SVOA Microbiology

e-ISSN 2634-534X

ScienceVolks Open Access

Original Research

# Prevention of Hospital-Acquired Norovirus Outbreaks Using a Complexity Theory-Based Model Integrating Organisational Management, Staff Behaviour and Technology

**Ian K Hosein[1,2*], Rosie E Madeloso[3]**

[1]Department of Medical Microbiology, Midlands Regional Hospital Tullamore, Republic of Ireland.

[2]Department of Microbiology, University of the West Indies, St Augustine, Trinidad & Tobago.

[3]Strategy and Partnerships Department, Barking, Havering and Redbridge University Hospitals NHS Trust, UK.

***Corresponding Author:** Dr. Ian K Hosein, Consultant Medical Microbiologist, Midlands Regional Hospital Tullamore, Arden Road, Tullamore R35 NY51, Republic of Ireland.

https://doi.org/10.58624/SVOAMB.2026.07.004

**Received:** Mach 16, 2026

**Published:** April 02, 2026

Citation: Hosein IK, Madeloso RE. Prevention of Hospital-Acquired Norovirus Outbreaks Using a Complexity Theory-Based Model Integrating Organisational Management, Staff Behaviour and Technology. *SVOA Microbiology* 2026, 7:2, 37-45. doi: 10.58624/SVOAMB.2026.07.004

## Abstract

An organisation with two hospitals in England experienced significant norovirus outbreaks in the winter periods between 2008–2011. Outbreaks occurred despite organisational educational efforts to improve staff hygiene practices and audits of hygiene compliance. In July 2012, to identify underlying drivers of these outbreaks and to develop related interventions, a mixed-methods research approach was undertaken, examining the organisation from a complexity theory perspective. Quantitative data on environmental cleaning, staff hygiene, hospital-acquired infections, and hospital bed availability were extracted from hospital databases. Qualitative data were obtained from semi-structured individual staff interviews and focus groups. The quantitative data demonstrated limited adherence to hygiene protocols with high rates of infection among patients and staff. Staff interviews revealed a minimal depth of understanding of norovirus transmission mechanisms and a perception of outbreak inevitability. Interviews also highlighted a lack of cross-professional team ownership with prevention of outbreaks being considered *a problem for nurses.* To address the drivers simultaneously, interventions were made using a complexity-based model integrating Organisational Management Accountability, Staff Behaviour Modification and, Technological issues such as equipment decontamination (OBT Model) with Leadership as the key underpinning all other drivers. Rapid interventions over a 2-week period began in late October 2012. Cross-disciplinary staff groups *were trained together* to foster shared ownership of infection prevention. Mobile handwashing sinks were introduced at ward entrances to augment handwashing sinks in patient bays; environmental and equipment cleaning were intensified and assured by use of washable ultraviolet markers on key surfaces such as commodes. The microbiology laboratory provided rapid PCR results on Norovirus from testing of faecal samples. Following this two-week implementation phase in October 2012, there were substantial reductions in infected patients (−66%), staff (−66%) and bed-days lost (−78%) from norovirus infection that winter (2012/2013). These reductions occurred during one of the worse years for norovirus infection in the UK at that time with strain G11.4 Sydney 2012. Further reductions continued the following winter (2013/2014): infected patients ( -83%), staff (-86%), and bed days lost ( -94%) as compared to the period 2011/2012. The Organisational-Behavioural-Technological model also resulted in a sustained transformation in organisational culture, with improved teamworking and hygiene practices.

***Keywords:*** *Hospital-Associated Infection; Norovirus Outbreaks; Mixed-Methods Research, Complexity Theory, Organisational-Behavioural-Technological Model (OBT)*

## Introduction

Norovirus causes hospital-acquired gastroenteritis worldwide which can lead to large outbreaks and disruption to patient care services through infections in patients and staff, as well as bed closures [1, 2]. An organisation with two nearby hospitals in England (1200 beds), providing secondary and tertiary care services, suffered large and prolonged outbreaks in the winter periods of 2009/10 and 2010/11. These occurred despite significant educational efforts by Infection Prevention & Control staff and perceived organisational compliance with standard control measures including hand hygiene, equipment and environmental decontamination, and patient isolation.

With concerns about further hospital outbreaks in the coming winter of 2012/2013 and critical impact on financial and clinical service viability, in July 2012, the organisation's executive management team invited one of us (IKH) with expertise in both hospital epidemiology and organisational management to investigate the previous outbreaks and to establish effective preventive measures. The executive team view (arising from the number of staff trained in hygiene and hygiene compliance data) was that required Norovirus controls had been applied pre-and during initial clusters with norovirus infection. Yet, these had failed to prevent the large outbreaks. Thus, a complexity-theory based perspective viewing the organisation as a *complex system* was adopted. This led to a mixed-methods research approach incorporating both quantitative and qualitative aspects being undertaken in August 2012 to investigate underlying causes of these outbreaks and thereby develop a targeted plan for outbreak prevention [3-5].

Quantitative data on environmental cleaning, hand hygiene, and outbreak impact on patients, staff and hospital beds were extracted from hospital databases. These data were then validated by direct observations. Qualitative information was obtained from individual staff interviews and focus groups exploring perceptions of outbreak causes.

Findings from both datasets were analysed to identify key drivers of the outbreaks. Improvement approaches for these drivers were then integrated within a complexity-theory based model leading to interventions to prevent outbreaks in the approaching winter of 2012/13. This study describes the investigative methodology, findings, development of a complexity-based model for interventions, and the subsequent successful outcomes of such interventions.

## Methodology

A mixed-methods study design combining quantitative and qualitative approaches was adopted. This was considered the most appropriate design from the ontological perspective of the organisation as a complex system.

Quantitative data on hygiene processes and norovirus impact were extracted from hospital databases. These were considered internally valid, having previously been reported to external regulatory authorities. Key impact metrics included hospital-acquired infections in patients and staff and "bed days lost", arising from partial or total ward closures where patients could not be admitted to otherwise available beds due to norovirus cases.

Hygiene processes assessed included hand hygiene and use of personal protective equipment (PPE), ward and toilet cleaning, hygiene in patient food services, and the response time for implementing isolation and decontamination controls from first suspicion of norovirus infection in a patient.

To verify the accuracy of reported information, detailed searches for underlying evidence on file and direct observations of processes such as hand hygiene were undertaken.

The qualitative component aimed to explore staff understanding of the outbreaks. Semi-structured interviews were conducted with individual staff (N=9) and in four focus groups (N= 10, 4, 3, 3). Open questions such as: *"So, what do you think is going on with the norovirus outbreaks?"* were used, followed by probing questions on ventured opinions to explore the "why".

All participants provided informed consent for interviews, and responses were anonymised.

Quantitative and qualitative results were then analysed thematically to identify key drivers of the outbreaks. Interventions based on these findings were implemented from the third week of October 2012, with ongoing monitoring of norovirus impact, hygiene processes, and staff perceptions.

**Findings**

1. Pre-intervention

*A. Quantitative*

Norovirus surveillance data from both hospitals demonstrated significant losses in bed-days during the winter periods of 2010/11 and 2011/12, with outbreaks of prolonged duration (Fig.1). Compliance rates for hygiene processes reported to external regulatory authorities were significantly above rates determined by detailed checks of data on file and direct observations (Fig. 2).

Whilst *the number* of handwashing stations on wards were suitable, 50% had no sinks at main entrances, with most sinks situated in 4-6 bedded patient bays where accessibility was noted to be limited by patient care equipment.

Observations in clinical areas indicated that handwashing was infrequent though alcohol gel was widely used. Staff would also walk about ward corridors and patient bays wearing gloves. When questioned about this practice, staff stated that the gloves were not contaminated since no patient care had taken place. Contact with gloved hands and the environment was observed.

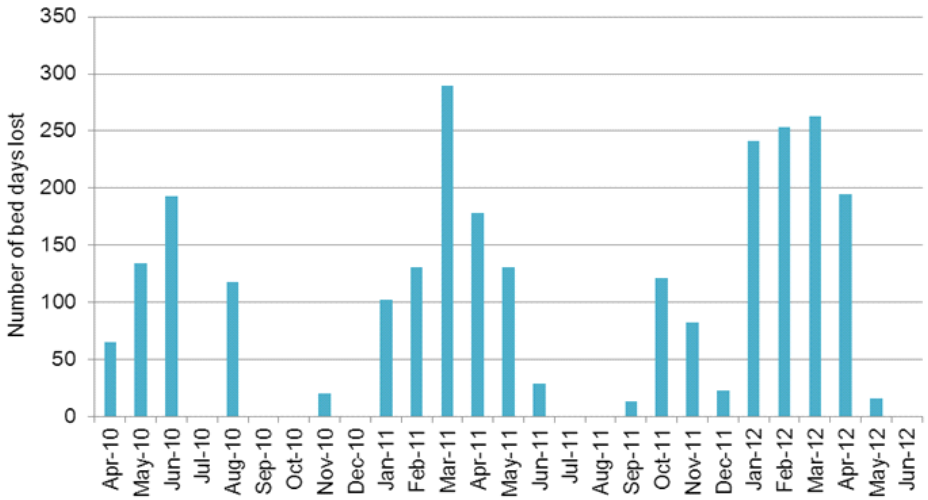


**Figure 1.** Pre-intervention hospital bed-days lost due to Norovirus impact 2010-2012.

| Perceived Organisational Compliance | Actual Compliance |
|---|---|
| Hand Hygiene<br>> 95% | 70% |
| Environmental Decontamination<br>>95% | 60% |
| Personal Protective Equipment<br>>90% | 70% |
| Hygiene in Patient Catering Services<br>>95% | 70% |
| Staff Understanding of Norovirus Infection from 10/10 Infection Prevention & Control Training Sessions | 4/10 |
| Rapid Isolation and Environmental Decontamination 9/10 with a possible case of Norovirus infection | 3/10 |

**Figure 2.** Pre-intervention Quantitative Findings on Hygiene Compliance. NB. For the last two rows, values are expressed as N/10, where 10 represents the maximum compliance score.

Alcohol gel placed throughout wards was noted as being “virucidal” on containers.

The agent employed was virucidal for enveloped viruses thereby excluding norovirus. However, staff would only use alcohol gel on entering and exiting wards and patient care bays, despite the availability of handwashing sinks in the bays.

Food was served on wards by catering services staff who kept gloves on between patients and were observed to have touched trays and bedside cupboards with the gloves during food distribution. Records indicated that the Infection Prevention & Control department had delivered regular training sessions to staff both in person and via the intranet and organisational training objectives had been met in terms of attendance numbers. However, no evaluation of the effectiveness of such training had been undertaken.

*B. Qualitative*

Staff expressed frustration at what was perceived to be the unappreciated efforts. Comments were from several standpoints including professional groups and cross- professional teams and included:

- “They just blame nurses and doctors get away” (professional group)
- “We are all excellent around here- what else could we do?” (view on behalf of all staff)
- “Norovirus comes in and just cannot be controlled” (organisation challenging external regulator expectations of better performance)
- “We are all very busy on wards; what do the infection control people do?” (challenge about staff roles and accountabilities)
- “We all work hard but they expect more”; “we just chase beds every day for management so don’t have time to care”; “when I am on call, it’s nice to have a norovirus ward I can reopen for beds” (views from clinical staff challenging executive management ownership of norovirus prevention)
- “We take steps if we have vomiting that is definitely spreading” (response regarding reaction time to a possible norovirus case/s)

*C. Analysis and Emergent Themes*

Analysis of both quantitative and qualitative information indicated a significant mismatch between reported and actual performance in hygiene metrics. It was noted that reported hygiene metrics such as hand hygiene or equipment decontamination was based on within-week (Monday to Friday) and daytime audits. There was a perceived excellence by staff in their efforts at norovirus prevention despite outbreaks indicating otherwise. Though staff training in hygiene had taken place on numerous occasions as per organisational plans, these were not effective in achieving depth of understanding of norovirus infection, transmissibility and required preventive modalities.

Underlying themes were:

— A lack of role clarity around decontamination of patient body fluids and proximal environment when there was an acute case of norovirus, particularly over weekends and at nights

— Delayed response time to initiate decontamination of body fluids and isolation following a suspected case of norovirus infection

— Insufficient team-working across professional groups and accountability structures, with prevention of outbreaks being perceived as an issue only for Infection Prevention & Control and for nursing staff in general

— A lack of distributed leadership to synchronise efforts with frontline teams not taking urgent and coordinated actions to prevent spread of infection from any existing norovirus case patients.

— Insufficient grasp of technological issues such as the limitations of alcohol gel, the need for more handwashing, suboptimal placement of handwashing sinks with none at ward entrances, and non-recognition of the potential for contamination of the gloved hand from environmental contact

The emergent themes suggested that issues around Leadership, Organisational Management, Staff Behaviour and Technology were interacting, leading to ineffective organisational performance in preventing norovirus infection in a complexity-based understanding and model as in Figure 3.

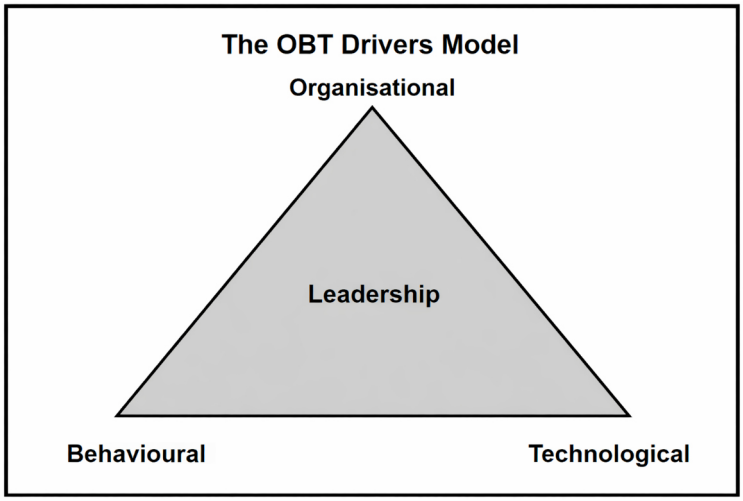


**Figure 3.** Complexity-based model arising from emergent themes in quantitative and qualitative findings.

**Inteventions**

The quantitative and qualitative findings led to interventions based on the derived complexity-based model for improvements in distributed leadership, organisational management, staff behaviour and technology.

Leadership and organisational management were addressed through direct support from the Chief Executive Officer and Chief Operating Officer, who recognised the need for a coordinated organisational response. Norovirus prevention was therefore explicitly placed as an operational imperative (and not just a clinical one) for the entire organisation with managers, doctors, nurses, and environmental services working together across professional boundaries to develop distributed leadership and shared managerial accountability.

Staff behaviour was addressed by an internal marketing campaign which reinforced team-working and a *can-do* attitude to prevention [6].

The campaign's strapline, *"There is No Mystery!*", arose as a response to earlier perceptions of a sense of mystery and inevitability around outbreaks. Language and imagery of impending battle was used to fuse organisational culture for preparedness as with: "protect each other" and, "stand together or you will fall together". This campaign was run over a 2-week period in October 2012, with formal staff training sessions led by the authors. Ten mandatory, multidisciplinary sessions were conducted, incorporating managers, doctors, nurses and ancillary staff, each attended by 50-70 staff members. Visualisation of the mechanisms by which Norovirus could spread using simulations included gloved hands touching the environment and then being used in patient care and, the consumption food by staff in a clinical area. In these sessions one critical message was that Norovirus *had to be ingested* to initiate infection. Graphs of the impact of norovirus outbreaks on bed closures generated much discussion. These sessions were different to any previously undertaken at the organisation since they focused on cross- professional accountability, promotion of team-working, and achieving depth of understanding of norovirus infection. Sessions were interactive with end-of-training assessments using multiple choice questions. In addition to these large-scale training in groups, there were continual "walkabouts" by the authors and Infection Prevention & Control nurses throughout all departments to give ad hoc training and respond to queries. Compliance for all drivers was also facilitated by senior nursing and middle management and, hospital executive team visits to all departments. Clinical directors of service groups were mainly medical staff and their role in leadership and accountability for norovirus infection prevention was emphasised.

To address technological issues around hand hygiene and environmental decontamination, mobile sink units were deployed at the entrances to all clinical areas to both enable and encourage more handwashing. Marks which fluorescence under UV light were used to flag high-touch surfaces, with the fluorescence used as a surrogate for bio-contamination. The objective was to affect staff behaviour by such visual demonstrations. UV markers were also used to assure adequacy of decontamination of surfaces that would be expected to be highly contaminated, such as commodes, where patient hand-to-mouth contact could occur [7]. Disposable bedside medical equipment was introduced for use in all case patients, and staff in each clinical area were advised to wear visors for all clinical contact when there was any suspicion of norovirus being present.

Cases occurring over that winter 2012-2013 were documented using the same national definitions for norovirus infection as used in previous years.

**Outcomes**

Following the implementation phase in October 2012, there were substantial reductions in infected patients (−66%), infected staff (−66%) and bed-days lost (−78%) when norovirus infection appeared in winter (2012/2013). The improvements occurred despite that winter being one of the worst for norovirus infection in England (Norovirus strain G11.4 Sydney 2012, data on file with public health authorities). Reductions continued the following winter (2013/2014) when Norovirus again appeared with infected patients ( -83%), infected staff (-86%), and bed days lost ( -94%) as compared to the period 2011/2012.

There was no spread of infections across the totality of any ward so that patients could be cohort-isolated in bays with the rest of a ward being kept open.

All quantitative metrics of hygiene checked in the initial phase of this study improved to >95%. Of note was the immediacy of actions for any suspected case of norovirus infection with cross-professional staff committed to this end with a strong sense of team-working. Staff behaviour improved and there was a greater distributed leadership with individuals and teams taking immediate and coordinated actions when Norovirus appeared. Norovirus prevention moved from being a “nursing issue” to one of joint ownership across the organisation. Technological enablement with the mobile handwashing sinks not only increased handwashing but also had the added value of reinforcing hygienic behaviours in general with infection prevention becoming a mind-set. Staff commented that their greater understanding of norovirus transmission generated confidence that outbreaks could be prevented.

Organisational culture and teamworking in general so improved that the executive team incorporated the OBT model ideas into Organisational Development plans.

| Improvement on Norovirus control | Number of Patients affected | Number of Staff reported sickness | Number of bed days lost |
|---|---|---|---|
| Year 2011-12 | 626 | 109 | 1432 |
| Year 2012 -13 | 316 | 44 | 378 |
| Year 2013 - 14 | 108 | 15 | 83 |
| % Improvement in 2012-13 compared to 2011-12 | 66 | 66 | 78 |
| % Improvement in 2013-14 compared to 2011-12 | 83 | 86 | 94 |

**Figure 4.** The numbers of patients and staff affected with norovirus infection and the number of bed days lost from ward closures in the winters of 2011/12, 2012/13 and 2013/14 with percentage improvements in the latter two winters.

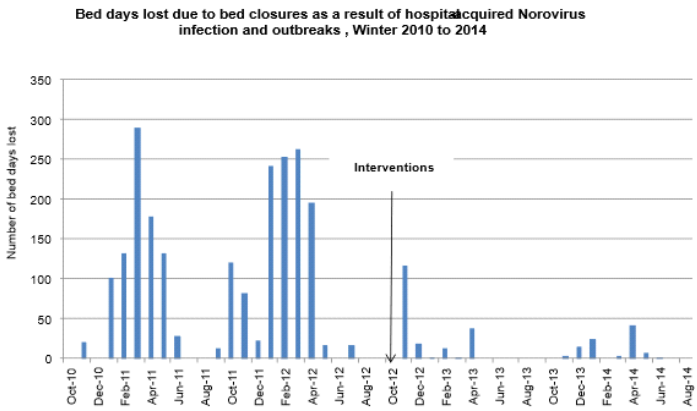


**Figure 5.** Significant reduction in bed days lost from ward closures after the intervention period in October 2012 with the OBT drivers model.

## Discussion and Conclusion

Norovirus outbreaks in hospitals have a significant global impact with acquisition of infection by patients and healthcare staff and disruption of patient care services.

Several studies and guidelines have explored and advocated outbreak control interventions with a focus on staff hygiene, environmental and equipment decontamination, and patient isolation [8-10]. To the best of our knowledge, this is the first study to use a complexity theory-based model derived from mixed methods research to prevent hospital-acquired norovirus outbreaks. Quantitative and qualitative methods were used to explore underlying factors for winter norovirus outbreaks which had occurred from 2008-2012 at two nearby hospitals in England which functioned as one organisation with the same board, management framework, and policies and procedures. The objective was to determine the drivers of previous outbreaks with a view to implementing derived interventions to prevent outbreaks in the then upcoming winter of 2012-2013. In August 2012, quantitative data on file on hygiene and clinical outcomes, and also qualitative information from staff views of underlying causes were obtained.

Analyses of the quantitative and qualitative information with thematic classification led to the description of underlying drivers as a lack of distributed leadership, insufficient organisational management input into staff role clarity, ineffective staff behaviour, and a limited grasp of technological issues around norovirus mechanisms of spread and decontamination. The qualitative information also indicated that these factors were interacting and hence a systems-based model was developed termed the Organisational, Behavioural, Technological Model (OBT) with Leadership as the key enabler for effective interactions of all drivers. The interventions for the model drivers were launched rapidly over a 2-week period in October 2012 and resulted in significant reductions in patient and staff infections, ward closures, and bed-days lost that winter and the following one.

The impact of Norovirus infection in the UK that winter (2012/13) with strain G11.4 Sydney 2012 was one of the highest on record, with widespread community-associated infections and hospital outbreaks; our investigations also indicated links between visiting relatives and patients acquiring infections. Thus, we propose that the successes at the organisation in preventing outbreaks were even more significant in the face of high rates of community-acquired infections.

This study provides a model which can be applied in high, middle and low resource settings for prevention of hospital-acquired norovirus outbreaks since we propose that it is the synergy amongst the drivers identified that is pivotal, and not investment in any one driver. The application of complexity theory to the prevention of hospital -associated norovirus infection and the derived Organisational-Behavioural- Technological Model (OBT) may also lead to a paradigm shift in approaches to the prevention of hospital-acquired infection. This systems-based approach may challenge, or provide an integrating framework for linear interventions on hygiene, environmental decontamination, leadership and staff behaviour [11-13].

It is noteworthy that the emphasis in this study was on the prevention of norovirus outbreaks but such emphasis led to reduction of spread from any clustering of cases.

## Institutional and Ethical Approval

The executive management team of the organisation concerned requested and approved this study and all interviewed staff gave informed consent.

## Conflict of Interest

All authors declare none.

## References

1. Lopman B, Steele D, Kirkwood C et al. The Vast and Varied Global Burden of Norovirus: Prospects for Prevention and Control. PLoS Med 2016, 13(4): e1001999.

2. Yu F, Fu J, Tan M et al. Norovirus outbreaks in hospitals in China: a systematic review. J Hosp Infect 2023; 142: 32-38

3. Plsek P, Greenhalgh T. The challenge of complexity in health care. *BMJ* 2001; 323 (7313) 625-628

4. Barasa E, Sassy M, English M et al. Hospitals as complex adaptive systems: A case study of factors influencing priority setting practices at the hospital level in Kenya. Soc Sci Med 2017; 174:104-112

5. Sax H, Clack L, Touveneau S et al. Implementation of infection control best practice in intensive care units throughout Europe: a mixed-methods evaluation study. *Implementation Science* 2013; 8(24), 1-11

6. Fortenberry J, McGoldrick P. Internal marketing: a pathway for healthcare facilities to improve the patient experience. Int J Healthcare Mgmt 2016; 9: 28-33

7. Meyer J, Nippak P, Cumming A. An evaluation of cleaning practices at a teaching hospital. Am J Infect Control 2021; 49:1,40-43

8. Otter J, Yezli S, Salkeld J et al. Evidence that contaminated surfaces contribute to the transmission of hospital pathogens and an overview of strategies to address contaminated surfaces in hospital settings. Am J Infect Control. 2013; 41 (5 Suppl) :S 6-11

9. Adams C, Peterson S, Hall A et al. Associations of infection control measures and norovirus outbreak outcomes in healthcare settings: a systematic review and meta-analysis. Expert Rev Anti Infect Ther 2022; 20(2), 279-290

10. Chadwick P, Trainor E, Marsden G et al. Guidelines for the management of norovirus outbreaks in acute and community health and social care settings. J Hosp Infect 2023, (136) 127-191.

11. Hansen S, Remschmidt C, Schroder C et al. Strengthening the role of hospital leadership in infection control-a multimodal educational intervention in German acute care hospitals. BMC Med Ed 2023; 23:1, 1-9.

12. Gaube S, Fischer P Lermer E. Hand hygiene insights: applying three theoretical models to investigate hospital patients' and visitors' hand hygiene behaviour. PLoS one 2021; 16:1, 1-27

13. Lopez-Alcalde J, Dancer S, Marti-Carvajal A et al. Decontamination of environmental surfaces in hospitals to reduce hospital acquired infections. Cochrane database of systematic reviews, 2010-08, Vol.2022 (11)