How to Select a Wipe

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REFLECTIONS ON INFECTION PREVENTION AND CONTROL

Our reflections on IPC based on clinical microbiology, epidemiology, science & literature, and the practical issues that we run into day to day

Choosing a wipe

- A wipe is a wipe is a wipe
  - Thank you for listening

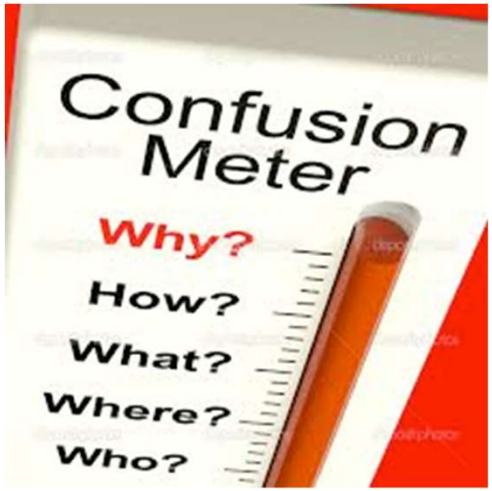
Medical device implicated in outbreak

- Axilliary temperature monitoring equipment was independent predictor of Candida auris infection in an Oxford Neurosurgical ITU outbreak when controlled for other factors
  - OR 6.9, p<0.001
    - Jeffrey, K. Presentation at Federation of Infection Societies Conference, Birmingham, UK. November 2017
- Authors stated
  - “Environmental survival appears to be key to C. auris persistence and transmission in healthcare settings”
  - “Our findings reinforce the need to carefully investigate multi-use patient equipment in any unexplained healthcare-associated outbreak”
- Who cleans this equipment?

Who is really caring for your environment?

Dumigan DG, Boyce JM et al AJIC 38:387-92 (2010)

- Cleaning is either carried out by
  - Low paid staff of low status who have been trained
  - Well paid staff of higher status, who have not been trained
- Procedures for cleaning patient care environments
  - Confusion about division of labour over cleaning responsibilities
- Systems to monitor cleaning are often ineffective
  - 'Housekeeping' yes; 'Clinical' No



Audit of Equipment

Anderson RE, Young V et al, JHI 78(3) 2011

- Many items of *clinical* equipment do not receive appropriate cleaning attention
  - ATP score showed surfaces cleaned by professional cleaning staff 64% lower than those by other staff (P=0.019)
- Nurses
  - do not clean very well
    - of 27 items cleaned by clinical staff, 89% failed the benchmark
  - are not very good at going to get the right equipment for cleaning

Human Factors and Cleaning

- Rock, C., et al., Using a Human Factors Engineering Approach to Improve Patient Room Cleaning and Disinfection. Infect Control Hosp Epidemiol, 2016. 37(12): p. 1502-1506.

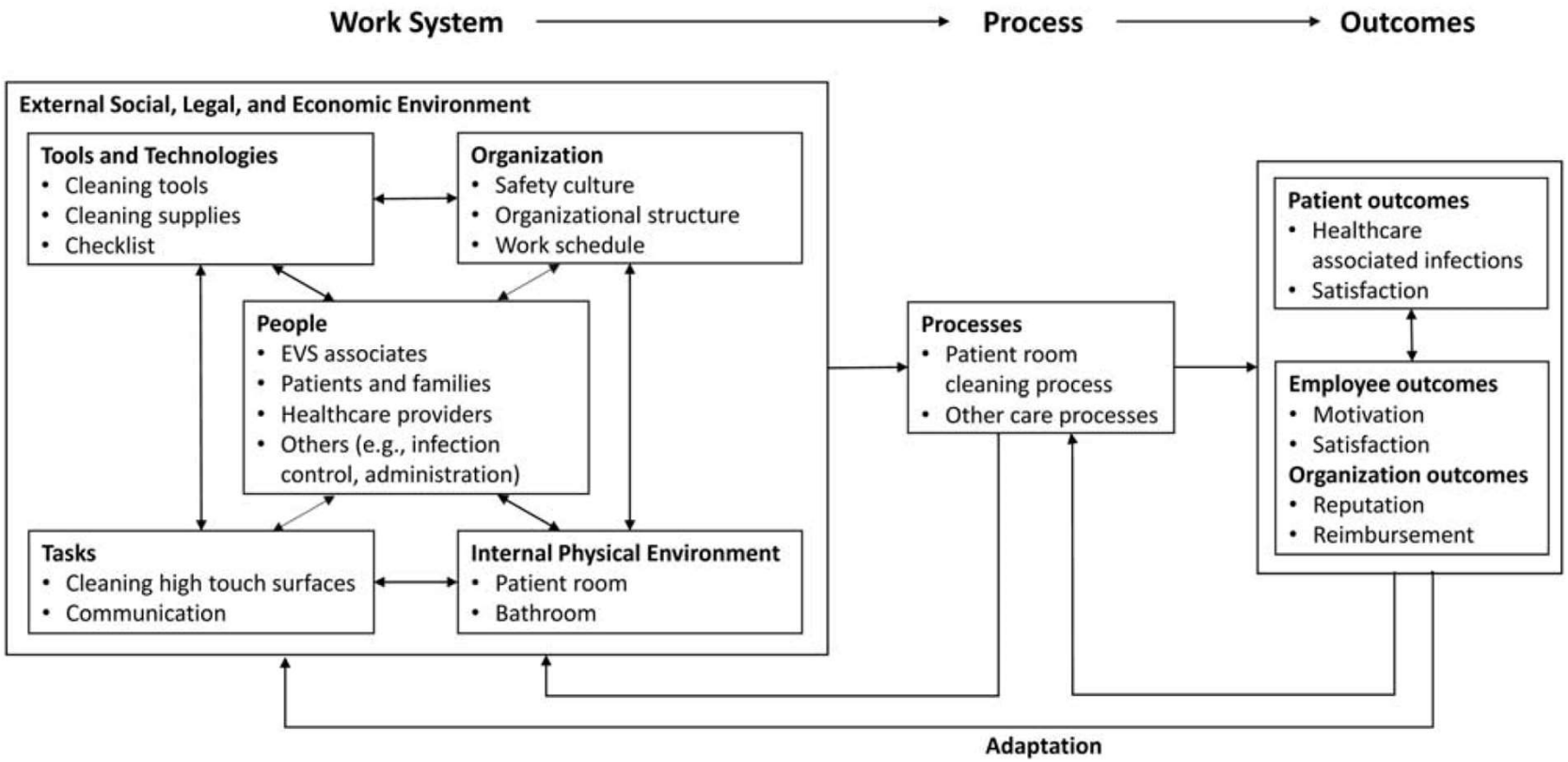


FIGURE 1. Systems Engineering Initiative for Patient Safety model for patient room cleaning. EVS, environmental services.

Human Factors Engineering
Cleaning the Environment

- Key HFE-related challenges
  - Delayed feedback
    - Audit results go up organisations, not down to those audited
  - Lack of connection with result
    - Does suboptimal performance matter? And to whom?
  - Complexity and Inefficiency
    - Tasks less convenient may be delayed, dropped or forgotten
  - Time Pressure and High Cognitive Workload
    - inability to observe “initiation” of infection makes it a cognitive challenge to keep IC procedures relevant to the task at hand
  - Few Infection Control Cues
    - IC measures disrupt workflows and create circumstances that may lead to HCWs purposely skipping or inadvertently overlooking tasks

HF – What do ‘consumers’ want”

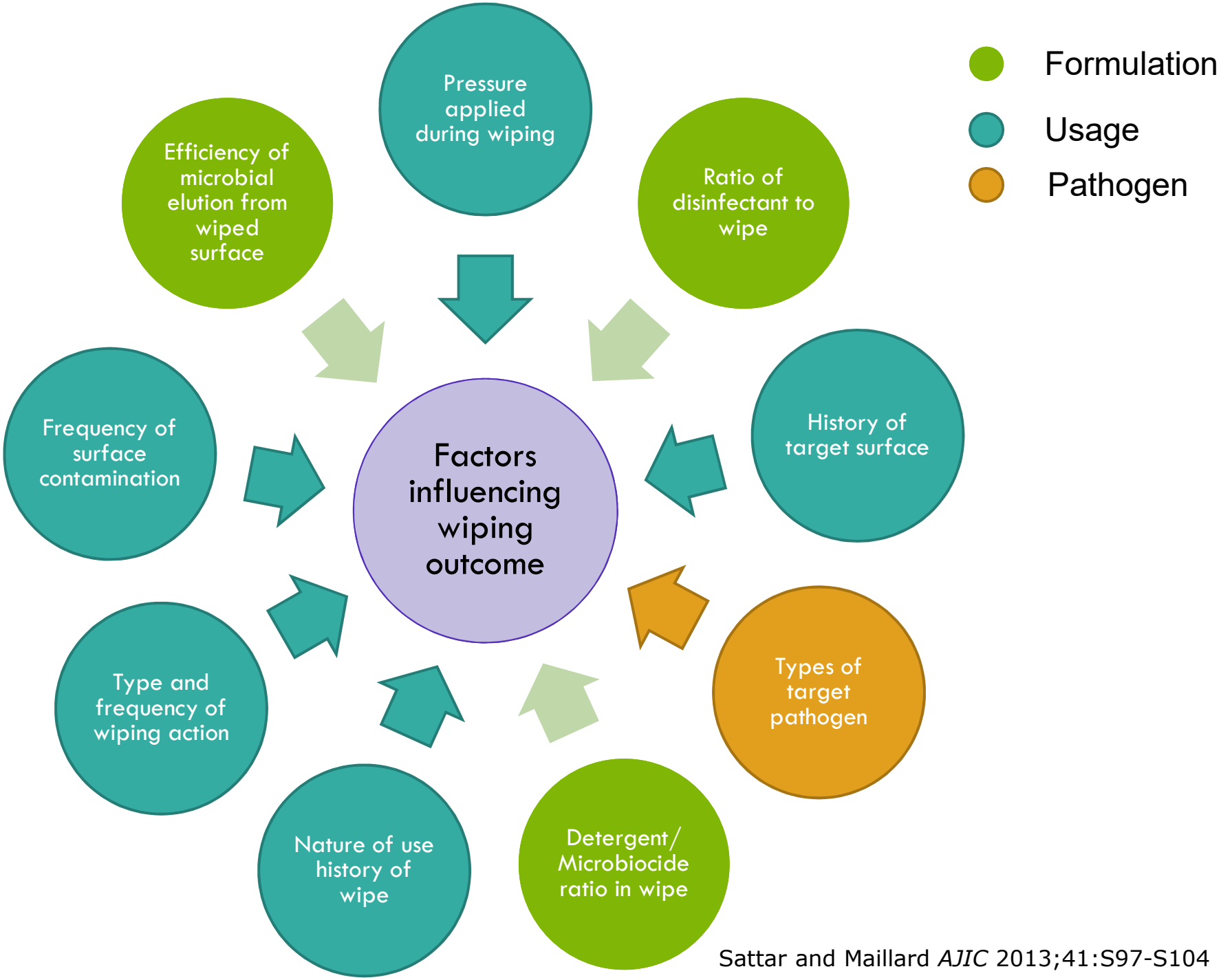
- IPC Practitioners asked what devices or design solutions that they would like to see
  - Anderson J. et al (2010) Crit Care Med 38(3) S269-81
  - A hood or box-like cabinet that could store items used for multiple patients between uses—such as glucometers and stethoscopes—that would bathe the items in ultraviolet light (or use some other mechanism) when the cabinet was closed;
  - High-tech cleaning equipment to disinfect entire contaminated rooms that is less time consuming than current methods, economic, and easy to use
  - A quick, easy, and safe way to clean keyboards before/after use
- All of these point to a ‘human factors’ approach but physical cleaning will always be required

Wipes

- Over recent years, wipes have become firmly established in clinical areas in the UK and other countries
  - Used on patients, equipment (from nasendoscopes to commodes) and the environment
  - For cleaning and/or disinfection
- Advantages relate to human factors
  - Convenient – can be placed at point of care
    - Compare with alcohol hand rub
  - Premixed and premeasured
  - Ready to use

Wipes can reduce the risk of pathogen transmission

- Evaluated impact of surface disinfection on the level of pathogen transfer from fomites to fingers
  - Mean $\log_{10}$ reduction of test microorganisms on fomites by disinfectant wipe treatment varied from 1.9 to 5.0, depending on microorganism and the fomite
    - Lopez GU, et al. Evaluation of a disinfectant wipe intervention on fomite-to-finger microbial transfer. Appl Environ Microbiol. 2014;80(10):3113-8
- Microbial transfer from disinfectant-wipe treated fomites was lower (0.1%) than from non-treated surfaces (up to 36.3%) for all types of microorganisms and fomites



Sattar and Maillard *AJIC* 2013;41:S97-S104

Observation of wipes in use

Williams et al. J Hosp Infect 2007

Surface initially wiped	Time applied (seconds)	Number of consecutive surfaces wiped (other surfaces)
Bed Rail	4	5: (bedside table, monitor X2, monitor stand)
Steel Trolley	6	2: (both shelves on the trolley wiped)
Monitor	4	5: (monitors, two keypads, monitor stand)
Bed rail	7	4: (table, monitor, keypad)
Bedside table	10	4: (folder, two bed rails)

Wipes have one or two functions

- Cleaning: Physical removal of microbial contamination
  - Dependent on contamination level (blood, faeces, vomit etc.), how it was applied (e.g. thin or thick smear), how long it was left to dry and how difficult the surface is to clean (textured vs. rough vs. smooth)
- Disinfection
  - How long before the disinfectant evaporates; how much is it inactivated by the organic matter in which the microbes are deposited; whether the microbe tested is innately susceptible to the disinfectant

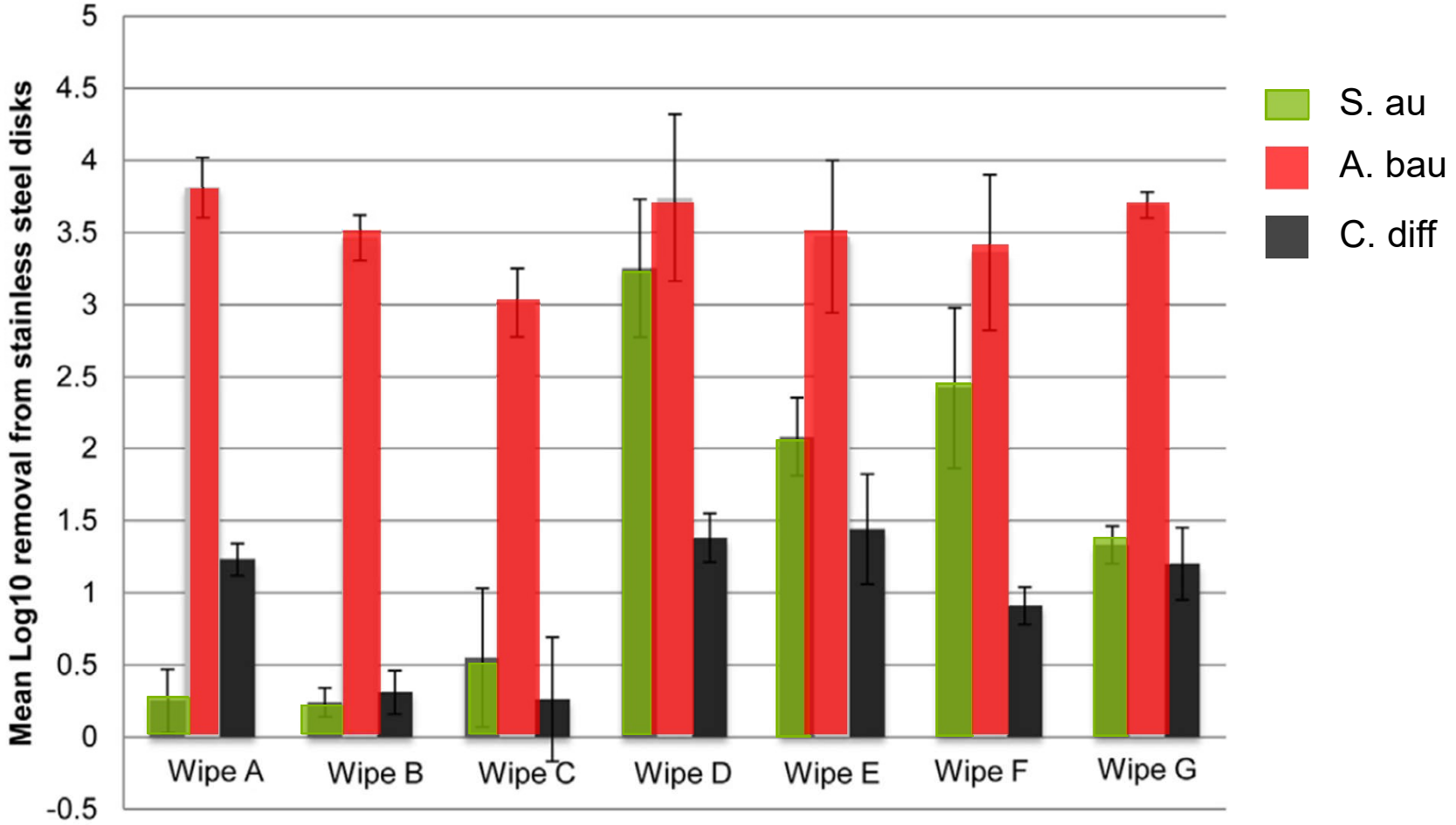
Another human factors problem solved

Not all wipes are the same

- Comparison of seven detergent wipes composed of non-ionic surfactants, preservatives and perfume
  - Ramm et at, (2015) AJIC 43(7)
- Significant differences in performance
  - Transfer and removal
  - Performance of wipes may be influenced by
    - type of nonwoven
    - quality of the raw materials and nonwoven
    - liquid to wipe ratio
    - product packaging

Detergent wipe efficacy

Ramm et al. AJIC; 43(7), 724-728



Transfer from Detergent Wipes

Wipes	Spores on wipes* (CFU)	Transfer first surface	Transfer second surface	Transfer third surface	Total transferred (%)
		% microbe/spore transfer			
S aureus					
A	66,890	66.43	82.28	64.74	213.45
B	3,633,282	11.01	9.75	13.14	33.90
C	5,078,282	8.58	66.05	44.83	119.46
D	4,941,786	0.04	0.03	0.04	0.11
E	14,537,759	0.43	0.39	0.37	1.20
F	13,388,894	0.09	0.07	0.21	0.37
G	16,705,056	0.00	0.00	0.00	0.00
A baumannii					
A	13,388,894	0.02	0.01	0.01	0.04
B	1,505,426	0.02	0.01	0.02	0.05
C	3,442,779	8.00	0.03	0.02	8.05
D	1,505,426	0.01	0.01	0.01	0.03
E	507,976	0.03	0.02	0.03	0.08
F	507,804	0.02	0.02	0.02	0.06
G	777,048	0.00	0.00	0.00	0.00
C difficile					
A	92,684	2.88	13.10	11.68	27.66
B	24,111	2.89	7.18	2.69	12.76
C	29,907	114.95	71.78	36.52	223.25
D	25,275	8.16	20.88	1.76	30.80
E	5,928	5.34	3.09	2.53	10.96
F	5,360	16.61	20.42	31.10	68.13
G	9,070	5.33	6.43	1.29	13.05

Ramm *et al. AJIC;* 43(7), 724-728

Detergent Wipes

- You add detergent and fluid to a surface to loosen surface soil
  - A bit like hand soap
- Ramm paper demonstrates that there is an element of moving things around
- Can form part of an effective multiple stage process
- Is a multiple stage process compatible with a human factors approach?

Choice of Disinfectant Product

- In the healthcare setting a number of disinfectants are available either as single substance products or in combinations
  - Choice will depend on intended use and target organism
  - Manufacturers instructions need to be followed to ensure correct application
  - Incorrect selection and/or use can lead to transference of microorganisms to clean surfaces or persistence from use of suboptimal concentrations of biocide

Commonly used Disinfectants Summary

- Hypochlorite
  - good general purpose disinfectant
  - dilution sensitive
  - rapidly deactivated by organic matter
  - May affect poor quality plated items
  - Cheap
  - Now being linked with Asthma and chronic respiratory disease in frequent users
- Alcohol
  - surface disinfectant
  - prior cleaning essential
    - Fixes proteins
  - min 30 sec contact time required
  - Useful for electrical items but compatibility issues with some plastics
  - Not effective against
    - Non-enveloped viruses
    - Spores

Hydrogen Peroxide

- Produce highly reactive hydroxyl-free radicals that damage protein and DNA while also decomposing to O_2 gas – toxic to anaerobes
- Weak (3%) to strong (25%)
- Fast efficacy, easier to comply with contact times, good compatibility
- Antiseptic at low concentrations; strong solutions are sporicidal
- More expensive; Unstable and is affected by organic matter

Peracetic Acid

- Germicidal effects are due to the direct and indirect actions of oxygen
- Oxygen forms hydroxyl free radicals which are highly toxic and reactive to cells
- Bactericidal, Virucidal, and Fungicidal
- Environmentally friendly by-products
  - Acetic acid, O_2, H_2O
- Good compatibility
- In higher concentrations is highly sporicidal
- Not affected by organic matter
  - May even enhance activity
- Stability issues, more expensive

Chemicals with Surface Action

Quaternary Ammonium Compounds and Detergents

- Act as surfactants
  - Anionic detergents have limited microbicidal power
  - Cationic detergents more effective because positively charged end binds well with predominantly negatively charged bacterial surface proteins
    - mechanical rather than a chemical action
- Soaps are weak microbicides; gain germicidal value when mixed with agents such as chlorhexidine or iodine

QUAT-Based Disinfectants

Rutala WA et al. Infect Control Hosp Epidemiol 2014;35:855

- Quaternary ammonium-based disinfectants (Quats) are widely for low-level disinfection of surfaces in healthcare facilities in the USA and a number of other countries
- Now on to the 5th Generation
  - Normally combinations of agents
  - Cheap, clean well, good compatibility, some persistent activity
  - Inhibit outgrowth of spores and mycobacteria, not sporicidal, some formulations not good for non-enveloped viruses, look at contact times

Formulations

- Formulated wipes with multiple disinfectants contain a number of agents to widen spectrum of activity and reduce risk of resistance
  - Formulated products reduce the risk of resistance
    - Cowley, N. et al (2015). "The Effect of Formulation on Microbicide Potency and Mitigation of the Development of Bacterial Insusceptibility." Appl Environ Microbiol. 81(20) 7330-8
- This is an accepted approach with antibiotic therapy
  - Rifampicin/Fucidin etc

A formulation may look like this

Agent	Product type
Benzalkonium chloride *(Alkyl dimethylbenzyl ammonium chloride)*	Quaternary ammonium biocide
Didecyldimethylammonium chloride (DDAC)	Quaternary ammonium biocide
Polyhexamethylene biguanide *(PHMB)*	Polymeric biguanide biocide
Phenylethanol	Slow acting preservative biocide
Phenoxyethanol	Slow acting preservative biocide
Dodecyl dimethyl amine oxide	Surfactant, improves wetting and soil penetration
EDTA di Na	Chelating agent, helps in hard water wettings
2,4-dichlorobenzyl alcohol	Biocide and vapour phase preservative, helps penetrate waxy coat of Mycobacteria
Water	Solvent

Factors Affecting Disinfectant Performance

- *Activity*
  - Microbicidal range; inactivation by organic matter, detergents, other chemicals; pH; dilution ....
- *Physical Contact*
  - Proteinaceous barriers; air bubbles; full immersion, coverage of large or intricate areas.
- *Exposure Time*
  - Short contact exposures (evaporation, immersion)

- *Factors relevant to disinfectant wipes are red*

Disinfectant tests

- There are European Standard (“EN”) and other (e.g. EPA, ASTM, OECD .....) tests for disinfectants
  - Disinfectant tests are single, repeatable, highly controlled situations – real life is not
- “Phase 1” tests (e.g. EN 1040) are essentially screening tests to allow disinfectants to proceed to further, more targeted testing
  - Quantitative suspension test for the evaluation of basic bactericidal activity
  - They should not be seen as validation for any particular application

Disinfection tests: applied

- “Phase 2, step 1” tests (e.g. EN 13727) are suspension tests simulating specific use situations (none of which are wipes)
  - Quantitative suspension test for the evaluation of bactericidal activity of chemical disinfectants for instruments used in medicine
  - Suspension tests allow greater access to the target than would normally be the case with wipes

Disinfection tests: applied to surfaces

- "Phase 2, step 2" tests (e.g. EN 14561) are surface tests – more accurately simulate the situation in which wipes are used
  - Quantitative carrier test for evaluation of bactericidal activity for instruments used in medicine
  - All of these tests can be done either in "clean" or "dirty" conditions (0.3% Bovine Serum Albumin + 0.3% erythrocytes)
    - "Clean" easier to pass
    - "Dirty" more difficult but may simulate 'use' conditions better

NaDCC 1000 ppm

Journal of Hospital Infection 89 (2015) 2–15

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevierhealth.com/journals/jhin

Development of a sporicidal test method for *Clostridium difficile*

A.P. Fraise[a,*], M.A.C. Wilkinson[a], C.R. Bradley[a], S. Paton[b], J. Walker[b], J.-Y. Maillard[c], R.L. Wesgate[c], P. Hoffman[d], J. Coia[e], C. Woodall[f], C. Fry[g], M. Wilcox[h]

Log_{10} Initial count (Challenge)	Contact time	Log $_{10}$ Reduction achieved	
		Clean conditions	Dirty Conditions
6.98	5 min	5.19	0.92
	10 min	5.38	0.93
	15 min	5.53	1.26
	60 min	5.83	0.89

Slide courtesy of Tina Bradley, Hospital Infection Research Laboratory, Birmingham, UK

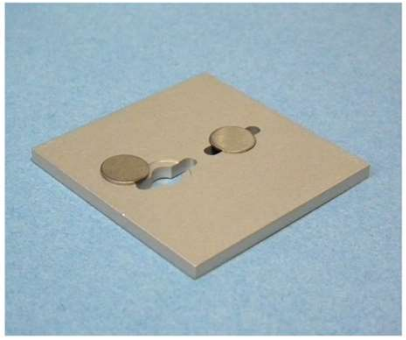
Disinfection tests: applied to wipes

- There are no standard tests for disinfectant wipes
- Any such test, standard or bespoke, must assess two components:
  - Cleaning: The physical removal of microbial contamination
    - This would depend on what the contamination was applied in (blood, faeces, vomit etc. simulants), how it was applied (e.g. thin or thick smear) , how long it was left to dry and how difficult the surface is to clean (textured vs. rough vs. smooth).
  - The effect of disinfection
    - How long before the disinfectant evaporates; how much is it inactivated by the organic matter in which the microbes are deposited, whether the microbe tested is innately susceptible to the disinfectant

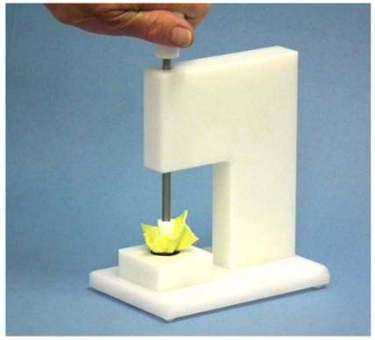
3-Step Wipe Test

New ASTM Intl. Standard (E2967-15) (04-15)

Purpose	Stage
Remove bioburden from a surface	Stage 1 – bacterial removal How good are the wipes in removing microbial contaminants? (not killing effect)
Prevent transfer of bioburden from the wipe to other surfaces	Stage 2 – bacterial transfer "adpression tests" Can the wipes transfer survivors to other surfaces (i.e. cross-contaminate)?
Where antimicrobial is present – kill the microbial bioburden	Stage 3 – Antimicrobial activity Can the wipes kill the bacteria they remove?



Sample Carrier with two 10-mm dia stainless steel disks



Loading a wipe onto a Boss using the Wipe Loader

The Wiperator wipes sample disks with an orbital motion

Sattar *et al.* *J Hosp Infect* 2015, 10.1016/j.jhin.2015.08.026

Do quats kill spores?

Maillard, J Hosp Infect (2018) in press

- No European standard test for claims of sporicidal efficacy in human healthcare
  - The closest equivalent (EN 13704 – a ‘clean’ test) was designed for use in food hygiene and has limitations that make it unsuitable for translation to the medical area
    - Spore prep (Clospore method), neutralisation to name but two
- Sporistatic (inhibit growth of spores)
  - They have their action by disrupting the membrane of vegetative cells36. Per EN 13704 protocol, once the biocide has reached the specified contact time, it should be neutralised and surviving organisms cultured on relevant medium, ensuring contact time is not inadvertently extended. Neutralisation of QACs is difficult and testing should be carried out in accredited laboratories

C. diff kill from 'sporicidal' wipes

Efficacy testing against C. difficile NCTC12727

Sporicidal Effect (against C.difficile 20291 Ribotype 027)	
	Sporicidal effect (log_{10} reduction ±SD) 5 min contact time
Unmedicated wipe	+0.42 (± 0.07)
Hypochlorite soaked wipe	4.64 (± 0.00)
Wipe A	3.74 (± 2.26)
Wipe B	+0.05 (± 0.10)
Wipe C	+0.11 (± 0.10)
Wipe D	+0.20 (± 0.04)
Wipe E	+0.26 (± 0.08)
Wipe F	+0.41 (± 0.20)
Wipe G	+0.32 (± 0.04)
Wipe H	+0.30 (± 0.05)
Wipe I	+0.12 (± 0.08)

Siani *et al. AJIC* 2011; 39(3), 212-218

C. diff transfer from 'sporicidal' wipes

Efficacy testing against C. difficile NCTC12727

Wipes	Bacterial Removal (log_{10} cfu/disk ± SD) 500 g surface pressure	Bacterial transfer following 10 s wiping time at 500 g surface pressure
Negative control	**1.13 (± 0.36)**	**5 consecutive transfers. TNTC**
NaOCl soaked wipe	**2.02 (± 0.21)**	**5 consecutive transfers. TNTC**
WIPE A	**4.09 (± 0.79)**	**No spore transferred**
WIPE B	**0.22 (± 0.07)**	**5 consecutive transfers. From 0 to TNTC**
WIPE C	**1.30 (± 0.33)**	**5 consecutive transfers. From 0 to TNTC**
WIPE D	**0.57 (± 0.07)**	**5 consecutive transfers. From 1 to TNTC**
WIPE E	**+0.08 (± 0.08)**	**5 consecutive transfers. TNTC**
WIPE F	**1.14 (± 0.65)**	**5 consecutive transfers. From 83 to TNTC**
WIPE G	**0.67 (± 0.11)**	**5 consecutive transfers of ≤43 bacteria**
WIPE H	**0.88 (± 0.13)**	**5 consecutive transfers. From 2 to TNTC**
WIPE J	**0.84 (± 0.66)**	**5 consecutive transfers. From 40 to TNTC**

Siani *et al. AJIC* 2011; 39(3), 212-218

Contact times are important

- Manufacturers will give indications of contact time necessary to achieve stated reductions
  - These may not be that realistic in practice
- Recent study looked at producing a validated cleaning procedure for cleaning blood glucose monitoring machines
  - had to wipe the surface 10 times with a chlorine wipe to achieve the recommended 1 minute contact time
    - Lin, S. Et al 2017. Demonstration of disinfection procedure for the development of accurate blood glucose meters in accordance with ISO 15197:2013. *PLoS One,* 12**,** e0180617.

Are contact times of surface disinfectants achievable?

- Oral paper delivered at CHICA conference in 2008
  - Omidbakhsh N. Surface Disinfectants and label claims: Realistically can contact times be met to achieve antimicrobial efficacy ? Canadian Journal of Infection Control. 2008;23(1):49.
  - Small study carried out by a Virox employee that was never published except in abstract form

The Study

- Aim was to determine the efficacy of several different disinfectant chemistries against common pathogens using a realistic contact time for each chemistry based on its evaporation rate and compare the results to the efficacy claims listed on the product labels
  - Accelerated Hydrogen Peroxide (AHP) , bleach, a quat, a quat-alcohol and a phenol, were tested for their drying time on a surface
  - Also tested for their antimicrobial activity at their drying time against S. aureus, P. aeruginosa, and MRSA, as representative bacteria using a quantitative carrier test method with the criteria of at least 6-log reduction to pass

Results

- All tested products dried in less than 5 min contact time with alcohol-based products drying significantly faster than any other chemistry (p-value of 0.000)
  - Quat and phenol carried a label claim of 10 min, but dried at less than 2-3 min, and those contact times, they were found ineffective
  - AHP dried at 3-4 min, regardless it was still efficacious
  - Bleach dried at less than 2 min, and it was not efficacious
  - Quat/alcohol dried at less than 30 seconds, and was not effective

QUATS are bad

Wishart & Riley, Med J Aus (1970)

INFECTION WITH *PSEUDOMONAS MALTOPHILIA* HOSPITAL OUTBREAK DUE TO CONTAMINATED DISINFECTANT

MICHAEL M. WISHART, M.B., B.S., M.R.C.O.G., F.R.C.P.A.* AND THOMAS V. RILEY, B.APP.SCI.
Department of Pathology, King Edward Memorial Hospital for Women, Subiaco, Western Australia

Pseudomonas in Quats

- Paper constantly cited in journals (100+ times) as evidence that Quats grow pseudomonas
  - New UK Gram-negative guidance (Wilson, 2017)
    - “agents used for cleaning can even become contaminated with Gram-negative bacteria, especially pseudomonads”
  - Actually was Stenotrophomonas (Xanthomonas) maltophilia
- Paper actually says that it was a contaminated water supply used to dilute Savlon solution (CHG 1.5%, Cetrimide 15%)
  - Remained in use in warm wards for many months following reconstitution
  - Method of washing the bottles was not effective
    - Biofilm likely
- When the water was sorted, problem went away

What about the wipe itself?

- Various physical variables do make a difference to wipe properties and selection
  - Wet strength
  - Absorbency
  - Grammage
  - Size

  - But price usually rules

Nonwoven fabrics

- Broadly defined as sheet or web structures bonded together by entangling fiber or filaments (and by perforating films) mechanically, thermally or chemically
  - flat or tufted porous sheets that are made directly from separate fibres, molten plastic or plastic film
- Majority of raw materials used for nonwoven wipes are polyester (PES) or polypropylene (PP)

Nonwoven wipes

- Advantages
  - May be saturated with an active ingredient
  - Delivers optimal concentration of the agent to the surface that it is used on
    - Detergent
    - Disinfectant
      - as long as contact times are achieved
  - Stabilised, so can be kept for extended periods
  - Closed, single use system minimises risk of contamination
  - Flexible placement so available at the point of use

Factors influencing moisture retention

- Disinfectant Absorbency and Release
  - How the disinfectant is absorbed by the wipe and then released onto the surface is a function of both wipe material and disinfectant formulation
    - fibre used will either enhance or hinder disinfectant absorption rate, as will the amount and type of surfactant used in the formulation
    - These properties play a key role in the wettability, compliance and cost of the product

Substrate affects wipe action

- Polypropylene does not absorb, so very good for delivering the disinfectant ensuring that contact times are achieved
- More absorbent fibres like viscose will pick up more effectively but there is a potential that not enough ingredient will be applied to the surface
- Mixed fibre helps achieve the best balance

Adsorption

- Surfactants adsorption at interfaces between fiber/fabric and liquid is influenced by many factors
  - length and nature of surfactants, the nature of the fibre surface, temperature, pH, and nature of the liquid
  - Significant factors for fibre adsorption properties include molecular structure (functional groups), molecular orientation, degree of crystallinity (amount of amorphous region), the sizes and shapes of surface porous structures
- Cotton has negative charge, which favours adsorption of cationic surfactants

The Adsorption Issue

- Problem
  - "Tests carried out by the manufacturer on these wipes showed an interaction between the active disinfectant and the wipe material resulting in inadequate disinfection properties. This interaction is attributed to the adsorption of active ingredients in the disinfecting solution onto the tissue fibres of the wipe"
    - Cationics bind to cellulose-derived fibre
  - Solution: Test fluid that is squeezed from a wipe, not the fluid that will be added to the wipe

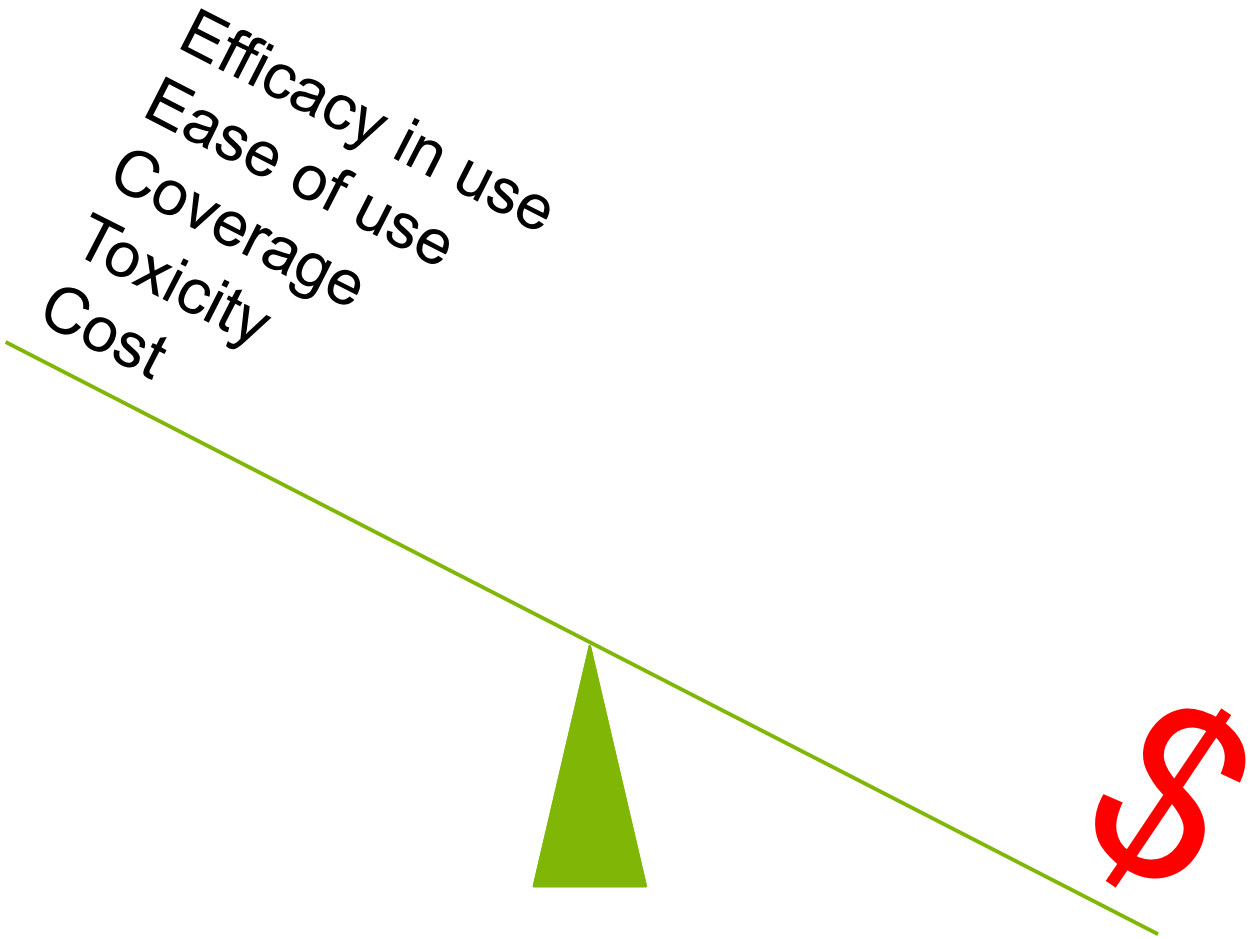
Factors to consider

IPC

- Efficacy against target pathogen(s)
- Finance
- Flexibility
- Ease of use
- Coverage
- Toxicity

Purchasing Dept.

Balance must be achieved



Check the true cost

	Product 1	Product 2
Cost/wipe	£0.05	£0.04
Surface area covered by 1 wipe (sq. ft)	11.5	6.5
No of wipes to disinfect a bed	8	14
Total cost (Consumables only)	£0.40	£0.56

Surface Compatibility

- Some plastics are incompatible with many agents (including sunlight!)
- Any manufacturer should provide
  - details of a validated cleaning (and disinfection where needed) protocol for any item used in healthcare that has to be decontaminated
  - a list of compatible agents
- The days of ‘ask your infection control team for advice are over’
  - If you can’t clean it, don’t buy it!

Key Points

- Wipes are not the perfect solution to environmental decontamination and are not the best option for ‘routine’ cleaning
  - However many items need cleaning regularly or between patient contacts and not always by staff that are professionally trained to clean
- So they do fit into an IPC programme
  - Convenient
  - Fast
  - Available at the point of care
  - Consistent application of active agent

Conclusion

- All wipes could be better
  - Better wipe materials would mean more effective removal of micro-organisms
    - However no procurement/supplies manager would pay for them
    - We need cost-effectiveness studies
- Ask about testing, contact time, wipe materials, coverage and not just Au$
  - A wipe is not a wipe is not a wipe