



Containing the burden of infectious diseases is everyone's responsibility

A call for an integrated strategy for developing and promoting
hygiene behaviour change in home and everyday life

"Every infection prevented means fewer antibiotics used"

A report commissioned by the International Scientific Forum on Home Hygiene
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The issues outlined in this paper were discussed by a group of experts in home and everyday life hygiene, at a meeting in London in March 2017. The meeting was held at the Royal Society of Public Health, London and was hosted by the International Scientific Forum on Home Hygiene. At this meeting it was agreed to prepare a consensus white paper summarising the issues which were discussed and outlining recommendation for change.

This report can be downloaded from:

<https://www.ifh-homehygiene.org/review/containing-burden-infectious-diseases-everyones-responsibility-call-integrated-strategy>

The International Scientific Forum on Home Hygiene is a not-for profit, non government organisation which was established in 1998, and is working to develop and promote hygiene in home and every day life based on sound scientific evidence (www.ifh-homehygiene.org)



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FOREWORD

Across the world, health agencies recognize the profound impact of infectious disease on health and prosperity. Equally, they recognize that prevention is central to fighting infection, and that hygiene in home and everyday life (HEDL) is a key part of this. A current driver is the part that hygieneⁱ plays in tackling antibiotic resistance, but it also reflects growing numbers of people at greater risk of infection being cared for in the community. Sustaining the quality of state-funded healthcare requires that the public take greater responsibility for their own health, including protecting themselves and their families against infection. Hygiene must be everyone's responsibility.

However, if we are to be successful in promoting hygiene as part of public health, there are barriers which need to be overcome. A key issue is the need to balance evidence of the health benefits of hygiene against possible risks, such as environmental impacts and toxicity issues. Another issue is the role of microbes in human health and whether we have become "too clean". Lack of a unified voice advocating for hygiene means these issues have tended to take precedence. Another barrier to change is public confusion about the need for hygiene and the difference between hygiene and cleanliness. To address this, we must work together to provide the public with a clear, consistent restatement of the importance of hygiene, and to change public perceptions about hygiene and good hygiene practice.

This paper is unique because it examines these issues in an integrated manner and focuses on making achievable, constructive recommendations for developing an effective and sustainable approach. The paper lays out a risk management strategy for hygiene in home and everyday life which gives hygiene appropriate priority within the context of environmental and other health concerns. This "targeted hygiene" approach needs to be placed at the heart of a multimodal prevention strategy, alongside vaccination and other interventions.

Based on the findings of this paper, we issue a call to action to national and international policy makers, health agencies and health professionals to recognize the need for an integrated, family-centredⁱⁱ approach to hygiene, and provide effective leadership to achieve this. This paper shows that many of the components of a behaviour change strategy are already in place, but need to be integrated rather than developed independently.

We also issue a call to scientists, health professionals, environmental and regulatory agencies, immunologists, microbiologists, the private sector (hygiene appliance and product manufacturers) and the media to work together, through innovative research and communication policies. A collaborative effort is vital if we are to overcome barriers to change and action integrated behaviour change programmes that really work.

The report represents the consensus views of an international, interdisciplinary group of experts in the field of infection prevention and hygiene. We recognise that this paper leaves many questions unanswered and would welcome further dialogue with stakeholders on how to develop policy. The aim of this paper is to provide a sound basis for such dialogue. At the 2016 launch of the European Human Biomonitoring Initiative, the EU commissioner for food safety said the followingⁱⁱⁱ which encapsulates the aim of this report.

"We must collectively recognise that risk and uncertainty are part and parcel of every decision we take. We need to engage people in a serious and rational debate. But in this world of information overload – from old media and new – information, misinformation, opinions, prejudices, truths, half-truths and un-truths all compete for public attention. We need better communication of science so that people can be better informed about risk assessment and management decisions"

i In this paper the term hygiene is used to refer to practices used to prevent spread of infectious diseases

ii The term "family-centred" is used in this report, to denote any type of social grouping living within a "household"

iii https://ec.europa.eu/commission/commissioners/2014-2019/andriukaitis/announcements/launch-european-human-biomonitoring-initiative-brussels-8-december-2016_en

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INTRODUCTION

This report sets out the issues that need to be addressed and the actions which need to be taken to achieve hygiene behaviour change in home and everyday life (HEDL).

In this report we aim:

- To show why hygiene in home and everyday life is an important health issue.
- To provide an overview of the issues shaping attitudes and policies for development of hygiene and promoting hygiene behaviour change in home and everyday life.
- To show why investment in hygiene promotion needs to be more focused and why it must be combined with strategies to overcome barriers to change.
- To set out a framework for a more effective approach to hygiene in HEDL.
- To make recommendations on research and communication strategies required to meet the challenge of “making hygiene everyone’s responsibility and aspiration, as part of healthy living”.

Section 1 is a summary of the key findings and recommendations of this report.

Section 2 outlines the evidence base for the findings and recommendations in section 1.

Section 3 lays out a risk-based strategy for effective hygiene in home and everyday life.

In Section 4 the recommendations for action set out in section 1 are examined in more detail.

Our ultimate aim is to engage our target audience in formulating an integrated strategy for achieving hygiene behavior change in HEDL in order to reduce the burden of infectious disease and tackle antibiotic resistance.

Who should read this report?

National and international health policy makers, health agencies and health professionals (Community medical practitioners (GPs) and carers, pharmacists etc,) responsible for development of infection prevention strategies in the community as a means to reduce the burden of infectious diseases and tackle antibiotic resistance.

Stakeholders in hygiene in home and everyday life including scientists, health professionals (particularly infection prevention and control professionals), environmental agencies, regulatory agencies, immunologists, allergists, microbiologists, etc., the private sector (domestic hygiene appliance and hygiene product manufacturers), consumer organisations, the media and other communicators of public health.

Scope of the report

This paper is written from the perspective of “westernized” models of domestic and everyday living, where water and sanitation is mostly adequate to good. It also addresses problems associated with social and health inequalities within these communities. Addressing hygiene issues in relation to populations living in low income communities in developing countries is outside the remit of this paper. This is not because they are not relevant to developing countries, but because, for these communities, improving water, sanitation and handwashing are current priorities, likely to yield the biggest reductions in hygiene-related disease, and are being addressed as part of the 2015 sustainable development goals.¹

SECTION 1. Setting out the issues – proposing solutions

Section 1 sets out the 4 key issues which we believe need to be addressed in order to achieve our stated goal of achieving hygiene behaviour change in home and everyday life (HEDL) in order to reduce the burden of infectious disease and tackle antibiotic resistance. It also *identifies strategies needed to address each of these issues*. The evidence base underlying the following points is set out in section 2.

Issue 1: Hygiene in home and everyday life - the need for an integrated approach

- Changes in recent years mean that infection prevention through hygiene in HEDL is becoming increasingly important. It is only when the contributory factors are viewed together, as in sections 2.1-2.3, that the extent of the hygiene-related disease burden is apparent. In particular, hygiene in HEDL is now being seen as an important part of the strategy to tackle antibiotic resistance. In the future, sustaining the quality of state-funded healthcare will require the public to take greater responsibility for their own health, including protecting themselves and their families against infection. Since hygiene habits formed during childhood persist into professional lives, parental and school hygiene education also underpin the training of health professionals, food handlers, etc.

The report concludes that national and international health policy makers, health agencies and health professionals need to give greater recognition to the importance of, and cost-saving implications of hygiene in HEDL. Change requires effective leadership to develop an integrated approach which addresses hygiene from the point of view of the “family unit” and the range of interdependent hygiene issues which they have to deal with (food hygiene, respiratory hygiene, hygiene associated with using the toilet or nappies, healthcare etc.). Current investment in hygiene promotion, as summarized in Appendix 1, provides a platform from which to make significant progress, but strategies need to be integrated rather than developed independently by different agencies.

Issue 2: Barriers to change – the need for a balanced approach.

In developing and promoting HEDL hygiene, a number of issues that represent a barrier to change need to be overcome if hygiene promotion is to succeed:

- Development of microbiome^{iv} science is demanding a fundamental rethink of our relationship with our microbial world. Whilst we have long understood that microbes cause infectious diseases, we now see the extent to which microbe: human interactions are essential for our health. It is now clear that diverse exposure to human, animal and natural environments, particularly in early life, are key to building a healthy microbiota. Failure to maintain a diverse microbiota is associated with an increasing range of diseases including allergic and autoimmune diseases (multiple sclerosis, type 1 diabetes, inflammatory bowel disease, etc.), which have risen dramatically in the last 50 years. It is believed that underlying causes of reduced microbial exposure are lifestyle changes such as caesarean section rather than natural childbirth, bottle rather than breast feeding, less sibling interaction, less time outdoors, excessive antibiotic use and altered diet. This realisation has fundamental consequences for hygiene because it poses the question “how can we develop lifestyles which sustain exposure to the right sort of microbes, whilst at the same time protecting against those that cause disease?” Unfortunately, the flawed simplistic 1989 hygiene hypothesis proposing a link between “too much hygiene and cleanliness” and the rise in allergic diseases is still being promoted by the media, and some experts, as a key underlying cause despite lack of evidence to support this. This is undermining public confidence in hygiene and strategies to improve hygiene behaviour. For example, it includes advice to consumers to avoid fundamental hygiene practices, such as handwashing.

iv Microbiome is the collective term for the microbiota (bacteria, fungi, viruses etc) and their genes which inhabit our environment and the human and animal gut, respiratory tract, skin, etc.

- In developing HEDL hygiene, it is important to ensure that the practices used for hygienic cleaning of hands, surfaces and fabrics are effective in reducing microbial contamination to safe levels, whilst at the same time ensuring sustainable use of resources (water, detergents, soaps, mechanical action, and sometimes heat or microbiocides). It is important to assess environmental and safety issues, and take account of concerns about possible links between use of microbiocidal products (disinfectants, antibacterials, sanitizers) and the rise in antibiotic resistance. Particularly in Northern Europe, whilst concerns about the environmental impact of hygiene products are strongly voiced, there is a tendency to down play the importance and well established benefits of hygiene. For example, whilst home laundering at lower temperatures provides the means to conserve energy, it is also associated with reduced hygiene efficacy. Also, although hygiene can in many cases be achieved by use of detergents and water, there are other situations where a disinfectant or hand sanitizer is needed. One of the problems is the lack of a strong unified voice lobbying on behalf of the importance of HEDL hygiene. What is needed is a more balanced approach where preventing infection is regarded as an equally important sustainability issue as environmental considerations.

The report concludes that scientists and health professionals with expert knowledge of the science and practice of HEDL hygiene need to agree a consensus evidence-based opinion, and work with other hygiene stakeholders such as allergists, environmentalists and regulators to ensure a balanced approach, where the importance of hygiene is given due recognition, and is focussed on maximizing protection against infection whilst also addressing other issues.

Issue 3: Changing public understanding and behaviour - what needs to be done?

In recent years, widespread misunderstanding about hygiene has developed, which is undermining efforts to promote behaviour change. Three issues need to be addressed:

- Lack of public understanding of hygiene - Hygiene is still largely seen as synonymous with cleanliness aimed at eradicating dirt – inappropriately regarded as the main source of harmful microbes. Consumers fail to understand that although cleaning is a means of achieving hygiene, visual cleanliness does not necessarily mean “microbiologically safe”. Some people are sceptical about the need for hygiene in our modern world, whilst others have extreme fear of invisible microbes. Because hygiene communications to the public are being developed independently, by different stakeholders without reference to a common strategy, advice is sometimes conflicting causing further confusion. This is compounded by ongoing messaging that “too much hygiene and cleanliness” is the underlying cause of rising allergies, etc. Educating influencers and policy makers, as well as the public is needed to ensure that public-facing advice is based on sound science rather than long held beliefs.
- Misunderstandings about germs – Using the term “germs” in a sinister way to arouse fear is counterproductive because it is no longer credible, particularly to health professionals who advise the public. In this outdated model, potentially harmful microbes and high risk situations are not properly differentiated from microbes and situations where there may be high levels of microbes that pose little risk. The public are confused and mistrustful of what they hear from the media and other sources. Promotion of hygiene through promoting germ or microbe fear has resulted in scepticism about the need for hygiene.
- Consumer concerns about hygiene issues - Messaging about hygiene practices and the need to conserve energy and water (e.g. low temperature laundering), together with messaging about environmental and human health impacts of hygiene products, particularly microbiocidal products, has made consumers increasingly concerned. Faced with these issues, and having become sceptical about “germ risks”, they increasingly reject established hygiene practices, thereby increasing their risk of infection, and fuelling demand for antibiotics. It could be argued that, if targeted use of microbiocidal products contributes to reducing infection risks, it could actually contribute to decreasing the need for antibiotics, which is a key part of tackling antibiotic resistance.

The extent to which misunderstanding about hygiene has occurred suggests that change is unlikely to happen unless we also work to change hygiene perceptions.

The report concludes that, to restore confidence in hygiene and achieve hygiene behaviour change, hygiene stakeholders need to work collaboratively with those who communicate directly with the public including community workers, the media and the private sector to ensure consistent and responsible messaging and advertising about hygiene practices and products. Consumers need clear restatement of the importance of hygiene and a simple, plausible targeted approach to hygiene based on breaking the chain of infection transmission, which replaces current simplistic notions of achieving hygiene through home cleanliness and germ elimination.

Issue 4: Targeted hygiene – the need for a strong evidence base for HEDL hygiene.

Improving consumer hygiene can only be achieved if it is underpinned by a strong evidence base which demonstrates the health benefits of HEDL hygiene. This is required not only to maximise protection from infection, but also to:

- argue the case for a balanced approach with opinion formers, health professionals, environmentalists, immunologists, regulatory authorities, etc.
- provide a plausible approach which restores public confidence in hygiene.

Section 3 outlines an evidence-based multimodal approach to HEDL hygiene based on risk management called “targeted hygiene”. It focuses on the simple plausible concept of breaking the chain of infection in situations where there is significant risk. It also includes a framework for developing effective hygiene practices, including hand hygiene, surface hygiene, laundering practices, etc. to break the chain of infection. Although risk assessment in HEDL is well supported by scientific data, we need a more robust evidence base for developing processes and products which deliver targeted hygiene and is applicable to detergent-based and other hygiene procedures, as well as those involving microbicides.

The report concludes that “targeted hygiene” needs to be placed at the heart of a multimodal infection prevention strategy, alongside vaccination and other interventions. The scientific framework for delivering effective targeted hygiene needs strengthening through collaborative research by academia and the private sector.

SECTION 2. The evidence base

This section sets out the evidence base showing why hygiene in home and everyday life (HEDL) is important, what the issues are which are shaping attitudes and policies on development and promotion of hygiene, and why they need to be addressed.

2.1. Historical perspective

In 1962, Nobel Prize winner Frank Macfarlane Burne wrote “To write about infectious disease is almost to write of something that has passed into history”. Around the same time, the US Surgeon General is alleged to have said “it is time to close the book on infectious diseases, declare the war against pestilence won, and shift national resources to such chronic problems as cancer and heart disease”. In 2018 such statements seem truly astounding, but reflect the ground swell of opinion at that time which heralded declining investment on infectious disease issues and public hygiene education during the latter half of the C20th. The belief, at that time, that we could rely on vaccines and antibiotics until freedom from infectious disease was attained, and that teaching our children about hygiene was no longer important, is hard to comprehend.²

2.2. Current perspective – the impact of hygiene-related infectious disease on health and prosperity

Across the world, health agencies recognise the profound impact of infectious disease on health and prosperity, and the need for investment, with particular emphasis on infection prevention strategies such as vaccines and hygiene.^{3,4,5,6} Growing concern about infectious disease is indicated by establishment of the European Centre for Disease Prevention and Control (ECDC) in 2005 (Note 1). Added to this, tackling antibiotic resistance is now a global priority⁷ where hygiene plays a vital role.

Since the 1980s, investment in infection prevention has focussed largely on hospital, institutional and manufacturing hygiene. Whereas infection control policies have, until now, been largely based on healthcare settings, whole genome sequencing (a method of microbial identification which can be used to trace the spread of infections) is now showing the extent to which infections originate in, or are cycled, via the community.^{8,9} Of concern is cycling of Methicillin Resistant Staphylococcus aureus (MRSA) and multidrug resistant Gram-negative strains from healthcare settings, into the home and back again on readmission to a healthcare setting.^{10,11,12,13} Another concern is hospital ward closures due to norovirus outbreaks brought in from the community.^{14,15}

Decades on, we are still suffering from indifference towards HEDL partly as a legacy of the statements made in the 1960s and 70s, and partly the decline in school hygiene education.¹⁶ There is a tendency, even amongst some experts, to assume that home and everyday life settings are predominantly occupied by normal healthy adults with healthy immune systems, and that foodborne infections only occur outside the home (Note 2). Indifference towards domestic food hygiene is exacerbated by difficulties of elucidating (and reporting) domestic cases, the focus being outbreaks, which most usually occur in restaurants or similar.¹⁷

Thankfully, things are changing. Healthcare professionals now recognize that reducing the burden of infection cannot be achieved without reducing circulation of pathogens and antibiotic resistant strains in the community.¹⁸ Policy-makers faced with ever-increasing costs, recognize that sustaining the quality of state-funded healthcare requires getting the public to take greater responsibility for their own health, and are investing in strategies which include promotion of hygiene behaviour change.^{19,20,21,22,23,24} Hygiene attitudes and habits formed during childhood are deeply ingrained and persist into professional lives, including healthcare and food workers, which means that parental and school hygiene education is vitally important.

2.3. Why is hygiene in home and everyday life so important?

Social, demographic and other changes in recent years mean that the importance of hygiene in HEDL is increasing rather than decreasing. A major problem is that the issues which contribute are currently being handled by different health agencies. It is only when viewed together that the true size of the hygiene-related disease burden is apparent. These issues are summarized below. This is based on more detailed reports by the Rudolfe Schulke Foundation²⁵ and the International Scientific Forum on Home Hygiene (IFH).^{5,26}

Antibiotic resistance and hygiene

Tackling antibiotic resistance is a global priority.^{27,28} Global action plans focus on 3 key areas – reducing antibiotic prescribing in humans and animals, developing new antibiotics and preventing spread of infection. Where early initiatives focussed on healthcare settings, policy makers now recognise that reducing spread of infection cannot be achieved without also reducing circulation of pathogens (or “silent” carriage of infectious strains) in home and community.¹⁸ Promoting hygiene in community settings addresses antibiotic resistance in two ways. Firstly it reduces the need for antibiotic prescribing. Secondly it provides a means to reduce the spread of resistant strains such as MRSA, and multidrug resistant Gram-negative strains across the community and across international borders. As persistent nasal or bowel carriage in the healthy population spreads in the community, this increases the risk of infection with resistant strains in both hospitals and the community.⁸

Globally, priority resistant strains are currently carbapenem-resistant strains of Enterobacteriaceae (CRE) and MRSA,²⁹ both of which are spread in the community as well as healthcare settings. Studies of the prevalence of antibiotic resistance strains in the community are reviewed in a 2012 IFH report.¹⁰ A 2017 study of 1465 people in the East of England show the extent of person-to-person spread of MRSA in the community.³⁰ A literature review of 15 studies indicated that the percentage of community-associated or community onset CRE ranged from 0-29%, the rates being highest in parts of Asia.³¹ The authors concluded that CRE in the community poses an urgent public health threat.

Gastrointestinal and respiratory diseases

Food-related, waterborne and non food-related infectious intestinal diseases (IID) remain at unacceptable levels. Despite people’s general belief that foodborne infections occur outside the home, (Note 2) data collected from 18 European countries, suggests that about 31% of foodborne outbreaks occur in private homes.³² A 2011 community-based study in England and Wales suggests that 1 in 4 people have a bout of IID each year, 1 in 20 a bout of norovirus.³³ Similarly, a 1996-1999 community study in The Netherlands³⁴ suggests that 1 in 3.5 people have a bout of IID and 1 in 25, norovirus.³⁵ Norovirus, mainly spread from person-to-person, is now the most significant cause of IID in the developed world, whilst rotavirus is the leading cause of gastroenteritis in children under 5.³⁶

On average, adults get 4 to 6 colds per year, while children get 6 to 8.³⁷ Data show that hands and surfaces contribute to spread of respiratory infections, particularly colds, but also influenza, and that good respiratory hygiene can limit spread.^{38,39,40} A large proportion of intestinal and respiratory infections circulating in the community are viral. Since viral infections are not treatable by antibiotics, prevention through hygiene is paramount.

“At risk” groups in the community

Societal and demographic changes mean that people with reduced immunity to infection make up an increasing proportion of the population, currently up to 20% or more.⁵ The largest proportion is the elderly,

who have generally reduced immunity that is often exacerbated by other illnesses like diabetes, etc. Risk groups also include the very young, patients discharged recently from hospital, and family members with invasive devices such as catheters. It includes people whose immuno-competence is impaired, as a result of chronic and degenerative illness (including those infected with HIV/AIDS) or because they are undertaking drug or other therapies. This includes those undergoing treatment for cancer and organ transplant recipients. Immunosuppressed persons are often also on medications such as antibiotics, which increase susceptibility to infections such as *Clostridium difficile*. In Norway, although smaller family sizes mean less exposure to infection, 82% of 1-2 year olds attend kindergarten which increases exposure of this vulnerable group to infection. A questionnaire study in Germany showed that children attending a day care centre were more likely to have common cold, bronchitis, pneumonia, otitis media and diarrhoea within the first 2–3 years of life. With the exception of common cold, from year 4 onwards these associations were no longer significant and even reversed for some of the infections.⁴¹

A key factor that makes these groups at greater risk, and to a wider range of infections, is that they are susceptible, not only to primary pathogens which affect the whole community such as *Campylobacter*, norovirus, colds, flu, etc, but are also at risk from facultative pathogens (*Pseudomonas aeruginosa*, coliforms, etc.) which can infect wounds, medical equipment and catheter-insertion sites (thereby gaining access to sterile areas of the body), and opportunistic pathogen such as *aspergillus* and legionnaires bacillus which are a risk for immunosuppressed people.

Much of the care of “vulnerable” groups in the home is carried out by the family who thus need an understanding of hygiene, which includes protecting family members against foodborne, respiratory, urinary tract and other infections as well as hygiene practices related to their underlying condition. In Germany, it is estimated that approximately three quarters of all people in need of care are currently being cared for at home.⁴²

Healthcare in the home

Governments are looking at prevention^{21,22} as a means to reduce health spending. Increased homecare is one approach, but ensuring that this is not accompanied by increased infectious disease risks is key, otherwise cost savings from shorter hospital stays are likely to be overridden by costs of re-hospitalisation and bed blocking. This is reflected in the 2014 “UK Five Year Forward View”^{21,22} (see also Appendix 1) which is a plan to respond to the growing demands of an ageing and sicker population. It centres around strategies to ensure that people remain healthy in the community by taking responsibility for their health. According to a survey carried out in Germany by the non profit foundation ZQP (Centre of Quality in Care), knowledge and implementation of infection prevention precautions in homecare is often perceived as insufficient (Note 3).

A current concern is rising levels of healthcare-associated blood stream infections. Most reported cases originate in the community, and those at greatest risk are the elderly and others with reduced infection immunity, particularly those who are at risk of urinary tract infections.⁴³ In response, the UK has launched an initiative to reduce Gram-negative healthcare-associated bloodstream infections by 50% by 2021,^{44,45} which includes advice to healthcare workers and patients on hygiene measures to reduce infection risk.⁴⁶

In May 2017, the World Health Assembly and WHO made sepsis a global health priority,⁴⁷ Community and health care-associated sepsis represents a huge global burden estimated at 31 million cases every year, 6 million of which result in death. The resolution makes reference to the need for prevention through “appropriate hand hygiene, access to vaccination, improved sanitation and water, and other infection control practices”.⁴⁸

Emerging pathogens

Emergence of new pathogens and new strains of existing pathogens is an ongoing concern. As soon as we begin to get one pathogen under control another emerges.^{3,5} It is difficult to believe that pathogens such as norovirus, *Campylobacter* and *Legionella* were largely unheard of in 1980. Health agencies recognise

that threats posed by emerging diseases such as avian influenza, etc. demand an immediate response, and, in the event of a pandemic, hygiene in HEDL must be a first line of defence during the early critical period before mass vaccination or other measures become available.⁴⁹ Changes in lifestyle (e.g food habits, more travel, denser population) facilitate rapid emergence and spread of new pathogens. This requires the public to be able to adapt their hygiene practices to meet new challenges. Climate change will also change infectious disease transmission patterns requiring better hygiene behaviour.⁵⁰

Health inequality

Across the world, most particularly, but not only in developing countries, there is an inequitable distribution of communicable diseases, sub-populations with poor educational attainment, low income, or other socio-economic factors carrying the highest burden of disease. Higher levels of infection tend to occur in low income communities, creating an additional burden on health and prosperity. This creates a vicious circle, which contributes to keeping these communities in poverty.^{51,52}

Semenza^{51,52} concludes that populations at high risk of infection in Europe coincide with low level of education, occupational class, or income level. It also includes migrants or people engaged in high-risk activities (e.g prostitution, IV drug use). These sub-populations suffer disproportionately from infections, some of which are not hygiene-related (STIs and HIV), whilst others are (respiratory and gastrointestinal infections, hepatitis, influenza, multidrug resistant infections). In low income populations, malnutrition also contributes to increased susceptibility to infection.⁵³ Being more at risk of infection than the general community, these groups have most to gain from improvements in hygiene awareness and behaviour.

Infectious disease as co-factors in other diseases

Data increasingly show that infectious diseases can act as co-factors in other diseases that manifest at a later date, such as cancer and chronic degenerative diseases, or as triggers for development of allergic diseases.⁵

Economic and social costs of hygiene-preventable disease

The economic and social burdens of infectious diseases are difficult to estimate. It requires data on expenses associated with inpatient and outpatient healthcare, as well as data on economic damage due to lost productivity when wage earners fall ill, need to take time off to care for a sick child, etc., or are permanently lost to the workforce. Data on disease rates is hard to come by and quality varies from country to country. Prevalence and incidence data must be collected from multiple sources. Cost calculations are difficult because of the multiple factors at play. It is often impossible to separate the proportion of disease that is hygiene-preventable.

Due to lack of data, the economic and social costs of common gastrointestinal, respiratory and skin, etc. infections are often ignored. Since the issues which contribute to the burden of hygiene-related disease and antibiotic resistance are currently considered separately, there is little appreciation of the true costs of the hygiene-preventable disease burden. What data exists, suggests that the financial burden of disease is enormous. In the UK, in 2013, for example, 21% of all days lost at work (approximately 27 million days) was caused by coughs, colds and flu and other infectious diseases.⁵⁴ Estimated costs are £745 million annually in the UK for infectious intestinal disease alone⁵⁵ and \$152 billion in the US for foodborne illness, far exceeding previous estimates of \$6.9-35 billion.⁵⁶

Without comprehensive data, government health agencies are unable to make fully informed decisions regarding the most cost-effective interventions for preventing or mitigating the effects of infectious diseases. Equally, it is difficult for those concerned with actioning infection prevention strategies in HEDL to make a convincing case for investment in change.

2.4. What are the barriers to changing hygiene behaviour?

Changing public hygiene behaviour represents a huge challenge. Hygiene promotion strategies can go some way but, on their own, are not enough. There are some significant barriers which must be overcome, at all levels, from government to consumers, if programmes are to succeed and deliver real health benefit:

2.4.1 The need for a “family-centred” approach to hygiene in home and everyday life

Although investment in hygiene promotion has started to rise, unfortunately this has happened in a piecemeal way. As each new issue has emerged, it has been allocated to the most appropriate agency, which then acts independently to address the problem. The 1980s saw rapid rises in food poisoning, prompting campaigns by national food agencies to improve food safety including domestic food hygiene. In the early 2000s, threats from emerging pathogens such as SARS and new influenza strains prompted national and international health agencies to formulate pandemic preparedness plans which included engaging the public in first line defence through good respiratory hygiene.⁴⁹ In the last 10 years we have seen healthcare professionals developing policies to control healthcare-related infection in the community. National and global strategies are now being developed to tackle antibiotic resistance. These include promotion of hygiene in HEDL to reduce the need for antibiotic prescribing and prevent spread of antibiotic resistant strains in the community.²⁷ A major EU initiative is “e-bug” which aims to ensure every child leaves school with an understanding of antibiotic resistance and how it is being tackled through good hygiene practice (Note 4). Initiatives aimed at improving hygiene in the community are being developed, mostly by government departments responsible for tackling antibiotic resistance.

This chronologically-driven response means that, within national health agencies, no single authority takes overall responsibility for communicating with the public. This means that the hygiene advice they receive is fragmented and often inconsistent. To be successful we need to look at hygiene holistically from the point of view of the individual, family, or domestic grouping (hereafter referred to as a family-centered approach) and how they see it, what they know and understand, and need to know about the infectious diseases issues which affect their lives.²⁶ Without leadership at national, regional or global level, achieving an integrated family-centred approach to HEDL hygiene is unlikely to happen. Without leadership there is also no co-ordinated authoritative voice to advocate on behalf of HEDL against the competing health issues outlined in this report.

2.4.2 The human microbiome, the so-called hygiene hypothesis, and our health

An issue likely to dominate future health policy is the recognition that our human microbiota (the microbes inhabiting our gut, respiratory tract, skin, etc.) constitutes an organ as essential to health as our liver and kidneys.⁵⁷ It is now clear that diverse exposure to human, animal, and natural environments, particularly in early life, are key to building a healthy microbiota. Failure to maintain a diverse microbiota is being associated with an increasing range of diseases (Note 5) including allergic (asthma, eczema, hay fever, food allergies) and autoimmune diseases (such as multiple sclerosis, type 1 diabetes and inflammatory bowel disease) which have risen dramatically, particularly in the last 50 years.^{57,58,59}

The realisation that microbial exposure is essential to health has fundamental consequences for hygiene because it poses the question “how can we develop lifestyles that sustain exposure to the right sort of microbes, whilst at the same time protecting against those that cause disease?”⁵⁷ Unfortunately current

efforts to change perceptions about the importance of hygiene are being made infinitely harder by the misconception which has arisen that a key factor which is depriving us of the microbial exposures we need is household hygiene and cleanliness. A survey of consumer media coverage from 1998 to 2017¹⁶ indicates that this concept originated from the wide media publicity given to the so-called hygiene hypothesis. In 1989 Dr David Strachan hypothesized that a cause of rising allergic diseases was lower incidence of infection in early childhood.⁶⁰ He suggested an underlying cause could be “*improved household amenities and higher standards of personal cleanliness*”. By naming it the “Hygiene” hypothesis, the notion that “we have become too clean for our own good” has arisen and continues to be publicised alongside the unsupported idea that being less “hygienic” could reverse this trend.¹⁶

This is despite ongoing evidence which now refutes the link to infection. Current understanding of the link between inflammatory disease and microbial exposure and the implications for hygiene is discussed in a 2016 review.⁵⁹ This shows that the problem lies in lifestyle, medical and public health changes over the last 40-50 years, which, particularly in early life, deprive us of exposure to microbial “Old Friends”.⁵⁹ These “Old Friends” are not infectious pathogens, but largely non-harmful species which inhabit the human gut and our natural environment. Lifestyle changes which are implicated, through research data include sanitation, clean water and food, C-section rather than vaginal childbirth, bottle rather than breast feeding, fewer siblings, urbanisation and less outdoor activity. Since communication between “Old Friends” and the immune system is mediated by the gut microbiome, excessive antibiotic use and altered diet can affect the microbiome in a way that increases inflammatory disease risks.⁵⁹

The media survey¹⁶ shows, however, that consumer media articles do not reflect the changes in scientific thinking about the underlying causes of reduced microbial exposure and immune disorders.¹⁶ In all 70% of 36 articles published from 1998 to 2017, including more recent articles, still emphasize the role of home cleanliness as a causative factor in rising allergies, etc., referring to the home environment as being too clean, hygienic, sanitized, oversanitized or sterile. Only 47% of articles refer to the lifestyle changes cited above as underlying factors, and even then, 14 of these 17 articles also include “home cleanliness” (including use of antibacterial products) as a causative “lifestyle change” despite the lack of data to support this. In 77% of articles, the idea of a link between reduced “Old Friends” exposure and household cleanliness was reinforced by including the terms dirty, clean or hygienic in the headline, whilst 72% of articles quoted overuse of antibacterials and hand sanitizers as underlying causes. In 15 out of 25, journalists quoted this as an opinion from an expert.

Evidence refuting the idea of a link to home cleanliness comes from studies showing that the microbiota of our living environment largely reflects that of its inhabitants (including pets) and the surrounding outdoor environment.⁶¹ It seems likely that, rather than excessive cleanliness, reduced microbial diversity in our homes reflects reduced microbial diversity of its inhabitants (due to fewer siblings, altered diet, antibiotic use, etc.), and homes being cited in microbiologically impoverished urban rather than rural settings.⁵⁹

Consumer responses to UK/US articles reviewed in the media survey¹⁶ suggest that the public fail to grasp the key concept. Many responses expressed a view that “dirt and germs” are important for building a strong immune system – otherwise children grow up “weak, sickly, prone to every ailment – and to allergies”. By associating germs with dirt, they conclude that too much cleanliness means that children fail to build the strong immune system which they require in order to not only “fight” infections but also “allergies”. They need simple clear communication that allergic reactions occur when the immune system “fights” allergens rather than ignores them (Note 6).

With the explosion of interest in the human microbiome, nutritionists and microbiomists are now encouraging us to reconnect with essential microbes by “getting out and getting dirty”.¹⁶ In interviews with microbiomists and nutritionists,¹⁶ they were asked what advice they would give families to increase their exposure to a diversity of microbes. Recommendations included getting outdoors and getting dirty, stroking pets, and avoiding antibiotics where possible. Worryingly, in some cases, the advice also included letting pets lick your face, sucking a babies pacifier to clean it, washing dishes by hand instead of using a dishwasher (Note 7) and, most importantly, not washing hands”.^{62,63} Although data suggests that these actions may increase exposure to Old Friends microbes, they are critical surfaces and actions (see section 5) likely to also increase the risk of exposure to infection. As yet there are no intervention studies

demonstrating that lifestyle changes, such as those discussed above, actually impact on inflammatory disease rates, but significant evidence that abandoning hygiene measures such as handwashing are associated with increased rates of respiratory and gastrointestinal disease.^{64,65,66,67}

The bottom line is that in future we are going to have to regard our microbial world very differently. Getting people to adopt lifestyles which sustain exposure to necessary microbes, whilst protecting against pathogens requires a significant change in public understanding of our microbial world, and what hygiene means. Providing consumers with unambiguous messages, as our knowledge of the microbiome and its implications for health and hygiene expands, will represent a considerable challenge.

2.4.3 Hygiene, safety and sustainability

Although infection prevention is intrinsically more sustainable than treatment, sustainability of hygiene procedures must also be considered. These include:

- Environmental impacts of hygiene procedures and products (Note 8).
- Human safety associated with use of hygiene products (Note 8).
- Concern about possible links between use of microbiocidal products (disinfectants, antibacterials, hand sanitizers) and antimicrobial resistance. (Note 9 - definition of terms).

Procedures must be effective in reducing contamination to safe levels, whilst at the same time avoiding overuse of resources (water, detergents, soaps, heat, mechanical action, microbiocides) and managing possible risks (environmental, toxicity, resistance, etc.). Yet again these risk issues tend to be addressed, with limited effort to counterbalance against the importance of mitigating infection through hygiene. Lack of an authoritative voice advocating for hygiene means that risk issues have been allowed to take precedence. Particularly in Northern Europe, concerns about environmental impacts are strongly voiced, with little attention to well-established evidence of the need for effective hygiene (section 2.3).

Sustaining access to clean water is a significant global challenge.⁶⁸ This means we must weigh practices which rely on access to running water (e.g. handwashing with soap, laundry and dishwashing) against using waterless products which inactivate microbes in situ e.g. hand sanitizers. Another example is the trend towards low temperature domestic laundering. Energy to heat domestic washing machine water contributes the largest part of environmental impact of laundering (Note 10). Decreasing laundry temperature however has a negative impact on hygiene efficacy (Note 11).^{69 70 71} Evidence suggests this could result not only in transmission of infection, but also spread of antibiotic resistant strains shed from the skin surface (e.g. MRSA) or in faeces (e.g. ESBL strains of enterobacteria) onto clothing, towels, etc. in contact with the body by healthy carriers living in the community (Note 12).

One of the most highly contentious issues is consumer use of antibacterial products. In the last 10 years, a particular concern has been antibacterial soaps used for routine handwashing, particularly those containing triclosan and other chlorinated hydrocarbons. Although tests show that they produce some increase in reduction of bacteria on hands compared with plain soap, intervention studies in community settings show no convincing evidence of reduced infection rates.^{72,73} Alongside this there are legitimate concerns about environmental and toxicity issues.⁷⁴ After detailed consideration, the US Federal Drug Administration (FDA) (Note 13) and the European Commission (EC) (Note 14) have decided, based on current evidence, that they are unconvinced that benefits of hand soaps containing triclosan outweigh risks, and have issued rulings on marketing of these products.

The 1990s saw an explosion in marketing of antibacterial cleaning products (and antimicrobial-impregnated materials e.g. chopping boards).⁷⁵ Whilst laboratory tests confirm the active ingredients kill bacteria in compliance with international standards, there is little data suggesting that routine use for cleaning is associated with reduced exposure to harmful microbes or reduced infection rates (Note 15).

A survey of media coverage over the period 1997 to 2017 shows that marketing of such products is opposed by many experts, on the basis that evidence of health benefit is insufficient to outweigh concern about environmental persistence and antimicrobial resistance.⁷⁶

This however creates problems, because the widely publicised opposition to routine use of antibacterial soaps, cleaners and impregnated materials is preventing objective assessment of evidence indicating that, in specific risk situations, cloth wiping and detergent-based cleaning can increase the spread of pathogens via hands and surfaces thereby increasing infection risks, and that, in this situation, targeted use of a disinfectant or sanitizer may be required.^{77 78 79 80 81} Data show that failure to use microbiocidal products in these situations can increase transmission and exposure to infectious microbes (Note 16).

For alcohol handrubs, data confirms they are as effective as handwashing with soap,^{82,83} and intervention studies demonstrate that promotion of alcohol handrubs in schools, offices and other settings can significantly reduce illness-related absenteeism and respiratory illness (Note 17). The key benefit is that, they can be used where there are no handwashing facilities. Because of this they facilitate increased compliance with hand hygiene,⁸⁴ giving the potential to increase the health impact of hand hygiene.⁸⁵ Since alcohols are unlikely to encourage resistance development (see below) there is little to suggest that risks outweigh health benefits, when used as part of targeted hygiene.

The survey of media coverage 1997 to 2017¹⁶ shows the extent to which marketing of microbiocidal products is opposed by experts and the public, even in situations where there is data showing that they are needed to break the chain of infection. Their conviction that risks outweigh benefits partly reflects lack of understanding of the issue on antimicrobial resistance. Antibiotics must be administered at low concentrations to avoid side effects, but declining drug levels between doses creates conditions favourable for emergence of resistant strains. By contrast microbiocides can be safely used at much higher concentrations, which rapidly kill microbes before they can enter the body thereby obviating the need for antibiotic prescribing. It is rarely considered that disinfectants or hand sanitizers, used as part of targeted hygiene (right place, right time, right product) could combat antibiotic resistance by reducing the need for antibiotic prescribing.

Although laboratory studies show that exposure of bacteria to certain microbiocides can induce the emergence of resistance, health professionals sometimes fail to understand that so-called resistance demonstrated in the laboratory is “reduced susceptibility” not “resistance”, and that development of reduced susceptibility to antimicrobial agents is common (Note 18) and may be only temporary (Note 19). There is also lack of appreciation that agents such as alcohol and oxidizing biocides are inherently less likely to cause development of resistance, partly because they exert a general cytotoxic effect (as opposed to antibiotics which target a specific bacterial cell receptor), partly because of their rapid killing action, and partly because they break down or evaporate i.e. they are non-residue forming.⁸⁶

A number of expert reports have been commissioned in the last 10 years. These agree that laboratory evidence does indicate that use of certain types of microbiocidal products could contribute to reduced susceptibility to antibiotics, but they also conclude that there is no evidence, as yet, that microbiocide use has contributed to antibiotic resistance in clinical practice”.^{87,88,89,90} Unfortunately the former statement is often quoted without reference to the latter, leading others to conclude that the problem has been identified under real life conditions. These expert bodies stress the hygiene importance of microbiocides, but also stress the need to use them prudently, and confine use to situations where there is identifiable risk of spread of harmful microbes (Note 20). Taken together, these examples demonstrate the need to evaluate use of microbiocidal products on a case by case basis according to the type of agent involved, where it is to be used, and the risk of infection exposure if microbiocides are not used.

To maximize efficacy and manage risks, there is need for a science-based framework which ensures that hygiene procedures are capable of reducing infection risks to an acceptable level, with prudent use of water, heat, microbiocides, etc. This is discussed in section 3.

2.4.4 Lack of public understanding of cleanliness and its relationship to hygiene

A key barrier to promoting hygiene behaviour change is public misunderstanding of hygiene, what it is, and what it means. At the turn of the C19th, when Florence Nightingale introduced stringent hospital cleanliness and showed a dramatic decrease in mortality of wounded soldiers, she was unaware of the germ theory of disease. Whilst growing knowledge of how infectious bacteria and viruses spread and cause infection has led to dramatic changes in microbial quality assurance in manufacture of foods, etc., this is not so for HEDL hygiene.

Throughout this paper, the term “hygiene” is used to define practices which protect us from infection, but consumers also use “personal hygiene” to mean clean and odour-free personal appearance. Consumers are unclear about the meaning of the term hygiene and fail to understand that although cleaning is a means of achieving hygiene, visual cleanliness does not necessarily mean “microbiologically safe” (Note 21). People still largely judge whether a surface (hands, environmental surfaces and fabrics) is free from harmful microbes by whether it is visibly clean. There is a lack of awareness that apparently clean surfaces can be heavily contaminated by harmful microbes. Public perceptions are illustrated by the 1998-2017 survey of UK and US media coverage¹⁶ which suggests that we still largely see hygiene as synonymous with cleanliness aimed at eradicating dirt – inappropriately regarded as the main source of harmful microbes. In common use, the terms cleaning and hygiene are often used interchangeably (Note 22). The International Association for Soaps, Detergents and Maintenance Products has produced a document aimed at achieving greater clarity on terminology associated with household hygiene products.⁹¹

Common use of the term “germs” also causes confusion. Whereas, in the past it was used to indicate harmful microbes, we now talk about good and bad germs.¹⁶ The media frequently talk about “millions of germs” on household surfaces but rarely explain that the majority are likely to be harmless. This is reinforced by ongoing portrayal of “germs and dirt” in a sinister way to suggest that they are harmful.¹⁶ Whilst some people develop extreme fear of invisible microbes, others are increasingly sceptical about the need for hygiene in our modern world, concluding “if there are so many dangerous microbes in our home, how come we have survived so long”.¹⁶ This is compounded by messaging, as discussed in section 2.4.2, that “too much cleanliness” is a cause of rising allergies, etc.

The survey of media coverage and consumer feedback¹⁶ shows that some believe the scaremongering about “germs” is a ploy to sell antibacterial products. Taken alongside media messaging about environmental and toxicity risks, and possible links between antibacterial use and antibiotic resistance,⁷⁶ they are tending to reject established hygiene practices and look for organic, environmentally friendly alternatives to commercially tested and approved disinfectants, thereby increasing infection risks and demand for antibiotic prescribing.

The outdated concept of “dirt and germs” as the source of infection in home and everyday life needs to be replaced with understanding the “chain of infection” i.e. where harmful germs originate, how they survive in the environment, how they transmit and how hygiene can break the chain of infection. This concept is outlined in Section 3 (Note 23).

It seems clear that, getting people to change hygiene behaviour depends not only on promoting hygiene practice but also changing public understanding and restoring their confidence in hygiene. We need the public to believe that infection doesn't “happen by accident or misfortune” - it is preventable in many cases.⁹² If we believe we have no control over whether we get an infection, we will not take measures to control it.⁹² We also need to persuade people of the direct benefits of hygiene to them as individuals e.g. avoiding loss of income, costs of childcare, disruption of family leisure activities, etc.

Section 3. Developing an evidence-based approach to home and everyday life hygiene

To meet new challenges, we need a framework for HEDL hygiene, based on scientific principles. To argue the case with opinion formers, health professionals, regulatory authorities and consumers, this needs to be a simple, plausible approach. In this section we show how the “explosion” of new data on how infections spread, and approaches such as risk management and Quantitative Microbial Risk Assessment (QMRA), have been used to develop a framework for HEDL hygiene which maximises protection against infection and spread of antibiotic resistant strains, whilst also addressing environmental and other issues.

Since the 1980s, scientists have adopted a risk management approach for developing hygiene in HEDL. This scientifically-validated system is the well supported approach developed by the food and other manufacturing sectors as the means to protect food, pharmaceuticals, etc from contamination during manufacture and processing, etc. Applied to HEDL it is known as targeted hygiene.^{64,93,94,95} In the following sections the scientific basis for targeted hygiene is outlined. Putting targeted hygiene into practice is set out in a teaching self-learning resource produced by the International Scientific Forum on Home Hygiene.⁹⁶

3.1 Targeted hygiene – identifying risk points

Targeted hygiene means breaking the chain of infection transmission (Note 23).

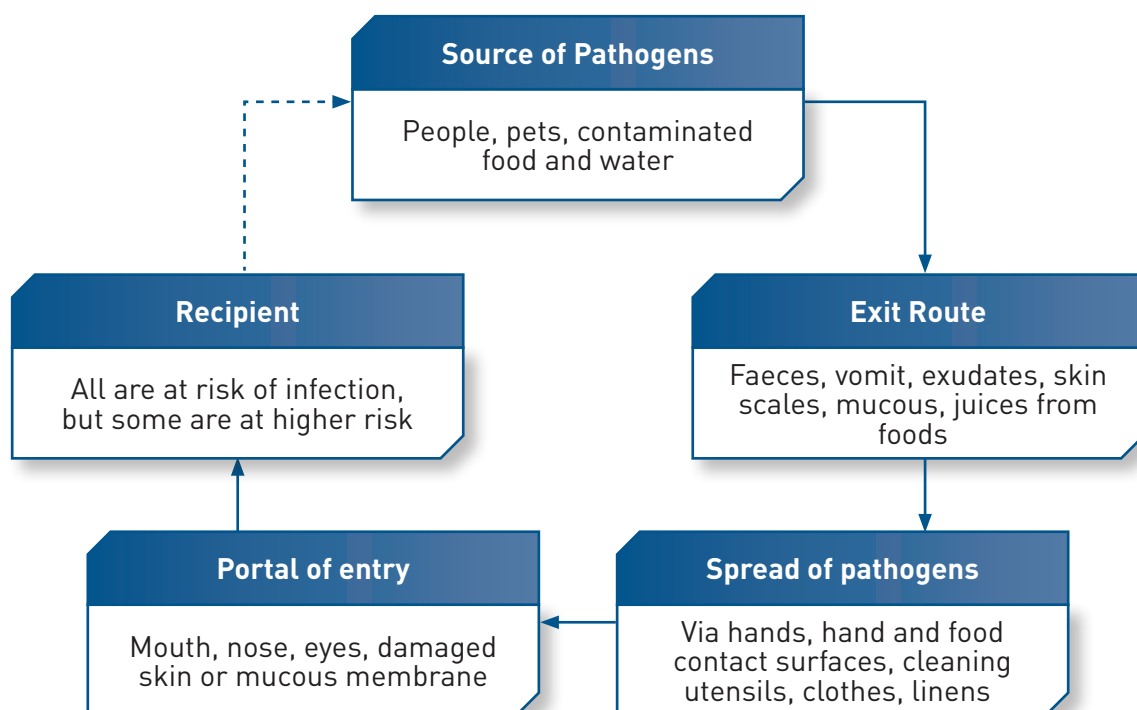


Figure 1: The chain of infection transmission

This easy to visualize concept is illustrated in Fig. 1. It shows that the sources of harmful microbes in everyday living environments are not places which are “dirty”, but mainly people (people who are infected and people who are healthy carriers of potentially pathogenic strains such as *S. aureus*), contaminated foods and domestic animals. Pathogenic organisms are continually shed into the environment from these sources.

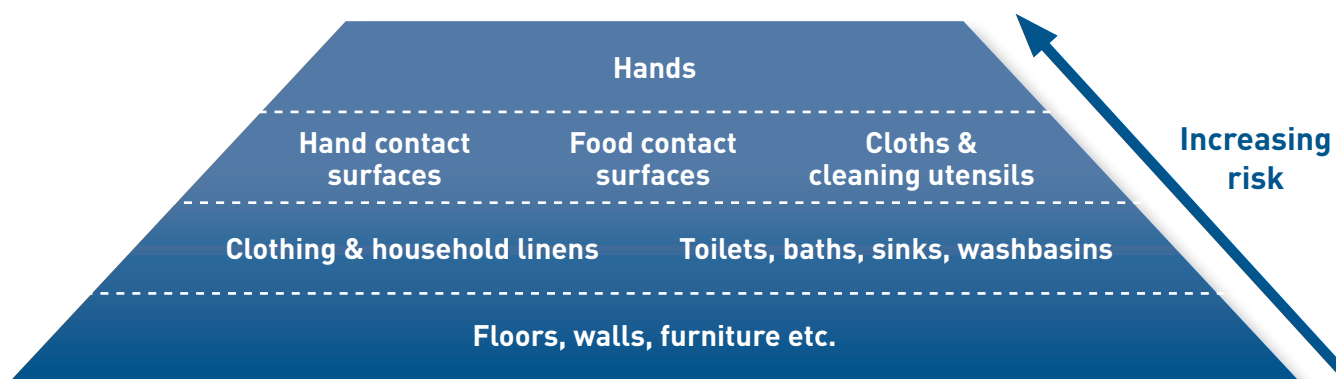


Figure 2: Ranking of sites and surfaces based on risk of infection transmission

Targeted hygiene means intervening at critical points in the chain of infection, at appropriate times, to break the chain of transmission. Microbiological evidence shows (see Fig. 2) that the critical points for transmitting pathogens are the hands, hand and food contact surfaces and cleaning utensils. Clothing and household linens, and toilets, sink and bath surfaces also contribute to the chain of infection, although risks associated with these surfaces are normally somewhat lower as they rely on other critical points such as hands to transfer the microbes from the fabric or sink surface to a susceptible person. Microbiological data confirms that critical times when pathogens are most likely to spread are during food handling, using the toilet, respiratory hygiene, care of domestic animals, where there is a family member who is infected, etc.⁹⁷ This ensures that hygiene interventions focus on situations where they maximise protection against infection, rather than situations where there is visible dirt (but not necessarily disease risk) or high microbial levels, but low risk because pathogens are unlikely to be present. “Cleanliness” achieved by routine non-targeted daily or weekly cleaning, may contribute to preventing spread of pathogens, but there is little data to suggest that its contribution is significant relative to hygienic cleaning at critical points at key times e.g. food contact surfaces during food handling.

3.2 Targeted hygiene – developing effective hygiene interventions

Equally important are the hygiene procedures (product plus process) used to get rid of pathogens from hands and other critical surfaces before they spread further. Data show how inadequate procedures can increase infection transmission.⁸² It also shows that we need more innovative research approaches to developing effective procedures and assessing their ability to prevent infection transmission. A framework for achieving this is outlined below.⁸²

This framework for developing effective hygiene procedures starts from the fundamental principle that hygienic (as opposed to visible) cleaning of hands, surfaces, fabrics, etc. can be achieved in one of 3 ways by:

- Physical removal of pathogens using soap or detergent-based cleaning or dry “wiping” – usually referred to as cleaning.
- Using an antimicrobial product (disinfectants or alcohol hand sanitizer) or processes (heat at 60°C or above) that inactivate/kill pathogens in situ – this is called disinfection.
- Combined action e.g. in laundering, physical removal is combined with heat inactivation.

The aim of a hygiene procedure is not “sterilization” (total absence of microbes), but reducing contamination to a level considered as safe. What is often overlooked is that all three are valid ways of reducing pathogens to a safe level, regardless of whether this is the hands, environmental surfaces or fabrics. Health agencies and health professionals often fail to take account of this. Whereas there is extensive published data on the efficacy of household disinfectants, this is not the case for physical removal processes.⁸²

At present there is a tendency to assume that, in all domestic situations, hygiene can be consistently achieved using soap or detergent and water, but there is little research data to confirm this and an increasing number of studies challenge this assumption.^{77,78,79,80,81} These show that wiping a surface with detergent (without subsequent rinsing) transfers contamination to the cloth and hands, which is then transferred to other surfaces, thereby facilitating transmission of microbes. In this situation cleaning and disinfection is required to break the chain of infection.

Laboratory suspension tests demonstrate the ability of microbiocidal products to inactivate harmful microbes under conditions simulating use (temperature, presence of soiling, relevant microbial species), but do not assess what health professionals need to know. Firstly we need to know whether, when used correctly (product plus process), the hand, surface or laundry hygiene procedures which we recommend, (regardless of whether it involves cleaning alone or cleaning plus disinfection) will reduce contamination to a “safe” level.

We also need data on disinfectant products, hand sanitizers or other new technologies which are benchmarked against detergent-based cleaning or wiping technologies to determine the relative efficacy. Without such data, it is difficult to give evidence-based advice to the public about what hygiene procedure should be used in different situations.

To address this issue, Bloomfield, Carling and Exner propose a “hygiene assurance” framework for developing hygiene procedures (those involving removal by cleaning and those involving inactivation with disinfectant).⁸² This involves a 4 stage hierarchy as illustrated in Table 1, and is equally applicable to hands, surfaces and fabrics.

Stage 1	Quantify efficacy by suspension tests under laboratory test conditions relevant to intended use	Provides evidence of ability to inactivate microbes
Stage 2	Quantify efficacy by surface tests under laboratory test conditions relevant to intended use	
Stage 3	Demonstrate hygiene procedure (product + process) delivers appropriate safety target levels on hands, surfaces and fabrics, under conditions of use and prevents onward transmission	Provides direct quantitative evidence of reduced exposure to pathogens
Stage 4	Demonstrate reduced infection rates through clinical intervention studies, or QMRA	Used to quantify reduction in infection rates

Table 1: Proposed hierarchy for developing hygiene procedures used on contaminated hands, environmental surfaces and fabrics.

Stage 1 and 2 apply only to products or processes with microbiocidal action and are designed to demonstrate, under laboratory conditions simulating use (presence of soil, temperature, types of potentially harmful organisms likely to be present), that they have the ability to inactivate microbes (Note 24). The purpose of stage 3 is to assess whether a hygiene procedure (products plus process - regardless of whether it involves detergent-based cleaning only or whether it involves use of a disinfectant) reduces contamination on hands, surfaces or fabrics to a safe level under conditions simulating use and prevents onward transmission of pathogenic microbes. This enables a number of things to be determined:

- It provides quantitative evidence that procedures, when used in risk situations, reduce transmission of pathogens, and thereby reduce human exposure.
- It ensures that new products/processes/technologies are at least as effective as existing ones in terms of breaking the chain of infection.

- It provides evidence of the extent to which inclusion of microbiocide (or new technologies) gives enhanced efficacy compared with procedures involving “cleaning” only.
- It enables development of new procedures which combine kill and removal in an additive or synergistic manner to deliver required safety target levels with reduced use of energy and chemical products.

Although the hygiene assurance level approach could be very useful for comparing hygiene efficacy across a range of situations, it is important that it is not used inappropriately to set performance requirements unless or until more comprehensive data is available on the relationship between log reduction (LR) in contamination levels and infection risk reduction. This is further discussed below.

3.3 Targeted hygiene - estimating the effect of hygiene procedures on rates of infection in home and everyday life

Stage 4 takes evaluation a stage further by providing a quantitative estimate of effectiveness of the procedure (product plus process) in reducing infection rates. Although there is still a tendency to demand that intervention studies assessing the impact on infection rates take precedence, it is increasingly accepted that this is not feasible for HEDL hygiene. Interdependence of transmission routes via hands, surfaces and fabrics make it impossible to determine separate effects of different interventions, whilst the large population sizes required to produce a significant result makes the cost prohibitively expensive (Note 25).

In the last 20 years Quantitative Microbial Risk Assessment (QMRA) has been increasingly used to estimate the impact of interventions on infection rates. QMRA involves using published data (initial pathogen level, extent of transfer via hands and surfaces, infectious dose, etc.) to model the chain of infection and give a quantitative estimate of infection risk. The log₁₀ reduction in contamination produced by the hygiene procedure (determined in stage 3) is then used to estimate the reduction in infection rates (example in Note 26). This allows a number of issues to be resolved:

- A 2014 study⁹⁸ showed how QMRA can be used to set safety target levels. This contrasts with the current situation where a pragmatic approach is used based on performance criteria which have been accepted for many years, but have no clinical basis (Note 27). In this study researchers constructed a mathematical model; using data from the literature quantifying rates of bacterial transfer where a contaminated surface was touched with the fingers, and the fingers then touched the mouth, nose or eyes. From this they estimated that, for a single touch of the surface, an average, 2LR was sufficient to achieve a 10⁻⁶ safety target level (i.e a risk of infection less than 1 in 1 million) for E.coli and Listeria, whilst norovirus required an LR of 3.44. For Pseudomonas spp, Salmonella spp, and S. aureus it was estimated that no decontamination process was required.⁹⁸ It should be noted that these calculations were based on ambient levels of surface contamination, rather than levels that would occur in risk situations.
- Since exposure to a given residual dose of pathogens (e.g. from surface to hand to mouth) carries the same level of risk, this obviates the need to carry out all 4 stages of testing for every new cleaning or cleaning and disinfection procedure. Once the LR required to meet the safety target level is determined through QMRA, it can be used as a performance standard for any hygiene practice to be used in that risk situation.
- QMRA-generated data can be used to determine the added health benefit from new products or technologies compared with existing products by calculating how a quantifiable increase in efficacy (e.g. using a process which produces a 3 rather than 2 LR) (Note 24) can translate into a significant decrease in the rate of infection within community/national/global populations.

- A 2018 study shows how quantitative modelling can be used to assess the relative risk from different surfaces. In this study, researchers constructed a mathematical model, using data from a norovirus outbreak aboard a cruise ship.⁹⁹ They estimated that wiping of surfaces with chlorine bleach could reduce the outbreak by 10% (range 3-59%) However if 80% passengers who did not wash their hands were to change their hand hygiene habits, the outbreak would be halted.

At present, many health experts reason that disinfectants or hand sanitizers should only be used in home situations, where there is an infected person or a person with compromised immunity.¹⁰⁰ The hygiene assurance framework allows us to start by deciding the safety target level appropriate to the situation and then deciding what sort of hygiene procedure can be used to achieve this in the most sustainable manner, either by wiping, by detergent cleaning or whether detergent cleaning plus a disinfectant is needed. This means, for example, that, even in routine family situations, cleaning plus disinfection may be needed for frequent hand contact surfaces or food contact surfaces which cannot be rinsed under running water to achieve the required safety target level.

3.4 Targeted hygiene and sustainability

Whilst targeted hygiene was adopted as a means to develop effective hygiene practice for HEDL, it also provides a framework for building sustainability into hygiene and use of hygiene products because it meets the following criteria:

- It maximises protection against infection.
- It minimises environmental impacts and maximises safety margins against hazards.
- It minimises risks of development of antibiotic resistance.
- It looks to sustain “normal” interaction with the microbial flora of our environment to the extent that is important to build a balanced immune system.⁵⁷

In public and domestic situations, there is pressure to deliver hygiene in a manner which is sustainable. Data from stage 1 and 2 with stage 3 tests facilitates understanding of how inactivation and removal processes can work synergistically to optimize log10 reduction on hands, surfaces and fabrics. It can be used to develop new approaches to hygienic cleaning, including new cleaning and disinfectant agents, new technologies, and surface modification to facilitate detachment. The Federal Drug Administration (FDA) and European Union (EU) Biocidal Products Regulations are designed to ensure that products making a microbiocidal claim are effective and safe. It is important that these regulations do not restrict future development of new technologies and approaches, where low level microbiocidal action involving heat or chemicals (including chemicals (e.g. detergents) not registered as biocides, but which have low level microbiocidal action^{70,82,71}) are combined with removal processes (e.g. detergency and rinsing) to deliver hygiene with minimum environmental impact.

SECTION 4. A strategy for change – recommendations for action

This paper highlights the major contribution that hygiene in home and everyday life makes to reducing the social and economic burden of infectious disease and tackling antibiotic resistance (sections 2.1 – 2.3). Alongside this, section 2.4 considers the ongoing conflict between hygiene and the issues undermining current efforts to achieve hygiene behaviour change, such as environmental and toxicity issues, antimicrobial resistance, etc. From section 2.4, we conclude that, partly because of the extensive publicity afforded to these issues, and partly due to lack of a unified voice advocating on behalf of HEDL hygiene, these issues have tended to take precedence. Section 2.2.4 also shows how consumer understanding and motivation towards adopting good hygiene is being undermined by unbalanced publicity given to these issues as opposed to the importance of hygiene.

Section 3 lays out a risk-based strategy for effective hygiene in HEDL which gives hygiene appropriate priority within the context of environmental and other human health concerns. We conclude that the “targeted hygiene” approach needs to be placed at the heart of a multimodal prevention strategy, alongside vaccination and other strategies.

Based on the findings of this report, we recommend the following actions. Since they are mutually dependent, they need to be developed simultaneously:

1. A call to national and international health agencies for integration and leadership

Whilst recent investments in public hygiene promotion mean that many of the components of a hygiene behaviour change strategy are in place, the following actions need to be taken to maximise the health impact from this investment:

- Government health agencies need to adopt a more **integrated approach which** addresses HEDL hygiene from the point of view of the “family unit” and the range of hygiene issues which they need to address (food hygiene, respiratory hygiene, hygiene associated with using the toilet, healthcare at home, etc.) and how all these actions work together based on the common principle of breaking the chain of infection through targeted hygiene. This contrasts with the current situation where different aspects of HEDL hygiene are dealt with by different agencies which means that hygiene advice received by the public is fragmented and often inconsistent.
- **Nationally, regionally and globally there needs to be an agency** tasked with co-coordinating HEDL hygiene promotion, and providing an authoritative voice to lobby on behalf of HEDL, against competing health issues. We are not suggesting the creation of a new agency, but that an existing agency should be allocated the task of co-ordinating activities related to HEDL hygiene. Leadership at national and regional level is key to enable sharing of learnings, and learning materials between different countries and regions, and supporting less affluent countries or disadvantaged communities.

2. A call to hygiene stakeholders for consensus action

Stakeholders in home and everyday life hygiene include a whole range of groups with different and often competing priorities and agendas. A key need is to achieve consensus approach between these stakeholders in order to overcome barriers to change and achieve consumer hygiene behaviour change. To do this the following needs to be undertaken:

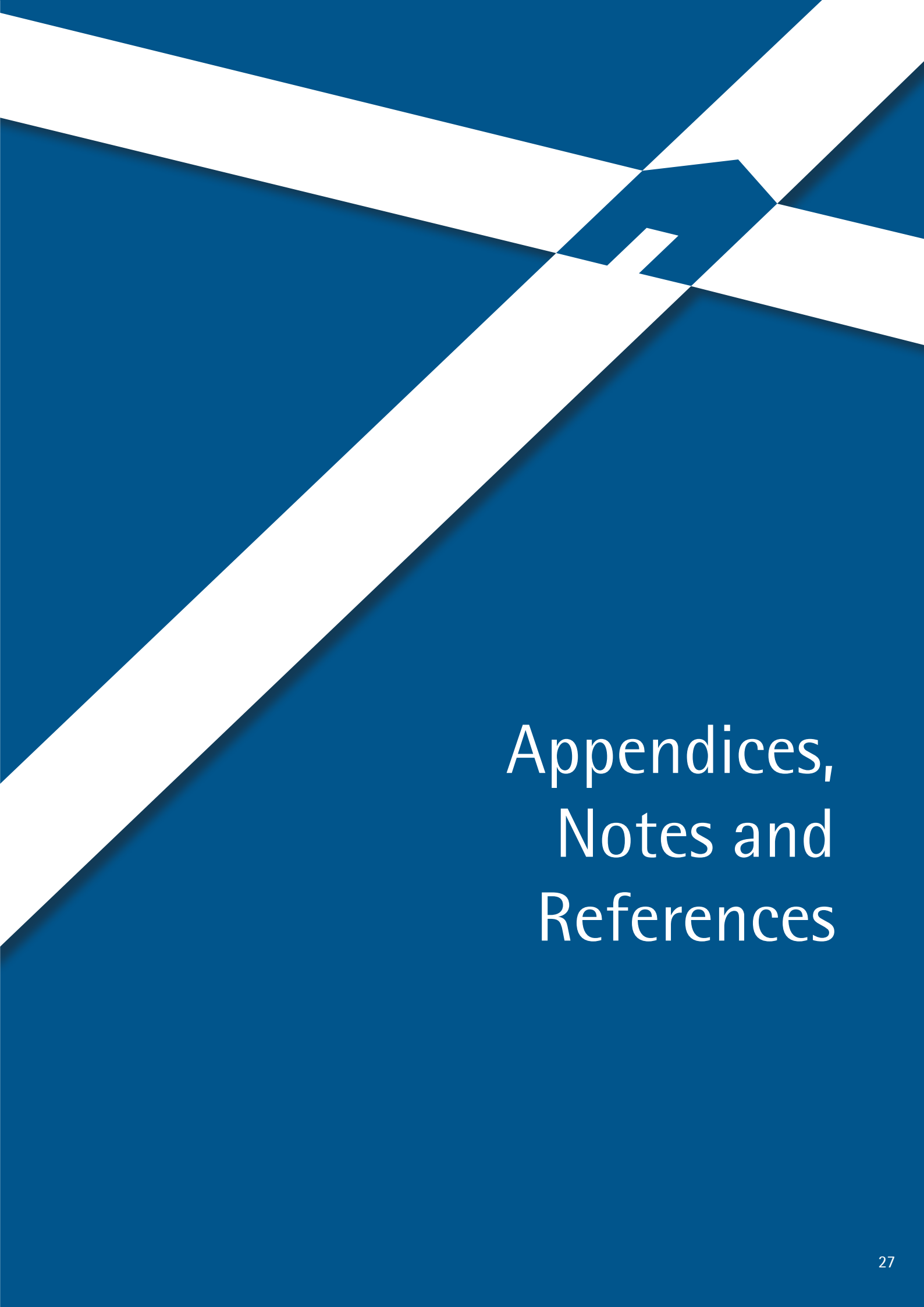
- **Further development of a scientifically-supported approach to HEDL hygiene.** Consensus will only be achieved if it is underpinned by a strong scientific evidence base. Targeted hygiene, as outlined in section 5, provides a risk management approach to HEDL hygiene. Although risk assessment is well supported by scientific data, we need a more robust framework for developing hygiene procedures, and realistic models which demonstrate their ability to deliver targeted hygiene under use conditions. Importantly the framework needs to be applicable to detergent-based or other removal procedures, as well as those involving microbicides which destroy microbes in situ. This framework needs further strengthening through research carried out by academia and the private sector.

- **Developing a consensus view on hygiene and hygiene issues.** To overcome barriers to change, hygiene stakeholders need to take a broader view rather than addressing only their own agendas. Collectively we need to address the question: How do we maximize protection against infection whilst also addressing the other issues i.e. ensure that health benefits of hygiene are properly weighed against any undesirable side effects. This will need compromise, and acceptance that targeted hygiene provides a scientifically supported basis for a more balanced approach. This will not be achievable without collaboration from environmentalists, regulators, health professionals, immunologists, microbiomists, etc. Engaging the media will also play an important role.

3. A call for concerted action from hygiene stakeholders who communicate with the public

Targeted hygiene provides the basis for a simple plausible approach which when communicated to the public can dispel current misunderstandings and build confidence in how hygiene benefits health. Engaging the media will play an important role here. Two issues need to be addressed:

- To achieve consistent and effective messaging, targeted hygiene must form the basis of all community infection prevention policies and public communications via the media and product advertising.
- Behaviour change will not happen until we achieve public understanding of hygiene, cleanliness and germs, how infections are spread, and how hygiene can prevent spread of infection. Although the 2017 review of media coverage¹⁶ does not represent a balanced cross section of opinion, it highlights a need for further studies to elucidate what the public understand about how infections spread and the role of hygiene in infection prevention. Changing public behaviour requires:
 - Researching public understanding of hygiene and to what extent, current misconceptions represent a barrier to behaviour change.
 - Researching how and to what extent better understanding of hygiene and hygiene issues can increase behaviour change produced by hygiene promotion strategies.
 - Developing behaviour change strategies tailored to home and everyday life. In reality many of the components of a strategy to change consumer behaviour, many of which are government funded, are already being developed. These are reviewed elsewhere.¹⁰¹ However, the extent to which strategies are being developed varies significantly in different countries and regions, with some countries making significant progress, whilst others are making limited progress and require greater investment. To address inequalities in the most cost effective way, sharing of materials and learning across countries and regions is essential.



Appendices, Notes and References

Appendix 1 – Strategies to promote hygiene in home and everyday life

This appendix reviews strategies currently being developed to promote improved hygiene behaviour in home and everyday life. Whilst these projects are being developed independently they reflect the increasing investment, at all levels, in developing and promoting hygiene behaviour change:

- **Development of support materials for use by the public, and by health professionals and others who communicate with the public:** Since around 2000, organisations such as The International Scientific Forum on Home Hygiene,¹⁰² the American Practitioners on Infection Control,¹⁰³ NHS Choices,¹⁰⁴ e-bug peer group community hygiene promotion (Note 29), etc., have developed a comprehensive range of guidelines, fact sheets, e-learning resource, hygiene advice materials, etc. on hygiene in home and everyday life settings. It includes advice on practices ranging from food hygiene to respiratory hygiene, hygiene in home healthcare, hygiene as a means to mitigate spread of antibiotic resistance, etc. These are being promoted through various channels:
- **Hygiene education in Schools:**
 - The e-bug hygiene education programme (Note 4). This EU- funded programme aims to ensure that all children in Europe leave school with a basic understanding of antibiotics, antibiotic guardianship and the basic principles of hygiene. To this end e-bug has produced a comprehensive range of lesson plans and support materials which are now translated into 27 European languages. The strategy is being developed by e-bug partners in these countries.
 - In Germany there is an initiative to reinstate school nurses who are trained to promote health including infection control.
 - In many countries there are non-government-funded initiatives for promoting hygiene in schools e.g Hygiene-Tips for Kids.¹⁰⁵
- **Public engagement on antibiotic resistance:** In 2016, Public Health England (PHE) launched an initiative to engage the public on antibiotic resistance and the important part hygiene plays in tackling the problem. PHE has prepared a toolkit of resources for public-facing organisations to improve public engagement on antimicrobial resistance.¹⁰⁶
- **Development of hygiene in home healthcare:** Although the focus remains on training of infection control practitioners in healthcare settings, in some countries, this is now being extended to training health professionals and other workers who deliver healthcare in domestic and other community settings e.g schools.
- In the UK training of community carers is being developed by local Community Infection Prevention and Control teams, in response to local needs, rather than being co-ordinated at national level. Community health workers are required to undertake vocational training and obtain a “care certificate”. This includes a component on Infection Prevention and Control. Training and certification is provided by privately run training agencies.
- In Germany the “Framework Hygiene Plan for Outpatient Service 2013”¹⁰⁷ serves as the basis for mobile nursing services/home healthcare and taking care of patients at home. Availability and implementation of infection control policies in ambulatory care is evaluated by a quality assessment procedure carried out yearly on behalf of the statutory nursing care insurance. There are also Technical Regulations (TRBA) as well as Accident Insurance and Occupational Safety Guidelines which give information on hygiene. Voluntary classes are offered by social service organizations such as “Malteser” or health insurances, which teach homecare hygiene for relatives.

In both UK and Germany numerous books, leaflets and websites are available, which are produced by a variety of NGOs, private organizations and others.

- **Food hygiene promotion:** Food hygiene in the domestic setting is promoted ongoing through a whole range of national and local initiatives and is an important component of strategies described above.
 - **SafeconsumE** is an EU-funded 5 year project launched in 2017 aimed at reducing the burden of foodborne illnesses.²⁰ The project focuses on changing consumer behaviour to reduce exposure to hazards and decrease risk through effective and convenient tools and products, communication strategies, education and an inclusive food safety policy. SafeConsumE is based on the assumption that consumer behaviour is both a core problem and solution to mitigating risk of foodborne illnesses. It involves 32 partner organisations in 13 European countries.
 - **NHS Choices** (www.nhs.uk) was launched in 2007 and is the official website of the National Health Service in England. It is a multichannel service for everyone engaging with the NHS and social care. It provides a comprehensive source of information for the public on hygiene¹⁰⁸ and hygiene issues, particularly food hygiene,¹⁰⁹ as a means to prevent spread of infection.
- **National hygiene initiatives**
 - **In 2008, the Danish Hygiene Council** was established.¹¹⁰ The council represents all aspects of hygiene - with a common desire for better gathering and use of knowledge. The council works through events, studies and small and larger campaigns that together can create a difference and better hygiene in Denmark. Hygiene Week is an annual event which focuses on a specific hygiene issue each year.
 - **In Sweden, Hygiene nurses in preschools (hyfs)** started in Gothenborg 2006 and established in the Västra Götaland County 2009, is a collaboration between the Department of Infectious Disease Control, Child Health Services and local authorities in the county. The aim is to improve hygiene in preschools and thereby decrease the number of infections and the consumption of antibiotic drugs among children.¹¹¹ In 2017 Hyfs initiated a National Network on Hygiene in Preschools, covering all Swedish regions and aimed at covering all municipalities. Every year a national Hygiene Week is arranged in co-operation with the Danish Hygiene Council.
- **Encouraging people to take more responsibility for their health**
 - In 2014 the UK NHS launched a Five Year Forward View. This is a plan to enable the NHS to respond to the growing demands of an ageing and sicker population and centres around prevention strategies to ensure that people remain healthy for longer – to coach people to take responsibility for their own health. This in turn will prevent hospital admissions and further health care requirements in primary care. The report identifies a need to support the 225,000 young carers and 110,000 carers aged over 85 to ensure that their needs are met. Promotion of hygiene is a crucial part of that support and enabling strategy.^{21,22} In 2017 the UK Kings Fund launched the Sustainable Transformation Plans (STPS) for delivering the 5 year Forward View at local level.²³ The aim is to utilise existing services more effectively and lower demand by increasing support for self care and empowerment.
 - In Germany an “Act to Strengthen Health Promotion and Preventive Health Care (Preventive Health Care Act)” was adopted in July 2015.²⁴ The objective is to strengthen health promotion in life settings for all age groups and promote cooperation between social security institutions, the Laender, and local authorities. The Federal Centre for Health Education (BZgA) has responsibility for implementation, quality assurance of health prevention measures. This includes hygiene and the production and mass distribution of various media (films, brochures, flyers) for issues pertaining to education of the general population in hygiene.
 - The European selfcare project¹⁹, funded by the EU and launched in 2014, is aimed at empowering people to take care of their own health. EU political decision-makers realise that consumers and patients are gradually taking a more active role, and that the future of state-funded healthcare depends on the public taking greater responsibility for their own health. An EU-funded pilot project was completed in 2017.¹¹² Of the 5 minor ailments chosen for study in the project, four (cough, cold, athletes foot and lower urinary tract infections) were infectious diseases. From the results of the pilot survey a set of guidelines on how to promote selfcare in minor ailments has been produced.



1. European Centre for Disease Prevention and Control was set up in 2005 to assist the EU by identifying and assessing the risk of current and emerging threats to human health posed by infectious diseases. <https://ecdc.europa.eu/en>
2. Biannual Public Attitudes Tracker. Food Standards Agency May 2017 <https://www.food.gov.uk/sites/default/files/biannualpublicattitudetracker-may-2017.pdf>. This is a biannual survey asking the public about their food safety concerns. The May 2017 survey indicated that whereas 36% of people were concerned about food safety when eating out, only 17% were concerned about food hygiene at home.
3. When questioned, 76% of homecare personnel said they believed that insufficient hygiene knowledge was preventing correct implementation of infection prevention precautions by patient's relatives, whilst 11% regarded knowledge of infection prevention of professional caregivers was insufficient. Also, 38% of homecare personnel believed that there is not enough time during home visits to comply with hygiene regulations. Of those questioned, 27% believe that community healthworkers are afraid of acquiring infection (MRSA, ESBL-forming pathogens, *C. difficile*) from patients, and 57% confirmed "contact" with "problem germs" in the past 12 months.¹¹³
4. The EU-funded e-bug programme (www.e-bug.eu) aims to ensure that all children leave school with a basic understanding of antibiotics, antibiotic guardianship, and the principles of hygiene. The programme is now in 26 European countries. Learning materials have also been produced for senior students and adults.
5. Failure to build and maintain a diverse human microbiome has been associated with a whole range of diseases including allergies, autoimmune diseases such as multiple sclerosis and rheumatoid arthritis, type 1 diabetes, irritable bowel disease, depression and reduced stress resilience, defence against infection, mucosal immunity, etc. See also: The role of the microbiome in human health and disease: an introduction for clinicians *BMJ* 2017; 356 doi: <https://doi.org/10.1136/bmj.j831> (Published 15 March 2017). <https://www.pfizerpro.co.uk/news/role-microbiome-human-health-and-disease-introduction-clinicians>.
6. To explain the OF mechanism, Professor Graham Rook likens the immune system to a computer programme, which is present at birth, but contains almost no data.⁵⁹ After birth, exposure to a diversity of organisms is required to build memory of the diverse molecular structures present in our world. This allows not only recognition of dangerous organisms which need to be "attacked", but also self and harmless allergens which need to be tolerated, because attack results in the development of inflammatory diseases.⁵⁹
7. In giving this advice, microbiomists were drawing on 2 studies, one which showed that children whose mothers "cleaned" their pacifiers by sucking them clean were less likely to develop asthma,¹¹⁴ and eczema, and another which showed that machine dishwashing is associated with higher risk of allergy than hand dishwashing.¹¹⁵
8. In using hygiene procedures and products in HEDL, it is important that benefits outweigh potential risks. The sustainability of cleaning products across their life-cycle, including human and environmental safety, is addressed by the A.I.S.E Charter for Sustainable Cleaning <https://www.sustainable-cleaning.com/en.home.orb> which requires continuous improvement as well as setting standards. The EU Biocidal Products Regulation prevents this initiative being extended to disinfectants for example, but under this regulation, product manufacturers must demonstrate both human safety and environmental safety through standard scientific risk assessment for each product formulation for it to continue to be sold. <https://echa.europa.eu/regulations/biocidal-products-regulation/legislation>.
9. Terms used in this report are as follows:
 - Antimicrobials – a generic term to denote both antibiotics and microbiocides.
 - Antibiotics – drug used to treat infectious diseases.
 - Microbiocides – chemical agents applied to surfaces (hands, environmental surfaces or fabrics in order to kill/inactivate microbes (bacteria, viruses or fungi).
 - Disinfectants – chemical agents or products which have microbicidal action i.e. kill/inactivate microbes.
 - Handrubs – products which are applied to hands to kill/inactivate microbes. These are also called hand sanitizers. The term handrubs is the official European term, whilst the term sanitizers is use in the US and also in Europe.
 - Antibacterials – a chemical agent or product which kills or inactivates bacteria. This term is also sometimes used as a general term for products which kill bacteria, and also viruses and fungi. The term is not officially recognized in Europe.

10. If everyone in Europe reduced laundry temperatures when possible it could make a real difference. Energy savings of a reduction of only 3° in the average wash temperature of people in Europe is equivalent to eliminating the emissions produced by around 700,000 cars. <http://www.iprefer30.eu/animations/UK/wash-brochure-uk.pdf>.
11. There is need for research to determine how machine wash cycles could be adjusted to achieve hygiene effectiveness equivalent to that at 60°C.¹¹⁶
12. *S. aureus* strains are extensively shed onto clothing from healthy persons who may carry this organism. Studies show that up to 30% of the population in the community are persistent or intermittent carriers of *S. aureus*, of which a significant, but unknown proportion carry MRSA.³⁰ Carriage of resistant strains of enterobacteria in faeces is review by Bloomfield, 2013¹⁰
13. In 2016, FDA issued a rule on effectiveness and safety of antibacterial soaps, which came into effect September 2017. FDA concluded, based on lack of scientific evidence for the effectiveness of antibacterial soap, that the risk posed by the use of antibacterial soap outweighs its benefits; thus consumer antiseptic products containing one or more of 19 ingredients, including triclocarban and triclosan, can no longer be marketed. See: US Food and Drug Administration. Safety and effectiveness of consumer antiseptics; topical antimicrobial drug products for over-the-counter human use. https://www.federalregister.gov/documents/2016/09/06/2016-106_21337/safety-andeffectiveness-of-consumer-antiseptics-topical-antimicrobial-drug-products-for. 2016.108 7.
14. Following an opinion of the European Chemicals Agency (ECHA) delivered under the Biocidal Product Regulation (EU) No 528/2012, the Commission has adopted the Commission Implementing Decision (EU) 2016/110 to ban triclosan for its biocidal use as a disinfectant for human hygiene (e.g. hand soap disinfectants), as the evaluation of this use showed unacceptable risks to the environment. <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016D0110&from=EN>
15. Although hygienic cleaning of surfaces as part of daily or weekly routines produces a reduction in contamination levels, microbes are constantly being shed or spread into the environment, from sources such as people (infected or colonized), domestic animals, contaminated air, food and water. This means that contamination levels can return to precleaning levels within as little as 1-2 hours.⁷⁹
16. Bloomfield, Carling and Exner reviewed 10 laboratory or field studies which demonstrate that significant bacterial or viral pathogenic contamination can remain on surfaces after detergent-based cleaning or wiping and that this is subsequently transferred to the hands or spread to other surfaces via hands and cleaning utensils.⁸²
17. These studies are reviewed in a 2016 research paper by Arbogast et al.¹¹⁷
18. In reality, any “stressful” exposure (cold, heat, desiccation acid, alkali, microbiocides) causes bacterial populations to deploy protection mechanisms ensuring their survival, including mechanisms which reduce susceptibility to antimicrobials, but not necessarily resistance. A 2004 study showed that antibiotic resistance genes are induced by exposing bacteria to natural substances, common to domestic settings. Of 9 herbs and spices, 19 food and drinks and 7 household products tested, 24 (69%) inhibited bacterial growth and 22 (63%) induced resistance gene expression. Mustard, chilli and garlic were powerful gene inducers. None of the products made hygiene claims!¹¹⁸
19. Effects of antimicrobial agents on microbial populations vary significantly according to their chemical properties, the differing biochemical mechanisms by which bacterial become resistant to different antimicrobials and whether the change in susceptibility is likely to be permanent (i.e. passed on to subsequent generations) or only temporary (i.e. susceptibility is restored once the “stress” is removed).
20. The misguided concept which emerged in the 1990s, was that using products which could kill microbes in a “gentler” manner, could help to avoid development of resistance. The term “antibacterials” was introduced to distinguish them from disinfectants which were deemed to be “stronger” and thought to be more likely to induce resistance. In reality, it is when microbial populations are exposed to sublethal concentrations that resistance is more likely to develop.
21. In the Oxford English Dictionary, hygiene is defined as “practices through which people maintain or promote good health”. This means that the term can also be used to describe practices such as personal and oral hygiene which are associated with social acceptability. In Europe, it is also used to describe other public health issues such as obesity, alcohol abuse, air quality, etc.

22. In a pilot study of what people (117 participants) understand by the terms clean and hygienic, most people said that clean means absence of visible dirt and hygienic is something more than clean (reduction or germs to safe level/protection of health). However, up to 25% were unclear about the difference between clean and hygienic i.e. if it's visibly clean – it's hygienic. A further 10% assumed that clean meant a detergent was used, whilst hygienic meant a disinfectant or alcohol handrub was used. Particularly in Germany, it is acceptable to use "hygiene" to describe practices and products which maintain visual cleanliness, but are not specifically intended to protect against infection.
23. The chain of infection and the principles of targeted hygiene are outlined in a simple e learning resource produced by the International Scientific Forum on Home Hygiene: Breaking the chain of infection – an e-learning resource. https://www.ifh-homehygiene.org/e_learning/breaking_the_chain/story.html.
24. Microbicidal activity is usually expressed as the Log₁₀ reduction in the level of microbial contamination. Log₁₀ 3, 4, 5, reduction is equivalent to 99.9, 99.99 and 99.999% reduction.
25. This shift of opinion is reflected in a 2005 document produced by the UK Health Development Agency which concluded that "Although the randomised controlled trial (RCT) has the highest internal validity and, where feasible, is the research design of choice when evaluating effectiveness, however, many commentators felt the RCT may be too restrictive for some public health interventions, particularly community-based programmes. In addition, supplementing data from quantitative studies with the results of qualitative research is regarded as key to the successful replication and ultimate effectiveness of interventions".¹¹⁹
26. Haas and co-workers used published data to model transfer of E. coli O157 from hand-to-mouth following contact with contaminated ground beef. Using data on typical levels of E.coli contamination in raw meat, rates of transmission during handling, etc., it was assessed that, if all individuals washed their hands with soap following contact with ground beef (log reduction in contamination on hands assessed as 0.3), this would result in an estimated 0.014 infections/year. If an alcohol hand rub is used (log reduction assessed as 4.3) the risk would be reduced to an estimated 0.00005 infections per year, equating to 99.9996% risk reduction compared with handwashing with soap.¹²⁰
27. Presently, the most-used approach is a pragmatic approach, where performance criteria are based on LR's which we could reasonably expect to achieve. The precedent for this is seen in CEN and EPA disinfectant tests where "pass" levels of 3, 4 to 5 LR are set for suspension and surface tests. These levels, which we have accepted for 20 or more years, are not based on any clinical knowledge, but on the basis that they are known to be achievable by currently-used disinfectants. By contrast, accepted "pass" levels are rarely considered for procedures which involve removal of pathogens such as handwashing with soap (HWWS), the efficacy of HWWS is mostly assumed.
28. In a recent study Ryan et al. used QMRA for setting safety target levels i.e. for estimating the LR on a surface needed to reduce the infection risk to an acceptable level. For each of 7 microorganisms, data were extracted from the literature and infection risk determined for a scenario where a contaminated surface was touched with the fingers, and the fingers then touched the mouth, nose or eyes. Using dose-response models, hand to mouth infection risk for a single touch of the contaminated surface suggested that, on average, 2LR was sufficient to achieve the 10⁻⁶ safety target level for E.coli and Listeria, whilst norovirus required an LR of 3.44. For Pseudomonas spp, Salmonella spp, and S. aureus it was estimated that no decontamination process was required.⁹⁷ It should be noted that these calculation were based on ambient levels of surface contamination, rather than levels which would occur in risk situations.
29. Beat the Bugs is a six week community hygiene course aiming to increase awareness and change behaviour around antibiotic use. The course comprises 6 sessions: Introduction to microbes, hand and respiratory hygiene, food hygiene and antibiotics <http://www.e-bug.eu/beat-the-bugs/>



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