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DISINFECTION

Whitepaper

Why manual disinfection is not enough - and why cold fogging makes the difference

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Steinemann Disinfection (CleanService Group AG) | Wilerstrasse 2180 | 9230 Flawil | Switzerland | +41 71 555 11 30 | disinfection@steinemanngroup.com | steinemann-disinfection.ch

1 Limitations of manual and surface disinfection

Many hospitals, medical practices and industrial facilities rely on manual surface disinfection. Wiping and spraying remain important, but they have systemic limitations that have been repeatedly documented in the literature.

Limited reach

A frequently cited study by Richard P. Carling, a US infectious disease specialist and hospital hygiene expert at Yale-New Haven Hospital, conducted a multicentre investigation of the "thoroughness of terminal cleaning" **in 23 acute-care hospitals**.
Method: before routine cleaning, defined "high-touch" objects (control panel/call button, bed frame, bedside table, door handles, light switches, toilet, washbasin tap, etc.) were marked with an invisible fluorescent UV marker; after cleaning, investigators checked whether the marker had been removed (= correctly cleaned).

Result: At the median, only 49% of the marked contact surfaces were cleaned correctly; more than half remained insufficiently treated. Hard-to-reach areas performed particularly poorly (e.g. undersides of bed frames, rear sides of equipment), while clearly visible surfaces were cleaned correctly much more often [1].

In a later randomised quality programme across **36 acute-care hospitals**, the baseline value was 48%; structured target-surface monitoring, weekly feedback and management interventions increased correct cleaning to 77% - a gain of 29 percentage points, but still not complete coverage [2].

A case series from Mafraq Hospital (Abu Dhabi) illustrates the range: initially, only 11% of the observed target surfaces were cleaned correctly; the rate improved substantially only after UV-marker monitoring with feedback to staff was introduced [5].

These studies show precisely where gaps arise: **hard-to-access, concealed or "forgotten" surfaces (rear sides, undersides, niches, cable harnesses) are systematically missed.**

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Dependence on personnel and process variability:

The quality of wipe disinfection demonstrably depends on training, motivation and time pressure. Dancer summarises that even well-designed protocols are implemented inconsistently - partly because of insufficient surface wetting and contact times that are too short [3].

A review by Carling & Huang shows that training and feedback programmes do help (typically increasing correctly cleaned surfaces from ~48% to 60-80%), but residual gaps of 20-40% remain and cannot be closed completely through staffing measures alone [2][3].

Invisible risks: air as a reservoir (not addressed by wiping):

Manual surface disinfection does not affect room air. Several studies show that people in a room emit substantial quantities of biological aerosols. Qian et al. quantified size-resolved emission rates in an occupied lecture room and estimated release at the order of magnitude of 3.7×10^7 bacterial particles per person per hour; some of the particles are in the respirable range and can therefore remain suspended for a long time [6].

Hospodsky et al. demonstrated in a classroom study that occupancy significantly increases airborne bacterial concentrations (compared with an empty room) and that the source is predominantly human (skin and clothing shedding) [7].

For viruses, Morawska et al. argue that aerosols can remain infectious for hours under typical indoor conditions - which makes ventilation/filtration and air-side disinfection strategies key controls [8].

Conclusion: Even when surfaces are wiped perfectly, the air remains an infection pathway that wiping does not address.

Persistence and resistance on surfaces (despite cleaning):

In a systematic review, Kampf shows that numerous pathogens can survive on dry surfaces for days to months: for example, noroviruses for weeks and spores of Clostridioides difficile for up to five months [9].
Biofilms provide additional protection: Donlan describes that microbial communities in an extracellular matrix can be highly resistant to wipe disinfection; viable cells remain detectable even after "aggressive" cleaning [10]. This explains why point-based surface disinfection can leave residual contamination despite the correct product and correct application - especially in cracks, joints, textiles and pipework.

The evidence is consistent: manual surface disinfection reduces risks, but it does not eliminate them. Objective marker studies show only 49% thoroughly cleaned "high-touch" surfaces at the median (before intervention) and at most ~70-80% after intensive programmes - with persistent gaps in hard-to-access locations [1][2][3][5]. In addition, the air remains untreated, even though it carries relevant loads [6][7][8]. Long-term persistence (norovirus, spores) and biofilms increase the residual risks [9][10].

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2 Three-dimensional instead of point-based action

CleanCubes nebulise 7.5% H_2O_2 into a fine cold aerosol. The droplets are in the micrometre range, remain airborne long enough to inactivate airborne germs and then deposit evenly on surfaces - including rear sides, undersides and niches. This addresses air + surfaces in a single process, whereas wiping reaches only contact surfaces [11].

Homogeneous coverage

CleanCubes generate strong vortex flows to distribute the aerosol throughout the entire room. In accordance with EN 17272, uniform efficacy must be demonstrated using biological indicators (BI) at several room positions (including "difficult" zones). The standard requires efficacy and distribution tests; CleanCubes can be validated along these specifications [12].
Studies with H2O2 cold fogging showed, particularly for spores of Geobacillus stearothermophilus, that multi-cycle applications can achieve log reductions of up to ~5 and that homogeneous distribution is decisive [13].

Effective against demanding pathogens (including non-enveloped viruses, spores and biofilms):
Kampf summarises that non-enveloped viruses (e.g. adeno-, noro-) are considerably more resistant than enveloped viruses; H_2O_2 aerosols are significantly effective here at adequate dose/contact time [14].
For spores (e.g. C. difficile), several H2O2 cold-fogging cycles are advisable; Andersen et al. demonstrated complete inactivation in real-world environments only after three cycles, not after one or two [13].
Biofilms can be addressed more effectively through aerosol penetration than through wiping processes, which primarily wet only the uppermost layer [10].

Standardisation, automation, documentation

CleanCubes run fully automatically: dose, time and process steps are predefined, reproducible and auditable. This eliminates the main sources of error in manual disinfection (contact times that are too short, forgotten surfaces, uneven wetting) [12][13].

2.1 Clinical evidence close to practice

In a before-after setting, routine use of cold fogging reduced the incidence of C. difficile infections from 4.6 to 2.7 cases per 10,000 patient-days (-41%, $p < 0.001$) and further to 1.4 during the extended observation period - a robust, sustained effect in real-world care [16]. In a prospective evaluation study, hybrid H_2O_2 fogging showed clear reductions in environmental bioburden compared with standard EVS cleaning (e.g. aerobic colony counts/ATP load), consistent with BI inactivation according to international standards [17]. Both approaches address exactly the gaps that UV-marker studies reveal for manual cleaning.

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2.2 Residue-free safety

After reaction, H_2O_2 breaks down into water and oxygen - without chlorinated residues and without a QAC film. This makes H2O2 cold fogging more material- and environmentally friendly than many alternatives, provided condensation is avoided and limit values are complied with [15].

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3 Why “wiping alone” is not enough

1. **Objectively measured gaps: 49% thoroughly cleaned “high-touch” surfaces at the median (baseline) and only 60-80% even after programmes - residual gaps remain [1][2][3][5].**
2. **Air remains untreated: humans emit ~10^7-10^8 bioaerosol particles per person per hour; aerosols can remain infectious for hours - wiping does not address this [6][7][8].**
3. **Resilient pathogens: noroviruses, spores and biofilms persist; point-based wiping processes do not reliably reach them [9][10].**

3.1 Why CleanCubes are the logical complement:

1. **3D action: air + all surfaces in one standardised cycle, including concealed zones.**
2. **Validated homogeneity: according to EN 17272 with BI verification, including in “shadow areas”.**
3. **Effective against demanding target organisms: multi-cycle H2O2 cold-fogging protocols for spores, robust action against non-enveloped viruses and biofilms.**
4. **Automation: reproducible quality, documentation for audits, decoupling from staff variability.**
5. **Residue-free application: breaks down into H_2O and O_2, with no chlorinated residues.**

3.2 Practical recommendations

• Keep the basics: manual cleaning remains mandatory (removal of organic load).
• Add H2O2 cold fogging: use CleanCubes cyclically - e.g. after discharges, after procedures, during outbreaks, in high-risk zones (endoscopy, IMC/ICU), and in waiting/treatment rooms with high turnover.
• Validate & document: place BI at several room positions; record processes (concentration, RH, contact time).
• Safety & materials: avoid condensation, check sensitive materials; comply with limit values (e.g. 1 ppm before re-entry).

This transforms a point-based hygiene concept (wiping) into holistic, three-dimensional infection protection that is scientifically supported, standardised and auditable.

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4 References

[1] Carling PC et al. (2008). Identifying opportunities to enhance environmental cleaning in 23 acute care hospitals. Infect Control Hosp Epidemiol. PMID: 18171180. https://pubmed.ncbi.nlm.nih.gov/18171180/
[2] Carling PC et al. (2008). Improving cleaning of the environment surrounding patients in 36 acute care hospitals. Infect Control Hosp Epidemiol. PMID: 18851687. https://pubmed.ncbi.nlm.nih.gov/18851687/
[3] Carling PC & Huang SS (2013). Improving healthcare environmental cleaning and disinfection: current and evolving issues. Infect Control Hosp Epidemiol. DOI: 10.1086/670222. https://www.cambridge.org/core/journals/infection-control-and-hospital-epidemiology/article/improving-healthcare-environmental-cleaning-and-disinfection-current-and-evolving-issues/149C7D943A348162ACAC18B69FC46225
[4] Dancer SJ (2009). The role of environmental cleaning in the control of hospital-acquired infection. J Hosp Infect. DOI: 10.1016/j.jhin.2008.06.019
[5] Ng WK et al. (2014). How clean is clean: a new approach to assess and improve environmental cleaning. Oman Med J. PMC4645839. https://pmc.ncbi.nlm.nih.gov/articles/PMC4645839/
[6] Qian J et al. (2012). Size-resolved emission rates of airborne bacteria and fungi in an occupied classroom. Indoor Air (open-access via PMC). https://pmc.ncbi.nlm.nih.gov/articles/PMC3437488/
[7] Hospodsky D et al. (2012). Human occupancy as a source of indoor airborne bacteria. PLoS ONE. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0034867
[8] Morawska L et al. (2020). How can airborne transmission of COVID-19 indoors be minimised? Environ Int. DOI: 10.1016/j.envint.2020.105832. https://pmc.ncbi.nlm.nih.gov/articles/PMC7250761/
[9] Kampf G (2018). Persistence of pathogens on inanimate surfaces. BMC Infect Dis. DOI: 10.1186/s12879-018-3487-5
[10] Donlan RM (2002). Biofilms: microbial life on surfaces. Emerg Infect Dis. DOI: 10.3201/eid0809.020063
[11] Berger D (2021). Hydrogen peroxide as a disinfectant. PMC8233052. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8233052/
[12] EN 17272:2020. Chemical disinfectants and antiseptics — Methods of airborne room disinfection by automated process. https://knowledge.bsigroup.com/products/chemical-disinfectants-and-antiseptics-methods-of-airborne-room-disinfection-by-automated-process
[13] Andersen BM et al. (2006). Effect of aerosolized hydrogen peroxide on spores in rooms and ambulances. J Hosp Infect. PMID: 16337307. https://pubmed.ncbi.nlm.nih.gov/16337307/
[14] Kampf G (2020). Efficacy of disinfection against viruses. J Hosp Infect. DOI: 10.1016/j.jhin.2020.01.018
[15] PubChem. Hydrogen Peroxide (CID 784) – breakdown products H_2O/O_2. https://pubchem.ncbi.nlm.nih.gov/compound/Hydrogen-Peroxide
[16] Truitt CL et al. (2022). Evaluation of an aerosolized hydrogen peroxide disinfection system: reduction of C. difficile infection rates. Am J Infect Control. PMID: 35307211. https://pubmed.ncbi.nlm.nih.gov/35307211/
[17] Khandelwal A et al. (2022). Enhanced disinfection with hybrid hydrogen peroxide fogging. BMC Infect Dis 22:704. https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-022-07704-9