

Polished defences: Surface

Dr Kalisvar Marimuthu

Head, Infection Prevention, Control, and Outreach (ICON) Office, National Centre for Infectious Diseases, Singapore

Head, National Infection Control and Healthcare Epidemiology (NICHE), interim Communicable Diseases Agency, Singapore

Senior Consultant, Department of Infectious Diseases, Tan Tock Seng Hospital, Singapore

Adj. Asst. Prof of Medicine, Yong Loo Ling School of Medicine, National University of Singapore, Singapore

Date of presentation: 18 October 2024

Dr Kalisvar Marimuthu

Declaration of conflict of interest (COI)

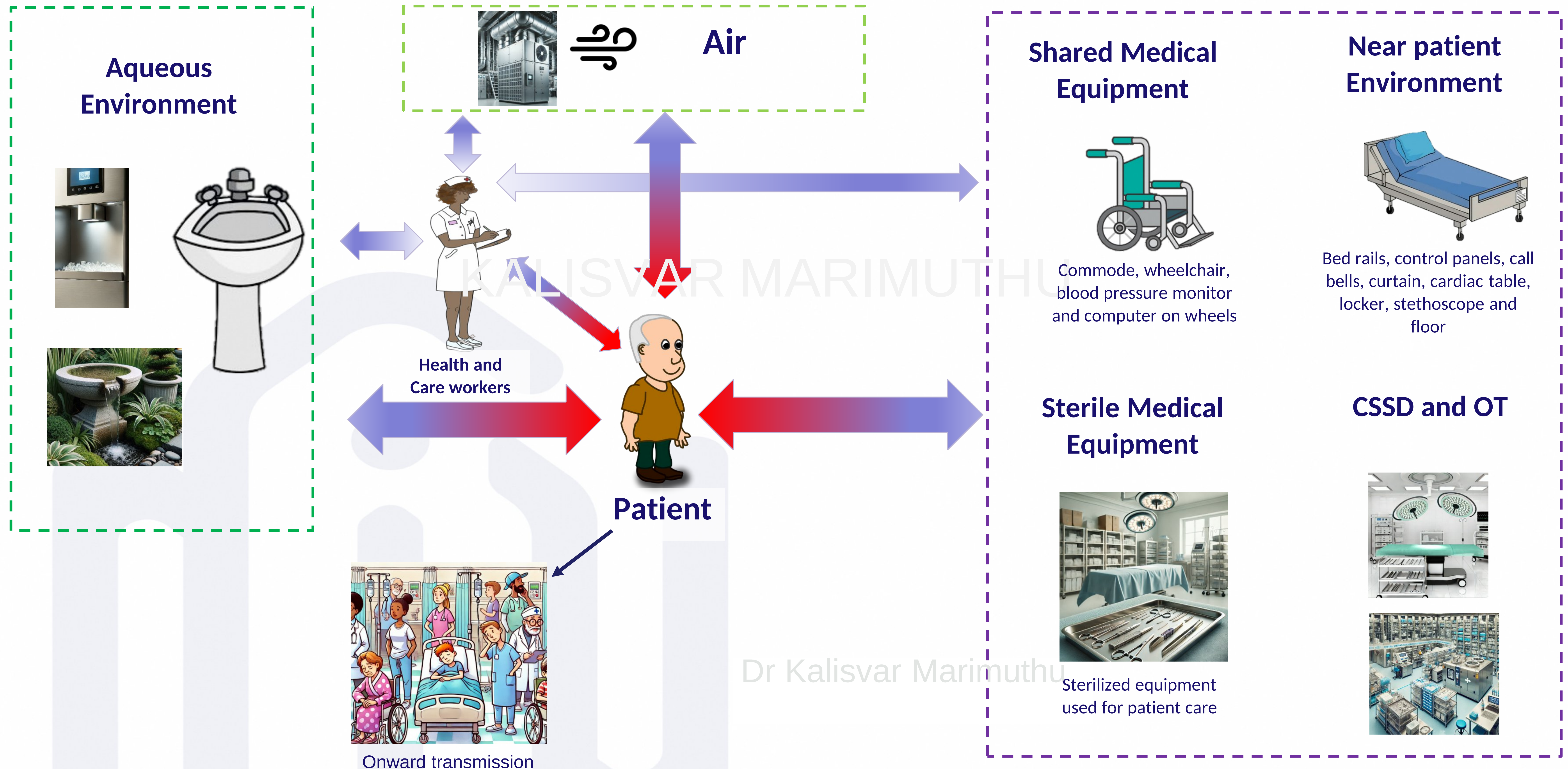
- No COI related directly to this presentation



Dr Kalisvar Marimuthu

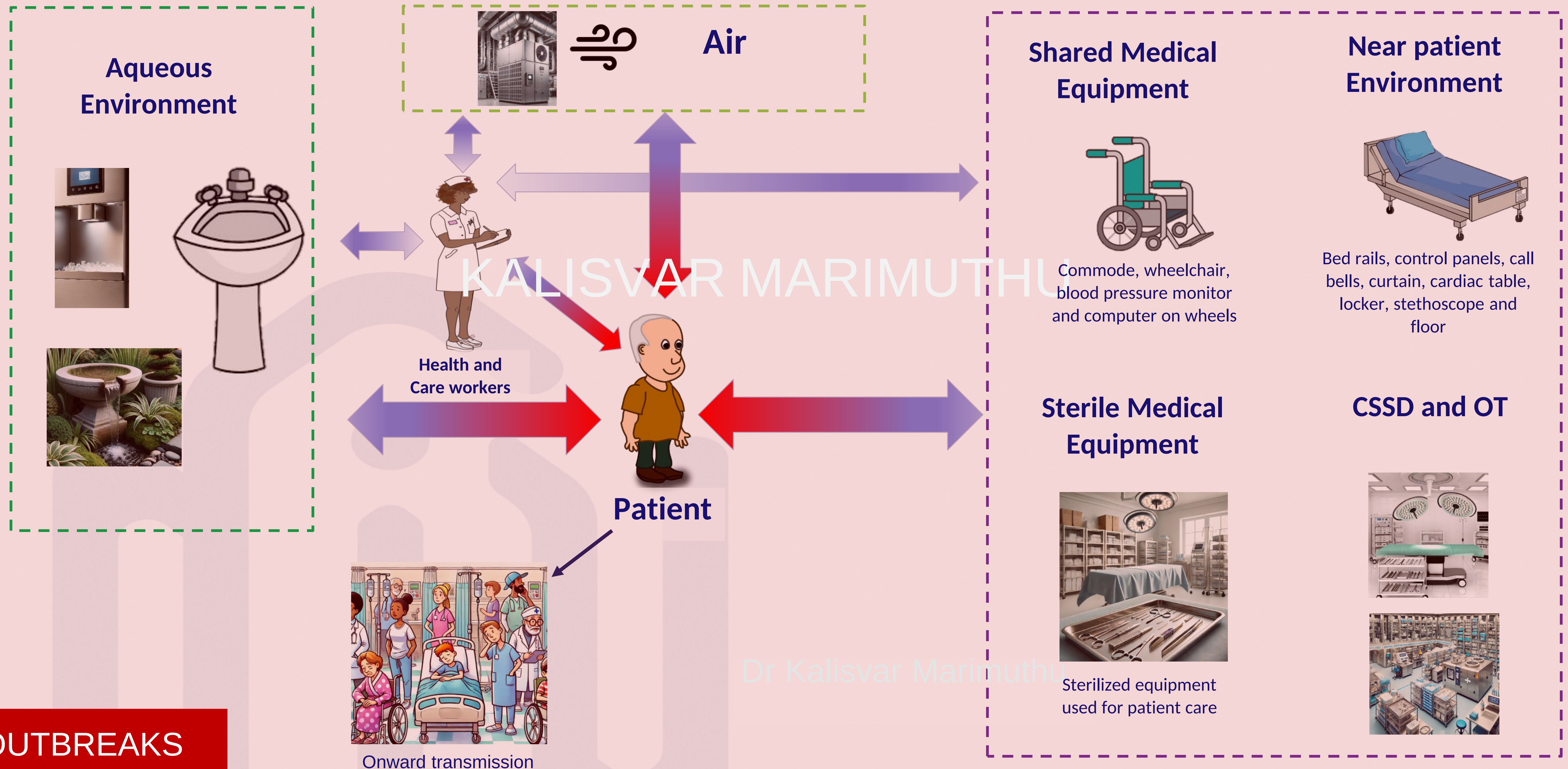
Role of environment in the transmission of pathogens

Stable/ Self-sustaining microbiome ↔ Transient pathway ↔ Unstable microbiome



Role of environment in the transmission of pathogens

Stable/ Self-sustaining microbiome ↔ Transient pathway ↔ Unstable microbiome



OUTBREAKS

- Surfaces and portable equipment in rooms of colonized or infected patients frequently become contaminated with healthcare-associated pathogens
- Many healthcare-associated pathogens survive for prolonged period on surfaces
- Pathogens on surfaces may be acquired on the hands of personnel or patients
- Admission to a room previously occupied by a colonized or infected patient increases the risk for acquisition by subsequent occupants
- Contaminated shared medical equipment has been implicated as a source for transmission of healthcare-associated pathogen
- Benign surrogate marker studies
- Multidrug-resistant organisms (MDRO) transfer to gown and gloves
- Reduction of MDRO colonisation and infection with cleaning and disinfection studies
- Clinical trial showing reduction in HAI with dedicated cleaning of shared medical equipment]

Objective:

- Assessed the effect of enhanced cleaning and disinfection of shared medical equipment on health-care-associated infections (HAIs) in hospitalised patients

Methods:

- Stepped-wedge, cluster randomised, controlled trial
- Ten wards of a single hospital located on the central coast of New South Wales, Australia
- Adult patients
- The research team approached five hospitals that met the eligibility criteria to gauge interest in participating but the study was funded for one hospital only
- The stepped-wedge design allowed all clusters to be exposed to the intervention and supported feasible rollout within a complex environment

Dr Kalisvar Marimuthu

- Five treatment sequences with two wards per cluster
- Two wards randomized to the treatment sequence every six weeks
- Outcome were measured across all clusters every two weeks

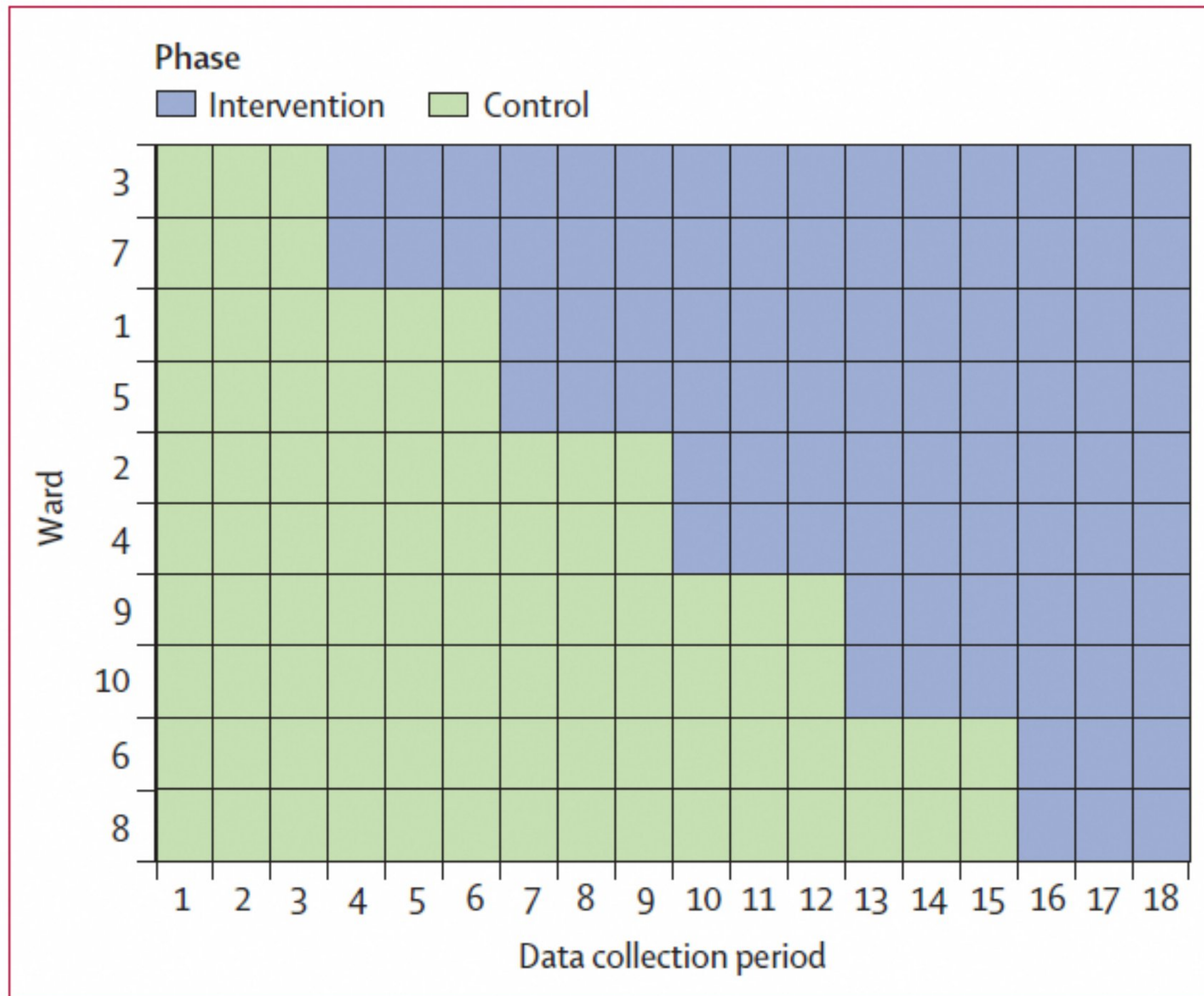


Figure 1: Stepped-wedge trial design

Each data collection period represents a 2-week period.

Dr Kalisvar Marimuthu

- Control phase: Usual cleaning of shared medical equipment
- Multimodal intervention: Dedicated 3 h of additional cleaning per weekday was provided to each ward cleaning and disinfection of shared medical equipment, education on cleaning techniques, and auditing of cleaning thoroughness with feedback to staff
- Outcome measurement:
 - Primary outcome:
 - o Healthcare associated infections (HAI): Two weekly HAI PPS
 - Secondary outcome:
 - o Types of HAIs from data
 - o Thoroughness of cleaning for shared medical equipment
 - the proportion of fluorescent marker dots that were completely removed during the fortnightly audits,
 - o The preferences of staff for receiving feedback on cleaning
 - o The cost-effectiveness of the intervention

- Shared medical equipment was items found on all ten wards, used by multiple patients or related to patient care, stored in common areas, that contacted intact skin, and were defined as non-critical

Table S2. Shared medical equipment cleaned and products used.

Type of equipment cleaned during the intervention
• Bladder scanner • Blood pressure monitor • Blood testing kit (glucose or ketones) • Commode[^] • Computer on wheels (excluding keyboards) • Infusion pump • Intravenous drip stand/pole • Medication trolley • Metal trolley • Patslide • Resuscitation trolley • Walking frames (pick-up frame, rollator frame and 4-wheel) • Wheelchair
Product (wipe) used to clean shared medical equipment
Clinell Universal wipes [®] were used for cleaning equipment [^] Clinell Sporidical wipes [®] were used for cleaning commodes
Example of label applied to cleaned equipment
 Note: green labels were used by the participating hospital prior to the study intervention.

Dr Kalisvar Marimuthu

Outcome:

	HAI point prevalence in the control phase, % (95% CI)	HAI point prevalence in the intervention phase, % (95% CI)	Absolute difference, percentage points (95% CI)	Relative difference, percentage points (95% CI)	OR (95% CI)	p value for OR
All HAIs	14.9% (10.4 to 19.4)	9.8% (6.1 to 14.1)	-5.2 (-8.2 to -2.3)	-34.5 (-50.3 to -17.5)	0.62 (0.45 to 0.80)	0.0006
Bloodstream infections, pneumonias, UTIs, and SSIs	6.3% (3.3 to 9.6)	4.0% (1.9 to 6.8)	-2.3 (-4.3 to -0.7)	-36.2 (-56.1 to -12.8)	0.62 (0.42 to 0.86)	0.013
All HAIs, excluding COVID-19	14.4% (10.2 to 19.0)	9.0% (5.7 to 13.4)	-5.3 (-8.1 to -2.7)	-37.2 (-51.3 to -19.5)	0.59 (0.45 to 0.77)	0.0002
All HAIs, excluding EENTs	13.0% (8.6 to 17.4)	8.3% (4.9 to 12.0)	-4.8 (-7.6 to -2.1)	-36.7 (-51.7 to -17.4)	0.60 (0.45 to 0.81)	0.0008

Model-based bootstrap results, showing predicted outcomes by study phase and absolute and relative differences in prevalence (intervention – control), after accounting for clustering and secular time trends. EENT=ear, eye, nose, throat, and mouth infection. HAI=health-care-associated infection. OR=odds ratio. SSI=surgical site infection. UTI=urinary tract infection.

Table 3: Estimated changes in HAI point prevalence attributable to the intervention

With ONLY 3 HOURS of dedicated shared equipment cleaning, HAI reduced by 38%

- Implemented as a program within the framework of facility-level IPC program
- WHO core components that are relevant to environmental hygiene:

CC1	Infection prevention and control (IPC) programmes	Related
CC2	National and facility-level IPC guidelines	Related
CC3	IPC education and training	Related
CC4	HAI surveillance	
CC5	Multimodal strategies for implementing IPC activities	
CC6	Monitoring, evaluation, and feedback	Related
CC7	Workload, staffing and bed occupancy	
CC8	Built environment, material, and equipment for IPC	Directly relevant

Environmental hygiene program plays a crucial role in surface hygiene

Organization and administration

- Leadership validation of environmental hygiene program activities
- Designated cleaning program manager or focal person

Staffing and training

- Appropriate number of paid and dedicated positions
- Documented training and education aligned to guidelines/WIs

Infrastructure and supplies

- Equipment supplies, procurement and management
- Physical space and water supply, and waste water management

Policies and procedures

- Cleaning guidelines and standards
- Work instructions, schedules and logs

Monitoring, feedback, and audits

- Standardized methodology for monitoring, applied routinely
- Timely feedback is provided

Environmental hygiene committee

- Can be a part of IPC committee
- Responsible for the institution-wide environmental hygiene

Dr Kailash Mahapatra

- Annual budget
- An annual budget is essential for an effective environmental cleaning program
- The major elements of a budget include:
 - Personnel (salary and benefits for cleaning staff, supervisors, and an overall program manager)
 - Staff training (at least pre-service and annual refresher)
 - Environmental cleaning supplies and equipment, including PPE for cleaning staff equipment for program monitoring (e.g., fluorescent markers, UV-lights)
 - Administrative costs
 - Production and printing costs for checklists, logs, and other job aids
 - Infrastructure/services costs, such as supporting water and wastewater services (as applicable) |

- Staffing involves paid positions that have:
 - Written job descriptions or terms of reference
 - Structured, targeted training (e.g., pre-service, annual, when new equipment is introduced)
 - Defined performance standards or competencies
 - Access to an on-site supervisor to ensure they can safely perform their work (e.g., address supply shortage, safety concerns)
- Appropriate number of staff
 - Differs by setting
 - Can be based on national expert opinion or measured parameters
- Staff should:
 - Be familiar with their job descriptions and performance standards
 - Perform duties only for which they were trained (e.g., cleaning staff should not be asked to clean high-risk wards (e.g., operating room), unless they have received specific training for that patient care area)
 - Know the identities and hazards of the chemicals that they could be exposed to in the workplace
 - Have supplies and equipment, including PPE, to perform their duties
 - Have working shifts consistent with acceptable norms for the given context |

- Staffing level
 - Most facilities will require full time staff
 - Factors influencing staffing level:
 - o Number of patient beds
 - o Occupancy level
 - o Type of cleaning (e.g., routine or terminal)
 - o Types of patient care areas (e.g., specialized care areas such as ICUs and ORs)
 - Staffing level should consider:
 - o Reasonable shift length
 - o Need for breaks
 - o Extra staff for contingencies (outbreaks and other emergencies)
 - Methods to estimate staffing level
 - o No single good method (e.g. time studies)
 - o Most reasonable approach would be: national guidance for staffing level based on some time studies |

- Training and education
 - Based on national- or facility-level guideline
 - It should be:
 - o Mandatory
 - o Structured
 - o Targeted
 - o Delivered in the right style
 - o Staff should be assessed competent before starting work independently
 - Develop the training program according to the intended audience, in terms of education and literacy level
 - Develop training content specifically for cleaning staff who could be responsible for cleaning procedures in specialized patient areas—particularly high-risk areas, such as intensive care units, operating rooms, and maternity units
 - If training is contracted out, specify the training requirements and content in the service level agreement |

- Training content should minimally include:
 - General introduction to the principles of IPC, including:
 - o Transmission of pathogens
 - o The key role cleaning staff play in keeping patients, staff and visitors safe
 - o How cleaning staff can protect themselves from pathogens
 - Detailed review of the specific environmental cleaning tasks for which they are responsible, including review of SOPs, checklists, and other job aids
 - When and how to safely prepare and use different detergents, disinfectants, and cleaning solutions
 - How to prepare, use, reprocess, and store cleaning supplies and equipment (including PPE)
 - Participatory training methods, hands-on component with demonstration and practice
 - Easy-to-use visual reminders that show the cleaning procedures (i.e., without the need for a lot of reading)
 - Orientation to the facility layout and key areas for the cleaning program (e.g., environmental cleaning services areas)
 - Other health and safety aspects, as appropriate |

- Training and education
 - Maintain training records, including dates, training content, and names of trainers and trainees
 - Select appropriate, qualified trainers, usually at facility level—generally, staff with IPC training who have been involved in the development of environmental cleaning policy are best qualified.
 - o Members of existing IPC or hygiene committees
 - o Cleaning program manager, or
 - Conduct periodic competency assessments and refresher trainings as needed (e.g., at least annually, before introduction of new environmental cleaning supplies or equipment)
 - Focus refresher trainings on gaps identified during competency assessments and routine monitoring activities |

- Guiding IPC principle: Effective implementation of interventions requires objective monitoring of staff compliance with regular feedback on performance
- Key composition:
 - Standardized methodology for monitoring
 - Applied on a routine basis
 - Timely feedback is provided
- Monitoring methods are divided into:
 - Direct: (e.g. performance observation) and indirect (e.g. environmental markings)
 - Objective (e.g. ATP luminescence) and subjective methods (e.g. assessment of cleanliness)
- Carling and Bartley basic components of environmental cleaning monitoring
 - i. Use of an objective, quantitative monitoring tool
 - ii. Performance rather than deficiency orientated
 - iii. Ongoing training by trained, unbiased individuals
 - iv. Objective performance feedback
 - v. Goal-oriented structured process improvement model

Monitoring methods for environmental cleaning (1)

Monitoring method	Monitoring staff	Monitoring frequency	Advantages	Disadvantages
Performance observation	Cleaning supervisors	At least weekly More frequent for new staff	• Can be used for large areas (units, wards) • Easy to implement • Benchmarking is possible • Simple and inexpensive • Allows immediate and direct feedback to individual staff • Encourages cleaning staff engagement and input • Identifies gaps for staff training/ job aid improvements	• Subjective—difficulty in standardizing methodology and assessment across observers • Labor-intensive • Results affected by Hawthorne bias (i.e., more of an assessment of knowledge than actual practice) • Does not assess or correlate to bioburden
Visual assessment	Cleaning supervisor/ focal point IPC	Weekly	• Can be applied to entire facility or specific units/wards • Easy to implement • Benchmarking is possible • Inexpensive • Allows immediate and direct feedback to individual staff	• Could be delay in feedback dependent on method used to compile results • Subjective—based on individual determinations of dust/debris levels • Does not assess or correlate to bioburden
Fluorescent markers	Cleaning supervisors (internal monitoring) IPC team (external monitoring)	Monthly	• Quick • Provides immediate feedback on performance • Minimal training required to perform • Objective • Benchmarking is possible • Relatively inexpensive	• Does not assess or correlate to bioburden • Labor-intensive as surfaces should be marked before cleaning and checked after cleaning has been completed • Some difficulties documented in terms of removal of markers from porous or rough surfaces (e.g., canvas straps) • Time-intensive • Need to vary frequency and objects to prevent monitoring system from becoming known • Risk of false positive

Monitoring methods for environmental cleaning

Monitoring method	Monitoring staff	Monitoring frequency	Advantages	Disadvantages
ATP bioluminescence (relative light units-RLU)	IPC team	4-6 monthly as a spot audit	• Quick • Provides immediate feedback • Minimal training required to perform • Objective	• Expensive • Low sensitivity and specificity • Lacks a standardized threshold or benchmark for determining the level or status of cleanliness (i.e., “safe” post-cleaning RLU levels) for specific surfaces or patient care areas • Variable benchmarks • Technology constantly changing • Interference of cleaning products, supplies and in some cases surfaces, which can both reduce or enhanced ATP levels (e.g., bleach, microfiber, stainless steel)
Environmental culture	IPC team/lab	When indicated	• High specificity but less sensitive • Provides direct indication of presence of specific pathogens (direct swab cultures) • May be useful for identifying source of outbreaks and/or environmental reservoirs • Objective	• Not recommended for routine use • Expensive • Prolonged time for results (>48hrs) • Requires access to laboratory resources and trained personnel for interpreting results • Lack of defined threshold or benchmark for determining the level or status of cleanliness (e.g., colony-forming units per surface area)

Roles of feedback

Type of feedback	Staff responsible	Strategy	Purpose
Real-time feedback	Supervisor Focal point	Open audit	• Training and education • Practice improvement
Cumulative feedback of audit findings	IPC team	Covert audit	• To assess the overall adherence or “real” adherence to cleaning requirements • Feedback usually submitted by IPC team as a report to the EH team, IPC committee, and senior management (where required)

Step 1. Categorize and score the risk factors that determine the need for environmental cleaning

Score	3	2	1	0
Probability of contamination with pathogens	Heavy contamination	Moderate contamination	Light contamination	-
Vulnerability of Population to Infection	-	-	More susceptible	Less susceptible
Potential for exposure	High touch surfaces	-	Low-touch surfaces	-

Probability of Contamination with Pathogens

Heavy Contamination (score = 3): An area is designated as being heavily contaminated if surfaces and equipment are routinely exposed to copious amounts of fresh blood or other body fluids (e.g., birthing suite, autopsy suite, cardiac catheterization laboratory, hemodialysis station, emergency room, client/patient/resident bathroom if visibly soiled).

Moderate Contamination (score = 2): An area is designated as being moderately contaminated if surfaces and equipment do not routinely (but may) become contaminated with blood or other body fluids and the contaminated substances are contained or removed (e.g., wet sheets). All client/patient/resident rooms and bathrooms should be considered to be, at a minimum, moderately contaminated.

Light Contamination (score = 1): An area is designated as being lightly contaminated if surfaces are not exposed to blood, other body fluids or items that have come into contact with blood or body fluids (e.g., lounges, libraries, offices).

Vulnerability of Population to Infection

More Susceptible (score = 1): Susceptible clients/patients/residents are most susceptible to infection because of their medical condition or lack of immunity. These include those who are immunocompromised (oncology, transplant and chemotherapy units), neonates (level 2 and 3 nurseries), and those who have severe burns (i.e., requiring care in a burn unit).

Less Susceptible (score = 0): For the purpose of risk stratification for cleaning, all other individuals and areas are classified as less susceptible.

Potential for Exposure

High-touch surfaces (score = 3): High-touch surfaces have frequent contact with hands. Examples include doorknobs, telephone, call bells, bedrails, light switches, wall areas around the toilet and edges of privacy curtains.

Low-touch surfaces (score = 1): Low-touch surfaces have minimal contact with hands. Examples include walls, ceilings, mirrors |

Step 2. Determine the total risk stratification score:

Risk Stratification Scores for High-Touch Surfaces (Score for Potential for Exposure = 3)

Probability of contamination with pathogens	More susceptible population (score = 1)	Less susceptible population (score = 0)
Heavy (score = 3)	7 (3+3+1)	6 (3+3+0)
Moderate (score = 2)	6 (3+2+1)	5 (3+2+0)
Light (score = 1)	5 (3+1+1)	4 (3+1+0)

Risk Stratification Scores for Low-Touch Surfaces (Score for Potential for Exposure = 1)

Probability of contamination with pathogens	More susceptible population (score = 1)	Less susceptible population (score = 0)
Heavy (score = 3)	5 (1+3+1)	4 (1+3+0)
Moderate (score = 2)	4 (1+2+1)	3 (1+2+0)
Light (score = 1)	3 (1+1+1)	2 (1+1+0)

Step 3. Determine the cleaning frequency based on the risk stratification matrix:

Total Risk Score	Risk Type	Minimum Cleaning Frequency
7	High Risk	Clean after each case/event/procedure and clean additionally as required
.....		
4–6	Moderate Risk	Clean at least once daily
		Clean additionally as required (e.g., gross soiling)
.....		
2–3	Low Risk	Clean according to a fixed schedule
		Clean additionally as required (e.g., gross soiling)
.....		

- Critical Role of Surface Contamination:
 - Surfaces and shared medical equipment can harbor pathogens for extended periods, contributing to healthcare-associated infections
 - Contaminated surfaces can transfer pathogens to healthcare workers and patients, increasing the risk of onward transmission
- Evidence of Impact:
 - Studies confirm that enhanced cleaning reduces pathogen transmission, with some interventions reducing HAIs by up to 38% (CLEEN study)
- Multimodal Cleaning Interventions:
 - Effective programs include additional cleaning hours, education on cleaning techniques, thorough auditing, and feedback to staff
 - Shared medical equipment, which frequently contacts multiple patients, must be cleaned regularly to minimize infection risk
- Importance of Monitoring and Feedback:
 - Regular audits (e.g., fluorescent markers, visual inspections) and real-time feedback improve cleaning performance and compliance
 - Implementing structured, evidence-based monitoring is essential for maintaining high standards of hygiene.

Thank you

Dr Kalisvar Marimuthu