

Valentin AS, Santos SD, Goube F, Gimenes R, Decalonne M, Mereghetti L, Daniau C, van der Mee-Marquet N; SPIADI ICU group. A prospective multicentre surveillance study to investigate the risk associated with contaminated sinks in the intensive care unit. Clin Microbiol Infect. 2021 Feb 25:S1198-743X(21)00100-2.

# Do we have enough arguments ?

**Table 1**
**The key epidemiologic features of HAP transmission.**

| Epidemiologic Feature | References |
|---|---|
| Shedding of gastrointestinal tract colonizing pathogens is unpredictable and prolonged; it fluctuates; and it is impacted by colonic flora disbiosis. | Donskey et al,[12] 2000; Chang et al,[13] 2009; Sethi et al,[14] 2009, Sethi et al,[15] 2010; Kundrapu et al,[16] 2015; Faired et al,[17] 2013; Miles et al,[18] 2015; Tschudin-Sutter et al,[19] 2015 |
| Environmental contamination by HAI pathogens is common, greatest on surfaces closest to the patient, quantitatively variable, and often sparse. | Chang et al,[20] 2011; Weber et al,[21] 2010; Donskey,[22] 2013; Sitzlar et al,[23] 2013; Linder et al,[24] 2014; Creamer et al,[25] 2014 |
| Environmental contamination is almost equally associated with colonize or infect a recipient patients. | Guerrero et al,[26] 2013; Linder et al,[24] 2014; Kundrapu et al,[16] 2015; Gavalda et al,[27] 2015 |
| All common HAI pathogens survive for many hours to months on a wide range of patient zone surfaces. | Kramer et al,[28] 2006; Dancer,[11] 2014; Munoz-Price & Weinstein,[29] 2015 |
| Health care personnel have frequent contact with HAP-contaminated surfaces | Guerrero et al,[30] 2012; Kundrapu et al,[31] 2012; Morgan et al,[32] 2012; Dancer,[11] 2014 |
| Contact with the environment is as likely to contaminate health care workers' hands. | Donskey,[22] 2013; Weber et al,[21] 2013; Ferng et al,[33] 2015, Thomas et al,[34] 2015 |
| The dose of pathogen needed to colonization or infect of a recipient with most HAPs is typically very low. | Weber et al,[21] 2013; Dancer,[11] 2014 |
| Surface-contaminating HAPs range widely in their sensitivity to chemical disinfects UV light and antimicrobial surface treatments. | Rutala & Weber,[35] 2014; Nerandzic et al,[36] 2015 |



Carling PC. Optimizing Health Care Environmental Hygiene. Infect Dis Clin North Am. 2016 Sep;30(3):639-60.

# What are the questions at this point ?

- What is the amount of direct transmission from the environment ?
- Improving environmental hygiene is associated with decrease of Health acquired infections (HAI) ?
- Are there any risks in improving the cleaning of the environment ?

# What is the amount of direct transmission from the environment ?

- Difficult to answer this question
- There are many risk factors and confounding factors
  - The patient's profile
  - The workload
  - Exposure to and duration of invasive procedures
  - The antibiotic selective pressure
  - The colonization pressure
- Improving Environmental hygiene is associated with improving hand hygiene

# A multimodal intervention program to control a long-term *Acinetobacter baumannii* endemic in a tertiary care hospital

Environmental decontamination
Hand hygiene
Antimicrobial stewardship
Contacts precautions
Active surveillance
Weekly reports
Regular meetings

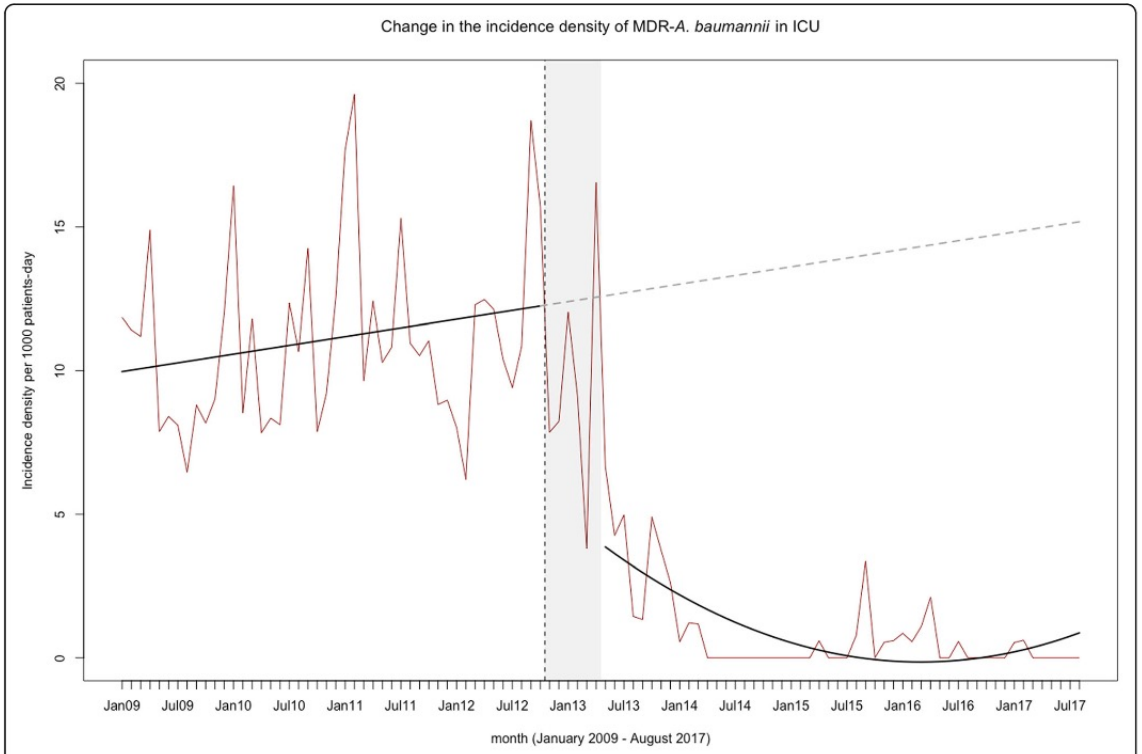



**Fig. 4** Interrupted time series analysis with transition 6-month period of the incidence density of multidrug resistant *A. baumannii* in the intensive care units

Valencia-Martín R, Gonzalez-Galan V, Alvarez-Marín R, Cazalla-Foncueva AM, Aldabó T, Gil-Navarro MV, Alonso-Araujo I, Martin C, Gordon R, García-Nuñez EJ, Perez R, Peñalva G, Aznar J, Conde M, Cisneros JM; In representation of A. baumannii eradication program. A multimodal intervention program to control a long-term Acinetobacter baumannii endemic in a tertiary care hospital. Antimicrob Resist Infect Control. 2019 Dec 4;8:199.

# Improving environmental hygiene is associated with decrease of Health acquired infections (HAI) ?

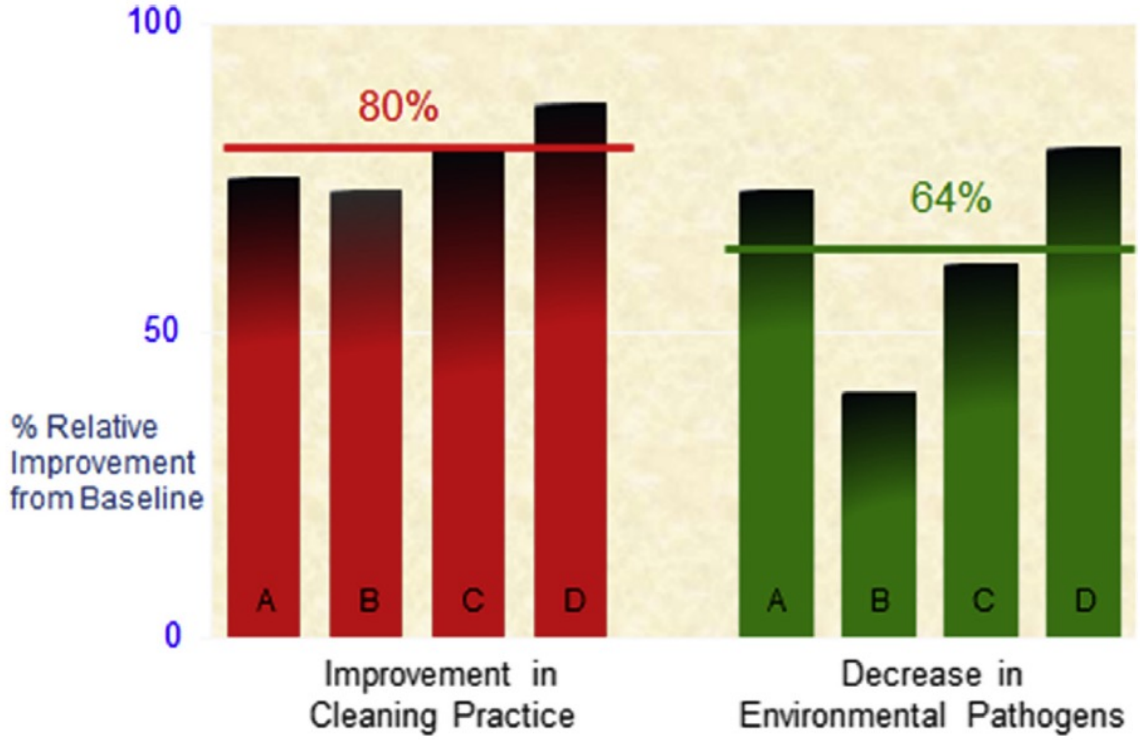



**Fig. 3.** Improving disinfection cleaning to decrease environmental surface contamination.

Carling P. Methods for assessing the adequacy of practice and improving room disinfection. Am J Infect Control. 2013 May;41(5 Suppl):S20-5.

# Improving environmental hygiene is associated with decrease of Health acquired infections (HAI) ?

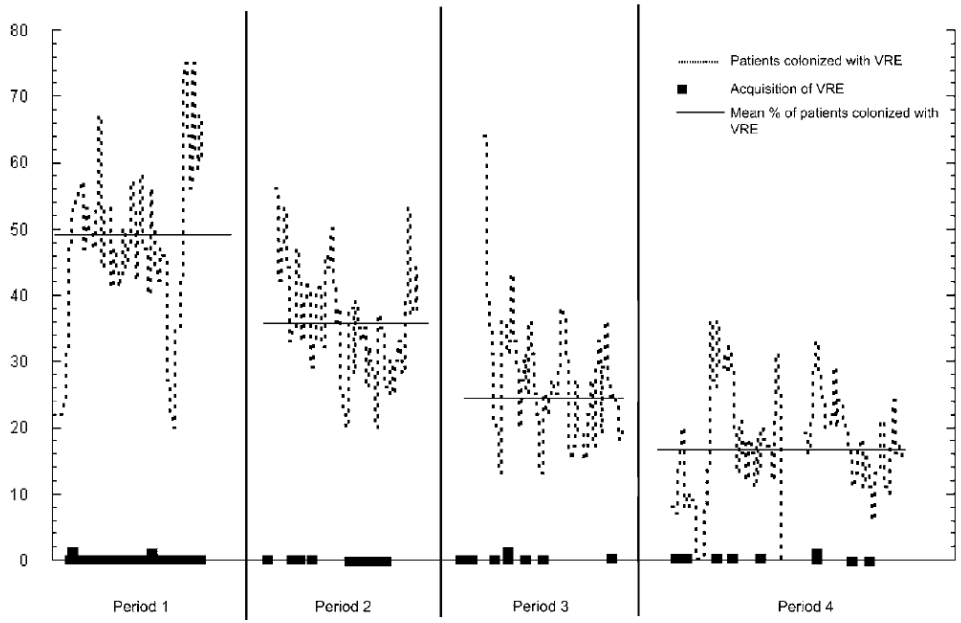
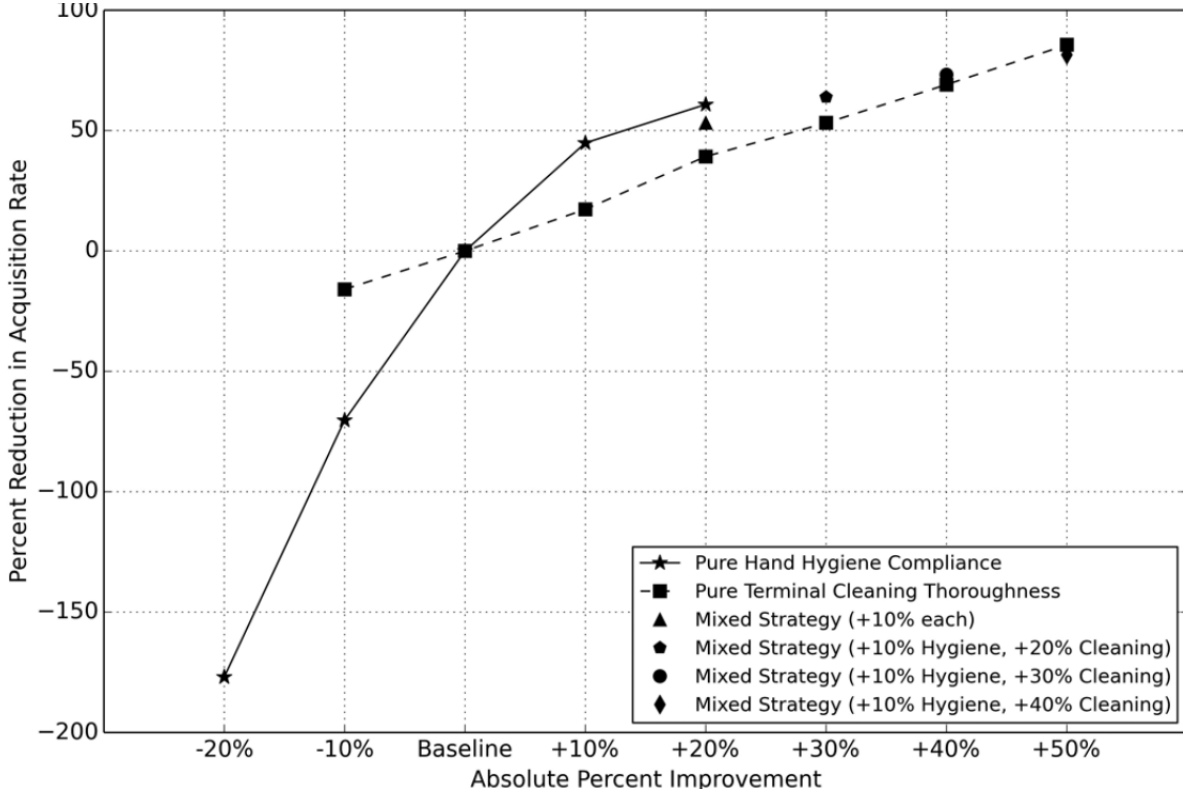



**Table 2. Predictors of MRSA and VRE Acquisition**

| Model[a] | Odds Ratio (95% Confidence Interval) | *P* Value |
|---|---|---|
| **MRSA** | | |
| Pre-ICU length of stay | 1.2 (1.1-1.3) | <.001 |
| Duration of room vacancy between occupants | 0.9 (0.8-1.0) | .03 |
| Age per decade increase | 1.1 (1.0-1.2) | <.001 |
| End-stage liver disease | 1.8 (1.2-2.9) | .008 |
| Prior occupant status and intervention interaction | | |
| Baseline | | |
| MRSA-negative | 1 [Reference] | |
| MRSA-positive | 1.3 (1.0-1.8) | .04 |
| Intervention | | |
| MRSA-negative | 0.6 (0.5-0.7) | <.001 |
| MRSA-positive | 0.5 (0.3-0.8) | .006 |
| **VRE** | | |
| Pre-ICU length of stay | 1.4 (1.3-1.6) | <.001 |
| Age, in decades | 1.1 (1.1-1.2) | <.001 |
| Male sex | 0.8 (0.7-1.0) | .05 |
| Surgical ICU (vs medical) | 0.5 (0.3-0.7) | <.001 |
| Diabetes mellitus | 1.3 (1.1-1.6) | .004 |
| End-stage renal disease | 1.5 (1.1-2.0) | .008 |
| Hematologic malignant neoplasm | 1.4 (1.0-1.8) | .04 |
| Prior occupant status and intervention interaction | | |
| Baseline | | |
| VRE-negative | 1 [Reference] | |
| VRE-positive | 1.4 (1.0-1.8) | .04 |
| Intervention | | |
| VRE-negative | 0.6 (0.5-0.8) | <.001 |
| VRE-positive | 0.9 (0.6-1.2) | .35 |

Hayden MK, Bonten MJ, Blom DW, Lyle EA, van de Vijver DA, Weinstein RA. Reduction in acquisition of vancomycin-resistant enterococcus after enforcement of routine environmental cleaning measures. Clin Infect Dis. 2006 Jun 1;42(11):1552-60. Datta R, Platt R, Yokoe DS, Huang SS. Environmental cleaning intervention and risk of acquiring multidrug-resistant organisms from prior room occupants. Arch Intern Med. 2011 Mar 28;171(6):491-4.

## Preventing the transmission of multidrug-resistant organisms (MDROs): Modeling the relative importance of hand hygiene and environmental cleaning interventions



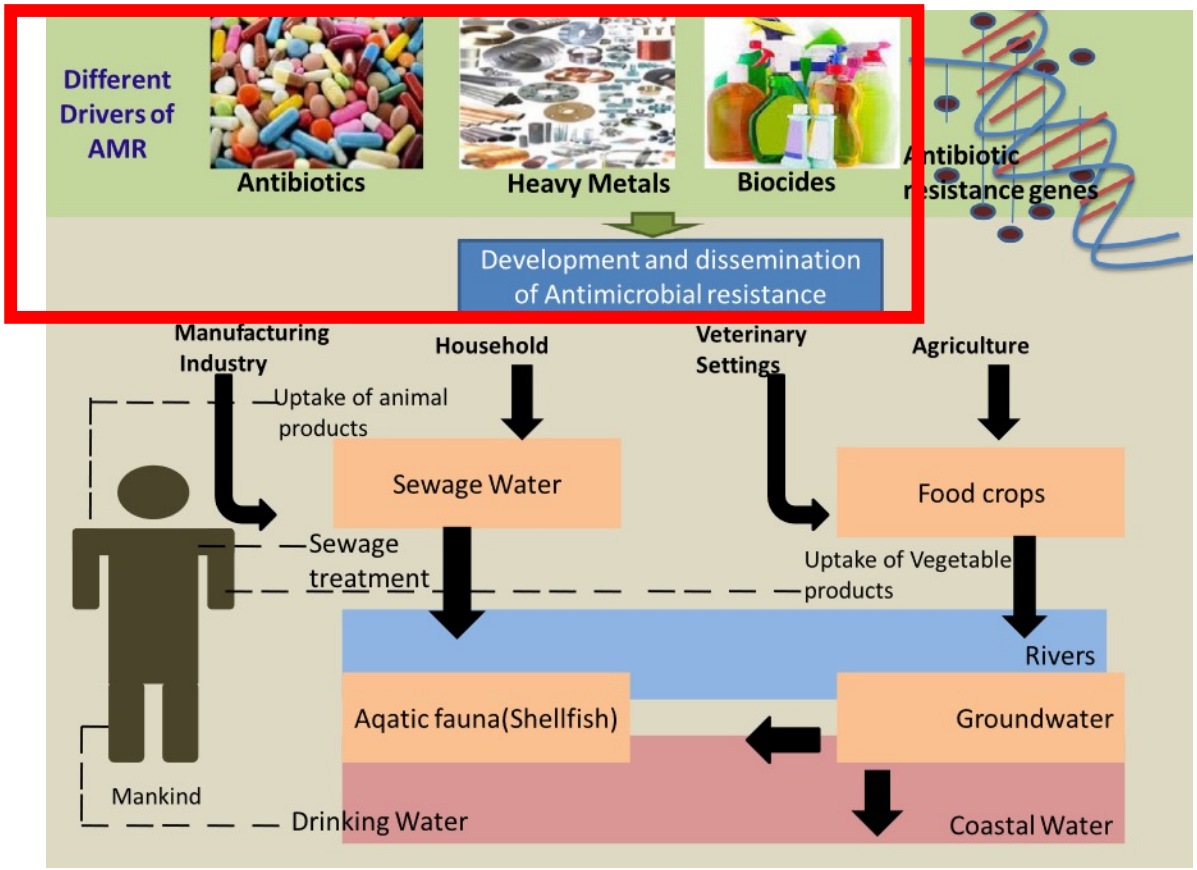

Barnes SL, Morgan DJ, Harris AD, Carling PC, Thom KA. Preventing the transmission of multidrug-resistant organisms: modeling the relative importance of hand hygiene and environmental cleaning interventions. Infect Control Hosp Epidemiol. 2014 Sep;35(9):1156-62.

# Improving environmental hygiene is associated with decrease of Health acquired infections (HAI) ?

- A large number of reports include cleaning as an important control component for outbreak

Donskey CJ. Does improving surface cleaning and disinfection reduce health care-associated infections? Am J Infect Control. 2013 May;41(5 Suppl):S12-9. Carling PC. Health Care Environmental Hygiene: New Insights and Centers for Disease Control and Prevention Guidance. Infect Dis Clin North Am. 2021 Sep;35(3):609-629.

# Are there any risks in improving the cleaning of the environment ?



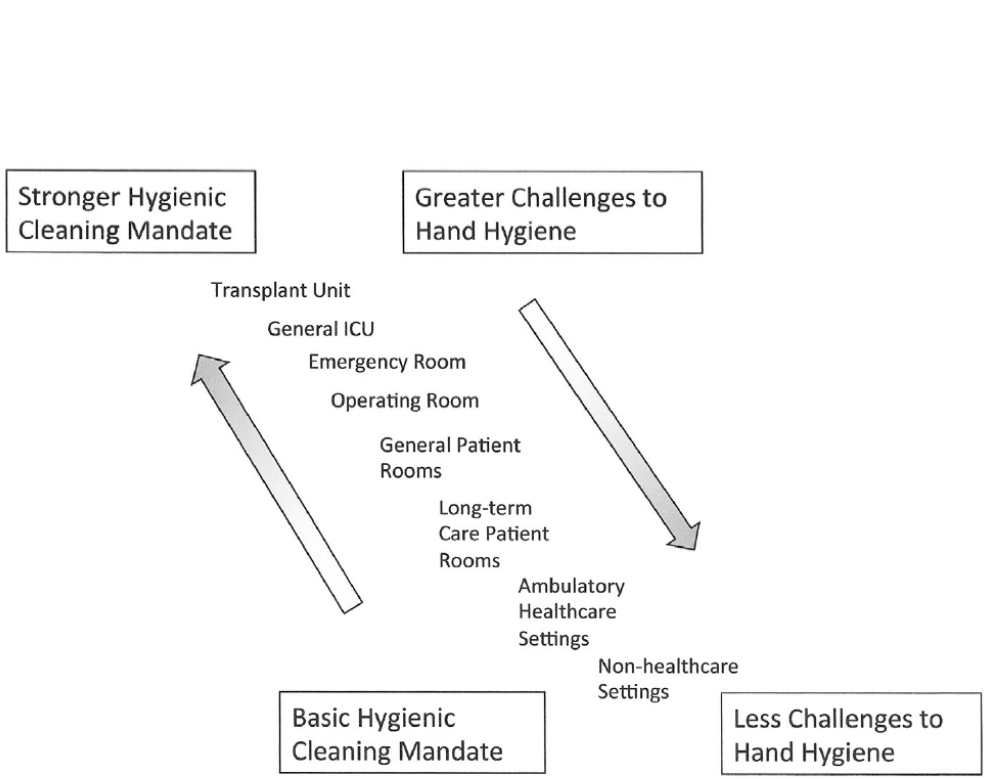

Samreen, Ahmad I, Malak HA, Abulreesh HH. Environmental antimicrobial resistance and its drivers: a potential threat to public health. J Glob Antimicrob Resist. 2021 Dec;27:101-111.

# A review on biocide reduced susceptibility due to plasmid-borne antiseptic-resistant genes—special notes on pharmaceutical environmental isolates

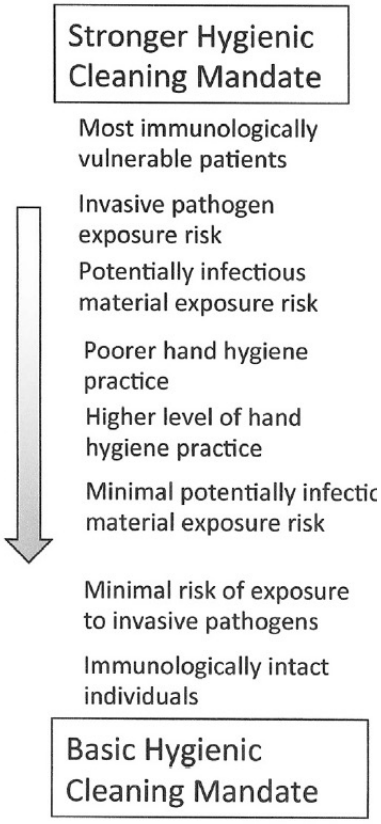
| Authors | Country | Test isolates (numbers tested) | Tested biocides | Reduced susceptibility (increased MIC values) correlated with the presence of genes: Significant correlation | Reduced susceptibility (increased MIC values) correlated with the presence of genes: Not significant correlation | Gene function |
|---|---|---|---|---|---|---|
| Abuzaid *et al.* (2012) | United Kingdom | *Klebsiella pneumoniae* (64) | CHG | *cepA* *qacΔE1* | – | cepA beta-lactamase gene; qacΔE1 efflux pump gene |
| Abuzaid and Amyes (2015) | United Kingdom | *K. pneumoniae* (34) | CHG | *cepA* | – | cepA beta-lactamase gene |
| Naparstek *et al.* (2012) | Israel | *K. pneumoniae* (126) | CHG | – | *cepA* | cepA beta-lactamase gene |
| Azadpour *et al.* (2015) | Iran | MDR *K. pneumoniae* (34) | QAC (dodecyl dimethyl ammonium chloride) | – | *cepA* *qacΔE1* | qacΔE1 efflux pump gene |
| Babaei *et al.* (2015) | Malaysia | MDR *Acinetobacter baumannii* (122) | CLX<br>BC<br>BZT | – | *qacE* | qacΔE efflux pump gene |
| Liu *et al.* (2017) | China | Carbapenem-resistant *A. baumannii* (51) | BC<br>CHG | *qacE* | *qacΔE1* | qacΔE1 efflux pump gene |
| Gomaa *et al.* (2017) | Egypt | *A. baumannii* (56) | CHG<br>Cetrimide | *qacE* *qacΔE1* | – | qacΔE1 and *qacE* efflux pump genes |
| Romão *et al.* (2011) | Brazil | *Pseudomonas aeruginosa* (124) | BC | – | *qacΔE1* | qacΔE1 efflux pump gene |
| Ignak *et al.* (2017) | Turkey | *Staphylococcus* sp. | BC<br>CHG | *qacA/B*<br>– | –<br>*qacA/B* | qacA/B efflux pump gene<br>qacA/B efflux pump gene |
| Conceição *et al.* (2016) | African countries (Angola, Cape Verde, São Tomé and Príncipe) | 82 MRSA and 219 MSSA | CHG | – | qacAB<br>norA | qacA/B efflux pump gene; norA—quinolone resistance protein against *S. aureus* |
| Vali *et al.* (2017) | Kuwait | MRSA (121)<br>MSSA (56) | CHG | – | *qacA* | qacA efflux pump gene |

Vijayakumar R, Sandle T. A review on biocide reduced susceptibility due to plasmid-borne antiseptic-resistant genes-special notes on pharmaceutical environmental isolates. J Appl Microbiol. 2019 Apr;126(4):1011-1022.

# Can we reduce the consumption of biocides ?








Carling PC. Health Care Environmental Hygiene: New Insights and Centers for Disease Control and Prevention Guidance. Infect Dis Clin North Am. 2021 Sep;35(3):609-629.

# Can we reduce the consumption of biocides ?

Table 5. Summary of advantages and disadvantages of common surface disinfectant.

| Disinfectant | Mechanism of Action | Cellular Effect | Antimicrobial Effect | Advantages | Disadvantages |
|---|---|---|---|---|---|
| Chlorine compounds | Oxidation of side chains amino acids in proteins | Unfolding tertiary structure and protein aggregation | Bactericidal, fungicidal, virucidal sporicidal | -Not flammable<br>-Fast-acting<br>-Low-cost<br>-Resistant to water hardness<br>-Relatively stable | -Salt residues<br>-Corrosive to metals<br>-Affected by organic matter<br>-Fabric discoloration<br>-Potential production of trihalomethane<br>-Irritating odor at high concentrations |
| Iodine compounds | Oxidation of thiol groups to disulfides in proteins | Modification of structural protein and/or alterations in enzyme activities | Bactericidal, virucidal | -Not flammable | -Limited spectrum of activity<br>-Degradation of silicone catheters<br>-Staining for surfaces |
| Alcohols | Denaturation and precipitations of cytoplasmic and membrane proteins | Alteration in metabolic processes, membrane damage | Bactericidal, fungicidal, virucidal | -Fast-acting<br>-Noncorrosive<br>-Nonstaining<br>-Suitable for small surfaces disinfection | -Not sporicidal<br>-Affected by organic matter<br>-No cleaning properties<br>-Deterioration of some instruments<br>-Flammable<br>-Rapid evaporation |
| Phenols | Denaturation of cytoplasmic and membrane proteins | Leakage of essential metabolites, release of $K^+$, membrane damage, cytoplasmic coagulation | Bactericidal, fungicidal, virucidal | -Low costs<br>-Not flammable<br>-Nonstaining | -Rapid absorption by porous materials and irritate tissues<br>-Potential depigmentation of skin<br>-Hyperbilirubinemia in infants |
| Quaternary ammonium compounds | Binding to phosphates and fatty acid chains in phospholipids of cell membrane and DNA | Depolarization, membrane damage, cytoplasmic coagulation | Bactericidal, fungicidal, virucidal (enveloped viruses) | -Good cleaning agents<br>-Surface compatible<br>-Long antimicrobial activity<br>-Low costs | -Not sporicidal<br>-Affected by water hardness<br>-Asthma after benzalkonium chloride exposure<br>-Affected by organic matter |
| Hydrogen peroxide and peracids | Oxidation of thiol groups to disulfides in proteins | Modification of structural protein and/or alterations in enzyme activities | Bactericidal, fungicidal, virucidal | -Fast-acting<br>-Safe for workers<br>-Non-toxic by-products<br>-Surface compatible<br>-Nonstaining<br>-Odorless<br>-Not flammable | -More expensive compared to other disinfectants<br>-Not sporicidal at low concentrations |
| Ozone | Oxidation of thiol groups in proteins and interaction with purine and pyrimidine bases | Modification of structural protein, alterations in enzyme activities, and/or DNA damages | Bactericidal, moldicidal, virucidal, protozocidal | -Fast-acting | -Gaseous form not safe<br>-Low stability solutions form<br>-Reacted with organic matter |
| UV light | chemical modifications of nucleotides caused by photon energy emitted | DNA damages (photohydration, photosplitting, photodimerization) | bacteria, fungi, viruses, spores | -Absence of residues or by-products<br>-Fast-acting | -No microbiocidal effect<br>-Eyes and skin damages for UV irradiation at 254-nm |

# Conclusion

- The risk of surface contamination is real
- The relationship between environmental contamination and acquisition is certain (in intensive care)
- The relation between environmental contamination and HAI is more questionable
- Reducing the risk need a bundle of actions including improving hand hygiene and decreasing invasive procedures
- Reducing the consumption of biocides is needed, we need to redefine which situations are at risk and which are not

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| | |
|---|---|
| August 10, 2022 | *(South Pacific Teleclass)*<br>**HEALTHCARE ASSOCIATED PNEUMONIA – WHY SHOULD WE BOTHER AND WHAT CAN WE DO?**<br>Speaker: **Prof. Brett Mitchell**, University of Newcastle, Australia |
| August 23, 2022 | *(European Teleclass)*<br>**DATA QUALITY INDICATORS IN NATIONAL TB INFECTION CONTROL PROGRAMS: READING BETWEEN THE LINES**<br>Speaker: **Dr. Eltony Mugomeri**, Africa University, Zimbabwe |
| September 14, 2022 | *(South Pacific Teleclass)*<br>**THE COST-EFFECTIVENESS OF TEMPORARY SINGLE-PATIENT ROOMS TO REDUCE THE RISK OF HAI**<br>Speaker: **Prof. Nicholas Graves**, Duke-NUS Medical School, Singapore |
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