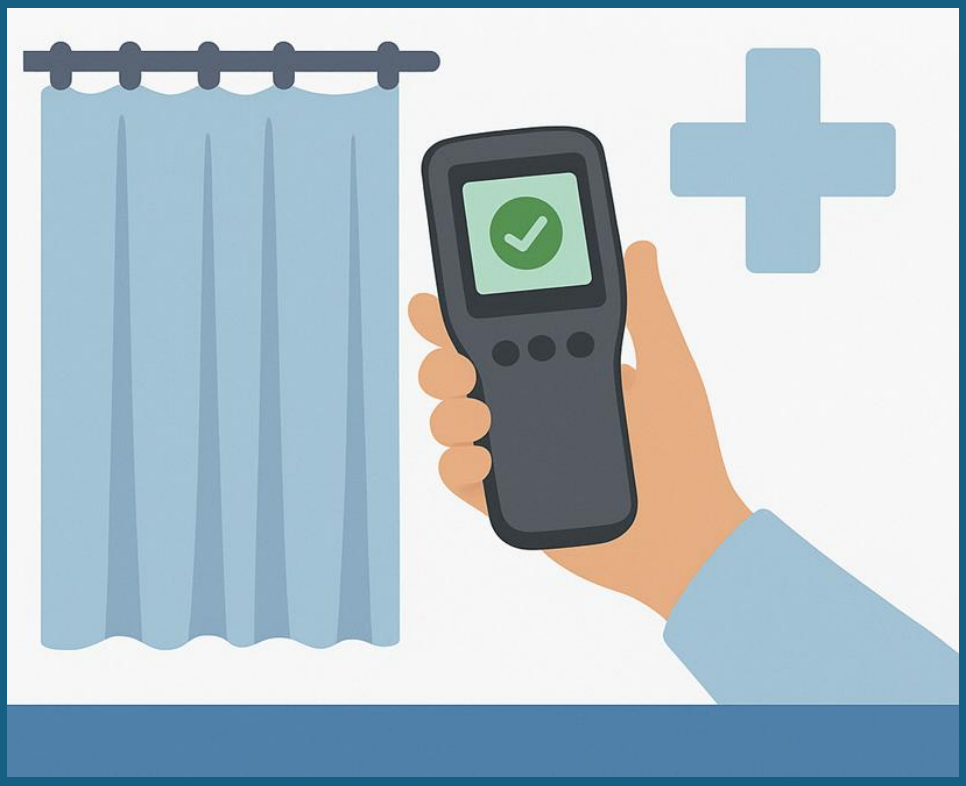
BENCHMARK FOR HEALTHCARE FACILITY CLEANLINESS USING ADENOSINE TRIPHOSPHATE MONITORING



MINISTRY OF HEALTH AND WELLNESS

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The assistance of Dr. D. Capiron (IPC Registered Medical Officer) and Dr. M. Ramrucha (Registered Medical Officer) in carrying out benchmarking tests is acknowledged.

PEER REVIEW

This document was sent to regional IPC teams for review.

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Introduction

The assessment of environmental cleanliness in healthcare facilities is a critical component of infection prevention and control (IPC), directly influencing patient safety, staff wellbeing, and public confidence in health services. One of the most objective and rapid tools for evaluating surface cleanliness is Adenosine Triphosphate (ATP) bioluminescence testing, which provides real-time, quantifiable data on contamination levels. Benchmarking the use of ATP across healthcare facilities therefore allows the Ministry of Health and Wellness (MOHW) to establish evidence-based standards, identify performance gaps, and drive targeted improvements in environmental hygiene practices.

Inadequate environmental cleaning and equipment disinfection or sterilization can be associated with hospital-acquired infections (HAI). Recent surveys have demonstrated an elevated rate of HAI in the public healthcare facilities of Mauritius thereby underlining the necessity to always keep our hospitals clean.

The importance of this exercise is underscored by the strong emphasis placed on cleanliness and infection control by MOHW. Several oversight and monitoring mechanisms have been put in place over the past five years, including Squad Teams, Special Monitoring Teams, IPC teams and administrative visits involving middle and upper management, as well as dedicated Environmental and General Cleanliness Teams. These structures reflect the Ministry's recognition of environmental hygiene as a priority area, particularly in response to recurrent public complaints about dirtiness in hospitals and the presence of pests such as rodents, pigeons, cockroaches, and ants.

Underlying these challenges are systemic issues such as inadequate staffing, lack of staff accountability, and shortages of cleaning and disinfection equipment. In this context, ATP benchmarking provides a practical, objective, and standardized approach to assess and improve cleaning effectiveness, support accountability, and guide resource allocation. By complementing existing monitoring mechanisms, this exercise strengthens the ministry's ongoing efforts to address public concerns and enhance the overall quality and safety of healthcare environments.

Background

ATP is an energy-carrying molecule found in all living and once-living material, including blood, saliva, bacteria, and other organic residues. Because of this, ATP is widely used as a universal marker of cleanliness.

ATP monitoring works by swabbing a surface and inserting the swab into a handheld device called a luminometer. The system uses a reaction involving luciferin and luciferase to produce light. The amount of light, measured in relative light units (RLU), indicates the level of organic residue on the surface. Results are available within seconds, and software can track cleaning trends and staff performance over time.

While ATP testing is quick and practical, it is not specific. It cannot distinguish between live and dead microbes or identify the type of contamination present. Instead, it provides an overall measure of organic material, which is important because such residues can serve as food for bacteria and compromise hygiene.

Timeline

- January 2020: A request for purchase of an ATP luminometer was made to Dr. A. G. Jeetoo Hospital by the Specialist in Infectious Diseases.
- August 2020: Specifications were finalized by the Biomedical Engineer; approval was sought, and the request was forwarded to the Procurement Unit.
- July 2021: It was disclosed that the request was lost.
- January 2022: Funds were not available for the procurement of biometers.
- January 2023: Another request for purchase was submitted to MOHW by the National IPC Focal Point.
- September and October 2023: Reminders were sent to the Procurement Unit of MOHW.
- November 2023: Specifications were updated by the Biomedical Engineer.
- May 2024: All bids failed due to excessive price deviations.
- June 2024: A third request for purchase was forwarded to Sir Seewoosagur Ramgoolam National Hospital (SSRNH).
- October 2024: The Hygiene ATP Testing Meter PCE-ATP 1 was received.
- November 2024: A protocol for benchmarking purposes was developed.
- December 2024 to February 2025: Tests were carried out according to the protocol over eight half-day sessions at SSRNH by Dr. D. Nuckchady, Dr. D. Capiron and Dr. M. Ramrucha.
- September 2025: Data analysis was completed, and this guide was written and submitted to MOHW for approval.

Methods to evaluate environmental hygiene

The three methods internationally used to assess cleaning practices are illustrated in table 1 together with their advantages and disadvantages. Table 2 displays the two methods used to assess the level of cleanliness. Table 3 summarizes these findings.

Method	Advantages	Disadvantages
Performance observations: observers (e.g., cleaning supervisors) use standardized perform structured observations using checklists that are specific to individual patient care areas. The goal is to rate the effectiveness of cleaning staff and adherence to the SOP (such as identifying the number of steps performed correctly).	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 of cleanliness: after an area has been cleaned, observers check the cleanliness of items. For example, using a gloved hand, wipe surfaces to inspect for dust.	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 (e.g., UV visible): a tracing agent (e.g., fluorescent material, chemical tracer) marks predetermined items and surfaces before cleaning. After cleaning, a trained observer uses a detecting agent (e.g., ultraviolet light, enzymatic detector) to determine if any tracing agent is left. The observer counts the items that still show tracing agent and gives a score based on how many were cleaned completely, partially, or not at all.	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

Table 1: Advantages and Disadvantages of Monitoring Methods for Assessing Cleaning Practice: Adherence to Cleaning Procedures. From US CDC.[1]

Method	Advantages	Disadvantages
ATP bioluminescence: detection of ATP indicates that organic material (microbial or biologic) is present on an object or surface. Objects are tested before and after cleaning to determine the effectiveness of a cleaning procedure. A numeric score can be generated based on the proportion of marked surfaces/ objects that were under the pre-determined threshold.	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 ATL 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 cultures: the only direct measurement of levels of microbial contamination after cleaning. In this process, cultures are taken (by swabbing or use of RODAC or contact agar plates) after an item is cleaned. Swabbing can indicate the presence of a specific bacteria on a surface. Contact agar plates can show the level of bacterial contamination on an area of a large, flat surface.	High sensitivity and specificity 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)

Table 2: Advantages and Disadvantages of Monitoring Methods for Assessing Cleanliness: Effectiveness of Cleaning Procedures. From US CDC.[1]

METHODS	ATP Monitoring	Microbiology Testing	Blacklight	Visual Inspection
EASE OF USE Can it be used by any level user?	★★★	★	★★★	★★★★
OBJECTIVE Does it measure without bias?	★★★★	★★★★	★★	★
SPECIFIC Does the method detect microbiological matter?	★	★★★★		
QUANTITATIVE Are results numeric and measurable?	★★★★	★★★★		
QUALITATIVE Can results be categorized as Pass/Fail?	★★★★	★★★★	★★★★	★★★★
TIMELINESS Does the method minimize time investment?	★★★★		★★	★★★★
LOW COST Are supplies and other costs affordable?	★★		★★	★★★★
TRAINING TOOL Does the tool confirm proper cleaning?	★★★★	★	★★★★	★★
MANAGEMENT TOOL Is the data collected powerful for managers?	★★★★	★★★★	★	★
FRAUD-PROOF Are results protected from manipulation?	★★★★	★★★★		
SOFTWARE ANALYSIS Does the product come with software?	★★★★		★	★

Table 3: Side-by-side comparison of methods to measure cleanliness. From Hygiena.[2]

- Performance observations are being carried out occasionally by IPC teams but take too much time and are subject to the Hawthorne bias.
- Visual assessments are routinely and frequently being conducted by a wide cadre of staff but are too subjective e.g., contaminated high-touch surfaces may appear grossly clean. Cleaning checklists can also be dishonestly filled.
- Fluorescent markers have been utilized by IPC teams, but it is labour-intensive and not easily amenable to validation by national teams.
- General cultures of environmental swabs using contact agar plates are expensive, require skill, need human resources and can take a prolonged period of time to get results. Interpretation can be complicated too.
    - Identification of *Staphylococcus aureus* has been used as a hygiene indicator in some studies.[3, 20]
    - Routine environmental sampling is not recommended by the US CDC due to its poor correlation with patient outcomes.[4]
    - Microbiological sampling of the environment is usually considered if one of the following occur:[4]
        - There is an outbreak,
        - For research purposes,
        - For monitoring a biohazardous situation e.g., during the spill of a bioterrorist agent, and
        - For quality assurance reasons in which case the tests are to be performed at infrequent intervals.
    - Environmental prevalence surveys may be conducted if all of the following apply:[5]
        - An outbreak is noted,
        - A culprit organism has been identified or is suspected,
        - A microbial source from the environment is conjectured and
        - A presumed epidemiological link with the source is observed.
    - Doing simple aerobic colony counts (ACC), shown in figure 1, has been suggested by the World Health Organization (WHO) as a technique that can be used by low resource countries.

Figure 1: Samples of dip slides demonstrating surface contamination as "light, medium or heavy". From WHO.[6]

Given the above, it was decided to proceed with the use of ATP biometers for a more objective assessment of cleanliness in the hospital environment. The following caveats are however acknowledged:

- The acceptable RLU limits depends on several factors like:
    - The surface material,
    - The surface age, and
    - The cleaning procedure including time, temperature, and cleaning chemicals.[7]
- There are no specific standards or regulatory limits on RLU to define what is considered "clean".[7]
- RLU values do not consistently correlate with colony forming units (CFU) when evaluating an environmental surface.[7]
- Several studies have shown that various pathogens exhibit different RLU readings.[8]
- Residual detergents and disinfectants can either increase or decrease RLU readings.[9]
- Inconsistent ATP measurements may be caused by microfiber products, manufactured plastics, stainless steel, any organic substrate, or even the material of surfaces being cleaned.[8]
- ATP biometers do not easily detect bacterial spores or viruses.[7]

Benchmarking methodology

Literature review

By systematically reviewing published studies and guidelines, current practices can be better understood, performance indicators can be identified, shortcomings described by others can be learnt from and credibility is enhanced.

Onsite testing

Onsite testing can complement literature reviews because it generates real-world evidence, verifies performance, builds confidence of stakeholders, thus allowing them to trust new technologies, and supports adaptations to local context.

Three types of items were tested:

- Environmental surfaces,
- Medical equipment and cloth, and
- Intravenous fluids given to patients.

Three types of assessment were carried out:

- Evaluating how the RLU increases over time for a disinfected / cleaned time,
- Checking how the RLU changes after soiling, and
- Determining whether different surfaces or fluids commonly encountered in the hospital setting affected the RLU values.

The following steps were followed:

- All assessments were made in an office area under room temperature and pressure.
- The swabs were stored under -10℃ to -20℃.
- All reagents had to reach room temperature before use i.e., users waited for 10-20 minutes after removal from the fridge.
- All swabs were taken for 60 seconds over a 10x10cm^2 area for solid surfaces of the right size, an equivalent area for medical equipment and 10ml of fluid when liquids were involved.
- The swab tip was kept at 15 to 30 degrees angle, and the sampling area was swabbed in a zigzag manner; the user rotated the swab tip while swabbing to maintain close contact with the sampling area.
- The swabs were shaken with the reagent for five seconds with swinging to the left and right at 30 degrees.
- For the purposes of soiling:
    - 2.5ml of soil was used,
    - 2.5ml of saliva was added,

    - 2.5ml of tap water was employed, or
    - Unsanitized hands were place in contact with the fluid or surface for 30 seconds.
- For disinfection:
    - Wipe for 30 seconds with a cotton cloth soaked in 0.1% hypochlorite or 70% ethanol depending on material compatibility.
    - If the surface was visibly soiled, soap and water had to be applied first.
    - Surfaces had to be dry before testing could be carried out.
- With respect to time lapse assessments, the user could swab the surface every few minutes to every few hours for a maximum of 48 hours, as determined by the quantity of reagents available.

Results

Literature review

A threshold of 25 to 1,000 RLU have been used in various studies to define cleanliness, with a commonly used limit being 100 (see figure 2).[3, 10-15, 17, 20-23] ATP luminometers were considered useful tools to improve cleanliness in the hospital setting.[11-14, 18, 23] RLU values in cleaner areas like operation theatres were typically lower.[16] Higher thresholds like 500 or 1,000 may be considered for places like toilets and sluice rooms.[24] Even though some organizations prefer not to test cloths[26], sterile drapes had < 10 RLU upon unwrapping in one study.[27]

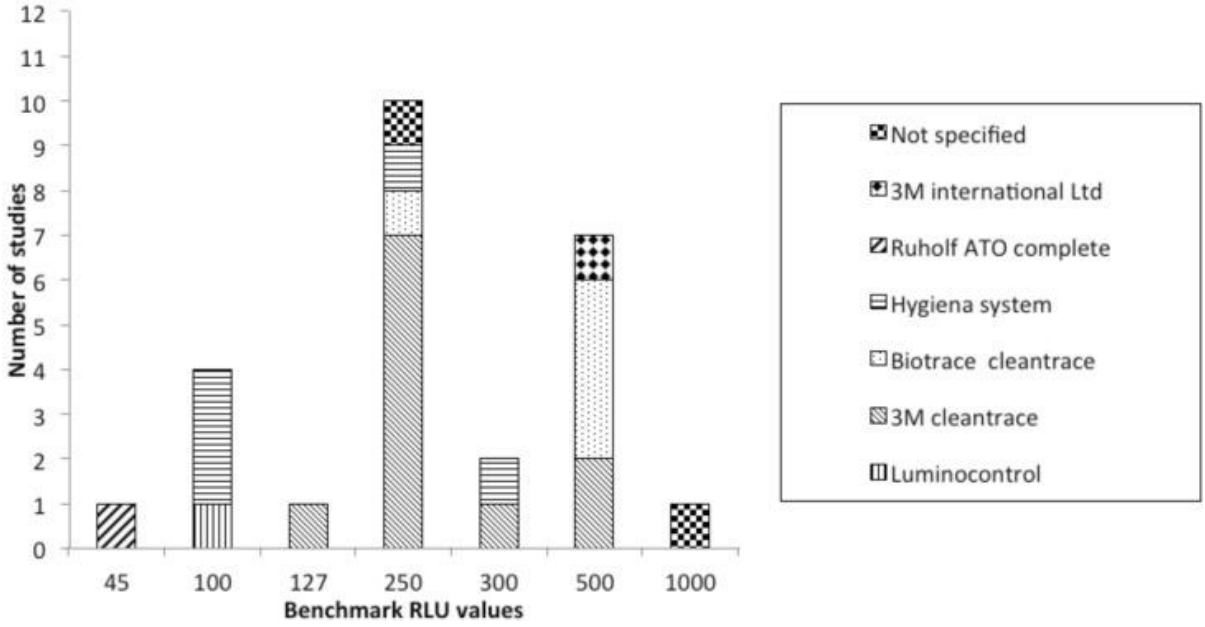

Figure 2: The benchmark Relative Light Units (RLU) values according to the different brands of bioluminometers used in the studies included in a review. From Nante et al.[15]

The association between RLU and CFU is displayed in figure 3 – although the relationship is generally poor, some studies have noted significant correlation; roughly every rise in RLU by 20 units above 100 correspond to one log increase in CFU.[15] The sensitivity and specificity of ATP biometers at a threshold of 100 RLU to detect <2.5 cfu/cm^2 ACC (a commonly utilized threshold for ACC) is 57% and 57% respectively.[3]

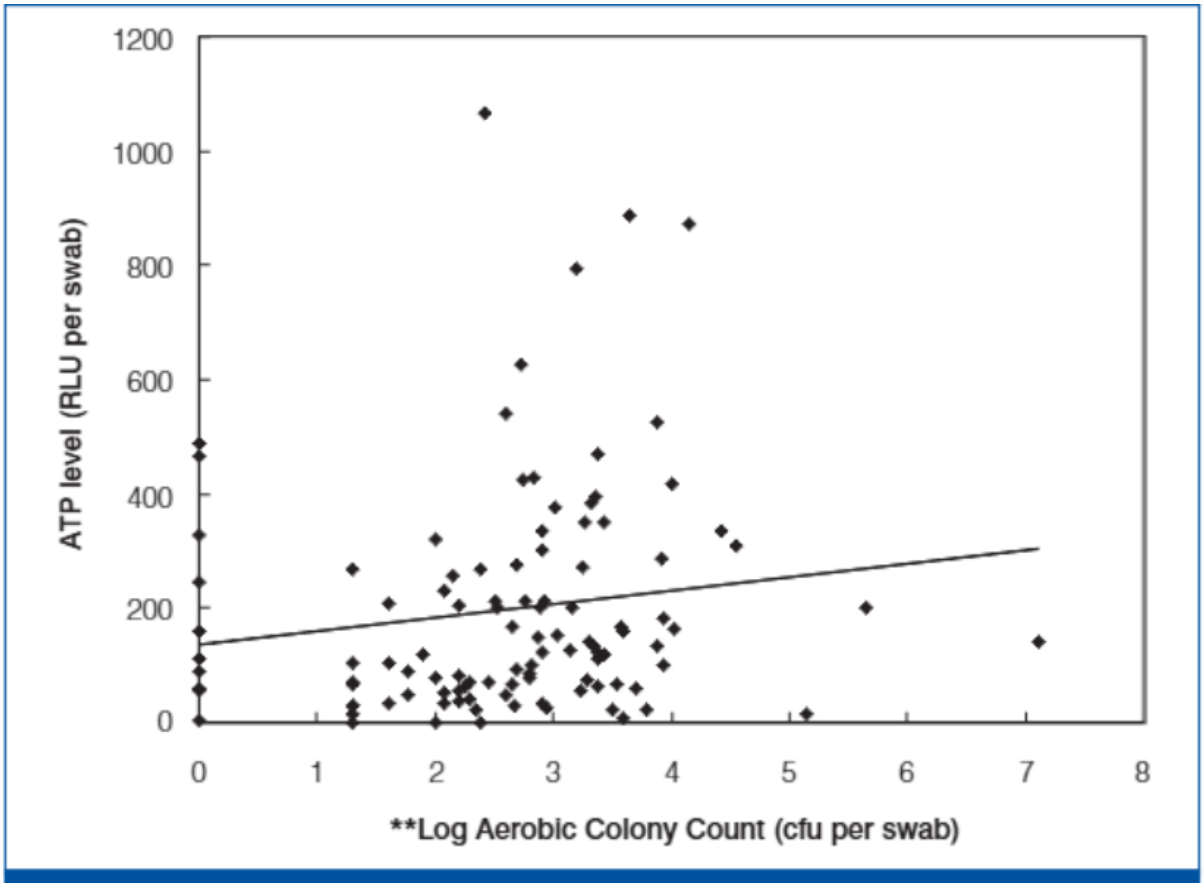

Figure 3: Correlation between ATP bioluminescence result (expressed in relative light units per swab) and aerobic colony count (colony forming units per swab); R = 0.15. From Willis et al.[12]

Onsite testing

70 tests were carried out. Sterilized equipment, sterile IV fluids (normal saline, dextrose 5% and intravenous paracetamol) and cleaned medical equipment consistently had ≤ 5 RLU.

All disinfected high-touch surfaces had ≤ 34 RLU one minute after disinfection; values did not differ significantly by surface type (metallic doorknob, granite, wooden surface or plastic). Ceramic flooring gave 253 RLU after disinfection with hypochlorite (from 764). Disinfection systematically decreased the RLU in all cases – the average drop was 20x less (range 3-55x).

77% (10/13) of soiled surfaces or equipment (excluding those contaminated with tap water) had > 100 RLU (mean 1,605; median 221).

Concerning clothing, sterile surgical drapes, gauze or gowns had ≤ 1 RLU while a lab coat that was cleaned and disinfected had an RLU that dropped from 147 to 32.

Leaving a high-touch surface exposed to air for eight hours (given that such surfaces should be disinfected three times per day per national protocol) would increase the RLU from 10 to 13 on average (see figure 4). However, touching these surfaces with one's hands would increase the RLU to above 100.

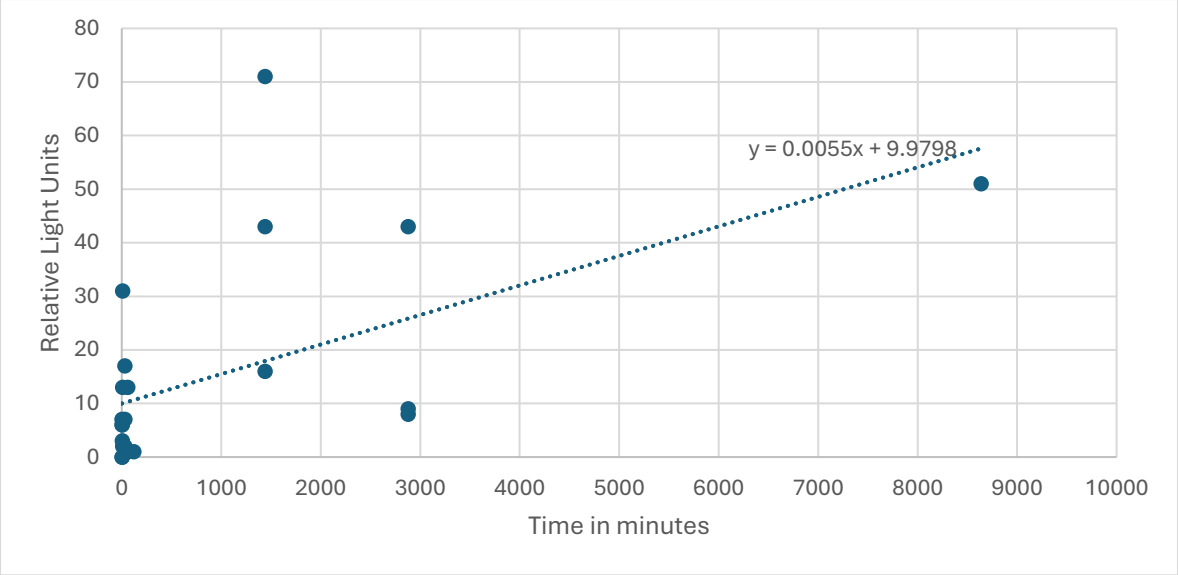

Figure 4: Change of RLU over time in minutes after disinfection of surfaces.

Opening an IV fluid and leaving it exposed to the air for six hours did not change the RLU.

The small sample size due to monetary limitations is acknowledged.

Assessment framework

Budgetary constraints were taken into account when elaborating the framework mentioned below.

- In all instances, visibly dirty areas will fail the inspection for cleanliness.
- All RLU thresholds mentioned below are per $100cm^2$ area covered with swabs taken for 60 seconds using the Hygiene ATP Testing Meter PCE-ATP 1.
    - Use of other biometers may require additional benchmarking.
- Threshold by location for high-touch surfaces:
    - High-risk areas like operation theatre, adult ICU, neonatal ICU and sterile area of the Central Sterilization Services Department: < 50 RLU
    - Other patient areas: < 100 RLU
- Threshold by item tested:
    - Critical or semi-critical medical equipment before use on patients (after cleaning, disinfection and/or sterilization): < 10 RLU
    - Non-critical equipment in direct contact with patients: < 50 RLU
    - IV fluids for injection into patients: < 10 RLU
    - Floor: < 300
    - Critical cloth like surgical drapes, gauze and gowns: < 10 RLU
    - Non-critical cloth like bedside curtains, doctor's coats and patient linen (after cleaning): < 100 RLU
        - Do not test cloth that are unlikely to lead to cross-contamination e.g., (a) higher RLU may be acceptable for clothes worn in administrative areas and in laboratories and (b) bedside curtains should have < 100 RLU when a new patient is moving in but not necessarily when the same patient is staying in his / her bed over a number of days.
- Definition of high-touch surfaces:
    - Horizontal surfaces that are frequently in contact with humans are considered high-touch surfaces. Vertical surfaces like walls are excluded.
    - Examples: bed frame, equipment trolley, patient trolley, patient bedtable / bedside locker, work counters, tap handles, doorknobs, light switches, workstations, and touch screens.
    - The following can be tested but are not commonly found in the public healthcare facilities of Mauritius: commode seats, overbed tables, remote controls, grab bars in patient bathrooms, computer keyboards / mice and door push plates.
- Monitoring frequency:
    - Routine:

        - Three or more randomly selected locations (like wards) per month per hospital.
    - During an outbreak in a specific ward:
        - At the time of notification and every week thereafter until the outbreak is controlled or until > 80% of tested surfaces are within norms twice consecutively whichever occurs first.
    - In a ward where a pathogen is endemic:
        - Monthly until > 80% of tested surfaces are within norms twice consecutively.
- Sample size:
    - Five or more high-touch surfaces, clean / disinfected / sterilized equipment (including bedpans), cloth or IV fluids per ward assessed.
    - During outbreaks of *Burkholderia cepacia,* testing of IV fluids is preferred.
- Interpretation:
    - > 80% of surfaces tested within a location should be within norms for the place to be deemed clean.

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