

# Investigation of slip resistance and the hygienic cleaning of floors in hospital settings

Prepared by the **Health and Safety Laboratory**  
for the Health and Safety Executive 2011

# Investigation of slip resistance and the hygienic cleaning of floors in hospital settings

Kevin Hallas  
Marianne Loo-Morrey  
Alison Darby  
Kirsty Ormerod  
Lesley Morten

Harpur Hill  
Buxton  
Derbyshire  
SK17 9JN

Slip and trip accidents in the healthcare sector continue to be a cause for concern. Over 50% of RIDDOR reported major injuries in this sector are related to slips, trips and falls, both to staff and to patients. These accidents often result in serious injury and due to the vulnerability of the client group, in some cases have contributed to fatalities. Such accidents also result in significant cost to the NHS as a result of lost time, additional care requirements and financial claims by those suffering injury. The selection of suitable flooring is an important factor in the prevention of slips, as required by the Workplace (Health, Safety and Welfare) Regulations 1992.

As such, where the floor will get wet or contaminated in normal use, the floor should not be slippery. Increased slip resistance of floor coverings can control the slip risk in some hospital environments, especially areas likely to become wet or subject to other surface contamination. However, there continues to be inconsistency in floor specifications in hospitals with the selection of smooth floors in many areas being common practice. NHS Trusts have raised concerns about the potential for the texture of slip resistant surfaces to adversely affect hygienic cleaning of floors, resulting in increased infection risk. The current research was carried out to compare the levels of bacterial contamination remaining after cleaning, for floors with a range of slip resistance.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

© Crown copyright 2011

*First published 2011*

You may reuse this information (not including logos) free of charge in any format or medium, under the terms of the Open Government Licence. To view the licence visit [www.nationalarchives.gov.uk/doc/open-government-licence/](http://www.nationalarchives.gov.uk/doc/open-government-licence/), write to the Information Policy Team, The National Archives, Kew, London TW9 4DU, or email [psi@nationalarchives.gsi.gov.uk](mailto:psi@nationalarchives.gsi.gov.uk).

Some images and illustrations may not be owned by the Crown so cannot be reproduced without permission of the copyright owner. Enquiries should be sent to [copyright@hse.gsi.gov.uk](mailto:copyright@hse.gsi.gov.uk).

# EXECUTIVE SUMMARY

## BACKGROUND

Slip and trip accidents in the healthcare sector continue to be a cause for concern. Over 50% of accidents in this sector are related to slips, trips and falls, both to staff and to patients. These accidents often result in serious injury and due to the vulnerability of the client group, in some cases have contributed to fatalities. Such accidents also result in significant cost to the NHS as a result of lost time, additional care requirements and financial claims by those suffering injury. The selection of suitable flooring is an important factor in the prevention of slips, as required by the Workplace (Health, Safety and Welfare) Regulations 1992

As such, where the floor will get wet or contaminated in normal use, the floor should not be slippery. Increased slip resistance of floor coverings can control the slip risk in some hospital environments, especially areas likely to become wet or subject to other surface contamination. However, there continues to be inconsistency in floor specifications in hospitals with the selection of smooth floors in most areas being common practice. NHS Trusts have raised the issue of hygienic cleaning of safety floors, since the texture of slip resistant surfaces may have potential implications for the surface cleaning efficacy. The current research was carried out to compare the levels of bacterial contamination remaining after cleaning, for floors with a range of slip resistance.

## METHOD

The slip resistance of flooring was assessed using HSE's preferred method, the Pendulum Test. The regular cleaning staff, using methods described in the NHS Cleaning Manual, undertook all cleaning. The cleanliness was assessed using the contact plate method, consisting of agar plates used to take samples from the flooring, which are cultured and then the bacteria counted. In parallel with this method, the Cardiff & Vale NHS Trust also undertook ATP Bioluminescence measurements.

## RESULTS

The results show that a range of flooring with slip resistance ranging from a Pendulum Test Value (PTV) of 14 to a PTV of 50 were used for the study. These present a high slip potential when wet and a low slip potential when wet respectively. The contact plate bacteria counts show that each of the floors in the study can be cleaned to a hygienic standard using the standard cleaning practices. The results also show that not every floor was always cleaned to this standard, though this is equally true of smooth floors as it is of safety floors. The contact plate method and ATP Bioluminescence measurements did not give good agreement, suggesting the ATP method offers limited use in this environment.

## CONCLUSION

The ability to clean a typical hospital floor to a hygienic standard is not influenced by the slip resistance of the flooring. Therefore, the cleanability of the flooring should not be a barrier to the use of slip resistant flooring in foreseeably wet or contaminated work areas in hospitals.



# CONTENTS

<b>EXECUTIVE SUMMARY</b> .....	<b>III</b>
<b>1 ACKNOWLEDGEMENTS</b> .....	<b>2</b>
<b>2 BACKGROUND</b> .....	<b>3</b>
2.1 Aims.....	3
2.2 Objectives.....	4
<b>3 LITERATURE REVIEW</b> .....	<b>5</b>
3.1 Introduction.....	5
3.2 Government Guidelines and Standards.....	5
3.3 Cleaning Chemicals.....	6
3.4 Cleaning Methods.....	7
3.5 Summary of cleaning methods.....	8
3.6 Flooring.....	8
3.7 Sampling methods.....	9
3.8 Summary of sampling methods.....	10
3.9 Falls in healthcare.....	10
<b>4 METHOD</b> .....	<b>11</b>
4.1 Selection of test sites.....	11
4.2 Quantifying level of contamination.....	11
4.3 Measuring the slip resistance.....	11
<b>5 RESULTS</b> .....	<b>13</b>
<b>6 DISCUSSION</b> .....	<b>21</b>
6.1 Literature review.....	21
6.2 Experimental.....	21
6.3 Sealants & Maintenance.....	22
6.4 Hospital activity.....	22
6.5 Alternative methods of cleaning.....	23
<b>7 CONCLUSION</b> .....	<b>24</b>
<b>8 REFERENCES</b> .....	<b>25</b>
<b>9 BIBLIOGRAPHY</b> .....	<b>28</b>
<b>10 APPENDIX 1: SLIP RESISTANCE TEST DATA</b> .....	<b>29</b>
<b>11 APPENDIX 2: COMPLETE ATP VS AGAR CHARTS</b> .....	<b>32</b>

# **1           ACKNOWLEDGEMENTS**

The research was undertaken with the assistance of Cardiff & Vale NHS Trust and East Cheshire NHS Trust.

The authors would like to thank Caroline Murch and her colleagues at University Hospital Wales (Cardiff) and Llandough Hospital, and David Halicki and Teresa Hill at Macclesfield District Hospital for their invaluable contribution to the work.

## 2 BACKGROUND

Slip and trip accidents in the healthcare sector continue to be a cause for concern. Over 50% of accidents in this sector are related to slips, trips and falls, both to staff and to patients. These accidents often result in serious injury and due to the vulnerability of the client group, in some cases have contributed to fatalities. Such accidents also result in significant cost to the NHS as a result of lost time, additional care requirements and financial claims by those suffering injury.

The selection of suitable flooring is an important factor in the prevention of slips, as required by the Workplace (Health, Safety and Welfare) Regulations 1992. In particular, regulation 12 requires that:

(1) Every floor in a workplace and the surface of every traffic route in a workplace shall be of a construction such that the floor or surface of the traffic route is suitable for the purpose for which it is used.

(2) Without prejudice to the generality of paragraph (1), the requirements in that paragraph shall include requirements that—

(a) the floor, or surface of the traffic route, shall have no hole or slope, or be uneven or slippery so as, in each case, to expose any person to a risk to his health or safety;

As such, where the floor will get wet or contaminated in normal use, the floor should not be slippery. Increased slip resistance of floor coverings can control the slip risk in some hospital environments, especially areas likely to become wet or subject to other surface contamination. However, there continues to be inconsistency in floor specifications in hospitals with the selection of smooth floors in most areas being common practice. Although clear guidelines for surface cleaning do exist for the healthcare sector (The National Patient Safety Agency, 2007) a recent research report (Fox, 2009) found some inconsistency amongst NHS Trusts in the issue of hygienic cleaning of (especially) safety floors and recommended that further research (*this research project*) should be carried out in this area.

Feedback to the HSE Healthcare Sector policy team from HSE inspectors is that there is a view amongst many duty holders that smooth floors are easier to clean and reduce the risk of harbouring infection; a key risk in the health care sector. As a result, duty holders are reluctant to specify safety flooring which would help to reduce the number of slip accidents. HSE does not have any evidence to either support or refute these duty holders' perceptions, as there is currently an absence of research covering cleaning and infection control standards in relation to slip potential in hospital settings. Consequently, the HSE Healthcare Sector policy team has been asked for a steer from HSE inspectors and there is a need to provide consistent guidance to the field and duty-holders. This research will inform that guidance.

### 2.1 AIMS

1. Ascertain whether increased slip resistance of flooring has any impact on infection control within the hospital environment
2. Investigate whether safety floors can be hygienically cleaned to an acceptable level for infection control standards using existing and recommended cleaning methods

## **2.2 OBJECTIVES**

1. Review existing relevant guidance and research on this subject.
2. Compare types of flooring typically found in hospitals with respect to slip resistance and ability to clean to acceptable infection control standards.
3. Investigate whether, and to what extent, sealants have an impact on the slip resistance of hospital flooring.
4. To investigate the impact of floor slip resistance/types in relation to cleaning and infection control in different health care and hospital settings, including consideration of especially clean areas such as operating theatres, critical care units and isolation rooms for infected patients.
5. If safety flooring proves to be significantly more difficult to clean to an acceptable infection control standard than non-safety flooring, to trial alternative cleaning method(s) on safety flooring.

## **3 LITERATURE REVIEW**

### **3.1 INTRODUCTION**

The aim of the project is to investigate the notion that safety flooring is difficult to clean to a hygienic standard and therefore its widespread use would compromise the cleanliness of hospitals. The aim of this literature review is to provide an overview of the current NHS guidelines and standards on cleaning and provide an overview of the research on floor cleanability that has been conducted to date.

The information in the review is presented as follows:

- Current government guidelines and standards
- Discussion of cleaning chemicals
- A review of different cleaning methods
- Flooring
- Sampling methods used to assess the levels of micro-biological contamination
- Slip and trip accidents in the NHS

### **3.2 GOVERNMENT GUIDELINES AND STANDARDS**

In recent years the rising number of hospital acquired infections has led to growing awareness of the importance of cleanliness and hygiene in reducing the number of patients and staff acquiring infections in healthcare facilities. It has led to a reappraisal of how cleaning should be commissioned and conducted and minimum standards have been defined.

Numerous pieces of guidance for the NHS and Healthcare sector have been issued in recent years that aim to improve the levels of cleanliness in hospitals and other healthcare facilities. Much of this guidance is strategic and sets out aspirational standards that hospitals should work to (Department of Health, 2006a, National Patient Safety Agency, 2007, Department of Health, 2009). They include strategic goals such as:

- Provide and maintain a clean and appropriate environment in managed premises that facilitates the prevention and control of infections
- Ensure, so far as is reasonably practicable, that care workers are free of and are protected from exposure to infections that can be caught at work and that all staff are suitably educated in the prevention and control of infection associated with the provision of health and social care

Guidance (Department of Health, 2004a) also details the standards of cleanliness to be reached, for example, “The complete floor, including all edges, corners and main floor space, should have a uniform finish and be visibly clean with no blood or body substances, dust, dirt, debris and spillages.”

Other guidance such as A Matron’s Charter: an action plan for cleaner hospitals (Department of Health, 2004b) is aimed more at effecting culture change about cleaning in the NHS. In recent years the move to the use of contract cleaners has, on occasions, led to cleaners feeling distanced from the facilities they work in, as they could be working somewhere else the following day. NHS staff can sometimes be unclear about what authority they have to ask a cleaner to carry out extra tasks such as cleaning up spills, as some cleaners are not part of the NHS. The key messages of the guidance include:

- Keeping the NHS clean is everybody’s responsibility
- Cleaning staff will be recognised for the important work that they do and should be made to feel part of ward teams

- Specific roles and responsibilities for cleaning will be clear.

More detailed guidance on how cleaning should be commissioned, managed and undertaken is also available (Department of Health, 2004a, The National Patient Safety Agency, 2007a, The National Patient Safety Agency, 2007b, The National Patient Safety Agency, 2009). The revised guidance on contracting of cleaning (Department of Health, 2004b) is a best practice guide designed to assist with the evaluation of cleaning contracts. It sets out the revised national specifications for cleanliness and discusses the recommended minimum cleaning frequencies that need to be followed for compliance with the National Specifications. It provides managers with the tools to set cleaning specifications, compare contracts and audit the cleaning being carried out.

Detailed guidance on how cleaning should be conducted and scheduled (The National Patient Safety Agency, 2007b, The National Patient Safety Agency, 2009) is also available, for example guidance was issued in 2007 which was intended to standardise the colour coding of hospital cleaning materials equipment throughout the NHS. Prior to this guidance, colour coding of cleaning equipment could vary from one hospital to another even within the same NHS Trust. Details of the standardised colour coding system are given in the table below.

<b>Colour</b>	<b>Where used</b>
Red	Bathrooms, washrooms, showers, toilets, basins and bathroom floors
Blue	General areas including wards, departments, offices and basins in public areas
Green	Catering departments, ward kitchen areas and patient food service at ward level
Yellow	Isolation areas

Table 3.1 Details of the NHS standardised colour coding system for cleaning equipment and materials which came in effect on 31<sup>st</sup> March, 2008.

Details of the exact cleaning regimes to be used are not set in any guidance, as the cleaning regime (e.g. which chemical should be used) and the method (wet mopped or machine cleaned) will vary from hospital to hospital and location to location depending on the floors and surfaces in situ.

It is interesting to note there is comparatively little guidance to indicate how cleaning should be monitored and audited. What guidance there is suggests the use of visual inspection methods to determine if areas have been satisfactorily cleaned or not.

In addition to the numerous guidance documents issued in the UK there are a range of international publications dealing with cleaning in healthcare environments. Advice issued by the World Health Organisation suggests that the use of microbiological sampling of surfaces can be useful as a quality control check on cleaning or when cleaning practices are being changed (World Health Organisation, 2002).

### **3.3 CLEANING CHEMICALS**

Worldwide there are considerable differences of opinion regarding the most effective cleaning chemicals to use to reduce the risk of hospital-acquired infections. In the UK the preference is generally for detergent based cleaning systems, as it is believed that this is the most effective means of removing the dirt and soilant that potentially dangerous micro-organisms may be associated with.

In other countries such as France and the USA the preference is to use disinfectants that are intended to kill any micro-organisms present. However, disinfectants may have a reduced effect

if soiling levels are heavy, and some decontamination products incorporate both detergent and disinfectant components. In recent years there has been growing concern that widespread and indiscriminate use of disinfectants may be contributing to the development of resistant strains of bacteria (Deo et al. 2010). It is therefore not a clear-cut decision regarding which approach is best.

There has been a limited amount of research that directly compares the efficacy of cleaning using detergents or disinfectants (Wilcox et al. 2003). The study was not conclusive regarding whether detergents or disinfectants were most effective at eliminating bacteria, however it did suggest that cleaning using a combination of detergent followed by disinfect was more effective than using either chemical on its own.

### 3.4 CLEANING METHODS

There is a wide range of cleaning methods available for healthcare facilities to choose from. In addition new cleaning technologies (Kravitz 2004), such as micro fibre systems, are constantly being developed and introduced to the marketplace, further increasing the range of choice available to managers of healthcare establishments (Department of Health 2007, Rutala et al. 2007).

Numerous studies have been conducted to assess the effectiveness of different cleaning methods (Dharan et al 1999, White et al. 2007). The following table describes various floor cleaning methods and summarises their strengths and weaknesses.

<b>Cleaning Method</b>	<b>Strengths</b>	<b>Weakness</b>
Wet mopping, inc. with micro-fibre	Effective at removing dirt and microbes Quiet, it minimises disturbance to patients	Chemicals need to be the correct concentrations Tools need to be clean and well maintained
Machine cleaning	Good at removing dirt and contamination Good for cleaning large areas	Can be difficult to access confined spaces Chemicals need to be the correct concentrations Equipment needs to be well maintained Can be noisier and more disruptive of patients
Dry micro-fibre systems	No chemicals used, no risk of resistance developing Quick method of cleaning, trained staff can clean an area more quickly than with conventional methods Effectively removes dirt, soil and microbes	Microbes remain alive on cleaning materials Cleaning materials need to be transported securely to laundering facilities to avoid contamination Cost of investment in micro-fibre cleaning systems and ongoing cost of laundering kit Staff need to be retrained Disinfectants cannot be used in conjunction with micro-fibre cleaning materials

Table 3.2 Summary of commonly used routine daily cleaning methods.

In addition to routine daily cleaning regimes healthcare facilities also need to have procedures in place for periodic deep cleaning of areas (Department of Health 2007). It is important to have deep cleaning procedures and protocols in place as they form a vital part of infection control when dealing with outbreaks of infections such as MRSA or the winter vomiting bug (Norovirus) and following the discharge or transfer of an infected patient.

Two main methods of deep cleaning are discussed in the available literature:

1. Steam cleaning
2. Chemical vapour

Both methods are effective at eliminating microbes from surfaces in healthcare environments. Steam cleaning has also been shown to be effective at removing dirt and soil from surfaces, and also has the additional advantage that bacterial resistance is unlikely to develop.

### **3.5 SUMMARY OF CLEANING METHODS**

On balance there is no one single cleaning method that is suitable for all locations and occasions in healthcare facilities. Cleaning should be undertaken using an integrated approach, which combines the use of routine daily cleaning methods with periodic deep cleaning when necessary.

Effective cleaning is highly dependent on a number of factors:

- Having the right equipment and supplies for the job
- Cleaning equipment needs to be in good condition and well maintained
- Cleaning chemicals need to be used at the right concentration
- Cleaning techniques being carried out correctly
- That areas are accessible for cleaning within the existing constraints of the clinical environment

In order for cleaning to be carried out effectively it is vital that cleaning staff are well equipped, properly trained and well supervised. It is important that cleaning staff feel valued for the work that they do and are considered to be an important part of the healthcare team (Department of Health 2004b).

### **3.6 FLOORING**

NHS guidance available in the UK recommends that flooring should be slip resistant when wet (Department of Health 2006b). This would appear to be simple common sense, but as the majority of cleaning methods used in healthcare environments leave the floor wet immediately after cleaning some consideration of the source of wet contamination is required. The cleaning of floors that are slippery when wet needs to be managed carefully, and as such, floors that are only ever wet due to cleaning do not necessarily have to be slip resistant.

The majority of the studies reviewed do not mention the type of flooring involved. From the limited number of studies where details of the flooring were reported, the following flooring types were identified (Lankford et al. 2006, Frabetti et al 2009):

- Vinyl tiles
- Smooth vinyl
- Textured linoleum
- Rubber
- Ceramic tiles

It should be noted that in UK healthcare establishments, resilient flooring (vinyl, linoleum or rubber) forms the majority of the flooring installed. None of the papers identified in the current review report the slip resistance characteristics of the floors involved in the studies. None of the flooring materials identified are likely to satisfy current NHS guidance, which indicates that flooring should be slip resistant when wet.

None of the studies reviewed here suggest that the flooring type has any effect on the cleanability of the floors assessed. However, common sense would suggest that joints in the floor and gaps between tiles could potentially act as reservoirs for dirt and microbes. It would therefore seem sensible to minimise the number of flooring joints where possible through the specification of sheet flooring. Where tile floors are already in situ it may be beneficial to use a micro-fibre cleaning regime as they are better at removing dirt and microbes from joints and cracks than conventional cleaning systems (Department of Health 2007, Rotal et al. 2007).

Numerous studies have been conducted to assess:

- The ability of a range of cleaning techniques to effectively remove dirt and biological matter from floors
- The effectiveness of different cleaning methods
- The effect of changing cleaning regimes on the level of microbes present

To date there have been no studies to systematically assess the cleanability of different types of flooring (e.g. smooth vinyl and slip resistant safety vinyl). Nor has there been any work to establish which cleaning techniques are most effective for different flooring types.

Despite the requirement in existing NHS guidance that flooring should be slip resistant when wet there can be a reluctance to specify slip resistant safety flooring for use in healthcare establishments, as it can be perceived as difficult to clean. Despite manufacturers assurances that safety flooring can be effectively and hygienically cleaned using the appropriate cleaning regime, the suspicion remains that it may not be possible to achieve the required levels of hygiene with these flooring materials. A rigorous and detailed study to compare the levels of cleanliness achievable with smooth flooring and safety vinyl is urgently needed to address these fears.

### **3.7 SAMPLING METHODS**

In the studies reviewed, two different methods were used for sampling microbe levels, traditional contact plates (also known as agar plates and impression plates) (Verity et al. 2001, Wilcox et al, 2003 and De Lorenzi et al. 2006) and ATP bioluminescence (Willis et al. 2007 and Andersen et al. 2009).

The contact plate method consists of gently pressing the agar plate onto the floor surface and then sending it to a laboratory for culturing over a set time period. Once cultured, the number of colonies are counted (Hall & Hartnett. 1964) and the colony data reflect the level of bacteria present on a surface. There is a brief time delay while the plates are cultured, but this is typically 2 to 3 days at maximum.

Adenosine Tri Phosphate (ATP) bioluminescence is an indirect method of assessing microbial contamination, based on the fact that organisms generate ATP as a means to store and then, later release energy. The presence of ATP is indicative of viable microorganisms on a sampled surface and can therefore be used as a marker for microbial contamination – a large concentration of ATP on a surface following cleaning and disinfection is indicative of poor cleaning with its associated risk of contamination. With ATP bioluminescence, the floor is swabbed and a hand-held scanner then generates a measurement result. ATP provides an instant result but there is no standardised test method and different brands of meter use different tracers. This means that there is no universal pass / fail threshold and the threshold can differ by more than an order of magnitude depending on the meter used (Andersen et al. 2009).

One of the limitations of the research undertaken to date is a failure to take into account the time elapsed between floor cleaning and sampling. Where this is not strictly controlled, cleaning methods cannot be directly compared since re-colonisation of floor surfaces commences as soon

as cleaning ceases. In certain studies, the sampling was carried out 10-15 minutes after cleaning (Dharan et al. 1999), whereas there was a time window of up to one or two hours following cleaning permitted in other studies (White et al. 2007, De Lorenzi et al. 2006, Wren et al. 2008).

The total duration of certain studies may have also failed to take into account the potential seasonal variation in microbe levels (Wren et al. 2008). This could mean that, where an intervention was thought to have successfully reduced microbial levels, it was actually a distorted impression brought about by natural changes to the environment owing to seasonal variation.

### **3.8 SUMMARY OF SAMPLING METHODS**

Where an accurate measure of microbial levels is required, contact plates should be used for sampling, despite the time delay brought about by laboratory culturing. This approach is simple, reproducible and quality control can be applied by using commercially available plates and a standardised sampling method. Although the reliability of ATP bioluminescence is questionable, it is thought to have a useful role in the hospital environment in terms of quality control. For example, spot checks would, traditionally, have relied on visual inspection backed up with contact plate sampling but ATP bioluminescence has been shown to be more reliable than visual checks alone, in most cases (Willis et al. 2007). Since it provides instant results, ATP measurement may also be a useful training tool for demonstrating the difference between ineffective and effective cleaning.

### **3.9 FALLS IN HEALTHCARE**

Research suggests that an average of 2% of in-patients fall during the course of their hospital stay, but the risk can vary, with more falls occurring on geriatric wards, followed by general medical and surgical wards (Hignett & Masud 2006).

A survey of several NHS trusts in the UK suggests that in some care environments (acute hospital, primary care trust and mental health) patient falls were ranked as the most common type of adverse incident that occurs to patients (Hignett & Masud 2006). Other studies suggest that as many as 41% of the adverse events and near misses that happen to patients may be slips, trips and falls (Shaw et al. 2005). These and other studies suggest that patient falls should be given a high research and risk management priority within the NHS.

Many of the flooring materials installed throughout the NHS estate pose a high slip risk when wet or otherwise contaminated. As discussed earlier, many of the floor cleaning methods routinely used throughout the NHS leave the floor wet after cleaning. It is therefore vital that the cleaning for floors is managed to prevent slips and trips as far as is reasonably practicable. In other words, wherever possible, pedestrians should be prevented from walking on freshly cleaned floors until the floors have had the chance to dry (Health & Safety Executive 2005).

Examination of RIDDOR data indicates that in the last five years (04/05 to 08/09) NHS employees have suffered almost 1300 slip and trip accidents directly related to the cleaning of floors. There are further accidents to members of the public, though these are not well captured by the RIDDOR system, due to the high injury threshold. Hospital records would give a clearer indication of the number of accidents to members of the public that are related to cleaning activities. These figures for staff accidents highlight the importance of managing the cleaning of high slip risk floors appropriately, so that pedestrians are not allowed to enter areas before the floors have a chance to completely dry.

## **4 METHOD**

The literature review and discussions with the NHS trusts failed to identify a prescribed method of monitoring the hygiene levels of hospital flooring in the NHS. It was suggested that taking microbiological swabs of the floor is not common practice. Consequently the approach taken was to investigate the reduction in flooring contamination achieved by cleaning. The reduction in contamination achieved by cleaning safety flooring was compared to that achieved when cleaning non-safety flooring. In this way, the ability to hygienically clean safety flooring has been assessed.

Should the reduction in flooring contamination for safety flooring be significantly less than that achieved for non-safety flooring, the efficacy of alternative cleaning regime(s) was to be investigated, though this proved to be unnecessary.

### **4.1 SELECTION OF TEST SITES**

At Cardiff and Vale NHS Trust, seven different floors at two hospitals were identified to be included in the study. At Macclesfield District Hospital, seven different floors were included at 13 discrete locations to be included in the study. The floors were situated in different clinical areas, including treatment rooms. In order that the data for these floors will be the most widely applicable, the flooring chosen was at least 6 months old, but no more than 5 years old. The floors selected represent the full range of wet slip resistance likely to be encountered in the health sector.

### **4.2 QUANTIFYING LEVEL OF CONTAMINATION**

The degree of contamination of the flooring was assessed using contact plates (agar plates) to sample a defined area of flooring before and after cleaning. The agar plates were incubated in the laboratory, and a microbial colony count made for each plate to generate colony forming unit (CFU) counts for the specified surface area sampled. This process was repeated on four separate occasions at the Cardiff hospitals and twice at Macclesfield Hospital, at intervals of at least a week apart, to obtain typical results for the defined area of flooring.

Alongside this work undertaken by HSL scientists, Cardiff and Vale NHS Trust used an ATP bioluminescence system from 3M to monitor the amount of protein present on the same flooring areas, before and after cleaning. This is a surrogate measure for the presence of microbes, as protein is needed for microbes to grow. A comparison of the findings using the two hygiene monitoring methods is included in section 6.2. The equipment used was a calibrated uni-lite NG meter in conjunction with 3M clean trace clinical ATP swabs, following the 3M hygiene management guide manual.

### **4.3 MEASURING THE SLIP RESISTANCE**

Slipperiness assessments were undertaken using standard HSL / HSE techniques in accordance with BS:7976-2 (2002) and 'The UK Slip Resistance Group Guidelines' (UKSRG 2005). Data generated during the assessments are presented in detail in Appendix 1.

Measurements of the floor surface Pendulum Test Value (PTV), closely related to coefficient of dynamic friction, were made using a calibrated Stanley Pendulum instrument. The test slider material used was Slider 96 Rubber, also known as Four-S Rubber (Standard Simulated Shoe Sole), developed to represent a footwear material of moderate slip resistance. Data was generated [i] in the as-found dry condition and [ii] after application of low volumes of water by

hand spray. Where appropriate, further measurements were taken using a surface microroughness transducer, set to the Rz parameter.

The slip resistance of all flooring areas included in the study was measured at the beginning of the project, and again after all the hygiene monitoring had been completed.

## 5 RESULTS

Floor coverings with a wide range of slip resistance were identified at each site in order to compare the effectiveness of cleaning on different floors. For presentation of the results, the floors have been arranged in increasing slip resistance (higher PTV is more slip resistant, i.e. less slippery). The Pendulum test value (PTV) quoted is in the wet condition using Slider 96 Rubber, which indicates the slip potential to shod pedestrians.

Although barefoot pedestrians will also use some of the areas, it was decided that further testing was an unnecessary complication as the main thrust of the research was to understand cleaning. The Rz surface microroughness measurement is widely used as a surrogate measure of slip resistance, as the roughness of the surface is intrinsic to the wet slip resistance of a floor material.

Area No	Area Description	Floor Type	PTV	Rz ( $\mu\text{m}$ )
1	UHW Theatre One	0.5m Standard Vinyl Tiles	12	5.1
2	UHW Pool Room Corridor	Standard Vinyl	14	4.7
3	LD Crash Room 1	Standard Vinyl	17	5.7
4	LD E4 Wet Room Corridor	Standard Vinyl	22	10.8
5a	LD Exam Room 4 Corridor	Safety Vinyl	29	24.2
5b	UHW Pool Room	Safety Vinyl	29	26.1
6	LD E4 Wet Room	Safety Vinyl	42	29.0
7	LD Exam Room 4	Safety Vinyl	50	39.7
8a	Mac Theatre 2 Scrub area	Standard Vinyl	14	3.4
8b	Mac Theatre 2 adjacent fire exit	Standard Vinyl	14	3.4
8c	Mac Theatre 2 adjacent op table	Standard Vinyl	14	3.4
9a	Mac Ward 10 Corridor Adjacent bedroom 2	Vinyl with fine texture	18	13.1
9b	Mac Ward 10 Bedroom 2 bedside	Vinyl with fine texture	18	13.1
10a	Mac Maternity Suite Pool Rm 4 / 5 bedside	Safety vinyl w/ circular profile	23	N/A
10b	Mac Maternity Suite Pool Rm 4 / 5 Toilet	Safety vinyl w/ circular profile	23	N/A
10c	Mac Ward 10 Bathroom 4 Toilet Area	Safety vinyl w/ circular profile	23	N/A
10d	Mac Ward 10 Bathroom 4 Shower Area	Safety vinyl w/ circular profile	23	N/A
11	Mac Maternity Suite by sink	Safety Vinyl	27	12.6
12a	Mac Ward 10 Clean Utility Adjacent Sink	Safety vinyl	35	24.8
12b	Mac Ward 10 Clean Utility Adjacent Door	Safety vinyl	35	24.8
12c	Mac Out Patients Corridor Under sink	Safety vinyl	43	20.7

Table 5.1 Area numbers, area description, flooring description and wet slip resistance results.

UHW = University Hospital Wales, Cardiff & Vale NHS Trust

LD = Llandough Hospital, Cardiff & Vale NHS Trust

Mac = Macclesfield District Hospital, East Cheshire NHS Trust

Note: Number denotes different floor covering, letter denotes different test area with same floor type. Rz measurement is not possible on profiled vinyl (10a-d).

The pendulum test and surface microroughness measurements have been the subject of significant development work over recent years, in order to ensure that they provide reliable slip resistance measurements. The United Kingdom Slip Resistance Group (UKSRG) produces detailed guidelines for the use of these methods, and gives figures for the interpretation of the test results, which are reproduced below:

Pendulum Test Value	Rz Microroughness ( $\mu\text{m}$ )	Wet Slip Potential
0 – 24	< 10	High
25 – 35	10 – 20	Moderate
36 +	> 20	Low

Table 5.2. Interpretation of Pendulum Test Value & Rz Microroughness according to UKSRG Guidelines', Issue 3, 2005

Area No	Area Description	Chemical	Equipment
1	UHW Theatre One	Haz-tabs	dolly mop
2	UHW Pool Room Corridor	Haz-tabs	micromop
3	LD Crash Room 1	GP	dolly mop
4	LD E4 Wet Room Corridor	Actichlor	synthetic mop
5a	LD Exam Room 4 Corridor	GP	dolly mop
5b	UHW Pool Room	Haz-tabs	micromop
6	LD E4 Wet Room	Actichlor	synthetic mop
7	LD Exam Room 4	GP	dolly mop
8a	Mac Theatre 2 Scrub area	GP	Wet pick up & dolly mop
8b	Mac Theatre 2 adjacent fire exit	GP	Wet pick up & dolly mop
8c	Mac Theatre 2 adjacent op table	GP	Wet pick up & dolly mop
9a	Mac Ward 10 Corridor adjacent bedroom 2	Vermop	Mop
9b	Mac Ward 10 Bedroom 2 bedside	Vermop	Mop
10a	Mac Mat Suite Pool Rm 4 / 5 bedside	Jontex	Mop
10b	Mac Mat Suite Pool Rm 4 / 5 Toilet	Jontex	Mop
10c	Mac Ward 10 Bathroom 4 Toilet Area	Vermop	Mop
10d	Mac Ward 10 Bathroom 4 Shower Area	Vermop	Mop
11	Mac Mat Suite by sink	Jontex	Mop

Table 5.3. Area description and cleaning regime.

Vermop = Hot water & Jontex

The hygiene monitoring took the form of contact (agar) plates placed on the floor surface before and immediately after cleaning. This transfers any contamination onto the surface of the plate, which is then incubated for a period of time to allow any bacteria to grow. When working with Cardiff & Vale, this involved taking the samples from around the hospital and then refrigerating the sample to minimise growth whilst they were shipped to HSL for analysis. The logistics of this, and fitting in the sampling with other duties, meant that the time period between sampling and analysis was not constant from one week to the next. It should be noted therefore, that the absolute levels of contamination couldn't be compared from one week to the next. The results should only be compared within a round of testing (i.e. the data from each week should be considered separately). This is reflected in the way the data is presented below.

It should also be considered that some plates were so heavily contaminated that an exact bacteria count was not possible. Counting was stopped when the bacteria count exceeded 300 on a single plate, as counts above this are prone to counting error. As can be seen from the charts below, the plates tended to contain either “too many to count” or less than 200 bacteria. The charts have been scaled to reflect this, with bars over 200 not shown to their full value. The inclusion of data points with no defined value means that the change in the level of bacteria following cleaning cannot be expressed as a percentage of the level before cleaning. The data presented is absolute values of bacteria on the agar plates after culturing.

The hospitals involved were fully operational at the time of the study and this meant that some of the test areas were inaccessible during data collection visits due to operations or treatments being carried out. Some data are therefore missing for certain areas throughout the series of tests. The test areas, along the x axis, have been arranged in order of increasing slip resistance, so the most slippery (when wet) floors are at the left, and the most slip resistant on the right.

If the slip resistance had a negative effect on the cleanability of the flooring, it would be indicated by a greater number of bacteria colonies (greater CFU, i.e. taller bars) towards the right hand side of the charts. If the floors with little wet slip resistance were easier to clean, it would be expected that there would be fewer bacteria colonies, (lower CFU, i.e. bars to the left of the graph would tend to be lower). Note that zero bacteria count is represented as 0.5 on the chart in order to show that a measurement was taken, as opposed to 0 which shows that area was not evaluated at the visit.

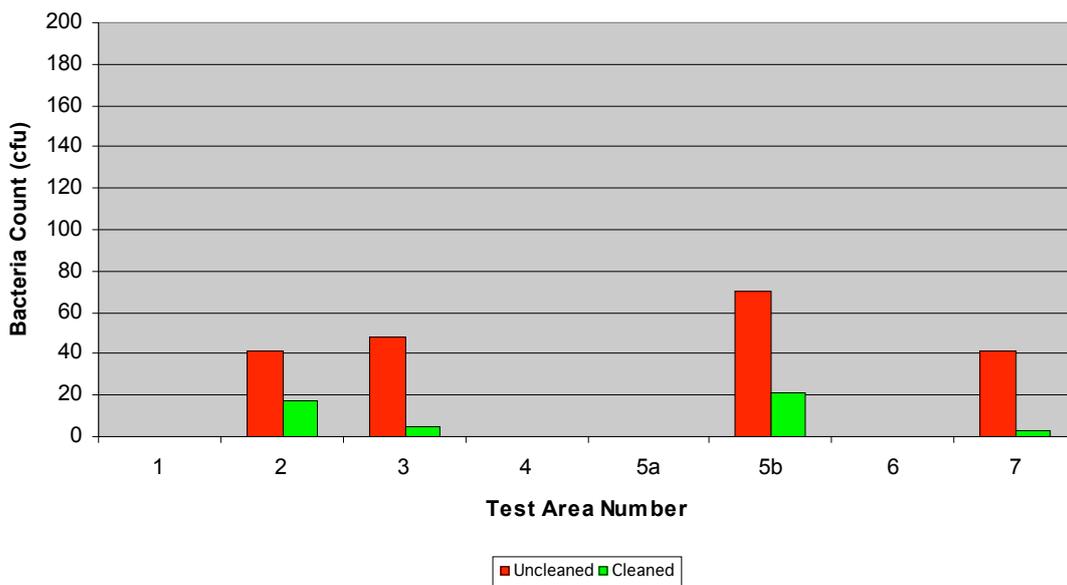


Figure 5.1. Cardiff & Vale NHS Trust, Uncleaned vs Cleaned, Bacteria Count by Area, Week 1

At Cardiff & Vale, the first week of monitoring only looked at four of the eight test sites selected. This was partly due to the time consuming sampling regime and partly due to unavailability of test locations due to their use by patients. The chart (Figure 5.1) shows that none of the floors were completely free from bacteria after cleaning, but that floor 7, the most slip resistant, was cleaned as effectively as floor 3, which is a smooth vinyl which presents a high slip potential when wet.

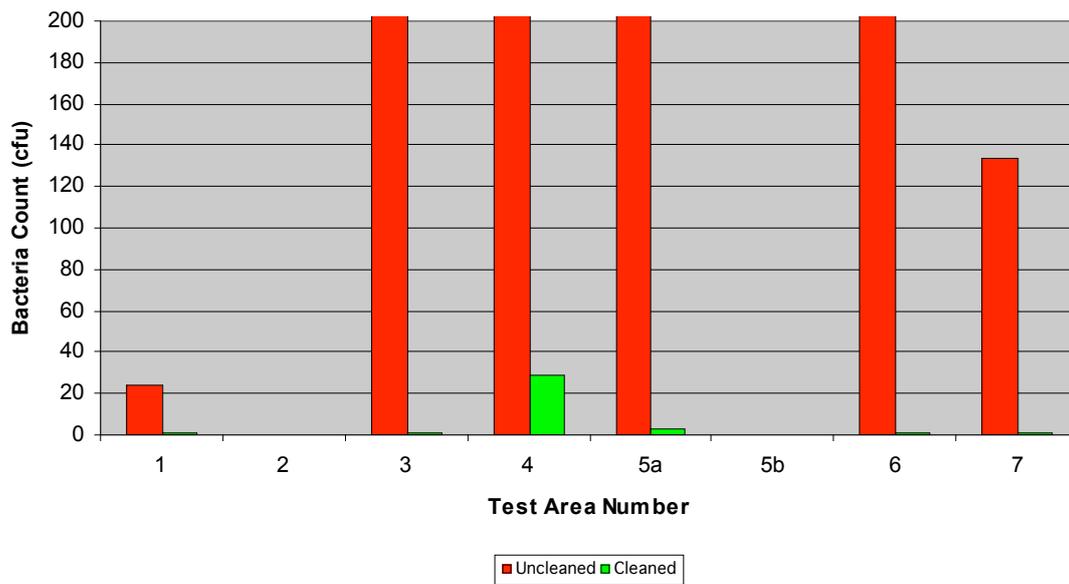


Figure 5.2. Cardiff & Vale NHS Trust, Uncleaned vs Cleaned, Bacteria Count by Area, Week 2

The data presented in Figure 5.2 shows that there was significant bacterial contamination in areas 3, 4, 5a, 6 & 7 before cleaning was undertaken. Following cleaning, the bacteria count was reduced to much lower levels in areas 4 & 5a and to none in areas 3, 6 & 7. The cleaning also eliminated the lower level of bacterial contamination at area 1.

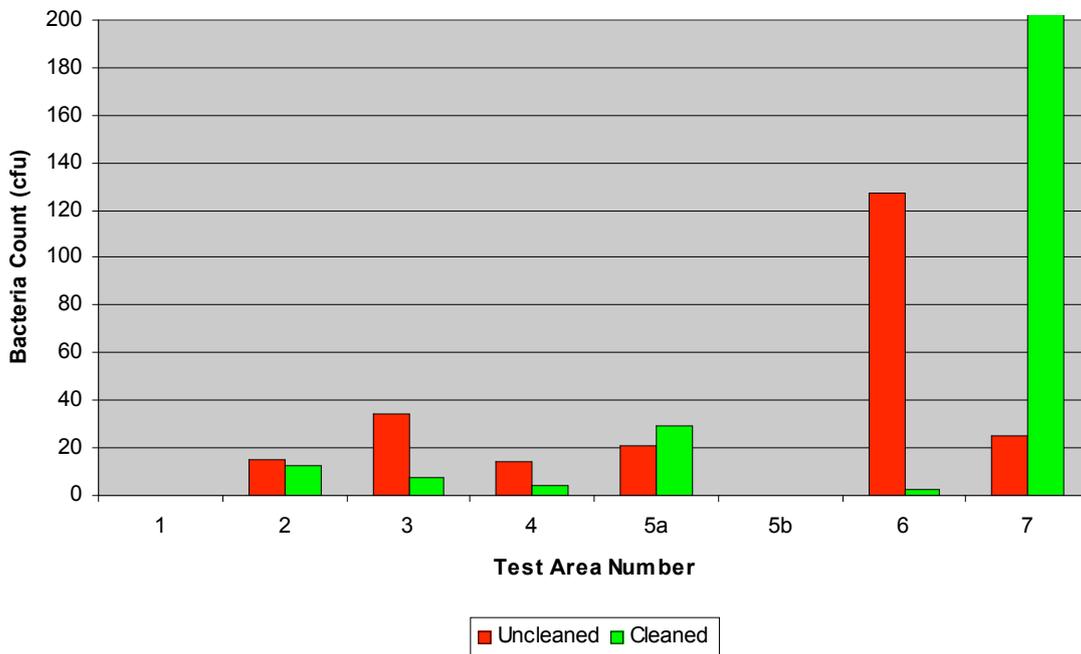


Figure 5.3. Cardiff & Vale NHS Trust, Uncleaned vs Cleaned, Bacteria Count by Area, Week 3

The data presented in Figure 5.3 shows mixed results. Areas 2 & 5a showed little change in bacteria count following cleaning, with area 5a increasing slightly. Areas 3 & 4 showed a more significant reduction in bacteria count, but from relatively low levels before cleaning. Area 6 shows a clear reduction from a high starting point to no bacteria following cleaning. Area 7 shows significantly higher bacteria count after cleaning than compared with the uncleaned floor,

suggesting that the cleaning regime on this occasion has actually spread contamination across the floor.

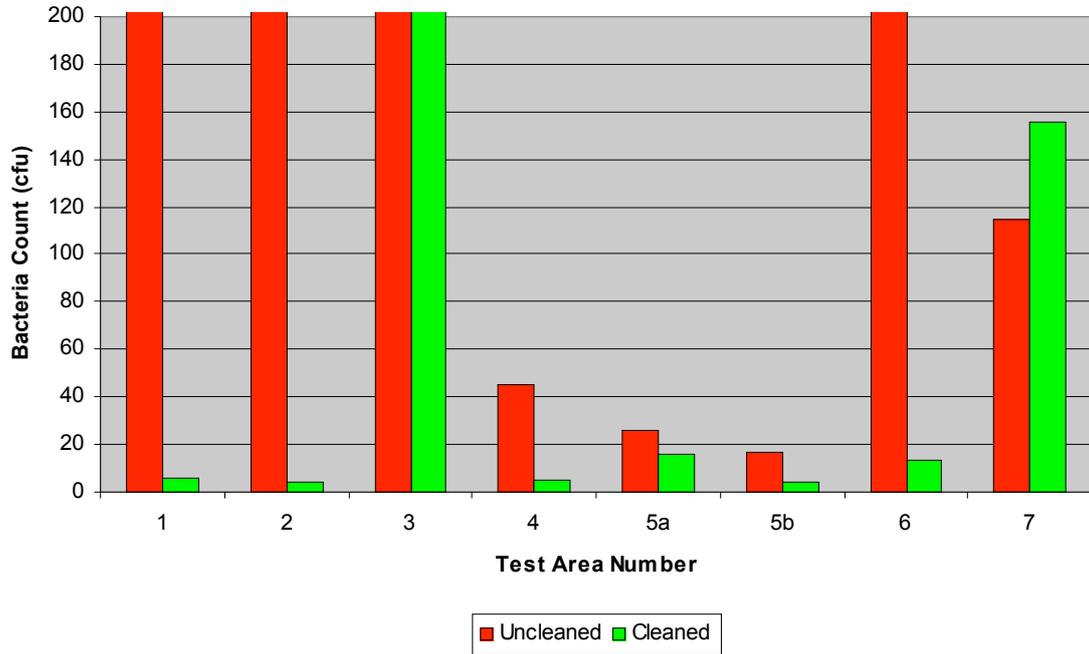


Figure 5.4. Cardiff & Vale NHS Trust, Uncleaned vs Cleaned, Bacteria Count by Area, Week 4

Figure 5.4 shows the final round of testing at Cardiff & Vale. Areas 1, 2, 4 & 6 show significant reductions in bacteria following cleaning. Whilst areas 1 & 2 are smooth (slippery) vinyls, area 6 is a slip resistant floor, with a pendulum test value of 42. Area 3 and area 7 show no improvement following cleaning.

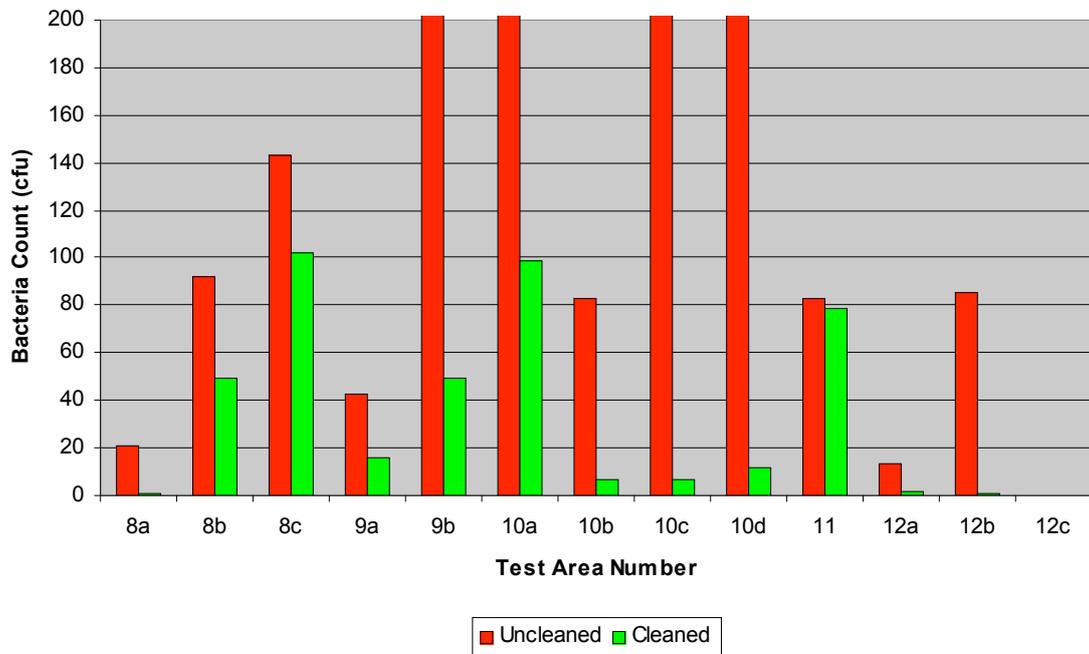


Figure 5.5. Macclesfield Hospital, Uncleaned vs Cleaned, Bacteria Count by Area, Week 1

The test data presented in figure 5.5 is from Macclesfield District Hospital. A microbiologist from the Health and Safety Laboratory undertook the sampling, allowing a greater degree of control over the incubation process. Even with this greater level of control it is not suggested that the data in figure 5.5 be compared directly with the data presented in figure 5.6.

As can be seen in the data from Cardiff and Vale, the data from Macclesfield shows significant reductions in the level of bacterial contamination following cleaning. The variation in bacteria count following cleaning does not depend on the slip resistance of the flooring, as floors at the extremes of the spectrum being tested have been cleaned to leave no bacteria, whereas other floors have significant bacterial contamination after cleaning.

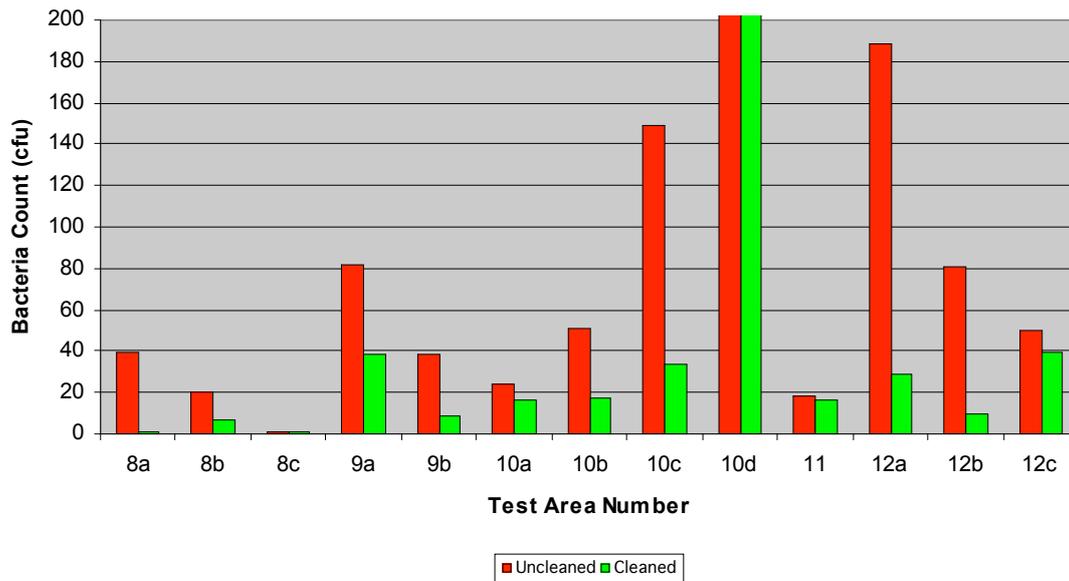


Figure 5.6. Macclesfield Hospital, Uncleaned vs Cleaned, Bacteria Count by Area, Week 2

The final series of test data from Macclesfield shows the same as the first series, with some floors showing significant improvement and others remaining contaminated following cleaning.

The use of ATP Bio-luminescence as a surrogate measure for bacteria is suggested in the literature, and was included by Cardiff and Vale in the monitoring at their hospitals. Figure 5.7 shows the ATP data along with the bacteria count data shown on figure 4.

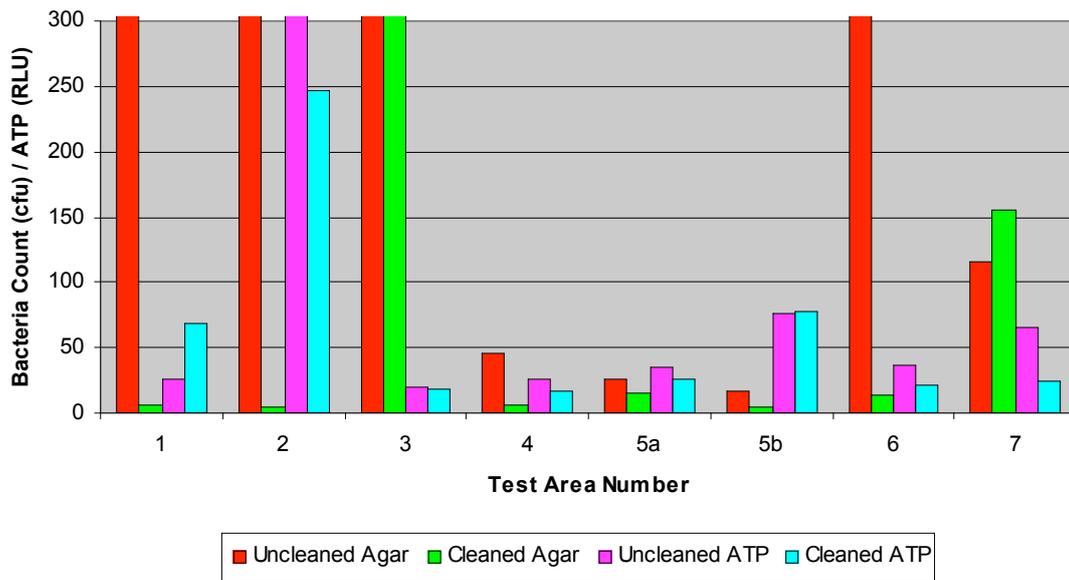


Figure 5.7. Cardiff & Vale NHS Trust, Uncleaned vs Cleaned, Bacteria Count & ATP (RLU) by Area, Week 4

The series of tests shown in figure 5.7 does not show good agreement between the two methods of monitoring contamination. It is very difficult to argue with the presence of many contaminating bacteria on contact plates. If the ATP results for the same area do not reflect this then this particular ATP test is, at best, inconsistent.

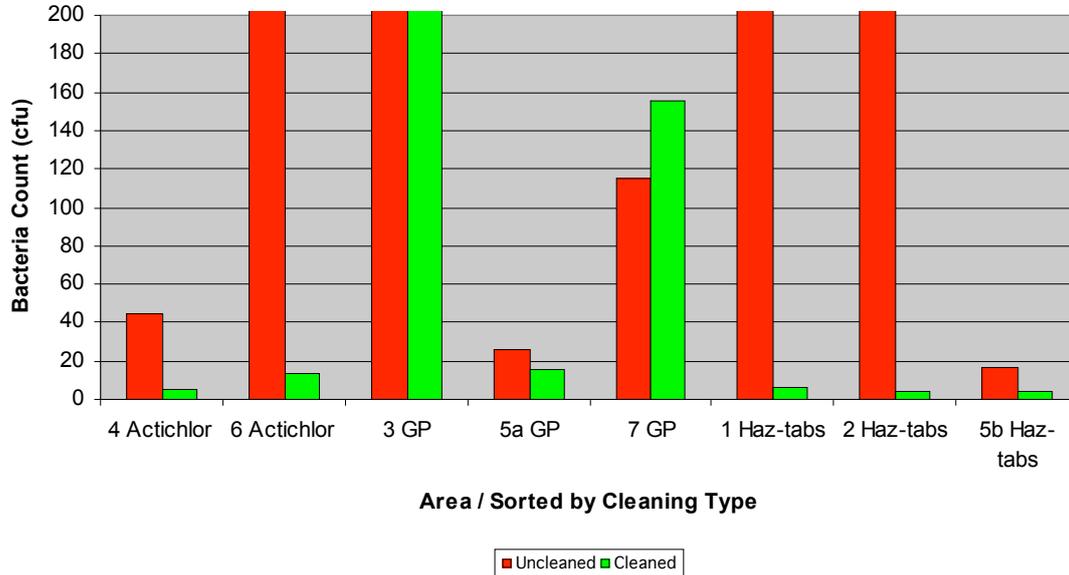


Figure 5.8. Cardiff & Vale NHS Trust, Uncleaned vs Cleaned, Bacteria Count, by Cleaning type & area, Week 4

Each cleaning type highlighted in Figure 5.8 was carried out on at least one standard vinyl (one of 1, 2, 3 & 4) and on at least one safety vinyl (one of 5, 6 & 7). Again, the flooring material does not show a systematic effect on the cleanability. There is variation between cleaning methods, and when applying the same cleaning method in different areas. It should be noted that a different person undertook each of the cleaning methods, so that introduces further variation,

but such variations are also likely to be the case within a given healthcare premises on a week by week basis, so the approaches used were consistent with the real working situation. Areas 5a and 5b have the same flooring material but were cleaned using different techniques. The initial contamination was relatively low in both areas, with reductions in bacteria level with both cleaning techniques.

## 6 DISCUSSION

### 6.1 LITERATURE REVIEW

The literature review is presented in section 3 and the guidance identified indicated that floor cleaning and hygiene tends to be aspirational or strategic, rather than prescriptive. Routine swabbing of floor surfaces is not required or recommended by any of the documents reviewed. This was confirmed by feedback from NHS trusts, where swabbing is not routine practice for monitoring microbiological contamination. Only in the World Health Organisation guidance is this kind of pro-active monitoring suggested.

There have been numerous studies using both the contact plate method and the ATP Bioluminescence method, though there is uncertainty regarding the reliability of the latter method when applied within this context.

Previous research looking at different cleaning methods and chemicals, both on surfaces and on flooring materials, has been reported. None of the studies have considered the slip resistance of the flooring involved, and only one study reports the types of flooring included in the study, none of which would be expected to be slip resistant when wet.

It should also be noted that in all of the previous studies, researchers undertook the cleaning, rather than hospital staff employed in that role. This creates a slightly false situation, which does not necessarily reflect the time available to cleaners in their normal routine.

### 6.2 EXPERIMENTAL

The regular cleaners for each area undertook all floor cleaning, and they were asked to undertake the cleaning as they normally would, and not take extra steps due to the researchers being present. The objective of understanding the influence of the floor was explained, and it was stressed that the study wanted to investigate what was possible in normal conditions, not in ideal conditions that would be difficult to reproduce on an ongoing basis.

The research has looked at flooring across two trusts, involving three hospital locations (Cardiff, Llandough & Macclesfield). Cleaning has been studied on 12 resilient flooring materials that are commonly used in hospital buildings. The slip resistance of the floor in wet conditions ranged from a Pendulum Test Value (PTV) of 12 (high slip potential) to a PTV of 50 (low slip potential).

The improvement in cleanliness varied across the different areas and across the different types of flooring. There was no systematic trend that could be linked to the type of flooring tested, and other factors are likely to have influenced the contamination levels identified. This would suggest that the cleaning methods used, and their execution leads to some variability, and that this has greater influence on overall contamination levels than any variability due to flooring type.

HSL scientists have found that some methods detect some groups of microorganisms far better than others, particularly those methods reliant on measuring a particular marker such as ATP. The physiological status of bacteria varies dramatically, and is dependent on the type of microorganism present, on associated nutrient status and levels of moisture. The presence of tough spore structure can allow microbial persistence even in dryer conditions, whereas more active vegetative cells are normally associated with raised moisture levels. Some biocidal products can also inhibit ATP production as part of their effect to kill bugs, and this may be relevant here (Dinning 1998 & Fairbanks 1984).

Whereas the contact plates will tend to pick up a majority of viable bacteria (i.e. as long as they are species capable of agar growth), the ATP test is a measurement of a physiological marker for the organisms. The exact nature of how the ATP swabs are processed is uncertain, but ATP levels can vary in bacterial cells, e.g. they may be reduced in spores or cells that have been dormant / dried out for some time in dusts etc, which can mean that little ATP may be present and an underestimate could potentially result (Hansen et al. 2004). These same cells (with low ATP) may still be viable and eventually grow well on agar, so this is may generate an under-representation with a biochemical test such as ATP. ATP methods have developed significantly over the last couple of decades, but no method is infallible, and different brands of test may also influence outcome.

ATP testing was developed within the food industry, where contaminating organisms are often associated with high levels of nutrients and moisture (dirty cloths and soiled food preparation surfaces), so those bugs would tend to have a high energy status and correspondingly high levels of cellular ATP to measure within their cells. This is not often the case for bacteria harboured on essentially dry, dusty floor surfaces that may actually be free of organic deposits (hence the low ATP levels that may be present in floor-based bacteria).

Where there is a reasonable agreement between the viable bacterial counts and the ATP measurement it is likely that the microorganisms present were recently deposited from their source material, and so present in a reasonable nutrient state. Such organisms would normally grow well on agar plates and would also be likely to have detectable ATP levels.

The different cleaning methods employed produced differing levels of cleanliness. As might be reasonably expected, the acti-chlor and haz-tabs chemicals were more effective than the general purpose cleaner, in terms of reduced level of bacteria following cleaning (see figure 5.8). Both of these products contain hypochlorite components, and this active agent is known to be highly effective against even the most robust microorganisms.

### **6.3 SEALANTS & MAINTENANCE**

The project was undertaken to establish whether, and to what extent, sealants have an impact on the slip resistance and infection control properties of flooring. As none of the hospitals taking part in the study use sealants, this aspect was not studied. However, given the lack of influence of the flooring on the ability to clean to a hygienic standard, it seems unlikely that sealers are either necessary or influential in this respect.

Although the drying time would not be of concern from a hygiene point of view, it is important from a safety perspective. There are many variables that determine the drying times of flooring, for example floor temperature, air temperature, humidity, mop type, amount of water deposited etc. It was therefore agreed that drying times would not be considered as they were beyond the scope of this project.

### **6.4 HOSPITAL ACTIVITY**

Flooring was identified in a range of operational areas, including treatment rooms and operating theatres. The type of floor used in such areas does not seem to be consistent or determined by the use of the area, as similar areas had quite different flooring. One of the operating theatres was fitted with smooth vinyl tiles, which may seem to offer an easy clean surface, but in fact have numerous joints which are likely to harbour bacteria and other contamination. Given that the results do not show an influence of the slip resistance of flooring on the hygienic cleaning of the floor, the use of safety flooring in operational areas could be considered.

The level of contamination remaining after cleaning was variable. There are numerous possible reasons for this, which should be studied in greater detail. There is a lack of research using regular hospital cleaning staff and practices, which could be a key to furthering the understanding of hygiene control. The importance of human factors in undertaking cleaning should not be underestimated.

## **6.5 ALTERNATIVE METHODS OF CLEANING**

Three methods of cleaning were employed, as per the cleaning manual (NPSA, 2009). The Ecolab haz-tab system which uses a dosed tablet of cleaning chemical which is dissolved into a measured quantity of water. Mop heads are placed in the bath of cleaning solution to soak. The heads are then fitted to a mop handle and used to clean an area of flooring. When the head is finished with, it is removed and a freshly soaked head is used to replace it. There is some uncertainty as to how much floor can be cleaned with one mop head. The second technique employed was to use a dolly mop, with a general purpose (detergent) cleaning solution. This is not pre-dosed, so may tend to be of a more variable concentration. The dolly mop is intended for use in areas with c-dif contamination, as c-dif cannot be effectively removed from the microfibre mops during the laundry cycle. Finally, where contamination is more likely to be found, or where it would have a more detrimental effect on patients, the Acti-chlor system is used with a microfibre mop.

At the two hospitals in Wales, the three systems were in use in the test areas. The results do not show a difference in bacteria levels after cleaning due to the type of flooring being cleaned. The results do show significant variation in the cleanliness of the floor after cleaning due to other factors. The data presented in figure 5.8 suggests that the Acti-chlor and haz-tabs cleaning chemicals are more effective than the general purpose cleaner. This would have been expected from the previous research discussed in the literature review, which showed that a combination of detergent and disinfectant was more effective than either chemical alone.

## 7 CONCLUSION

The slip resistance of the floor covering was not a determining factor in the ability to clean the floor to a hygienic standard using conventional cleaning regimes. Therefore, the cleanability of the flooring should not be a barrier to the use of slip resistant flooring in foreseeably wet or contaminated work areas in hospitals.

The cleaning regimes set out in the Cleaning Manual, and undertaken by the hospitals regular cleaners, were effective at cleaning each type of flooring, regardless of their material type.

There was variation in the level of contamination present after cleaning, which may be due to numerous factors associated with cleaning technique, cleaning reagents and tools used. These variables were beyond the scope of this study.

The agreement between the contact plate method and the ATP Bioluminescence method was not good across all of the test sites. It was therefore concluded the ATP method would be of limited use for assessment of floor cleanliness in the hospital setting, and that the simpler contact plate method has more application within this context.

## 8 REFERENCES

“The Workplace (Health, Safety and Welfare) Regulations 1992”, <http://www.legislation.gov.uk/uksi/1992/3004/contents/made>

The National Patient Safety Agency. (2007). “The national specifications for cleanliness in the NHS: a framework for setting and measuring performance outcomes.” <http://www.npsa.nhs.uk/nrls/improvingpatientsafety/cleaning-and-nutrition/national-specifications-of-cleanliness/>

Fox, D. “Slip and trip workshops for NHS staff; A survey and case study evaluation”, HSE Research Report RR731, 2009, <http://www.hse.gov.uk/research/rrpdf/rr731.pdf>

Andersen, B.M., Rasch, M., Kvist, J., Tollefsen, T., Lukkassen, R., Sandvik, L. and Welo, A., “Floor cleaning: effect on bacteria and organic materials in hospital rooms”, *Journal of Hospital Infection*: 71: 57-65, 2009.

De Lorenzi, S., Finzi, G., Parmiggiani, R., Cugini, P., Cacciari, P. and Salvatorelli, G., “Comparison of floor sanitation methods”, *Journal of Hospital Infection*: 62: 346-348, 2006.

Deo, A.A., Kulkarni, A.S. and Meshram, S.U., “Monocationic surfactant induced ultra structural changes in antibiotic resistant”, *Escherichia coli*, *Indian Journal of Medical Research*: 131(6): 825-828, 2010.

Department of Health, “Revised guidance on contracting for cleaning”, 2004a.

Department of Health, “A matron’s charter: an action plan for cleaner hospitals”, 2004b

Department of Health, “Standards for better health”, 2006a

Department of Health, “Health Technical Memorandum 61”, 2006b

Department of Health., “An integrated approach to hospital cleaning: microfibre cloth and steam cleaning technology”, 2007.

Department of Health, “Health and Social Care Act 2008: the Code of Practice for the Prevention and Control of Healthcare Associated Infections (the ‘Code of Practice’), Updated 2009.

Dharan, S., Mourouga, P., Copin, P., Bessmer, G, Tschanz, B. and Pittet, D., “Routine disinfection of patients’ environmental surfaces. Myth or reality?”, *Journal of Hospital Infection*: 42: 113-117, 1999.

Frabetti, A., Vandini, A., Balboni, P., Triolo, F. and Mazzacane, S., “Experimental evaluation of the efficacy of sanitation procedures in operating rooms”, *American Journal of Infection Control*: 37: 658-664, 2009.

Hall, L.B. and Hartnett, M.J., “Measurement of the bacterial contamination on surfaces in hospitals”, *Public Health Reports*: 79(11):1021-1024, 1964.

Health & Safety Executive, “Slips and trips: The importance of floor cleaning”, HSE information sheet, Slips and Trips 2, 2005.

Hignett, S. and Masud, T., 2006, "A review of environmental hazards associated with in patient falls", *Ergonomics*, 49: 5, p. 605 – 616.

Kravitz, R., "Evolutionary tale. A look at different floor cleaning methods", *Health Facilities Management*: 17(11): 35-36, 2004.

Lankford, M.G., Collins, S, Youngberg, L., Rooney, D.M., Warren, J.R. and Noskin, G.A., "Assessment of materials commonly utilized in health care: Implications for bacterial survival and transmission", *American Journal of Infection Control*: 34: 258-263, 2006.

Rutala, W.A. and Weber, D.J., "Surface disinfection: should we do it?", *Journal of Hospital Infection*: 48 (Supplement A): S64-S68, 2001.

Shaw, R., Drever, F., Hughes, H, Osborn, S. and Williams, S. 2005, "Adverse events and near miss reporting in the NHS", *Quality and Safety In Health Care*, 14, p.279 – 283.

The National Patient Safety Agency, "The national specifications for cleanliness in the NHS: a framework for setting and measuring performance outcomes", 2007a

The National Patient Safety Agency, "Colour coding hospital cleaning materials and equipment: Safer practice notice 15", 2007b

The National Patient Safety Agency, "Revised Healthcare Cleaning Manual", 2009

Verity, P., Wilcox, M.H., Fawley, W. and Parnell, P., "Prospective evaluation of environmental contamination by *Clostridium difficile* in isolation side rooms", *Journal of Hospital Infection*: 49: 204-209, 2001.

Wilcox, M.H., Fawley, W.N., Wigglesworth N., Parnell, P., Verity, P. and Freeman, J., "Comparison of the effect of detergent versus hypochlorite cleaning on environmental contamination and incidence of *Clostridium difficile* infection", *Journal of Hospital Infection*: 54: 109-114, 2003.

Willis, C., Morley, R., Westbury, J., Greenwood, M. and Pallett, A., "Evaluation of ATP bioluminescence swabbing as a monitoring and training tool for effective hospital cleaning", *British Journal of Infection Control*: 8(5):17-21, 2007.

White, L.F., Dancer, S.J. and Roberston, C., "A microbiological evaluation of hospital cleaning methods", *International Journal of Environmental Health Research*: 17(4): 285-295, 2007.

World Health Organization, Department of Communicable Disease, Surveillance and Response. WHO/CDS/CSR/EPH/2002.12., "Prevention of hospital-acquired infections. A practical guide". 2nd edition, 2002.

Wren, M.W.D., Rollins, M.S.M., Jeanes, A., Hall, T.J., Coën., P.G. and Gant, V.A., "Removing bacteria from hospital surfaces: a laboratory comparison of ultramicrofibre and standard cloths", *Journal of Hospital Infection*: 70: 265-271, 2008.

United Kingdom Slip Resistance Group "United Kingdom Slip Resistance Group Guidelines", Issue 3, 2005,

Dinning, Al-Adham, Eastwood, Austin, Collier, "Pyrrithione biocides as inhibitors of bacterial ATP synthesis", *Journal of Applied Microbiology*, Volume 85, Issue 1, pages 141–146, July 1998

Fairbanks B.C., Woods L.E, Bryant R.J., Elliott E.T., Cole C.V. and Coleman D.C., "Limitations of ATP estimates of microbial biomass" *Soil Biology and Biochemistry*, Volume 16, Issue 6, 1984, Pages 549-558

Hansen D., Benner D., Hilgenhaener M., Leisebein T., Brauksiepe A & Popp W. "ATP measurement as method to monitor the quality of reprocessing flexible endoscopes" *German Medical Science* 2004;2

## 9 BIBLIOGRAPHY

Hallas K., Houlihan R., Shaw R., Thorpe S., “Comparison Of Site-Based Friction Measurement And Slip Potential” Contemporary Ergonomics, 2008, Taylor & Francis

Shaw R., Hallas K., Lemon P., Thorpe S., “Floor Cleaning – Drop that mop!” Contemporary Ergonomics, 2005, Taylor & Francis

Hallas K., Shaw R. “The Efficacy of Cleaning Regimes” HSL/2005/26, HSE, [http://www.hse.gov.uk/research/hsl\\_pdf/2005/hsl0526.pdf](http://www.hse.gov.uk/research/hsl_pdf/2005/hsl0526.pdf)

## 10      APPENDIX 1: SLIP RESISTANCE TEST DATA

### Llandough Hospital

**Test Area 1:** Medical Emergency Assessment Unit. Crash Room 1

**Flooring type:** Standard vinyl

**Rz Surface Microroughness:** 5.7 µm

**Pendulum Test Values:**

Slider	Condition	Contamination	Test Direction	PTV	Slip Potential
96	As Found	Dry	1	72	Low
96	As Found	Dry	2	72	Low
96	As Found	Dry	3	75	Low
96	As Found	Water-wet	1	19	High
96	As Found	Water-wet	2	17	High
96	As Found	Water-wet	3	17	high

**Test Area 2:** Medical Emergency Assessment Unit. Exam Room 4

**Flooring type:** Green safety vinyl

**Rz Surface Microroughness:** 39.7 µm

**Pendulum Test Values:**

Slider	Condition	Contamination	Test Direction	PTV	Slip Potential
96	As Found	Dry	1	66	Low
96	As Found	Dry	2	67	Low
96	As Found	Dry	3	65	Low
96	As Found	Water-wet	1	50	Low
96	As Found	Water-wet	2	53	Low
96	As Found	Water-wet	3	52	Low

**Test Area 3:** Medical Emergency Assessment Unit. Corridor adjacent to Exam Room 4

**Flooring type:** Grey safety vinyl

**Rz Surface Microroughness:** 24.2 µm

**Pendulum Test Values:**

Slider	Condition	Contamination	Test Direction	PTV	Slip Potential
96	As Found	Dry	1	63	Low
96	As Found	Dry	2	62	Low
96	As Found	Dry	3	63	Low
96	As Found	Water-wet	1	29	Moderate
96	As Found	Water-wet	2	30	Moderate
96	As Found	Water-wet	3	32	Moderate

**Test Area 4:** Medical Emergency Assessment Unit. Ward East 4, Corridor.

**Flooring type:** White vinyl

**Rz Surface Microroughness:** 10.8 µm

**Pendulum Test Values:**

Slider	Condition	Contamination	Test Direction	PTV	Slip Potential
96	As Found	Dry	1	67	Low
96	As Found	Dry	2	70	Low
96	As Found	Dry	3	68	Low
96	As Found	Water-wet	1	26	Moderate
96	As Found	Water-wet	2	22	High
96	As Found	Water-wet	3	24	High

**Test Area 5:** Medical Emergency Assessment Unit. Ward East 4. Male wet room and toilet

**Flooring type:** Green safety vinyl

**Rz Surface Microroughness:** 29.0 µm

**Pendulum Test Values:**

Slider	Condition	Contamination	Test Direction	PTV	Slip Potential
96	As Found	Dry	1	63	Low
96	As Found	Dry	2	60	Low
96	As Found	Dry	3	64	Low
96	As Found	Water-wet	1	44	Low
96	As Found	Water-wet	2	42	Low
96	As Found	Water-wet	3	42	Low

### University Hospital Wales

**Test Area 6:** Consultant Led Maternity Unit, Operating Theatre 1 (Rm 2F487)

**Flooring type:** 0.5m vinyl tiles

**Rz Surface Microroughness:** 5.1 µm

**Pendulum Test Values:**

Slider	Condition	Contamination	Test Direction	PTV	Slip Potential
96	As Found	Dry	1	77	Low
96	As Found	Dry	2	74	Low
96	As Found	Dry	3	75	Low
96	As Found	Water-wet	1	17	High
96	As Found	Water-wet	2	12	High
96	As Found	Water-wet	3	18	High

**Test Area 7:** Consultant Led Maternity Unit, Birthing Pool Room (Rm 2F494)

**Flooring type:** Grey safety vinyl

**Rz Surface Microroughness:** 26.1 µm

**Pendulum Test Values:**

Slider	Condition	Contamination	Test Direction	PTV	Slip Potential
96	As Found	Dry	1	60	Low
96	As Found	Dry	2	59	Low
96	As Found	Dry	3	59	Low
96	As Found	Water-wet	1	29	Moderate
96	As Found	Water-wet	2	32	Moderate
96	As Found	Water-wet	3	32	Moderate

**Test Area 8:** Consultant Led Maternity Unit, corridor adjacent to Pool Room

**Flooring type:** Smooth vinyl

**Rz Surface Microroughness:** 4.7 µm

**Pendulum Test Values:**

Slider	Condition	Contamination	Test Direction	PTV	Slip Potential
96	As Found	Dry	1	61	Low
96	As Found	Dry	2	68	Low
96	As Found	Dry	3	66	Low
96	As Found	Water-wet	1	16	High
96	As Found	Water-wet	2	15	High
96	As Found	Water-wet	3	14	High

**Test Area 9:** Midwife led Delivery Suite. Kitchenette

**Flooring type:** Yellow safety vinyl

**Rz Surface Microroughness:** 16.9 µm

**Pendulum Test Values:**

Slider	Condition	Contamination	Test Direction	PTV	Slip Potential
96	As Found	Dry	1	64	Low
96	As Found	Dry	2	64	Low
96	As Found	Dry	3	65	Low
96	As Found	Water-wet	1	34	Moderate
96	As Found	Water-wet	2	36	Moderate
96	As Found	Water-wet	3	31	Moderate

**Note:**

Midwife led Delivery Suite has a birthing pool room with same flooring as consultant led maternity unit pool room, and the corridors in the midwife led unit are the same material as the consultant led unit.

# 11 APPENDIX 2: COMPLETE ATP VS AGAR CHARTS

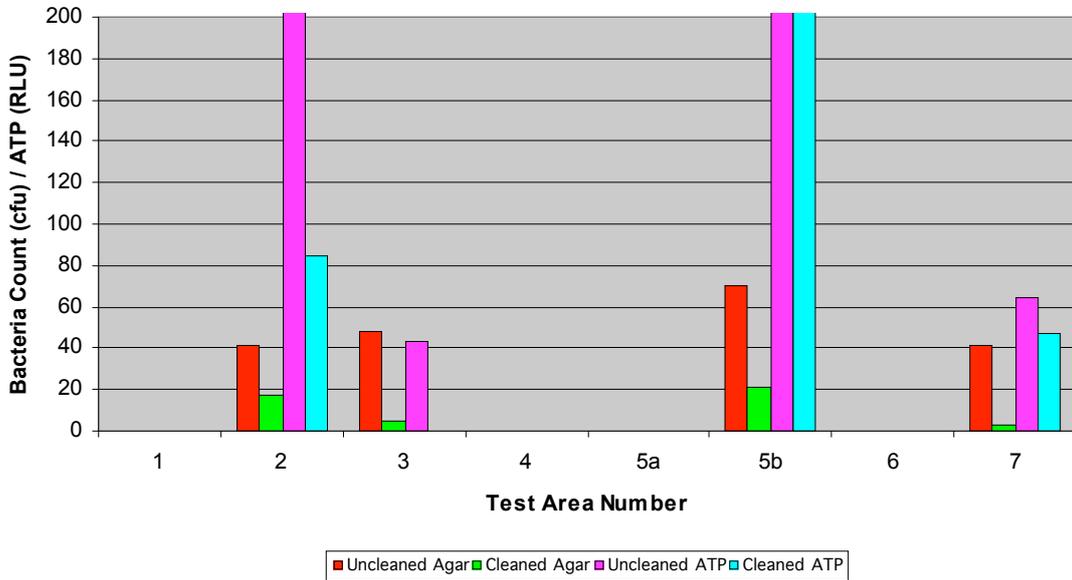


Figure 11.1. Cardiff & Vale NHS Trust, Uncleaned vs Cleaned, Bacteria Count (cfu) & ATP (RLU) by Area, Week 1

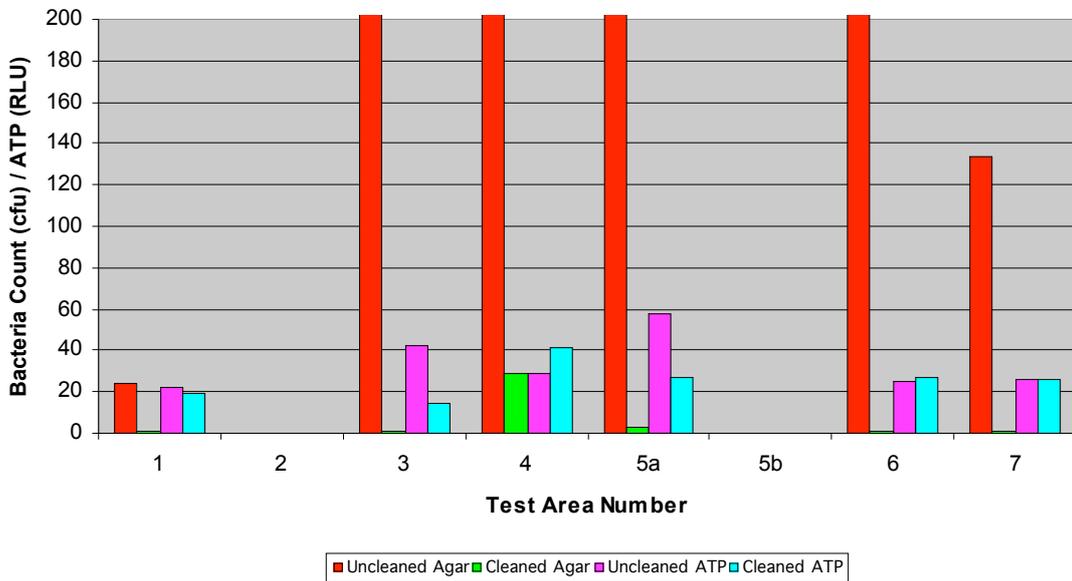


Figure 11.2. Cardiff & Vale NHS Trust, Uncleaned vs Cleaned, Bacteria Count (cfu) & ATP (RLU) by Area, Week 2

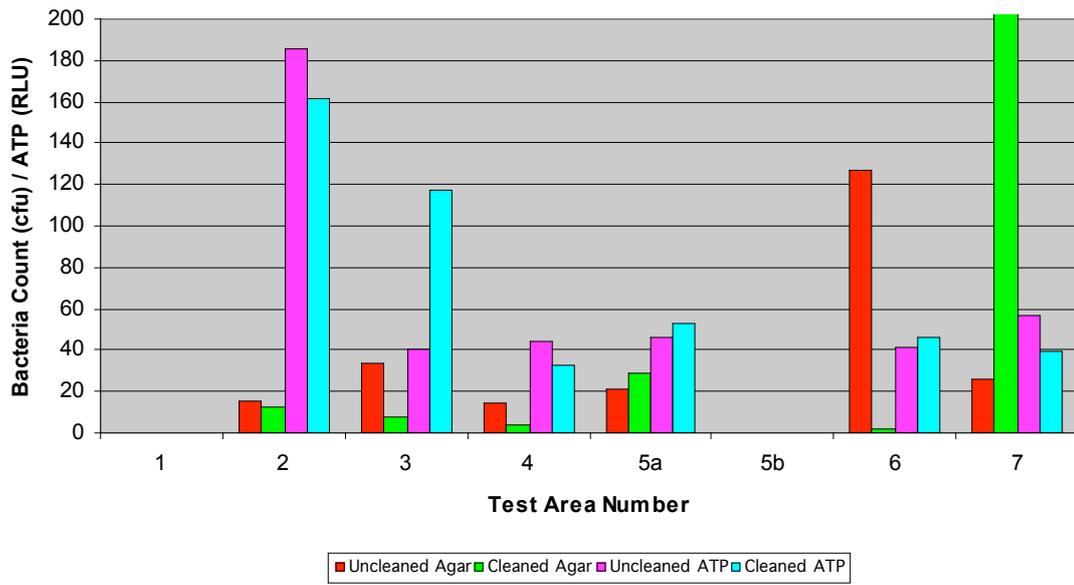


Figure 11.3. Cardiff & Vale NHS Trust, Uncleaned vs Cleaned, Bacteria Count (cfu) & ATP (RLU) by Area, Week 3

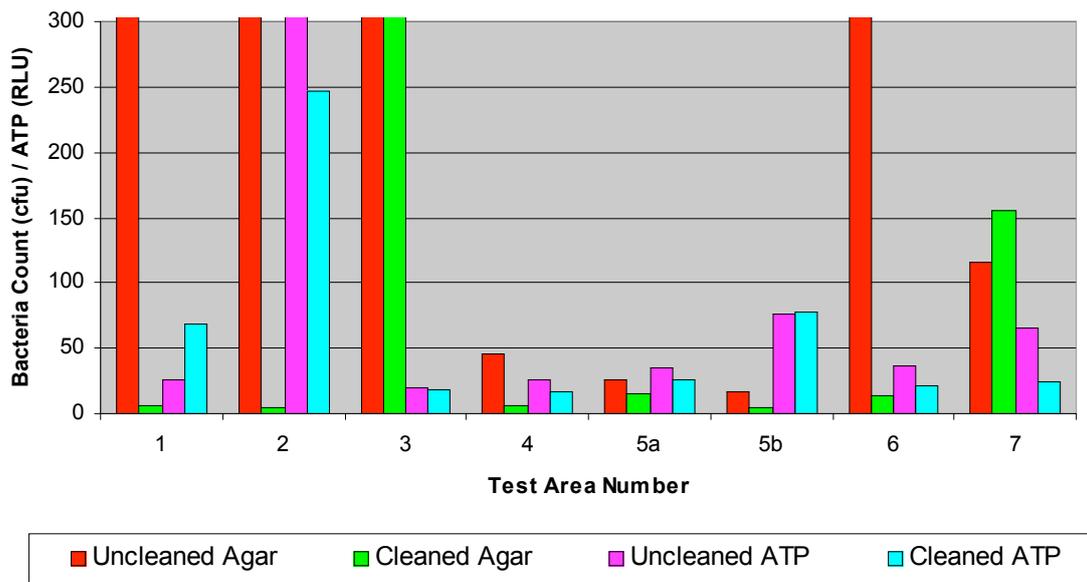


Figure 11.4. Cardiff & Vale NHS Trust, Uncleaned vs Cleaned, Bacteria Count (cfu) & ATP (RLU) by Area, Week 4







# Investigation of slip resistance and the hygienic cleaning of floors in hospital settings

Slip and trip accidents in the healthcare sector continue to be a cause for concern. Over 50% of RIDDOR reported major injuries in this sector are related to slips, trips and falls, both to staff and to patients. These accidents often result in serious injury and due to the vulnerability of the client group, in some cases have contributed to fatalities. Such accidents also result in significant cost to the NHS as a result of lost time, additional care requirements and financial claims by those suffering injury. The selection of suitable flooring is an important factor in the prevention of slips, as required by the Workplace (Health, Safety and Welfare) Regulations 1992.

As such, where the floor will get wet or contaminated in normal use, the floor should not be slippery. Increased slip resistance of floor coverings can control the slip risk in some hospital environments, especially areas likely to become wet or subject to other surface contamination. However, there continues to be inconsistency in floor specifications in hospitals with the selection of smooth floors in many areas being common practice. NHS Trusts have raised concerns about the potential for the texture of slip resistant surfaces to adversely affect hygienic cleaning of floors, resulting in increased infection risk. The current research was carried out to compare the levels of bacterial contamination remaining after cleaning, for floors with a range of slip resistance.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.