IFH
INTERNATIONAL
SCIENTIFIC FORUM
ON HOME HYGIENE

Developing and promoting hygiene in home and everyday life to meet 21st Century needs

"What can we learn from the COVID-19 pandemic?"

A report commissioned by the International Scientific Forum on Home Hygiene

July 2021

This report was commissioned by the International Scientific Forum on Home Hygiene and prepared, as a consensus document, by a group of 18 experts in hygiene representing 10 countries worldwide.

This report can be downloaded from:
https://www.ifh-homehygiene.org/review/developing-and-promoting-home-and-everyday-life-hygiene-meet-21st-century-needs

The International Scientific Forum on Home Hygiene (IFH) is a not for profit, non-commercial, Registered Charity (UK Charities Commission Reg No. 116912) which was established in 1997 with the mission to promote health and wellbeing through improved hygiene (infection prevention and control) in home and everyday life settings.

The IFH is unique in that it addresses hygiene from the viewpoint of the home and more importantly the family or household. It is dedicated to understanding the interrelated actions family members undertake in their everyday lives to protect themselves from infectious disease:

Contents

FOREWORD

Following a meeting in London, England in 2018, a group of experts in hygiene agreed to prepare a consensus report summarizing why hygiene in home and everyday life (HEDL) is important and what needs to be done to ensure it is fully recognised as an equal partner with hygiene in healthcare and institutional settings in controlling the burden of infectious diseases and tackling antimicrobial resistance (AMR).[1]

An issue highlighted in the report was the growing threat from a global pandemic, possibly due to a respiratory pathogen such as influenza. If this happened, hygiene in our homes and everyday lives would be the vital first line of defence to mitigate spread before other measures, such as vaccines and antimicrobials, become available. These fears were realised in early 2020 when the COVID-19 pandemic spread rapidly across the world in the absence of effective first-line mitigation measures.

In light of these events, IFH has prepared this revised 2021 white paper to explore what needs to be learned from the COVID-19 pandemic. As stated in the 2018 paper, in the past, HEDL hygiene has tended to be considered less important than infection prevention and control in health facilities. Hopefully, the COVID-19 pandemic will refocus the attention of politicians, healthcare professionals, academics and others on the vital role of public hygiene understanding and hygiene behaviour when living with an infection for which we have no effective pharmaceutical interventions. We need to recognise that the next pandemic, the spread of antimicrobial resistance, is already underway. Public hygiene behaviour has a major, but hitherto under-recognised, role to play, by driving down infection rates and the associated need for antimicrobial use, the main driver of AMR.

This report is intended to be constructive and pragmatic, providing a framework for workable solutions. It centres around our understanding of how a risk management approach provides us with the best option for developing hygiene strategy which is effective in addressing the issues we currently face, including sustainable use of the resources needed to perform hygiene practices. This report calls on the many stakeholder groups including scientists, healthcare professionals, environmentalists, the media etc to work together to achieve the objectives set out in this report. **It is only by working together that we will be able to achieve the health benefits hygiene in home and everyday life offers**.

Dr Sally Bloomfield, Chairman, International Scientific Forum on Home Hygiene;

Professor Lisa Ackerley, Vice Chairman IFH; Visiting Professor, University of Salford, Chartered Environmental Health Practitioner; Professorial Fellow & Member of the Board of Trustees, RSPH.

Professor Carlo Signorelli, Professor of Hygiene and Public Health, University Vita-Salute San Raffaele- Milan, Italy and Director of the School of Public Health (Igiene e medicina preventiva) Incoming President, Association of Schools of Public Health in the European Region (ASPHER) Past-President, Italian Association of Public Health (Società Italiana di Igiene), IFH Scientific Board Member

Professor Elizabeth Scott, Associate Dean and Professor, College of Natural, Behavioral, and Health Sciences, Simmons University, Boston, USA IFH Scientific Board Member.

Director emeritus Prof. Dr. med. Dr. h.c.Martin Exner, Institute of Hygiene and Public Health, Prevention and Outbreak Management / One Health. University Hospital and University of Bonn, Germany, IFH Scientific Board Member

Professor KJ Nath, President, Institution of Public Health Engineers, India; Former Director, All India Institute of Hygiene & Public Health, Kolkata. IFH Scientific Board Member.

Professor Sabiha Essack, Antimicrobial Research Unit, College of Health Sciences, University of Kwa-Zulu-Natal, Durban, South Africa.r.

Professor Anthony C. Hilton, Pro-Vice Chancellor and Executive Dean, College of Health & Life Sciences Aston University, UK

Dr Elizabeth Redmond, Senior Research Fellow, Zero2FIVE Food Industry Centre, Cardiff Metropolitan University, Wales, UK

Professor Sumanth Gandra, Associate Professor of Medicine, Department of Medicine, Division of Infectious Diseases, Washington University School of Medicine, St. Louis, Missouri, USA

Professor Syed A. Sattar, Professor Emeritus of Microbiology, Faculty of Medicine, University of Ottawa, Ottawa, Ontario, Canada

Professor Charles Gerba, University of Arizona, USA

Professor Kelly Reynolds, Chair of Community, Environment and Policy Department, Director, Environment, Exposure Science and Risk Assessment Center, Zuckerman College of Public Health, The University of Arizona, USA

Dr Amanda Wilson, Rocky Mountain Center for Occupational and Environmental Health, University of Utah, USA; Department of Family and Preventive Medicine, School of Medicine, University of Utah, USA

Lars Münter, Administrative Director of Danish Council for Better Hygiene; Comms Lead Self-Care Week Europe

Dr Solveig Langsrud, Nofima - Norwegian Institute of Food, Fisheries and Aquaculture Research

Professor Susanne Knøchel, Head of Science, Department of Food Science, University of Copenhagen, Denmark; Former Chairman and Secretary of the Council for Better Hygiene

Dr Dirk Bockmuhl, Faculty of Life Sciences, Rhine-Waal University of Applied Sciences, Germany.

SUMMARY

The report shows that hygiene in our homes and everyday lives is of paramount importance in the 21st century and has played a critical role in fighting the Coronavirus pandemic in 2020/21. Fundamental changes in the last 30 years have reinstated hygiene on the public health agenda. These changes include not only threats posed by emerging pathogens, most particularly respiratory pathogens, but also new strains of existing pathogens, particularly those resistant to antimicrobial agents. It also includes growing numbers of those more vulnerable to infection now, living or being cared for in domestic settings.

The report evaluates how household hygiene needs to change to meet 21st century needs. It centres around developing a risk management approach (Targeted Hygiene) for addressing the issues we currently face.

This report also includes findings of a new study on public understanding of hygiene carried out in 23 European countries. The poll indicates that the public is confused about what hygiene means and how it differs from cleanliness. It shows that, although the public's actions are to some extent guided by their perception of risk, there is limited understanding of key risk situations and when (and where) hygiene is needed.

The major findings are:

- **Hygiene in our homes and everyday lives (HEDL) is of paramount importance in the 21st century,** but needs to be better recognised by national and international policy makers as an equal partner with infection prevention in healthcare and other settings, and given a more equal allocation of resources.
- **If hygiene in HEDL is to be effective, it needs an approach appropriate to the issues we currently face**. Targeted Hygiene provides a framework for developing hygiene that is effective and also addresses sustainability and other issues. However, work is needed, using new scientific methods, to develop this approach and estimate its effectiveness in reducing infection risks.
- Targeted Hygiene provides a framework for addressing hygiene-related issues including sustainable use of resources (chemicals, energy, microbiocides), minimizing environmental impacts and adverse effects that cleaning and cleaning agents might have on human interaction with essential microbes. **Lack of a unified voice advocating for hygiene in home and everyday life means these issues can be regarded as more important, leaving hygiene and its importance in second place**.
- **Achieving the benefits of Targeted Hygiene depends on getting the public to understand and adopt this approach**. Misunderstandings and myths around hygiene and cleanliness are currently undermining efforts to promote hygiene behaviour change. To achieve behaviour change we need further work to explore cognitive influences on hygiene understanding and behaviour, and better understand the drivers for behaviour change. Only by incorporating these learnings into hygiene promotion strategies will we be able to realise the health benefits that Targeted Hygiene can deliver.

Scope of the report

This white paper outlines the 5 key issues that need to be considered in developing and promoting home and everyday life hygiene:

- The importance of HEDL hygiene in preventing the spread of infectious diseases.
- Development of a risk management approach whereby hygiene practices are targeted at the key moments when there is the highest risk of infectious microbes being spread and causing infection.
- Application of new approaches for developing effective and sustainable hygiene protocols and procedures.
- Identification of barriers to changing hygiene behaviour.
- Investigation of public understanding of hygiene.

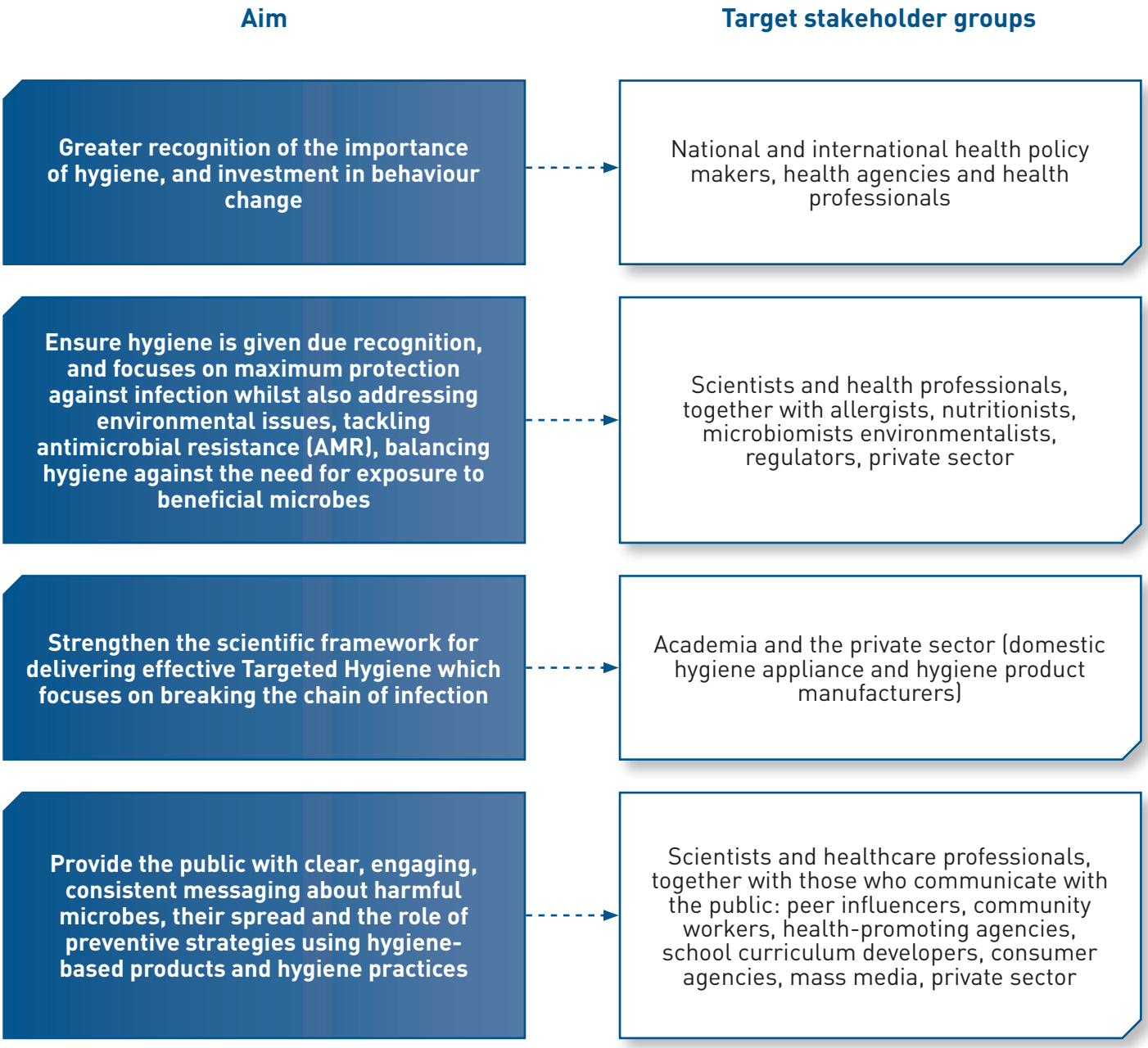
This paper is written from the perspective of domestic and everyday living in high-income countries (HICs), where water and sanitation standards are mostly adequate to good. In principle, the recommendations are also appropriate to low-and middle-income countries (LMICs) but need to be adapted for environments that lack access to basic amenities (water, sanitation) essential to practicing hygiene.

Definition of Hygiene: When used in the context of this report, the term "hygiene" will refer solely to practices aimed at promoting good health by breaking the chain of infection. We realise that a much broader definition is often used, e.g. The Oxford English Dictionary defines hygiene as "practices through which people maintain or promote good health" and thus includes oral and personal hygiene, and health issues such as obesity, alcohol abuse etc. It can also include air quality and general cleanliness (absence of dirt, tidiness and living in a clean-looking environment) which is regarded as conferring a health benefit, by promoting a feeling of well-being.

Abbreviations of terms used in this report can be found in Annex 2

Who should read this report?

The aim of IFH is to develop and promote hygiene in home and everyday life (HEDL) settings and achieve hygiene behaviour change. This can only be accomplished by engaging with and working with, *inter alia*, the following key stakeholders groups:



Section 1. The need for hygiene in home and everyday life settings

It is difficult to comprehend that, in the 1970s, with vaccines and antibiotics freely available, some experts were predicting infectious diseases would soon be a thing of the past.[2] As a result, investment in hygiene promotion declined. Since then fundamental changes have occurred which have reinstated hygiene on the health agenda. Developing hygiene for HEDL, appropriate to current needs, requires an understanding of these changes.

1.1 Emergence of new pathogens and new microbial threats

A key driver has been the ongoing emergence of new pathogens, especially viral pathogens. The 1980s saw the emergence of the norovirus winter vomiting "bug" which is highly transmissible and now endemic in the community. Studies in England and Wales[3] and the Netherlands[4] suggest that, respectively, 1 in 20 and 1 in 25 people have a bout of norovirus each year. Norovirus mainly spreads from person-to-person although food is increasingly seen as a vehicle. It is now recognised as the most significant cause of infectious intestinal disease in the developed world.[5] A 2016 review from Africa reported a mean overall prevalence of 13.5% in children <5 years old hospitalized with acute gastroenteritis.[6]

As norovirus is not treatable by antibiotics, and there is no vaccine available, hygiene remains the first line of defence. Since hospital outbreaks originate in the community, reducing circulation in the community is also a means to reduce hospital outbreaks.[7]

1.2 The global pandemic

From 2000 we have seen the emergence of respiratory infections prompting concern about a global pandemic. This included the previously unknown severe acute respiratory syndrome (SARS) in 2003,[8] an avian influenza virus pandemic caused by the H1N1 virus strain in 2009[9] and the COVID-19 pandemic in 2020. Prior to the 1970s, it was assumed that spread of respiratory viruses was via droplets and aerosols. In the last 30 years microbiological[10] and epidemiological data[11,12] have shown that hands and surfaces also contribute and that hand hygiene can help limit spread. Preparedness plans recognise that in the early stages of a pandemic public hygiene behaviour is essential to mitigating spread before other measures can be put in place.[13,14,15] Professor Peter Piot, Former Director of the London School of Hygiene and Tropical Medicine said "As the historical foundation of public health, good hygiene is one of the most important tools we have in fighting pandemics".[16]

1.3. Tackling antimicrobial resistance (AMR) – a global threat[17]

AMR is one of the biggest threats to global health, food security and development today. Tackling AMR focuses on education, surveillance, infection prevention, antibiotic use and finding new antibiotics. Where early initiatives focussed on infection prevention in healthcare settings, policy makers now recognise that this cannot be achieved without reducing spread in the community.[18] An EU Health policy brief[19] states "Patients and their families are key elements in the chain of transmission in healthcare facilities. Studies of the impact of patient and family-oriented education on the rate of hospital-acquired infections are needed".

Collignon concludes[20] "Reduction of antibiotic consumption will not be sufficient to control AMR because contagion, the spread of resistant strains and resistance genes, seems to be the dominant contributing

factor. Measures to improve sanitation, access to clean water, governance and public healthcare expenditure are needed to tackle AMR on a global scale". LMICs are disproportionately affected by AMR, exacerbated by sub-optimal WASH (Water, Sanitation, Hygiene) infrastructure[21] and antibiotic misuse exacerbated by the COVID-19 pandemic, further illustrating the need for hygiene in resource-limited settings.[22]

Hygiene in HEDL addresses AMR by preventing infections, thereby reducing the need for antibiotic prescribing. It also provides a means to reduce the spread of resistant bacteria such as methicillin-resistant *Staphylococcus aureus* (MRSA), and multi-drug resistant. Gram negative strains.[23,24,25,26] WHO,[27] EU[28] and US[29] action plans emphasize the need for society-wide engagement, focussing on prevention first. At present, National Action Plans (NAPs) mostly focus on healthcare facilities. An exception is the UK[30] and Canadian action plans.[31] The UK plan states "when it comes to preventing infection, the public has a huge part to play."[30] It highlights the e-bug programme (www.e-bug.eu) which aims to ensure all children in Europe leave school with an understanding of AMR and the role of hygiene.

A recent review[32] shows that NAPs in low and middle-income communities (LMICs), also pay insufficient attention to community WASH programmes. It is forecast the annual death toll from AMR infections could reach 10 million by 2050, of which 9 million are likely to be in LMICs in Africa and Asia.[33] An area where progress is being made is the African region, where half of the seven plans[34] recognise the importance of community WASH programmes. The South African NAP has implemented interventions to mobilise communities to adopt basic infection prevention and hand hygiene and recognises access to safe WASH services are critical to community hygiene.

1.4. Social and demographic changes

In the 1970s, in HMICs (High and Middle Income communities), the importance of hygiene was downplayed on the basis that healthy people in home settings are at little risk of infection. Social and demographic changes mean that, in recent years, the number of people at increased risk of infection living in the community (referred to in this paper as vulnerable groups) has significantly increased, now accounting for 20% or more of the population.[35,36] It is estimated one in five people worldwide is at increased risk of severe COVID-19 due to underlying health conditions.[37] The largest proportion is the elderly, who have reduced immunity to infection, often exacerbated by co-morbidities such as diabetes and cancer. It also includes the very young, patients discharged from hospital and family members with invasive devices such as catheters. Also at risk are those with chronic and degenerative illnesses (e.g. HIV/AIDS) or receiving immunosuppressant therapies. For immunosuppressed individuals, antibiotics increase susceptibility to *Clostridioides difficile* infection.

Vulnerable groups are also at risk from opportunistic pathogens such as *Pseudomonas aeruginosa, Escherichia coli* and *Klebsiella* spp which infect wounds, catheter-insertion sites, and contaminate medical equipment. Other opportunistic pathogens found in home settings that particularly affect vulnerable groups are *Legionnaires' bacillus and Aspergillus* spp.[10]

Populations across the world that live under stress, such as those living in poverty and degradation or who belong to racial and ethnic minorities, experience higher rates of illness and death across a wide range of health conditions, including infectious diseases.[38,39] Data shows continuous stress caused by microaggressions associated with racism have a physiological impact resulting in a constant heightened inflammatory response and increased susceptibility to infection.[38] Yet again, the COVID-19 pandemic has highlighted that addressing these issues is key to improving resilience to infectious disease threats.

1.5 Foodborne infection and home hygiene

Foodborne infections place a heavy toll on health and prosperity which could be significantly reduced by implementation of good food hygiene.[40,41] The evidence base for the following is set out in Appendix Note 1. A barrier to hygiene behaviour change is that the public tends to believe foodborne infection is more likely to occur outside the home. In reality UK data suggests 12-17% of outbreaks are associated with the home,[42] whilst data from 18 European countries indicate 31% of outbreaks occur in private homes.[43] In US and Canada the home was implicated in 7-46% of outbreaks.[42]

Foodborne illness is a hygiene issue for which we have estimates of economic and societal gains that could be achieved by improved food hygiene behaviour in the home. A US study[44] estimated the annual economic loss from *Campylobacter* and *Salmonella* spp to be $6.9 and $4.7 billion, respectively. A 2018 UK report estimated the burden (direct and indirect (loss of earnings, school absenteeism etc)) is around £3bn.[45]

Section 2. Development of hygiene policy in home and everyday life spaces to meet 21st Century needs

In line with changes over the last 30 years, it has become apparent that guidance on hygiene practices needs to be reviewed to ensure it is appropriate to the issues we face, now and in the future. Since 1997, The International Scientific Forum on Home Hygiene (IFH) and our partners have taken advantage of the growing evidence base on how infections are spread, to develop an approach to hygiene in home and everyday life known as Targeted Hygiene.[1,38,46,47] Targeted Hygiene is based on risk management approaches developed by the food and pharmaceutical industries since the 1960s to control microbial risks. Microbiological and other data used in developing Targeted Hygiene is set out in an IFH review.[10] Targeted Hygiene means focusing hygiene practices at the times (moments) and in the places that matter most. This approach recognises the inadequacy of C20th approaches based on the public's belief that, by maintaining cleanliness by regular cleaning and disinfection, it is possible to "keep" a home hygienic. There is poor understanding that the main risk is from humans, domestic animals and food-handling.[10]

2.1 The Chain of Infection and Targeted Hygiene

Understanding Targeted Hygiene depends on understanding how infections spread i.e. the Chain of Infection (Figure 1). Targeted Hygiene recognises that the major sources of harmful microbes in HEDL settings are not places that are "dirty". In reality they are mainly people, foods and domestic animals who occupy these spaces, who may carry and/or be contaminated with pathogenic or potentially pathogenic microbes. It includes those who are clinically ill, but also healthy carriers of harmful microbes that can cause infection in others. COVID-19 highlights the importance of asymptomatic infection, where data suggests that 30% or more cases are asymptomatic.[48] A study of UK households from April to June 2020 suggested 75% of people with SARS-CoV-2 were asymptomatic.[49] Households appear to be the highest risk setting for transmission of COVID-19.[50,51,52] Persuading the public to behave at all times as if they are infected presents a significant challenge. Hygiene is also important in preventing the silent spread of AMR strains across the community and onwards into hospital settings.[53]

Figure 1: The chain of infection transmission

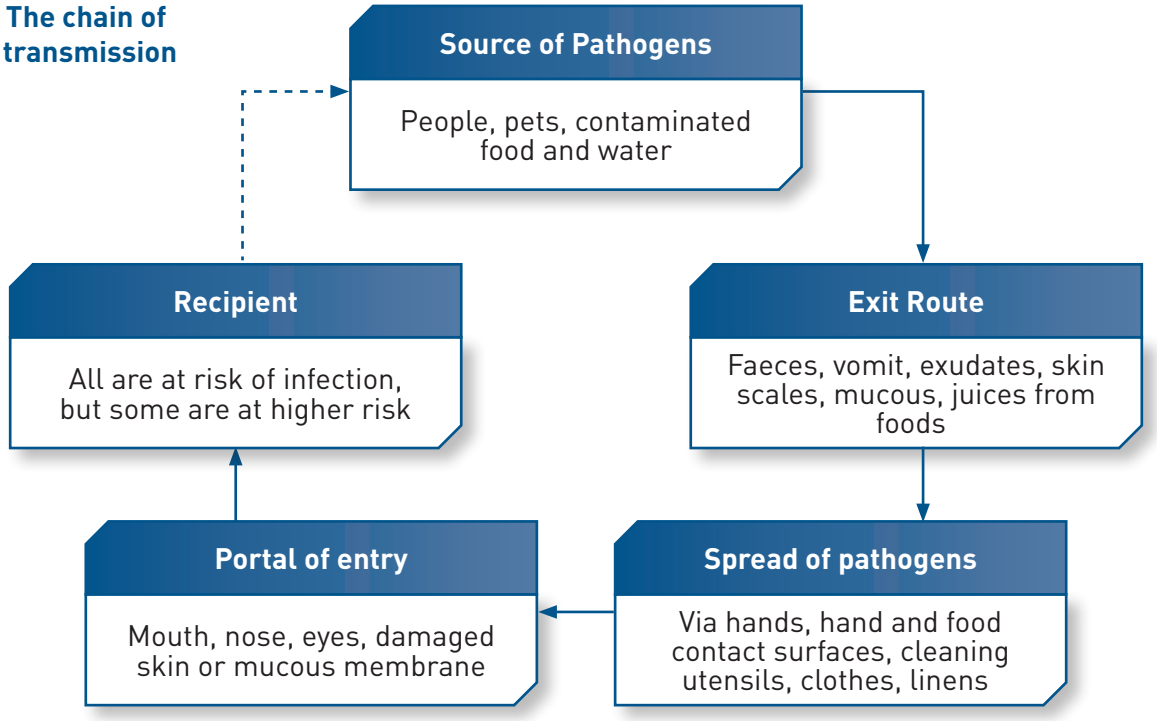


Figure 1, shows, when there is an infected person, animal or contaminated food or water source in the home, harmful organisms will be shed from these sources into the environment during daily life activities and can spread via surfaces (hands, body surfaces, environmental surfaces, cleaning utensils, clothing and linens etc) and the air such that we become exposed to them via our mouth, eyes, nose, open wounds, damaged membranes etc and can develop an infection. Hygiene practices are used to prevent this from happening i.e. break the chain of infection. If we are not exposed to harmful microbes we cannot be infected.

2.2 The 9 key moments when hygiene matters

Evaluation of microbiological data related to the spread of harmful microbes in living environments,[10] coupled with assessment of people's behaviour, indicates there are 9 key moments in our daily lives where harmful microbes are most likely to be spreading:

1. During food handling
2. Whilst eating with fingers
3. Using the toilet or changing a baby's nappy
4. Coughing, sneezing, nose-blowing
5. Touching surfaces frequently touched by other people
6. Handling and laundering, clothing, towels and bed linens etc
7. Caring for domestic animals
8. Handling and disposing of rubbish
9. Caring for an infected family member

Development of the "key moments" concept of Targeted Hygiene dates from the 2019 Royal Society for Public Health (RSPH) poll[46] when it became clear that, although the public say they understand Targeted Hygiene, they tend to see it as "targeting the places that are risky". The moments (times not places) approach communicates a visual concept that hygiene is about taking action when harmful microbes are likely to be spreading.

To be effective these actions need to be performed not only at the moments when harmful organisms are most likely to be spreading, they also need to focus on the surface or airborne vectors (called control points) through which we are most likely to be exposed to them, via the mouth, nose, eyes, etc. These control points are identified using standard principles of risk assessment, i.e. the infection risk from contaminated hands, surfaces, etc depends on both probability of contamination with harmful microbes at that moment, and the probability of subsequent exposure to these microbes if they are allowed to spread, assuming they remain viable.

Although these are not the only moments when hygiene practices are needed, it is argued that, routinely practicing hygiene at these moments, could substantially reduce the risk of infection. It could be argued, for example "before touching eyes, nose, or mouth" should be included as a tenth moment. Also, since listing the 9 moments,[46,47] data from COVID-19, has shown that infected droplets and aerosols can also be generated by speaking, shouting and singing.[54] If, we can educate the public to visualize hygiene as "taking action at risk moments" this provides a sound basis for prompting action when and where needed, thereby building behaviour change in the future.

By examining the 9 moments, it is possible, (as shown in Fig. 2) to construct a "ranking of surfaces" according to the likelihood they are involved (i.e. are critical points) in infection transmission at risk moments:

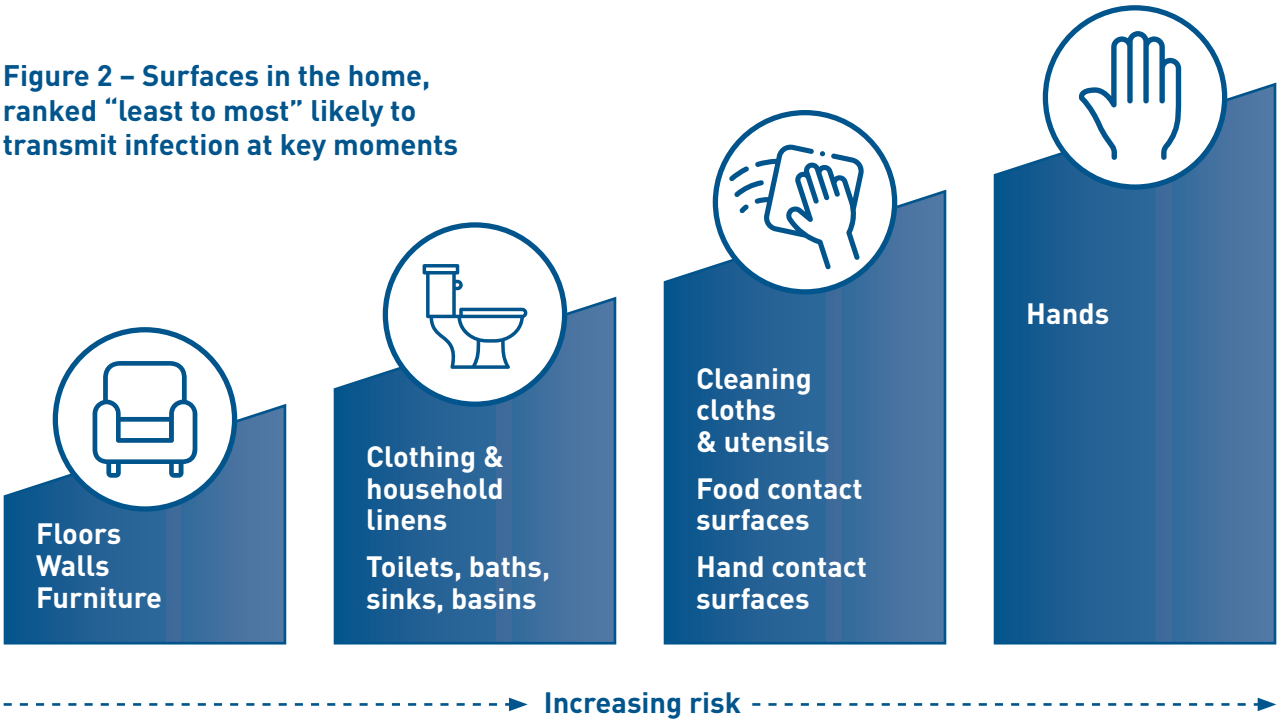
1. Surfaces with the highest risk, i.e. surfaces most often associated with the key 9 moments, include the **hands, hand contact surfaces, food contact surfaces and cleaning utensils (including kitchen cloths, sponges, washing up brushes etc)**.

2. **Clothing (particularly clothing in contact with the human body), bed linens, hand and bath towels and face cloths** etc, can also contribute to spread, although risks related to these surfaces are somewhat lower since they may rely on additional chain links, such as hands, to transfer the microbes from the fabric to a susceptible person.

3. **Toilets and sink, bath, washbasin and shower surfaces** can also contribute to establishing a chain of infection although, again, data suggest risks are normally lower as they rely on the other "chain links" such as the rates of transfer from surfaces to hands and hands to face.[55]

4. By contrast, **floors, walls, furniture and other surfaces** (i.e. not hand or food contact surfaces) are considered as low risk and of less concern. Although they may look visibly dirty and have high levels of microbes, they are considered low risk partly because harmful microbes are unlikely to be present[10] and partly because we do not have frequent exposure to them. This means the daily/weekly routine of keeping floors, furniture, etc visibly clean contributes little to preventing microbial exposure, compared with practices carried out at critical moments.

Figure 2 – Surfaces in the home, ranked "least to most" likely to transmit infection at key moments



Although this is a useful ranking, it is not a constant. Toilets are considered relatively low risk based on data showing that they do what they were designed to do, i.e. get rid of faecal pathogens from the home safely. But if someone has norovirus infection or diarrhoea, splashing and aerosol generation can contaminate hand contact surfaces.[56,57]

Similarly, risks associated with floors increase where there is a crawling baby on the floor, or in communities where it is the custom to sit on the floor to eat during family gatherings, religious festivals etc. To contain this risk, however, hygiene practices must be used immediately before using the floor. Particles bearing bacteria, viruses etc settling onto floors, furniture (including soft furnishings) and other horizontal surfaces can be resuspended due to airflow patterns, or turbulence (walking, etc).[58] Resuspended particles can be inhaled or resettle back onto contact surfaces.[59] This is a risk for drought-

tolerant organisms such as *S. aureus* (including MRSA),[60] *C. difficile*[56] and norovirus.[61]

Although the principles and routes of transmission of infections are the same, regardless of the setting, it is acknowledged the 9 key moments of hygiene in their current form is not applicable in LMIC contexts where open defecation, poor/lack of access to clean water, sanitation and electricity, high population densities in slums/informal settlements, close contact with food and animals pose additional challenges. Targeted Hygiene needs to be reconceptualised for these settings where vulnerabilities are exacerbated by poor socio-economic determinants of health and wellness.

2.3 Learnings about infections transmitted via the air and contact surfaces

SARS-CoV-2 has given new insights into virus transmission. The evidence base for the following is set out in Appendix Note 2. For COVID-19, airborne spread is likely the main driver, although opinions differ on the relative importance of aerosols which can travel a considerable distance and larger respiratory droplets where close contact is required. Opinion also differs about risks from hand contact with surfaces relative to airborne routes, some concluding that surface spread is negligible. Whilst this might be so in public spaces, particularly outdoors, where surfaces are rarely touched, it does not apply in home settings (thought to be the highest risk setting for transmission) where there are frequent opportunities to touch surfaces recently touched by others. A modelling study of occupationally acquired COVID-19 infection in a healthcare setting estimated contact routes contribute 8.2% to the total risk of infection[62] which suggests, in a large community population, efforts to reduce indirect contact routes could translate to meaningful reductions in infection risk.

It must be recognised that the relative importance of contact versus airborne routes is different for the different viruses of importance in HEDL settings. For influenza, data suggest that transmission via hands and contact surfaces is significantly less than via airborne routes. By contrast, for rhinovirus and norovirus, contact surface transmission is relatively more important, with some investigators maintaining rhinovirus contamination of the hands followed by touching the eyes or nose may be the most important route. Since risk management means simultaneous intervention at key control points, hygiene must be targeted at hands and hand contact surfaces as well as airborne routes. The problem is that surfaces cannot be disinfected every time they are touched. However, knowing they represent a risk, can act as a prompt to decontaminate hands after touching contact surfaces and focus on contact surfaces when cleaning.

To maximize protection in HEDL settings, hygiene policies must take account of the growing database of knowledge about differences in routes of spread of different bacteria and viruses.

2.4 Hygiene in everyday life settings

A key issue which COVID-19 has highlighted is the importance of hygiene in our shared use of public spaces. To reopen since COVID 19 lockdown, offices, restaurants, shops and supermarkets have had to implement strategies to make their facilities so-called "COVID secure". Despite national attempts to promote a targeted approach (hands, face, space, ventilation), some of the strategies adopted illustrate the ongoing belief that untargeted, "deep cleaning" can make a public space "COVID secure". As a result we have seen examples of what is being called "hygiene theatre".[63,64,65] These are ostentatious measures involving fogging and spraying of outdoor and indoor spaces aimed at giving peace of mind. There is a lack of awareness that safety depends on whether the public are sharing responsibility and adopting hygienic behaviours in public spaces. Facility managers are dependent on the public to keep facilities COVID-19 secure, and need to pay equal attention to enabling and encouraging the public to practice Targeted Hygiene, by organizing how they are seated and move about and providing easy access to hand sanitizers etc.[66]

Section 3. Targeted Hygiene practices and procedures

An equally important part of Targeted Hygiene is "breaking the chain of infection". To do this, hygiene practices (products and how they are used) are needed which reduce organisms on key surfaces (or air) at key moments, to an acceptable safety target level.*

3.1 Hygiene procedures and how they work

In principle (whether for hands, surfaces, fabrics or the air) there are two ways to achieve this:

- **Physical removal of pathogens** using soap or detergent-based cleaning followed by rinsing, or dry wiping – usually referred to as cleaning. Masks are also a means of removal to prevent spread of respiratory aerosols and droplets.
- **Using an antimicrobial product** (disinfectants, antibacterials or alcohol hand sanitizers) or processes (heat at 60°C or above, UV light) that inactivate/kill pathogens *in situ* – this is called disinfection.

Used singly, sequentially or in combination, both have the potential to reduce contamination to a safe level. While there is extensive published data on the efficacy of household disinfectants, this is not so for physical removal processes.[67] In some risk situations, removal processes are enough i.e. where microbes can be rinsed from the surface, but for surfaces that cannot be rinsed, a microbiocidal product may be needed.[68,69,70,71]

The COVID-19 pandemic has introduced a new element into Targeted Hygiene, namely the role of social isolation, social distancing, mask-wearing, and ventilation to reduce spread of airborne viruses. Lockdown strategies show these measures are effective, although there is uncertainty about the relative impact of hygiene measures, versus restricted population interaction.[72,73] The impact such measures can have on the burden of infectious disease is demonstrated by reports across the world showing significantly reduced rates of influenza and other notifiable diseases during the COVID-19 pandemic.[74,75,76,77]

Breaking the chain of infection also includes behaviours that avoid initiating spread. This is particularly important in food hygiene. Examples include automated soap dispensers, no-touch tap handles, avoiding eating food with fingers, careful preparation and storage of food, (e.g. not washing raw chickens under running water) and cooking food thoroughly.

3.2 Optimizing the efficacy and sustainability of hygiene procedures

A key feature of Targeted Hygiene is that it provides a framework for developing hygiene procedures that are cost effective.[78] Breaking the chain of infection requires consumption of detergents, soap, water, mechanical action, heat, disinfectants and other agents. In recent years there has been investment in developing test models simulating use conditions to evaluate how resources work, independently or together, to reduce contamination on hands, surfaces and fabrics[78] and how processes can be optimised to deliver hygiene with more cost-effective use of resources. An example of this is use of the Sinner circle[79] to optimise laundry hygiene.[80] Each resource contributes a percentage of the total hygiene performance and can, in principle, be compensated by the others e.g. laundering at low temperatures to save energy can be compensated by longer cycle times or low-level microbiocidal agents.

* To be infected, we must be exposed to an infectious dose (ID) of bacteria, viruses etc. The minimum dose for different pathogens may be as little as 10 particles for some viruses, up-to several thousand cells for bacterial species. The ID may be lower for those with low infection immunity.

We have also seen the development of Quantitative Microbial Risk Assessment (QMRA) which enables us to evaluate hygiene efficacy based on infection risk reduction.[81.82] QMRA can be conducted in tandem with environmental microbiology and/or human behaviour studies or use of published data. (Initial pathogen level, transfer rates via hands and surfaces, infectious dose etc) to model the chain of infection and give a quantitative estimate of infection risk from exposure (e.g. hand to mouth) and the risk reduction due to hygiene interventions. QMRA enables us to combine removal processes with microbiocidal processes (low or high level) to reduce infection risk to an acceptable level. It thus offers the means to develop procedures that ensure processes (heat, detergent, microbiocides etc) are more precisely tailored to infection risk, thereby avoiding overuse of resources.

Risk modelling can also be used to estimate the separate or combined efficacy of interdependent interventions (e.g. hand and hand contact surface hygiene). Modelling indicates hand hygiene alone is insufficient for limiting surface transmission [83,84] These approaches contrast significantly with current regulations that disinfectants must conform to standard performance tests (3, 4, or 5 log reduction (LR) in contamination) regardless of whether this might be greater than needed. In-use efficacy of the product plus process is rarely assessed and regulations do not allow for procedures where low level microbiocidal action is utilised. Recent studies show soap and detergents have measurable microbiocidal action against some bacterial and enveloped viral strains.[85,86]

Section 1 showed that, for hygiene to meet 21st Century needs, procedures must be effective against viral as well as bacterial pathogens. This is important because data now show that viral pathogens tend to have lower infectious doses.[87] This is borne out by QMRA estimates (summarised in Appendix Note 3) which indicate that LRs required to reduce norovirus and rhinovirus (cold virus) to a safe level, may be higher than for bacterial strains.

3.3 Longer lasting hygiene (LLH) technologies on hand contact surfaces

A key concept of Targeted Hygiene is using hygiene products at specific risk moments to prevent the onward spread of infectious microbes. This maximizes protection against infection but also limits any adverse environmental and health impacts from product residues (see section 5). For the risk moment "touching surfaces frequently touched by others", where it is impossible to decontaminate every time they are touched, there may be a case where, properly controlled, use of LLH products could have a measurable impact on infection rates.

The last 20 or so years has seen the development of antimicrobial coatings containing copper and other agents, which, when applied to contact surfaces around hospital patient beds, have been demonstrated to reduce healthcare-associated infection rates.[88.89.90.91] For LLH products to be accepted, key parameters must be met. Firstly, they must have bactericidal and virucidal[92] action against pathogens associated with HEDL settings. They must have rapid action (preferably within 1 min) to ensure the next person touching the surface does not pick up an infectious dose. Secondly, they must be tested using new approaches, as outlined above and demonstrate a significant impact on infection rates, which outweigh any risks associated with product residues. It is crucial also that LLH products are not promoted in a way that engenders a false sense of security that these products "keep the home hygienic" thereby obviating the need for intervention at key moments to prevent spread of infection.

Section 4. Public understanding of hygiene and hygiene issues

A key barrier to change is public misunderstanding of hygiene, what it means and how it differs from cleanliness. In 2018, RSPH carried out a UK online poll of 2000 people.[46,47] In 2020 AISE (International Association for soaps, detergents and maintenance products), in collaboration with IFH, extended this to a Europe-wide study in 23 countries categorised into 5 regions.[93] The study involved more than 4500 panellists:

- Western Europe: Belgium, the Netherlands, France, Germany, Switzerland
- Eastern Europe: Hungary, Poland, Rumania, Slovakia, Czech Republic, Bulgaria
- Southern Europe: Greece, Italy, Portugal, Spain, Turkey
- UK / Ireland
- The Nordics: Denmark, Finland, Norway, Sweden

The initial study was carried out pre-COVID-19 in February 2020. Trends observed in UK /Ireland in this 2020 poll were similar to the 2018 RSPH poll. Detailed results of both polls are published elsewhere.[47,93] Trends were largely similar across the EU but, for example, reported use of disinfectants ranged from 60% in Nordic region to 96% in Southern Europe.

4.1 To what extent does people's perception of risk influence their hygiene behaviour?

A key objective was to find out how the public's self-reported hygiene behaviours reflect their beliefs about infection risks and how their beliefs and actions align with Targeted Hygiene. Respondents were questioned about 10 different situations ranging from actions associated with the 9 key moments for hygiene, to others generally considered low risk. Results suggest, although their actions are to some extent guided by perception of risk, there was significant misunderstanding of what are key risk situations/moments and when (and where) hygiene needs to be practiced to maximise protection against infection:

- For key moments such as using the toilet, washing hands after handling raw meat and eating food with fingers, there was good awareness (85-89%) of risk which correlated with 83-90% respectively saying they washed their hands appropriately.
- Similarly, there was good awareness of risk associated with coughing and sneezing (80%) but only 60% reported washing hands at these moments.
- There was fairly good awareness (76%) of the importance of keeping pet feeding bowls separate from family feeding utensils, but only 45% reported doing this.

By Contrast:

- For cleaning cloths, considered as high risk, only 65% said not cleaning them after each use was high or medium risk. Only 49% reported they always or often did this.
- For routine cleaning of surfaces such as kitchen and bathroom floors, normally considered low risk, there was over estimation of risk and inappropriate use of disinfectants. In all, 64% said "not using disinfectant to clean kitchen and bathroom floors" was high/medium risk and 62% reported always/ often using a disinfectant.

4.2 To what extent does people's perception of risk influence disinfectant usage?

Similarly, when self-reported disinfectant usage was evaluated, it was found that, (of the 74% who said they used disinfectants in their home), 74% said they only used them in situations where they believed there was risk. In reality, however, self-reported use was observed in some risk situations where they are needed, whilst in other risky situations, they were only rarely used. Similarly, there was usage in situations normally considered as low risk:

- Although 74% said they used disinfectants on hand contact surfaces associated with the toilet, only 48% said they disinfected surfaces after handling raw meat and poultry and only 31% used them to clean the cleaning cloth.
- But there was widespread usage (53-65%) for routine cleaning of floors and other surfaces in kitchens and bathrooms (i.e. overestimation of risk).

4.3 To what extent has the COVID-19 pandemic altered hygiene behaviours?

To evaluate the impact of COVID-19, the poll was repeated in June 2020. Despite the opportunity for health authorities to promote messages which focused on targeted measures to prevent airborne and surface spread, there was little change in public perception of risk or adoption of hygiene behaviours that better aligned with Targeted Hygiene. However, there was increased awareness of the need for hygiene on public transport and in shops and supermarkets. The number of people who reported washing their hands on arriving home increased (80 to 88%). Increased disinfectant usage (78 to 82%) was also reported. The largest increases were in situations considered low risk (i.e. 5-9% increased use for cleaning bathroom and kitchen surfaces and floors, but only a 2-3% increase for cleaning surfaces after handling raw food, cleaning the toilet seat, flush handle and lid and cleaning cloths).

4.4 What is hygiene and how does it differ from cleanliness?

A fundamental concern highlighted by the UK and EU polls is the extent to which the public is confused about what hygiene means and how it differs from cleanliness. The February 2020 poll showed that, whereas a good proportion (58-68% across the 5 regions) agreed hygiene is more than cleaning, it's about protection of health, a significant number (15-20%) believed hygiene and cleaning are the same thing, whilst some (16-28%) believe hygiene means using a disinfectant and cleaning means using detergent or soap. Lack of clarity means the latter group of consumers may misinterpret product claims; if a product is labelled as a hygiene product, these consumers may assume it has microbiocidal action.

4.5 How do the media contribute to public understanding of hygiene?

This new data gives further support to the notion that the public still tend to believe places they perceive as "dirty" are a primary source of harmful microbes. COVID-19 has also offered insights. As stated previously, during the COVID-19 pandemic we have seen examples that illustrate the ongoing belief that untargeted "deep cleaning" of a public space by fogging and spraying can make it "COVID secure".[63,64,65]

Media articles and research publications refer to these cleaning strategies as "intensified *hygiene* measures" are misleading.[94] Risk assessment indicates intensified cleaning is a valid part of infection prevention in controlled environments such as hospital intensive care units and isolation rooms,[95,96] but when applied in uncontrolled spaces they should not be regarded as "hygiene" measures because they

contribute little to preventing spread from the major sources of infection (people, food and domestic animals). To get the public to adopt Targeted Hygiene we need to halt the misrepresentation of "hygiene" in the media. Articles that encourage deep cleaning to get rid of hidden germs in home settings are illustrated by a survey of UK and US media coverage during 1998-2017.[97]

4.6 Changing hygiene understanding and hygiene behaviour

Overall, the survey results suggest the public has rather limited awareness of the need to target hygiene practices and use products appropriately to break the chain of infection. The question we need to ask is "why do the public continue to focus on visible "cleanliness" and absence of odour in their homes as their indicator of "hygiene". Work carried out by the London School of Hygiene, and Tropical Medicine[98] argues we are genetically programmed to avoid "dirt" and our disgust instinct to avoid faeces and putrefied material act to increase survival and has become an evolved response. In our modern world, our instinctive belief that disease is associated with dirt or bad odours may deter people from making informed decisions based on risk assessment about where and when they need to practice hygiene. It may also be that our actions are driven by childhood hygiene instruction which includes avoiding dirt and germs.

Although the poll provides valuable data, further work is needed to explore cognitive influences on hygiene understanding and behaviour in relation to public understanding of the chain of infection and Targeted Hygiene. We also need to better understand the drivers and barriers for behaviour change and the adoption of Targeted Hygiene. To get the public to adopt Targeted Hygiene behaviour, we must halt the misrepresentation of "hygiene" in the media and medical literature as an inevitable cause of immunoregulatory disorders.[99] We must discourage suggestions about relaxing hygiene standards and ensure they are replaced by instructions for adopting Targeted Hygiene.[46,94]

Getting the public to change behaviour also depends on restoring confidence in hygiene.[100] We need to persuade people of the direct benefits both to themselves (avoiding loss of income, costs of childcare, disruption of family leisure activities) but also to others who they may infect. In the UK, people were upset by being told COVID-19 infection can only be spread from one person to another, concluding they were being "blamed". The UK public also seemed to adopt the belief that activities that were allowed were "safe" whilst those that were restricted were "unsafe". It is imperative promotion of Health Literacy also includes promotion of risk literacy.[101]

Section 5. What are the barriers to change?

As outlined in Section 3, changing hygiene behaviour is a significant challenge. In addition to getting the public to adopt Targeted Hygiene, there are a number of other barriers to behaviour change which need to be addressed at all levels, from government to the public, if programmes are to succeed and deliver real benefit. A key concern is sustainability. This includes not only sustainable consumption of energy and water, but also concerns about negative impacts of cleaning chemicals and biocides on the environment and health. Whilst Targeted Hygiene was originally developed as a means to develop effective hygiene practice, it also provides a framework for addressing these issues.

5.1. Targeted Hygiene, environmental and health impacts

Targeted Hygiene ensures prudent use of cleaning products and microbiocides, limited to situations where they deliver health benefits, while at the same time reducing the release of these agents into the environment. It thus minimises environmental impacts and maximises safety margins against health hazards.

5.2 Targeted Hygiene and antimicrobial resistance

There is concern that domestic use of microbiocidal products may be contributing to the rise in AMR. However, despite more than 20 years research, there is still no conclusive answer as to whether microbiocides might contribute to AMR by resistance to the microbiocide itself, but more importantly, co-selecting for resistance to antibiotics. Since laboratory data indicate that microbiocide-induced AMR is biologically plausible[18] for some types of biocides, it is strongly recommended that use must be prudent and appropriate. However, concerns about disinfectants must be properly weighed against the need for targeted use in situations where other hygiene practices are insufficient. What is overlooked is that failure to use disinfectants or hand sanitizers where infection risks are high, could increase the risk of AMR by increasing the need for antibiotic prescribing to combat resulting infection.[18]

5.3 Are we too clean for our own good?

Targeted Hygiene works to sustain interaction with the indigenous, mostly non-pathogenic microbes of our world, which are important to build a healthy microbiome.[102] Evidence shows loss of exposure to essential microbes from other humans, animals and natural environments is associated with the inability to develop or sustain a healthy microbiome, which in turn is an underlying cause of a range of allergic, autoimmune and other diseases which have become increasingly prevalent in the last 50 years. Data indicate 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 these microbial "Old Friends".[103] These include an increase in caesarean section rather than vaginal childbirth, use of formula rather than breast milk, smaller families and fewer siblings, urbanisation and less outdoor activity. Excessive antibiotic use and altered diet (e.g. a less diverse diet) can also affect the microbiome in a way that increases inflammatory disease risks.

In 1989 it was suggested this faulty immunoregulation was due to distortion of early life microbial inputs by domestic hygiene practices[104] a concept that was named the "Hygiene Hypothesis". In reality there is no good evidence to support this.[103] If hygiene is involved, its impact is likely to be small relative to lifestyle factors. Unfortunately, because of widespread publicity given to the hygiene hypothesis during the 1990s, the idea that "being too clean" is an underlying cause of these various diseases, has become received wisdom and has worked to undermine public confidence in hygiene. In the 2019 RSPH UK online poll,[47] the public were asked to identify factors that prevent children from coming into contact with bacteria they believed beneficial to their child's health. In all 59 and 56% of people respectively, identified lifestyle factors such as using too many antibiotics and spending too much time indoors. However, almost as many (55% and 52%) held the view that keeping homes too clean and using too many antibacterials were important.

So why does the "hygiene hypothesis" concept persist? In 2017, IFH surveyed 54 media articles published between 1997 and 2017 [97] which showed that 22/25 articles mentioned home or personal cleanliness as an underlying cause of reduced exposure to beneficial microbes. Since Targeted Hygiene works to ensure contact with indigenous microbial flora is sustained, it provides a means to argue against the belief that rising levels of allergies etc are related to "levels of home cleanliness".

Discussion and calls to action

This paper highlights the major contribution that hygiene in HEDL makes towards reducing the health, social and economic burden of infectious disease worldwide. The COVID-19 pandemic has demonstrated that, in any epidemic or pandemic, public hygiene behaviour has a key role in mitigating spread before other measures can be put in place. It is to be hoped, in the light of this experience, the general public, as well as policy makers, will now understand the devastating impact of living with a highly transmissible infection for which we have no pharmaceutical interventions. In the future, HEDL hygiene must be fully recognised as an equal partner with hygiene in healthcare and other settings in controlling the burden of infectious diseases and the threat of AMR.

COVID-19 has also highlighted the significance of the large number of people now living in the community who are more vulnerable to serious infection which may require hospitalisation. It showed how this issue can drive health strategy; in Europe, US and elsewhere, lockdowns were largely driven by the need to sustain hospital bed and intensive care availability.

Based on the findings of this report, we recommend the following actions:

1. Recognition of the importance of hygiene and the need for investment in hygiene behaviour change

One of the problems in getting action from government health agencies etc is that the various aspects of HEDL hygiene (food hygiene, healthcare hygiene, AMR, pandemic preparedness etc) are dealt with by different agency departments, or different agencies. Thus, domestic food hygiene is dealt with by a food agency which covers farm to fork, whilst tackling AMR in the community is dealt with by departments responsible for developing AMR policy and healthcare-associated infections. It is only when viewed together that the true impact of the hygiene-related disease in the community can be seen. In the future, health agencies need to look at hygiene holistically from the point of view of the domestic grouping, what they know and understand and what they need to know about the infectious disease issues that affect their lives.[105] Because different aspects of hygiene are dealt with by different agencies, the advice given to the public is fragmented and often inconsistent. Without integration and leadership, there is also no authoritative voice to advocate action on HEDL hygiene against competing health issues.

A question that needs to be asked is whether, during the COVID-19 pandemic, national and international health agencies were prepared for, and effective in, engaging and supporting the public to play their vital role.[106,107,108] In our experience government response was largely reactive, involving public information and advice through the internet and media about social distancing, wearing of masks and non-targeted handwashing. Despite extensive investment since 2003 to ensure preparedness in the health sector, there is little evidence of investment in ensuring the public would be able to understand and respond effectively and be prepared to take personal responsibility. In recognition of this, a group of experts are calling for the establishment of an international coalition for behaviour and social preparedness for epidemics, focusing on non-medical methods of cutting viral transmission rates.[109]

Calls to action:

- ***National/international policymakers, health agencies and professionals need to recognise HEDL hygiene as an equal partner with hygiene in healthcare, food safety etc.***
- ***Change requires effective leadership and an integrated approach that addresses hygiene from the point of view of the "family unit" and the interdependent and conflicting hygiene issues they have to deal with.***
- ***Appendix 1 of the 2018 IFH White paper1 reviews current strategies to promote hygiene behaviour change. These need to be integrated rather than developed independently. HEDL hygiene needs to be part of national and international self-care initiatives.***[110]

2. Ensure Targeted Hygiene is given due recognition, as the means to maximize protection against infection whilst also addressing other issues

This paper sets out a risk management approach to hygiene. We believe getting the public to adopt this scientifically proven approach could have a significant impact in reducing spread of infection. This is needed not just in tackling the COVID-19 pandemic but in addressing the whole range of ongoing issues outlined in Section 1.

To deliver the health benefits of Targeted Hygiene, however, we need wider acceptance and collaboration between agencies and stakeholders, and support for this approach by health and food safety policymakers and those who advise them. For health professionals, data from intervention studies are still the gold standard for setting evidence-based policies. They are less familiar and thus less accepting, of risk management approaches where interventions act in an interdependent manner to produce a single outcome. The need for alternative approaches to developing public health interventions is set out in a 2005 document produced by the UK Health Development Agency.[111]

COVID-19 has highlighted the importance of hygiene not just in our homes but in everyday life settings. As outlined in Section 2.4, preventing spread of infection in schools, universities, workplaces, shops, supermarkets, restaurants, public transport etc is mostly down to the public, to practice Targeted Hygiene whilst using the facility. By recognising and implementing this partnership and encouraging personal responsibility, hygiene could significantly reduce spread of all types of infections, such as colds, influenza and norovirus in public settings.

Targeted Hygiene offers the means to develop effective hygiene; but is also a framework for addressing other issues including sustainable use of resources, minimizing environmental impacts, minimizing effects that cleaning and cleaning agents might have on human exposure and interaction with essential microbes. Lack of a unified voice advocating hygiene in home and everyday life means these other issues can take precedence.

Calls to action:

- ***We need health and food safety policymakers to accept and adopt the principles of Targeted Hygiene in developing public hygiene policy.***
- ***We need managers of public spaces to recognize and implement policies that facilitate and encourage the public to practice Targeted Hygiene.***
- ***We need stakeholders such as allergists, environmentalists and regulators, to take a more balanced approach, where Targeted Hygiene (including targeted use of microbiocides) is given recognition because it reconciles the need to protect against infection with the need to protect the environment and mitigate AMR etc.***

3. The need for effective and sustainable hygiene procedures

For Targeted Hygiene to be effective, we need hygiene procedures that are effective in breaking the chain of infection. Whilst standard laboratory tests establish "proof of principle", they do not demonstrate "fitness for purpose". We need to generate and share new data using models simulating use conditions, not only on efficacy of disinfectants, but also of soap and detergent-based practices which work by removal of contamination, for which there is currently little data available. These test models should also be used to demonstrate how removal and inactivation can be combined to deliver hygiene.

Increasing understanding of how microbes are spread, together with QMRA now provides us with the tools to develop hygiene procedures that not only meet performance criteria based on standard tests, but also estimate how contamination can be reduced in compliance with agreed safety target levels based on infection risk.

This offers significant opportunities for industry to develop novel hygiene products and technologies that maximise protection against infection and sustainable use of resources. This approach however has implications for regulatory processes because it means we can no longer think of procedures as being *either* mechanical *or* microbiocidal. Current regulations do not allow for hygiene procedures that employ low-level microbiocidal action produced by product components such as detergents or active oxygen bleaching agents.

Another aspect COVID-19 has highlighted is that homes should be better designed to reduce the risks of infection spread. In designing kitchens, little attention is paid to layout, i.e., designing such that raw and ready-to-eat foods are stored, handled, prepared in different areas of the kitchen. Other features could include no-touch tap handles, toilet flush handles etc. and placement of hand sanitizers at the doors into high traffic shared areas such as the kitchen, toilet and bathroom. Ventilation should also be considered.

Calls to action:

- ***Academia, the private sector and regulatory bodies need to work together to take advantage of new insights and approaches for developing products and procedures and demonstrate their ability to reduce infection risks to a safe level, at key risk moments with sustainable use of resources.***
- ***Industry needs to recognise cleaning and hygiene products have an essential role in preventing the spread of infectious diseases and take greater responsibility for providing data on the in-use effectiveness of products and procedures to inform evidence-based development of hygiene policies for HEDL.***

4. The need to educate the public with clear and consistent messaging

Delivering the benefits that a risk management approach to hygiene could offer, depends on getting the public to adopt this approach. In recent years, misunderstanding has developed around hygiene which is undermining efforts to promote behaviour change. This has been exacerbated by an incorrect assumption that excessive cleaning and disinfection is depriving us of exposure to microbes which are essential to health.

The UK and EU polling surveys suggest the public has limited awareness of how harmful microbes are spread and poor understanding of the key risk situations/moments where hygiene is needed. COVID-19 further highlights public perceptions and behaviours still tend to be rooted in 20th Century where "home cleanliness" was seen as the means to protect against infection.

The poll further supports calls to action made in the 2018 IFH White paper[1] that, if hygiene promotion activities aimed at behaviour change are to be successful, they must be accompanied by public education on basic concepts of Targeted Hygiene and dispelling the myths which are still being reinforced through media and other published articles. We need further work to explore cognitive influences on hygiene understanding and behaviour, and to better understand the drivers for behaviour change. Only by incorporating these learnings into hygiene promotion strategies will we be able to achieve behaviour change.

Calls to action:

- ***We need to work collaboratively with those who communicate with the public including community workers, the education system, media and the private sector to engage the public on the importance of hygiene and their role in preventing infection. Targeted Hygiene provides a simple plausible approach which, when communicated to the public, can dispel current misunderstandings and build confidence in how hygiene benefits health. In particular we need:***
- ***government health policymakers to recognise public hygiene behaviour change will not happen, unless we also work to change public understanding of hygiene.***
- ***education authorities to accept hygiene must be a compulsory subject in the school curriculum (including the principles of Targeted Hygiene).***
- ***government health authorities to develop adult education programmes. "Healthy Hygiene" (which balances protection against infection, against exposure to microbes essential to our health) needs to be seen as an equal partner with other health promotion strategies (exercise, healthy eating, etc.).***
- ***manufacturers of cleaning and hygiene products and household appliances, to recognise their responsibility for:***
  - ***Engaging with and persuading consumers to adopt "Targeted Hygiene***
  - ***Engaging and educating consumers in a way that encourages them to restrict disinfectant use to risk situations.***
  - ***Creating a dialogue within the industry to agree on consistent and coherent approaches to terminology, product claims and usage advice.***
- ***to educate editors and authors working in the media about the value of Targeted Hygiene and ensure they do not give confusing and counterproductive messages.***

Looking to the future ------?

A key question that needs to be asked is - to what extent the pandemic will impact on attitudes to hygiene and hygiene behaviour in the future, both that of the public, but equally that of health policy makers and health agencies? Data cited in this report show the hygiene measures adopted during the pandemic had a significant impact on the prevalence of other notifiable infectious diseases, which suggests if we can achieve sustained improvement in public hygiene behaviour, it could have a significant impact on global health and prosperity. A key aspect of hygiene, as compared with vaccines and antimicrobials, is its potential to prevent a much broader spectrum of infectious diseases cost-effectively. If there was ever an opportunity to change public hygiene behaviour, it is now, whilst concern about COVID-19 is still a priority.

An even bigger challenge for the future is persuading the public to view their microbial world in a fundamentally different way. We need them to recognise the need to practice hygiene to protect against communicable diseases, but also the need to adopt lifestyles that reconnect them with essential microbes that can protect them against a wide range of non-communicable diseases. To do this however, we must first persuade the public that the latter is about lifestyle choices, not about relaxing hygiene standards, as "experts" and the media would have us believe, by referring to this concept as the "Hygiene Hypothesis".[112] Although the costs of a campaign to educate the public, the media and health professionals on these interconnected issues and dispel current misconceptions, would be substantial, the health gains of reducing the burden of both communicable and non-communicable diseases would be very considerable – and sustainable.

Appendices and References

Appendices and References

Appendix Note 1 Foodborne infection and home hygiene.

WHO has estimated that unsafe food causes 600 million cases of foodborne diseases and 420,000 deaths each year worldwide.[40] Norovirus and *Campylobacter* spp are the most frequent cause. Evaluating the proportion of foodborne illness attributable to the domestic setting is challenging.[42] UK data suggests 12-17% of outbreaks are associated with the home[42] whilst data from 18 European countries indicates 31% of outbreaks occur in private homes.[43] In USA and Canada the home was implicated in 7-46% of outbreaks.[42] Cognitive studies indicate consumers believe foodborne infections are more likely to occur outside the home.[113,114,115,116] This is linked to the concept of optimistic bias[117] indicating foodborne disease in the home is under-estimated.[118,119.120]

A US study[44] estimated the annual economic loss from *Campylobacter* spp in poultry to be $6.9 billion, *Salmonella* spp. in chicken and pork to $2.8 and $1.9 billion, respectively and *Toxoplasma gondii* in pork to $1.9 billion. A UK report estimated the burden for 2018 (both direct and indirect (loss of earnings, school absenteeism etc)) arising from the 13 main pathogens was around £3bn. Norovirus imposes the greatest burden (estimated annual cost £1.68bn) followed by *Campylobacter* spp (£0.71bn) and *Salmonella* spp).[45]

The Safeconsume project (www.safeconsume.eu) In 2018 a five-year EU Horizon 2020 programme was initiated with the aim of changing consumer behaviour to reduce exposure to food-associated pathogens and decrease risk of infection. The project involves researching consumer food hygiene behaviour and barriers to behaviour change and estimating population risks through risk modelling. It also involves development of tools products, information strategies, education and food safety policy.

Appendix Note 2 infections transmitted via the air and contact surfaces

Data generated for SARS-CoV-2 have provided new insights into airborne routes of transmission of viruses. Airborne transmission involves droplets of infected mucous which travel only short distances and smaller infected droplet nuclei (<5μm) which can remain airborne for minutes, to hours, and travel longer distances. There is disagreement on whether droplet nuclei should be regarded as airborne but for this report we use this term to distinguish droplet and aerosol transmission from surface and hand transmission.

Surfaces can be contaminated by settling of droplets and aerosols onto surfaces, or via the fingertips of an infected person who has picked up infected mucous or saliva by touching their mouth, nose or eyes. Laboratory studies show inability to detect viable SARS-CoV-2 within minutes on porous surfaces, to hours/days on non-porous surfaces but conclude that, under real-world conditions, risks of surface transmission are minor after 72 hours.[121]

For COVID-19, modelling and outbreak evidence indicate that person to person airborne transmission is likely the main driver of transmission,[52,62,72,122,123] although opinions differ as to the importance of aerosols[123,124] relative to droplets.[121,125] The extent of the risks from hand contact with surfaces relative to airborne routes is also uncertain. Some experts maintain transmission risks via surfaces are very low. In expressing this opinion, they are referring to non-targeted fogging and spraying of public spaces[63,64,65] where risks posed by these rarely touched surfaces will be less than in home settings, where there are frequent opportunities to touch surfaces recently touched by others. A number of studies suggest households are the highest risk setting for transmission of COVID-19.[126,127,128,129]

Other studies[83.122.130.131.132] conclude hands and hand contact surfaces make a non-negligible contribution to spread of SARS-CoV-2. Using modelling techniques and data from the Diamond Princess Cruise Ship outbreak,[124] it was estimated the contributions of short-range, long-range and surface transmission to infected cases were 35%, 35%, and 30%, respectively. Estimated contributions of large respiratory droplets and small respiratory aerosols were 41% and 59%. Another modelling study[62] of occupationally acquired

COVID-19 infection among healthcare personnel, suggests droplet and aerosol transmission predominate over the contact route, contributing 35%, 57%, and 8.2% respectively.

For other viruses of importance in HEDL settings (influenza, cold virus (rhinovirus) and norovirus), data generated since 1970[10] suggest the relationship between droplet, aerosol, surface and hand transmission is variable. For influenza virus, which like SARS-CoV-2 is an enveloped virus that has a relatively higher infectious dose and is relatively unstable on surfaces, data support transmission via hands and contact surfaces, but suggests it is less than via airborne routes. By contrast, for non-enveloped viruses, rhinovirus and norovirus, which are more robust and have a relatively low infectious dose, data suggest surface transmission is more important. Some investigators[133,134,135] maintain that, for rhinovirus, inoculation of the eyes or nose by contaminated hands may be the more important route of infection. These relationships are borne out by quantitative modelling which suggests risks from hand contact surfaces depend on dose-response relationships and the expected concentrations of pathogens on fomites. This is likely to be higher for norovirus and rhinovirus than influenza and SARS-CoV-2 virus.[136,137]

Appendix Note 3

In a 2014 study[81] a QMRA model was constructed; using data from the literature on ambient levels of pathogens typically found on domestic surfaces. Transfer rates were estimated where a contaminated surface was touched with the fingers and the fingers then touched the mouth, nose, or eyes. It was estimated, for a single touch, on average, 2LR was sufficient to achieve a 10^{-6} safety target level for *E.coli* and Listeria, whilst norovirus required an LR of 3.44. From this, they assessed that, for *Pseudomonas* spp, *Salmonella* spp, and S. *aureus,* no hygiene process was required in these situations (i.e., situations not associated with a key moment for hygiene). For norovirus, because of its low infectious dose, a hygiene procedure is required to achieve the same safety target level.

In a further study,[136] QMRA was used to estimate the LR on surfaces needed to reduce surface, to hand, to face infection risk for rotavirus, rhinovirus and influenza virus. Because of its relatively high infectious (ID_{50} 9.45 x 10^5), it was estimated that no intervention would be required for influenza virus, whilst for rhinovirus (ID_{50} may be as little as 10 particles) a 5LR is required to reduce the risk level to 10^{-6}.
A QMRA study using available data for coronavirus SARS CoV-2[137] suggests that, under low viral bioburden conditions, minimal LR values may be needed to reduce infection risks for a single hand-to-fomite touch to reduce risk levels to 10^{-6}, whilst, for higher bioburdens, LR values more than 2 may be needed.

REFERENCES

1. International Scientific Forum on Home Hygiene 2018 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". https://www.ifh-homehygiene.org/review/containing-burden-infectious-diseases-everyones-responsibility-call-integrated-strategy.
2. Fauci AS. Infectious Diseases: Considerations for the 21st Century. Clinical Infectious Diseases, 2001; 32: 675.
3. Tam CC, Rodrigues LC, Viviani L, Dodds JP, Evans MR, Hunter PR, Gray JJ, Letley LH, Rait G, Tompkins DS, O'Brien SJ. Longitudinal study of infectious intestinal disease in the UK (IID2 study): incidence in the community and presenting to general practice. Gut 2011; 61: 69-77.
4. de Wit, MA, Koopmans MP, van Duynhoven YT. Risk factors for norovirus, Sapporo-like virus and group A rotavirus gastroenteritis. Emerging Infectious Diseases 2003; 9:1563-9.
5. Lopman BA, Steele D, Kirkwood CD, Parashar UD The Vast and Varied Global Burden of Norovirus: Prospects for Prevention and Control. PLoS Med 2016;13(4): e1001999. doi:10.1371/ journal.pmed.1001999 Published: April 26, 2016
6. Mans J, Armah, GE, Steele, AD, & Taylor MB. (2016). Norovirus Epidemiology in Africa: A Review. *PloS one, 11*(4), e0146280. https://doi.org/10.1371/journal.pone.0146280, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4846019/pdf/pone.0146280.pdf
7. Bloomfield SF. Infectious disease prevention in the home and community - closing the circle. Perspectives in Public health 2015; 135:277-8
8. Shute N. SARS hit home. US News World Rep 2003; 134:38-42.
9. CDC. 2010. The 2009 H1N1 Pandemic: Summary Highlights, April 2009-April 2010. https://www.cdc.gov/h1n1flu/cdcresponse.htm
10. Bloomfield SF. Exner M, Signorelli C, Nath KJ, Scott EA. 2012. The chain of infection transmission in the home and everyday life settings, and the role of hygiene in reducing the risk of infection. https://www.ifh-homehygiene.org/review/chain-infection-transmission-home-and-everyday-life-settings-and-role-hygiene-reducing-risk
11. Little P, Stuart B, Hobbs FD, Moore M, Barnett J, Popoola D, Middleton K, Kelly J, Mullee M, Raftery J, Yao G. An internet-delivered handwashing intervention to modify influenza-like illness and respiratory infection transmission (PRIMIT): a primary care randomised trial. The Lancet. 2015;386:1631-9.
12. Rabie T, Curtis V. Handwashing and risk of respiratory infections: a quantitative systematic review. Tropical medicine & international health. 2006 Mar;11:258-67.
13. Influenza pandemic preparedness strategy UK 2011 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/213717/dh_131040.pdf
14. US National Strategy for pandemic influenza 2005 https://www.cdc.gov/flu/pandemic-resources/pdf/pandemic-influenza-strategy-2005.pdf
15. Pandemic Influenza Risk Management A WHO guide to inform & harmonize national & international pandemic preparedness and response 2017 https://www.who.int/influenza/preparedness/pandemic/influenza_risk_management_update2017/en/
16. Peter Piot Good habits must remain to beat the next pandemic.Telegraph,18thNovember 2020 https://www.telegraph.co.uk/business/2020/11/18/good-habits-must-remain-beat-next-pandemic/
17. WHO Antibiotic resistance .https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance
18. Maillard J-Y, Bloomfield S; 'Reducing antibiotic prescribing and addressing the global problem of antibiotic resistance by targeted hygiene in the home and everyday life settings,' due to be published in the American Journal of Infection Control 2020 48: 1090–1099.: https://www.ajicjournal.org/article/S0196-6553(20)30209-1/fulltext
19. The urgent need to foster research on Infection Prevention and Control to foster health security. https://eu-jamrai.eu/wp-content/uploads/2021/02/201207_EUJAMRAI_policy-brief_WP9_research-on-IPC.pdf.
20. Collignon P, Beggs JJ, Walsh TR, Gandra S, Laxminarayan R. Anthropological and socioeconomic factors contributing to global antimicrobial resistance: a univariate and multivariable analysis. Lancet Planet Health. 2018 Sep;2(9):e398-e405. DOI: 10.1016/S2542-5196(18)30186-4.
21. Essack SY. Global Antibiotic Resistance: Of Contagion, Confounders and the COM-B Model. Lancet Planetary Health 2018 2 (9) e376-377.
22. Sulis, Giorgia, Brice Batomen, Anita Kotwani, Madhukar Pai, and Sumanth Gandra. "Sales of antibiotics and hydroxychloroquine in India during the COVID-19 epidemic: An interrupted time series analysis." *PLoS medicine* 18, no. 7 (2021): e1003682.

23. Schages L, Wichern F; Geisen S; Kalscheuer R; Bockmühl D. Distinct Resistomes and Microbial Communities of Soils, Wastewater Treatment Plants and Households Suggest Development of Antibiotic Resistances Due to Distinct Environmental Conditions in Each Environment. Antibiotics 2021 10, 514. Doi.org/10.3390/antibiotics10050514.
24. Schages L, Lucassen R, Wichern F, Kalscheuer R, and Bockmühl DP. The household resistome – frequency of β-lactamases, class 1 integron and antibiotic resistant bacteria in the domestic environment and their reduction during automated dishwashing/laundering. Applied and Environmental Microbiology 2020 doi:10.1128/AEM.02062-20.
25. Lucassen R, Rehberg L, Heyden M, Bockmühl D Strong correlation of total phenotypic resistance of samples from household environments and the prevalence of class 1 integrons suggests for the use of the relative prevalence of intI1 as a screening tool for multi-resistance. PLoS ONE 2019 14(6): e0218277. https://doi.org/10.1371/journal.pone.0218277.
26. Rehberg L, Frontzek A, Melhus A and Bockmühl DP. Prevalence of b-lactamase genes in domestic washing machines and dishwashers and the impact of laundering processes on antibiotic-resistant bacteria. Journal of Applied Microbiology 2017 doi:10.1111/jam.13574.
27. World Health Organization. Global Action Plan on Antimicrobial Resistance. 2015. Geneva, Switzerland. https://www.who.int/antimicrobial-resistance/global-action-plan/en/.
28. A European One Health Action Plan Against Antimicrobial Resistance (AMR). https://ec.europa.eu/health/sites/health/files/antimicrobial_resistance/docs/amr_2017_action-plan.pdf
29. US national action plan for combating antibiotic-resistant bacteria 2020-2025 https://www.cdc.gov/drugresistance/us-activities/national-action-plan.html
30. Department of Health and Social Care. UK 5-year action plan for antimicrobial resistance 2019 to 2024. 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/784894/UK_AMR_5_year_national_action_plan.pdf
31. WHO AMR National Action Plans Library https://www.who.int/antimicrobial-resistance/national-action-plans/library/en/.
32. Essack S. Water, sanitation and hygiene in national action plans for antimicrobial resistance. Bulletin of the World Health Organization 2021; BLT.20.284232. https://cdn.who.int/media/docs/default-source/bulletin/online-first/blt.20.284232.pdf?sfvrsn=de007ed_5.
33. Review on Antimicrobial Resistance: Tackling Drug-resistant Infections Globally. 2014. Available from: https://amr-review.org/Publications.html.
34. WHO AMR National Action Plans Library https://www.who.int/antimicrobial-resistance/national-action-plans/library/en/.
35. Bloomfield SF, Exner M, Fara GM, Nath KJ, Scott, EA; Van der Voorden C. The global burden of hygiene-related diseases in relation to the home and community. 2009. International Scientific Forum on Home Hygiene. https://www.ifh-homehygiene.org/review/global-burden-hygiene-related-diseases-relation-home-and-community
36. DESTATIS Statisches Bundesamt Press release. 2017. https://www.destatis.de/DE/PresseService/Presse/Pressemitteilungen/2017/01/PD17_017_224.html
37. Clark A, Jit M, Warren-Gash C, Guthrie B, Wang HH, Mercer SW, Sanderson C, McKee M, Troeger C, Ong KI, Checchi F. How many are at increased risk of severe COVID-19 disease? Rapid global, regional and national estimates for 2020. medRxiv. 2020 Jan 1.
38. Wilder JM, The Disproportionate Impact of COVID-19 on Racial and Ethnic Minorities in the United States, Clinical Infectious Diseases 2021; 72: 707–709 https://doi.org/10.1093/cid/ciaa959.
39. CDC 2021 Racism and health https://www.cdc.gov/healthequity/racism-disparities/index.html.
40. WHO estimates of the global burden of foodborne diseases. Foodborne diseases burden epidemiology reference group 2007-2015. https://www.who.int/foodsafety/publications/foodborne_disease/fergreport/en/
41. Augustin JC, Kooh P, Bayeux T, Guillier L, Meyer T, Silva JD, Villena I, Sanaa M, Cerf O. Contribution of Foods and Poor Food-Handling Practices to the Burden of Foodborne Infectious Diseases in France. Foods. 2020 Nov;9(11):1644.
42. Redmond, EC, Curnin A, Eves A, Raats M, Day C, Morris J. Systematic review of he relative proportion of foodborne disease associated with food preparation or handling practices in the home. 2018 FSA. Research project report. https://www.food.gov.uk/research/foodborne-diseases/systematic-review-of-the-relative-proportion-of-foodborne-disease-caused-by-food-preparation-or-handling-within-the-home.
43. Rocourt J, Moy G, Vierk R, Schlundt J. The present state of foodborne disease in OECD countries. 2003. Food Safety Department, World Health Organization, Geneva, Switzerland http://www.who.int/foodsafety/publications/foodborne_disease/en/OECD%20Final%20for%20WEB.pdf

44. Scharff RL. Food attribution and economic cost estimates for meat-and poultry-related illnesses. Journal of food protection. 2020; 83:959-67.

45. UK Food Standards Agency 2020. The Burden of Foodborne Disease in the UK 2018. https://www.food.gov.uk/research/research-projects/the-burden-of-foodborne-disease-in-the-uk-2018.

46. Royal Society for Public Health. 2019 'Too clean or not too clean:' The case for targeted hygiene in everyday life report. https://www.rsph.org.uk/uploads/assets/uploaded/06b37f30-2241-4e98-aba93fc15346e7a5.pdf.

47. Bloomfield SF. RSPH and IFH call for a clean-up of public understanding and attitudes to hygiene 2019; 139: 285-288 https://journals.sagepub.com/doi/pdf/10.1177/1757913919878367

48. Oran DP, Topol EJ. Prevalence of asymptomatic SARS-CoV-2 infection: a narrative review. Annals Internal Medicine. 2020;173::362–367. doi:10.7326/M20-3012.

49. Petersen I, Phillips A. Three quarters of people with SARS-CoV-2 infection are asymptomatic: analysis of English household survey data. Clinical Epidemiology. 2020;12:1039.

50. Lopez Bernal J, Panagiotopoulos N, Byers C, Garcia Vilaplana T, Boddington NL, Zhang X, Charlett A, Elgohari S, Coughlan L, Whillock R, Logan S. Transmission dynamics of COVID-19 in household and community settings in the United Kingdom. medRxiv. 2020 Aug.

51. Jing QL, Liu MJ, Zhang ZB, Fang LQ, Yuan J, Zhang AR, Dean NE, Luo L, Ma MM, Longini I, Kenah E. Household secondary attack rate of COVID-19 and associated determinants in Guangzhou, China: a retrospective cohort study. The Lancet Infectious Diseases. 2020; 20:1141-50.

52. Wang Y, Tian H, Zhang L, Zhang M, Guo D, Wu W, Zhang X, Kan GL, Jia L, Huo D, Liu B. Reduction of secondary transmission of SARS-CoV-2 in households by face mask use, disinfection and social distancing: a cohort study in Beijing, China. BMJ global health. 2020 1;5(5):e002794.

53. Bloomfield SF. 2013 Spread of antibiotic resistant strains in the home and community. International Scientific Forum on Home Hygiene. http://www.ifh-homehygiene.org/review/spread-antibiotic-resistant-strains-home-and-community.

54. Miller SL, Nazaroff WW, Jimenez JL, Boerstra A, Buonanno G, Dancer SJ, Kurnitski J, Marr LC, Morawska L, Noakes C. Transmission of SARS-CoV-2 by inhalation of respiratory aerosol in the Skagit Valley Chorale superspreading event. Indoor air. 2021 Mar;31(2):314-23.

55. Lopez GU, Gerba CP, Tamimi AH, Kitajima M, Maxwell SL, Rose JB. Transfer efficiency of bacteria and viruses from porous and nonporous fomites to fingers under different relative humidity conditions. Applied and Evironmental Microbiology. 2013 15;79(18):5728-34.

56. Best EL, Sandoe JAT, Wilcox MH. Potential for aerosolization of *Clostridium difficile* after flushing toilets: the role of toilet lids in reducing environmental contamination risk. Journal of Hospital Infection 2012; 80:1-5.

57. Barker J, Jones MV. The potential spread of infection caused by aerosol contamination of surfaces after flushing a domestic toilet. Journal of Applied Microbiology 2005; 99:339-347.

58. Qian J, Ferro AR. Resuspension of dust particles in a chamber and associated environmental factors. Aerosol Science and Technology. 2008 29;42):566-78.

59. Dietz L, Horve PF, Coil DA, Fretz M, Eisen JA, Van Den Wymelenbergm K. Novel Coronavirus (COVID-19) Pandemic: Built Environment Considerations To Reduce Transmission Systems Apr 2020, 5 (2) e00245-20; DOI 10.1128/mSystems.00245-20.

60. Sexton JD, Reynolds KA. Exposure of emergency medical responders to methicillin-resistant Staphylococcus aureus. American journal of infection control. 2010 Jun 1;38:368-73.

61. Cheesbrough JS, Green J, Gallimore CI, Wright PA, Brown DWG. Widespread environmental contamination with Norwalk-like viruses (NLV) detected in a prolonged hotel outbreak of gastroenteritis. Epidemiology and Infection 2000; 125:93-98.

62. Jones RM. Relative contributions of transmission routes for COVID-19 among healthcare personnel providing patient care. Journal of Occupational and Environmental Hygiene. 2020 8;17:408-15.

63. Thompson D. Hygiene Theater Is a Huge Waste of Time. The Atlantic; 2020. Available at: https://www.theatlantic.com/ideas/archive/2020/07/scourge-hygiene-theater/614599/.

64. Palmer, M. 2020. Spray that costs pennies and kills viruses instantly could be a simple, cheap solution to Britain's Covid nightmare - as scientists ask why we're not already using it. https://www.dailymail.co.uk/news/article-8558121/Spray-costs-pennies-kills-viruses-instantly-simple-solution-Covid-nightmare.html?ito=email_share_article-bottom%22%20%5Ct%20%22_blank

65. Editorial 2021. Coronavirus is in the air — there's too much focus on surfaces. Nature 590:7.

66. 8 Moments for Targeted Hygiene: Guidance for Public Places and Workplaces. July 2020. SC Johnson Professional. https://www.scjp.com/sites/default/files/2021-02/UKLIT1531%208%20Moments%20for%20Targeted%20Hygiene%20White%20Paper.pdf.

67. Hygiene procedures in the home and their effectiveness: a review of the scientific evidence base (2008). International Scientific Forum on Home Hygiene. https://www.ifh-homehygiene.org/best-practice-review/hygiene-procedures-home-and-their-effectiveness-review-scientific-evidence-base

68. Cogan TA, Bloomfield SF, Humphrey TJ. The effectiveness of hygiene procedures for prevention of cross-contamination from chicken carcases in the domestic kitchen', Letters in Applied Microbiology 1999;29:354–58.

69. Cogan TA, Slader J, Bloomfield SF, Humphrey TJ. Achieving hygiene in the domestic kitchen: the effectiveness of commonly-used cleaning products. Jornal of Applied Microbiology. 2002;92:885-92.

70. Exner M, Vacata V, Hornei B, Dietlein B, Gebel J. Household cleaning and surface disinfection: new insights and strategies. Jornal of Hospital Infection. 2004;56 (suppl 2):S70-5.

71. Barker J, Vipond IB. Bloomfield SF. The effects of cleaning and disinfection in reducing the spread of Norwalk-like virus contamination via environmental surfaces. Journal of Hospital Infection 2004;58: 42-9.

72. Tang JW, Bahnfleth WP, Bluyssen PM, Buonanno G, Jimenez JL, Kurnitski J, Li Y, Miller S, Sekhar C, Morawska L, Marr LC. Dismantling myths on the airborne transmission of severe acute respiratory syndrome coronavirus (SARS-CoV-2). Journal of Hospital Infection. 2021 Jan 13.

73. European Centre for Disease Prevention and Control. Using face masks in the community: first update. 15 February 2021. ECDC: Stockholm. https://www.ecdc.europa.eu/en/publications-data/using-face-masks-community-reducing-covid-19-transmission.

74. How COVID-19 is changing the cold and flu season. Nature 2020, Dec 17th, 388-390.

75. Common Health. May 10, 2021 Twindemic' Averted: Not Much Flu In Massachusetts.and record low rates across the nation. https://www.wbur.org/commonhealth/2021/02/10/record-low-flu-rates-massachusetts

76. Reuss A, Klingeberg A, Schmidt N, Eckmanns T, Zacher B: Einfluss der COVID-19-Pandemie auf die Anzahl der gemäß IfSG meldepflichtigen Nachweise von Erregern mit Antibiotikaresistenzen und C. difficile- Infektionen. Roberts Koch Institute 2021. http://dx.doi.org/10.25646/8026.

77. COVID-19-Pandemie: Auswirkung auf meldepflichtige Infektionskrankheiten Epidemiological Bulletin 2021;7:8 -11 | DOI 10.25646/8026

78. Bloomfield SF, Carling PC, Exner M. A unified framework for developing effective hygiene procedures for hands, environmental surfaces and laundry in healthcare, domestic, food handling and other settings. GMS Hyg Infect Control. 2017;12:Doc08. DOI: 10.3205/dgkh000293, URN: urn:nbn:de:0183-dgkh0002937 http://www.egms.de/en/journals/dgkh/2017-12/dgkh000293.shtml

79. Sinner, H. (1960) €U ber das Waschen mit aushaltswaschmaschinen. Hamburg: Haus und Heim Verlag.

80. Bockmühl DP. Laundry hygiene-how to get more than clean. Journal of Applied Microbiology. 2017; 122:1124-33

81. Ryan MO, Haas CN, Gurian NL, Gerba CP, Panzl BM, Rose JB. Application of quantitative microbial risk assessment for selection of microbial reduction targets for hard surface disinfectants. American Journal of Infection Control. 2014;42:1165-72.

82. Haas CN, Marie JR, Rose JB, Gerba CP. Assessment of benefits from use of antimicrobial hand products: reduction in risk from handling ground beef. Int Journal of Hygiene and Environmental Health 2005;208:461-6.

83. Jones C. Environmental surface contamination with SARS-CoV-2-a short review Journal of Human Virology and Retrovirology 2020; 8: 15-9.

84. Lei H, Xiao S, Cowling BJ, et al. Hand hygiene and surface cleaning should be paired for prevention of fomite transmission. Indoor Air. 2019;00:1–11.

85. Ijaz MK, Whitehead K, Srinivasan V, McKinney J, Rubino JR, Ripley M, Jones C, Nims RW, Charlesworth B. Microbicidal actives with virucidal efficacy against SARS-CoV-2. American Journal of Infection Control. 2020;48):972-3.

86. Brands B, Brinkmann A, Bloomfield S, Bockmühl DP. Microbicidal action of heat, detergents and active oxygen bleach as components of laundry hygiene. Tenside Surfactants Detergents. 2016 Sep 15;53(5):495-501.

87. Yezli S, Otter JA. Minimum Infective Dose of the Major Human Respiratory and Enteric viruses Transmitted Through Food and the Environment. Food Environ Virol. 2011;3:1-30. DOI:10.1007/s12560-011-9056-7.

88. Muller MP, Macdougall C, Lim M, Armstrong I, Bialachowski A, Callery S, Ciccotelli W, Cividino M, Dennis J, Hota S, Garber G. Antimicrobial surfaces to prevent healthcare-associated infections: a systematic review. Journal of Hospital Infection. 2016; 92:7-13.

89. von Dessauer B, Navarrete MS, Benadof D, Benavente C, Schmidt MG. Potential effectiveness of copper surfaces in reducing health care–associated infection rates in a pediatric intensive and intermediate care unit: a nonrandomized controlled trial. American Journal of Infection Control. 2016; 44(8):e133-9.

90. Abraham J. Dowling K; Florentine S. Can Copper Products and Surfaces Reduce the Spread of Infectious Microorganisms and Hospital-Acquired Infections? Materials 2021; 14: 3444. https://doi.org/10.3390/ma14133444

91. Ellingson KD, Pogreba-Brown K, Gerba CP, Elliott SP. Impact of a Novel Antimicrobial Surface Coating on Health Care-Associated Infections and Environmental Bioburden at 2 Urban Hospitals. Clinical Infectious Diseases. 2020;71:1807-1813. doi: 10.1093/cid/ciz1077. PMID: 31665372.

92. Warnes SL, Keevil CW. Inactivation of norovirus on dry copper alloy surfaces. PloS one. 2013; Sep 9;8(9):e75017.

93. Developing household hygiene to meet 21st century needs: A collaborative industry/ academia report on cleaning and disinfection in homes & Analysis of European consumers' hygiene beliefs and behaviour in 2020. (International Association for soaps, detergents and maintenance products) & IFH (International Scientific Forum on Home Hygiene) April 2021 https://www.aise.eu/documents/document/20210407074132-aise_ifh_joint_hygiene_report_(7_april_2021)_final.pdf

94. FInlay BB, Amato BR, Azad M, Blaser MJ, Bosch TCG, Chu H, Dominguez-Bello MG, Ehrlich SD, Elinav E, Geva-Zatorsky N, Gros P, Guillemin K, Keck F, Korem T, McFall-Ngai MJ, Melby MK, Nichter M, Pettersson S, Poinar H, Rees T, Tropini C, Zhao L, Giles-Vernick T. The hygiene hypothesis, the COVID pandemic, and consequences for the human microbiome. Proceedings of the National Academy of Sciences. 2021 Feb 9;118 (6).

95. Otter JA, Yezli S, Perl TM, Barbut F, French GL. The role of 'no-touch' automated room disinfection systems in infection prevention and control. Journal of Hospital Infection 2013 83: 1-13.

96. Loveday HP, Wilson JA, Pratt RJ, Golsorkhi M, Tingle A, Bak A, Browne J, Prieto J, Wilcox M and U.K. Department of Health epic3: national evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. Journal of Hospital Infection 2014;86 Suppl 1: S1-70.

97. Perceptions of cleanliness, hygiene and hygiene issues – a survey of UK and US media coverage 1989 to 2017. 2017. The International Scientific Forum on Home Hygiene. https://www.ifh-homehygiene.org/review/perceptions-cleanliness-hygiene-and-hygiene-issues-%E2%80%93-survey-uk-and-us-media-coverage-1989.

98. Curtis V, De Barra M, Aunger R. Disgust as an adaptive system for disease avoidance behaviour. Philosophical Transactions of the Royal Society B: Biological Sciences. 2011; 366:389-401.

99. Scudellari, M. Cleaning up the hygiene hypothesis. Proeedings of the National Academy of Sciences USA 2017;. 114:1433-1436. doi:10.1073/pnas.1700688114

100. Ackerley L. Consumer awareness of food hygiene and food poisoning. Environmental Health. 1994; March: 69-74.

101. Boris Johnson must let grassroots football return for children's' mental health https://www.mirror.co.uk/sport/football/news/boris-johnson-must-grassroots-football-23529611

102. Rook G, Bäckhed F, Levin BR, McFall-Ngai MJ, McLean AR Evolution, man-microbe interactions, and life history Plasticity. Lancet 2017; 390: 521–30.

103. Bloomfield SF, Rook GAW, Scott EA, Shanahan F, Stanwell-Smith R, Turner P. Time to abandon the hygiene hypothesis: New perspectives on allergic disease, the human microbiome, infectious disease prevention and the role of targeted hygiene. Perspectives in Public Health 2016; 136:213–224

104. Strachan DP. Hay fever, hygiene, and household size. British. Medical. Journal 1989 299(6710): 1259-1260.

105. Scott E, Bloomfield SF, Exner M, Fara G, Nath K, Signorelli C, Van der Voorden C. Prevention of the spread of infection: the need for a family-centred approach to hygiene promotion. Am J Infect Control 2010;38:1-2.

106. Two decades of pandemic war games failed to account for Donald Trump Nature 2020 584, 26-29 doi:*https://doi.org/10.1038/d41586-020-02277-6*

107. WaterAid 2020 Hygiene the missing first line of defence against COVID 19. https://washmatters.wateraid.org/publications/hygiene-the-missing-first-line-of-defence-against-covid-19

108. The best time to prevent the next pandemic is now: countries join voices for better emergency preparedness. 1 October 2020. https://www.who.int/news/item/01-10-2020-the-best-time-to-prevent-the-next-pandemic-is-now-countries-join-voices-for-better-emergency-preparedness

109. Top experts call for major new coalition on non-medical pandemic research. https://www1.racgp.org.au/newsgp/clinical/top-experts-call-for-major-new-coalition-on-non-me

110. https://ec.europa.eu/health/funding/eu4health_en

111. Weightman A, Ellis S, Cullum A, Sander L, Turley R. Grading evidence and recommendations for public health interventions: developing and piloting a framework. UK Health Development Agency, London. 2005. http://www.nice.org.uk/niceMedia/docs/grading_evidence.pdf

112. Rook. G, Bloomfield SF. Microbial exposures that establish immunoregulation are compatible with Targeted Hygiene Journal of Allergy and Clinical Immunology 2021 https://www.jacionline.org/article/S0091-6749(21)00811-3/pdf.

113. Redmond EC, Griffith CJ, King S, Dyball M. Evaluation of consumer food safety education initiatives in the UK and determination of effective strategies for food safety risk communication (RRD-8). 2005 Food Standards Agency. London.

114. Wills WJ, Meah A, Dickinson AM, Short F. I don't think I ever had food poisoning'. A practice-based approach to understanding foodborne disease that originates in the home, Appetite 2015; 55:118-125.

115. Levy de Andrade M, Rodrigues RR, Antongiovanni N, Thimoteo da Cunha D. Knowledge and risk perceptions of foodborne disease by consumers and food handlers at restaurants with different food safety profiles. Food Research International, 2019; 21:845-853.

116. Biannual Public Attitudes Tracker. Food Standards Agency 2017 https://webarchive.nationalarchives.gov.uk/20180411183134/ https://www.food.gov.uk/sites/default/files/biannualpublicattitudestracker-may-2017.pdf.

117. Weinstein, N. Optimistic biases about personal risks. Science. 1989; 246:1232-1233.

118. Redmond EC, Griffith CJ. Consumer perceptions of food safety risk, control and responsibility. Appetite 2004; 43:309-319.

119. Redmond EC, Griffith CJ. Consumer food-handling in the home: a review of food safety studies. Journal of Food Protection. 2003; 66:130-161.

120. Prior G, Taylor L, Smeaton D, Draper A.2013 'Exploring food attitudes and behaviours: Findings from the Food and You Survey 2012'. London, Food Standards Agency.

121. CDC 2021. Science Brief: SARS-CoV-2 and Surface (Fomite) Transmission for Indoor Community Environments Updated Apr. 5, 2021. https://www.cdc.gov/coronavirus/2019-ncov/more/science-and-research/surface-transmission.html#print

122. Port JR, Yinda CK, Owusu IO, Holbrook M, Fischer RJ, Bushmaker TJ, Avanzato VA, Schulz JE, van Doremalen N, Clancy C, Munster V. SARS-CoV-2 disease severity and transmission efficiency is increased for airborne but not fomite exposure in Syrian hamsters. bioRxiv. 2020 Jan 1.

123. Greenhalgh T, Jimenez JL, Prather KA, Tufekci Z, D, Schooley R, 2021. Ten scientific reasons in support of airborne transmission of SARS-CoV-2. Published Online April 15, 2021 https://doi.org/10.1016/ S0140-6736(21)00869-2 www.thelancet.com Published online April 15, 2021

124. Azimi P, Keshavarz Z, Laurent JG, Stephens B, Allen JG. Mechanistic transmission modelling of COVID-19 on the Diamond Princess cruise ship demonstrates the importance of aerosol transmission. Proceedings of the National Academy of Sciences. 2021 Feb 23;118(8).

125. Cheng VC, Wong SC, Chan VW, So SY, Chen JH, Yip CC, Chan KH, Chu H, Chung TW, Sridhar S, To KK. Air and environmental sampling for SARS-CoV-2 around hospitalized patients with coronavirus disease 2019 (COVID-19). Infection Control & Hospital Epidemiology. 2020; 41:1258-65.

126. Bernal JL, Panagiotopoulos N, Byers C, Vilaplana TG, Boddington NL, Zhang X, Charlett A, Elgohari S, Coughlan L, Whillock R, Logan S. Transmission dynamics of COVID-19 in household and community settings in the United Kingdom. medRxiv. 2020 Jan 1.

127. Madewell ZJ, Yang Y, Longini IM, Halloran ME, Dean NE. Household Transmission of SARS-CoV-2: A Systematic Review and Meta-analysis. JAMA network open. 2020 Dec 1;3(12):e2031756.

128. Signorelli C, Odone A, Stirparo G, Cereda D, Gramegna M, Trivelli M, Rezza G. SARS-CoV-2 transmission in the Lombardy Region: the increase of household contagion and its implication for containment measures. Acta Bio Medica: Atenei Parmensis. 2020; 91(4).

129. Li F, Li YY, Liu MJ, Fang LQ, Dean NE, Wong GW, Yang XB, Longini I, Halloran ME, Wang HJ, Liu PL. Household transmission of SARS-CoV-2 and risk factors for susceptibility and infectivity in Wuhan: a retrospective observational study. The Lancet Infectious Diseases. 2021 Jan 18, 21:617-28.

130. Zhou J, Otter JA, Price JR, Cimpeanu C, Garcia DM, Kinross J, Boshier PR, Mason S, Bolt F, Holmes AH, Barclay WS. Investigating SARS-CoV-2 surface and air contamination in an acute healthcare setting during the peak of the COVID-19 pandemic in London. Clinical Infectious Diseases. 2020 Jan 1.

131. Ong SW, Tan YK, Chia PY, Lee TH, Ng OT, Wong MS, Marimuthu K. Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. Journal of the American Medical Association 2020 323:1610-2.

132. Kraay A, Hayashi M, Berendes DM, Sobolik JS, Leon JS, Lopman BA. Risk for Fomite-Mediated Transmission of SARS-CoV-2 in Child Daycares, Schools, Nursing Homes, and Offices. Emerging Infectious Diseases, 2021; 27:1229-1231. https://doi.org/10.3201/eid2704.203631

133. Van Cauwenberge PB, van Kempen MJ, Bachert C. The common cold at the turn of the millennium. American Journal of Rhinology 2000;14:339-343.

134. Gwaltney JM, Hendley JO. Mechanisms of transmission of rhinovirus infections. Epidemiological Reviews 1988; 10:242-258.

135. Gwaltney JM, Hayden G.F. Psychological stress and the common cold. New England Journal of Medicine 1992; 326: 644-645.

136. Wilson AM, Reynolds KA, Sexton JD, Canales RA. Modelling surface disinfection needs to meet microbial risk reduction targets. Applied and Environmental Microbiology 2018 84:e00709-18. https://doi.org/10.1128/AEM.00709-18

137. Wilson AM, Weir MH, Bloomfield SF, Scott EA, Reynolds KA. Modelling COVID-19 infection risks for a single hand-to-fomite scenario and potential risk reductions offered by surface disinfection. American Journal of Infection Control. 2021; 49:846-8.

Abbreviations used in this report

AISE	International Association for soaps, detergents & maintenance products
AMR	Antimicrobial resistance
HEDL	home and everyday life
HMICs	High and Middle Income communities
ID	Infectious dose
IFH	International Scientific Forum on Home Hygiene
LLH	Longer lasting hygiene
LMICs	low and middle income communities
LR	Log reduction
NAP	National Action Plan
QMRA	Quantitative Microbial Risk Assessment
RSPH	Royal Society for Public health
WASH	Water, Sanitation and Hygiene

The International Scientific Forum on Home Hygiene

Old Dairy Cottage, Woodhouse Lane, Montacute,
Somerset, TA15 6XL, UK
secretariat@ifh-homehygiene.org
www.ifh-homehygiene.org