A REPORT CELEBRATING 10 YEARS OF THE INTERNATIONAL SCIENTIFIC FORUM ON HOME HYGIENE

The global burden of hygiene-related diseases in relation to the home and community

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Foreword

In 1970, the Surgeon General of the United States is alleged to have said "it is time to close the book on infectious diseases, declare the war against pestilence won, and shift national resources to such chronic problems as cancer and heart disease". The last 40 years have shown that this optimism was misplaced; infectious diseases (IDs) are a continuing and significant burden on the health and prosperity of the global community. The emergence of new pathogens, and new pathogenic strains, including antimicrobial resistant strains, demand constant investment in new strategies. The situation is exacerbated by ongoing social, demographic and other changes which mean that people with reduced immunity to infection, either due to old age, chronic disease, medial treatments or other factors, now make up an increasing proportion of the global population – maybe as much as 20%. Technological advances and policy changes are being introduced to save costs or reduce the impact on the environment without any regard to their potential impact on ID risks. Across the world, governments are under pressure to fund the level of healthcare that people expect. A solution to this problem is increasing care in the community, but the gains are likely to be undermined by inadequate infection control at home.

In the developed world, although the reduction in ID mortality represents one of the great public health achievements of the last century, it is the pattern of ID that has changed, rather than the overall incidence, for example, with the old "killer diseases" being replaced by more viral infections, and emerging infections, such as *Campylobacter*, cryptosporidium and HIV. Whereas there is a tendency to assume that the common gastrointestinal, respiratory and skin infections circulating in the community are a minor concern, the health burden in terms of absence from work and school, together with increased pressure on health services, is considerable. In the USA, diseases caused by the major pathogens alone are estimated to cost up to US $35 billion annually (1997) in medical costs and lost productivity. Data increasingly shows that IDs can act as co-factors in other diseases that manifest at a later date, such as cancer and chronic degenerative diseases, or as triggers for the development of allergic diseases.

In the developing world, for decades, universal access to water and sanitation has been seen as the essential step in reducing the preventable ID burden, but it is now clear that this is best achieved by programmes that integrate hygiene promotion with improvements in water quality and availability, and sanitation. The neglect of hygiene goes a long way to explaining why water and sanitation programmes have often not brought the expected benefits. Although the current focus in developing countries is on investment in community water supply and sanitation in order to meet the Millennium Development Goals (MDGs), if the health benefits from achieving these goals are to be realised, sector professionals must look beyond provision of water supply hardware and toilet facilities.

Unfortunately, only fragmented data is available on the cost effectiveness of hygiene measures, making it impossible to assess the impact of hygiene relative to other interventions on the global burden of communicable disease. The 2006 Disease Control Priorities Project on diseases in developing countries, however, concluded that, for the "high burden" diseases such as HIV/AIDS, malaria, diarrhoeal disease and TB, hygiene promotion is the most cost-effective intervention in terms of DALYs (disability adjusted life years) averted.

In this report we have shown that a significant proportion of the global communicable disease burden is caused by diarrhoeal, respiratory and skin diseases, which could be significantly reduced by adequate water and sanitation combined with good hygiene practice. Although provision of water and sanitation is key, it is hygiene practice (handwashing, handling of food and water, disposal of faeces and other waste materials, care of at risk groups and people who are infected etc) which breaks the chain of infection and reduces the ID burden within and between communities. This in turn means that, if the global burden of hygiene-related disease is to be reduced in a manner which is economically sustainable it has to be a responsibility which is shared by the public. This is not about shifting blame, it is about facing reality. The key question is – how do we achieve this? Although governments now recognise the need for more emphasis on hygiene and hygiene promotion, this does not necessarily translate into action. A significant problem is that, in most countries, public health is structured such that the separate aspects of hygiene – food hygiene, personal hygiene, handwashing, pandemic flu preparedness, patient empowerment etc – are dealt with by separate agencies. This means that the information which the family receives is fragmented and largely rule-based. Fragmented knowledge is not enough to meet the challenges we currently face. Hand hygiene, for example, is a central component of all hygiene issues and it is only by adopting a holistic approach that the causal link between hands and infection transmission in the home can be properly addressed. We need a "total" approach which is family-centred rather than an agency-oriented approach. The basis of the IFH approach to ID prevention is "targeted hygiene", which means identifying the routes of transmission of infection in the home and community, and targeting hygiene measures at "critical points" to break the chain of transmission. In many cases it is difficult to assess which are the key interventions and it is likely that this varies between and within different local or global areas, regions and communities. Prioritising investment in disease reduction thus needs to be based on local conditions and evidence from implementation rather than pooled data from intervention studies. In low income communities, it is assumed that handwashing is the single most important hygiene promotion, but it is important for community workers to understand that this is not the only hygiene intervention. In the past there has been a tendency to demand that policy changes should only occur if there is data from intervention studies, such as handwashing studies, which directly demonstrate a health benefit. There is a need to use all the data available, including microbiological data and quantitative risk assessment methods if we are to properly assess the relative impact of different hygiene interventions in different communities. This is particularly so for disinfectant usage where lack of intervention data has meant that these products are not being used in situations where they are needed.

The key question is "how do we achieve behaviour change?". The argument continues over whether this is best done by social marketing of single hygiene messages such as those associated with hand hygiene, or whether it should be through a community-led total approach such as the Community Health Clubs pioneered in Zimbabwe. In the developed world hygiene has come to be seen as rather old-fashioned and disciplinarian. We need to reposition it alongside other values of healthy living such as good diet and exercise.

It is true that, in Europe, for example, 86% of deaths are now attributed to chronic conditions. These mortality statistics have driven public health investment towards reducing death rates from non-communicable diseases. The chronic disease problem however masks the triumphs of the public health and medical interventions that rolled back communicable disease mortality during the 20th century. The quandary of public health lies in the fact that successful communicable disease control is indirectly responsible for high chronic disease mortality statistics and the shift of investment away from the very systems which maintain it. The IFH was established in 1997. From a review of the evidence, at that time, the IFH Scientific Board concluded "Epidemiological and microbiological data suggest an a priori need for an improvement in hygiene awareness and hygiene practices in the home". In 2001 and 2002, IFH held two international conferences, one in London and the other in Delhi, which emphasised the need for "shared responsibility" in the fight against IDs. Since this time, there have been significant changes, which indicate that the need to address the issue of home and community hygiene and the importance of "shared responsibility" is increasing rather then decreasing. These changes are reviewed in detail in this report.

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Executive Summary

In the past 20 years or so, infectious disease (ID) has moved steadily back up the health agenda, prompting new emphasis on developing strategies for prevention and control. Increasingly this includes promotion of hygiene to the family, both at home and in their social and work lives outside the home. Indications are that a significant proportion of the global ID burden is caused by diseases which are hygiene-related (i.e. transmitted via food, water, faecal and other waste material, hands and other surfaces, and via the air) to the extent that, within the home and other settings, standards of hygiene, in relation to hand washing, handling of food and water, disposal of faeces and other waste materials, care of at risk groups and people who are infected, are key factors which determines the ID burden within and between communities. A number of factors/events contribute to the current situation.

- Despite significant investment at all levels, food-related, waterborne, and other non-food-related infectious intestinal diseases (IID) remain at unacceptably high levels, even in developed countries. This is despite the efforts of food producers to ensure the safety of the food chain. As stated in the 2003 World Health Organisation (WHO) report “foodborne illness is almost 100% preventable”. Preventing food-related infections relies on a combination of good hygiene practices during food preparation, cooking and storage. Whereas there has been significant investment in reducing foodborne disease, through food hygiene campaigns, there has been little attempt to reduce the burden of non-foodborne disease although it is apparent that, in the developed world at least, largely non-foodborne IDs (e.g. norovirus) account for up to 50% of the total IID burden.
- It is increasingly apparent that hygiene plays a significant part in limiting the spread of respiratory infections such as colds and influenza. The common cold is reported to be the most frequent, acute infectious illness to humans.
- New pathogens can spread quickly through communities. Agents such as rotavirus, *Campylobacter*, legionella, *E. coli* O157 and norovirus, largely unknown before the 1980s, are now leading causes of morbidity. Hygiene is an important first line of defence in limiting the spread of new pathogens. The most recent emergent pathogens include SARS and avian flu. In the event of a flu pandemic, it is likely that hygiene will be a first line of defence during the early critical period before mass vaccination becomes available. “Global Preparedness” means that respiratory hygiene needs to become part of our daily lives before the event.
- The problem of antibiotic resistance, which hinders effective treatment of infectious diseases, means that increasingly we need to rely on hygiene strategies to prevent the proliferation and spread of antibiotic resistant strains.
- Whereas pathogens such as methicillin resistant *Staphylococcus aureus* (MRSA) and *Clostridium difficile* (*C. difficile*) were once considered hospital-related problems, those responsible for ensuring the public are protected from infection in healthcare facilities increasingly realise that their ability to manage infection outbreaks is hampered by spread of pathogens such as MRSA, *C difficile,* and norovirus in the community, which in turn determines the number of infected people or carriers that walk into their facilities.
- Novel identification techniques are now showing the extent to which viral agents such as the norovirus, rotavirus and adenovirus are a cause of community-acquired infections, not only IID, but also respiratory and other infections. Since viral infections are not treatable by antibiotics, this reinforces the need for prevention through hygiene.
- The home is frequently a shelter to a range of different pets; more than 50% of homes in the English-speaking world have cats and dogs, with 60 million cats and dogs in the USA. Domestic cats and dogs can act as reservoirs of *Salmonella*, *Campylobacter* and other enteric pathogens. Although some data is

reported demonstrating that domestic pets can act as a source of infection in the home, there is little data to indicate the extent to which this may occur.

- There is growing evidence that some pathogens can act as co-factors or triggers in chronic degenerative and other diseases, which can manifest at a later date. These include cancer (e.g. human papillomavirus and cervical cancer), degenerative diseases (e.g. *Campylobacter* and Guillain-Barré syndrome) and long-term disease (foodborne illness has been estimated to result in chronic sequelae in 2–3% of cases). A significant proportion of childhood wheeze and asthma is believed to be triggered by respiratory infections.
- Whereas there has been a tendency to assume that the common gastrointestinal (GI), respiratory and skin infections circulating in the community are a relatively minor concern, the burden related to these infections in terms of absence from work and school, together with increased pressure on health services, is considerable.

The changing "hygiene climate" in the home and community not only reflects the constantly changing nature and range of pathogenic micro-organisms to which we are exposed, but also the social, demographic and other changes which are occurring within the global population which affect our resistance to infection.

Demographic changes and changes in health service structure mean that the number of people in the home needing special care, because they are at greater risk of infection is increasing. Up to 1 in 5 people in the community is at increased risk of infection. The largest proportion are the elderly who have a lot of co-morbidities which result in reduced immunity to infection which is often exacerbated by other illnesses like diabetes, etc. It also includes the very young, patients discharged from hospital, taking immunosuppressive drugs or using invasive systems, etc. It also includes the estimated 40 million people in the community infected with HIV/AIDS.

Governments are under pressure to fund the level of healthcare which people expect. Care of increasing numbers of patients in the community, including at home is one answer, but can be fatally undermined by inadequate infection control in the home.

A number of other trends in social behaviour, eating habits, availability and use of home appliances etc are increasing the risks of transmission of IDs amongst family members in the home. The demand for different and "exotic foods" stimulates increasing movement of foodstuffs from one region or country to another and creates problems in controlling microbial quality. Increasing population mobility due to factors such as air travel means that, as in the case of SARS, virulent pathogens can move rapidly across the world, making it difficult to contain epidemics related to novel pathogenic strains.

In the developing world, one of the main "drivers" for changing attitudes to hygiene in recent years has been the 2002 UN Millennium Development Goals, which have established not only the issues of water, sanitation, but also more recently, hygiene, on the global agenda. For decades, universal access to water and sanitation has been seen as the essential step in reducing the preventable ID burden, but it is now clear that this is best achieved by programmes that integrate hygiene promotion with improvement in water quality and availability, and sanitation. The neglect of hygiene goes a long way to explaining why water and sanitation programmes have often not brought the expected benefits. An analysis, presented in the 2006 Disease Control Priorities Project (DCPP) publication "Disease Control Priorities in Developing Countries" concluded that, for the "high burden" diseases such as HIV/AIDS, Malaria, diarrhoeal disease and TB, hygiene promotion is the most cost-effective intervention in terms of DALYs averted (up to \$10 per DALY averted due to diarrhoeal disease compared with e.g. up to approx \$1,000 per DALY averted by anti-retroviral treatment of HIV/AIDS). Trachoma is the world's leading cause of blindness, which mainly affects poorer communities in developing countries. Trachoma, however, is completely preventable through hygiene (face washing breaks the infection cycle). It is estimated that 92 million people suffer from trachoma and 8 million are visually impaired or blinded as a result. Up to 600 million individuals live in endemic areas and are at risk for contracting trachoma.

The purpose of this unique report is to draw together data on the global incidence and prevalence of IDs, for which it is generally accepted that community-based hygiene interventions (safe disposal of faeces, provision of safe water, and hygiene practices such as hand washing and safe handling of food) play a significant part in reducing the burden of infection. The report also examines the social and demographic factors that have influenced trends in these diseases over the past 20-30 years.

This review of global infectious disease covers both developed and developing countries and compiles data from epidemiological and microbiological studies. It is based on the 1997 keynote paper of the International Scientific Forum on Home Hygiene (IFH, www.ifh-homehygiene.org). It also contains data from the database of peer-reviewed, published scientific literature which has been accumulated by the IFH since 1997, together with contributions (peer-reviewed, published scientific literature) from the knowledge base of all the authors.

The IFH was established in 1997 in response to concerns about the need for an international body which could speak from a scientific/medical standpoint about home and community hygiene. One of the first projects which IFH undertook was a review of the evidence to establish whether there was a need to address this issue. From this keynote paper, the IFH Scientific Board concluded “Epidemiological and microbiological data suggest an a priori need for an improvement in hygiene awareness and hygiene practices in the home”. Since the publication of the 1997 review, there have been significant changes, which indicate that the need to address the issue of home and community hygiene is increasing rather then decreasing. These changes are reviewed in detail in this report.

1. INTRODUCTION – THE FALL AND RISE OF HYGIENE IN THE 20TH CENTURY

In the past 20 years or so, infectious disease (ID) has moved steadily back up the health agenda, prompting new emphasis on developing strategies for prevention and control. Increasingly this includes promotion of hygiene to the family, both at home and in their social and work lives outside the home. A significant proportion of the global ID burden is caused by diseases which are hygiene-related (i.e. transmitted via food, water, faecal and other waste material, hands and other surfaces, and via the air) which means that standards of hygiene, in relation to measures such as hand washing, handling of food and water, disposal of faeces and other waste materials, care of at risk groups and people who are infected are a key factor which determines the ID burden within and between communities.

There can be no doubt that advances in hygiene during the 19th and 20th centuries, along with other aspects of modern medicine, have improved both the length and quality of our lives beyond all recognition. During the second half of the 20th century, however, following on from the development of vaccination and antibiotic therapy, and the control of serious epidemics of the “old” infectious enemies, such as diphtheria, TB and typhoid fever, hygiene tended to lose its prominent position and the focus of concern shifted to degenerative, chronic diseases. In developed countries, hygiene education in schools was replaced by other subjects deemed more important. Nowhere has the decline in concern about hygiene been more evident than in the home, where there has been a tendency to assume that, compared with the hospital setting, most people are “normal and healthy”, and the infection risk is thus minimal. Social changes across the world mean that women increasingly work outside the home and have had less time for childcare and housework. This has led to a more superficial approach to hygiene and home cleaning, with speed and aesthetic factors more important than disease prevention.

Whereas, in 1970s, there was a feeling that it was only a matter of time before the fight against infectious diseases was over, we now know that this optimism was misplaced. In the USA, since 1980, deaths attributable to ID have risen from fifth to third rank as the most important cause of death.[1,2] Experience now shows that as soon as we begin to get one pathogen under control another emerges; indications are that poor hygiene has been a contributory factor in the global spread of pathogens such as norovirus, *Helicobacter pylori* (*H. pylori*), Legionella and *Campylobacter*, pathogens which were largely unheard of before the 1980s. The 1996 Rudolf Schulke Report[2] showed that, over the period 1972–1996, at least one new pathogen per year was reported. Many of these emerging infections have been caused by species which are normally present in the environment, but have become pathogenic to humans as a result of changes in technology (food technology, building design and operation etc) or societal changes. The other key concern is the emergence of new strains of already known and well-established pathogens. Some of these are a concern because they have developed altered or enhanced virulence properties (e.g. they have acquired the ability to produce a specific toxin, or enhanced levels of toxin). Others such as methicillin resistant *Staphylococcus aureus* (MRSA) represent a problem because they have acquired the ability to resistant the action of antibiotics.

Recent emergent pathogens include viruses such as SARS, avian and swine flu; more than anything, the outbreak of SARS has raised public awareness and concern about their role in spreading, and thus containing the transmission of infections. In the event of a flu pandemic, it is likely that hygiene will be a first line of defence during the early critical period before mass vaccination becomes available. “Global Preparedness” means that respiratory hygiene needs to become part of our daily lives before the event; the evidence suggests that not just coughs and sneezes, but also hand and surface hygiene play a part in reducing the spread of respiratory infections such as colds and also influenza.[3,4] If the public are to play their part, however, knowledge and awareness of these personal measures needs to be improved.[5]

Despite significant investment at all levels, food-related, waterborne, and other non-food-related infectious intestinal diseases (IID) remain at unacceptably high levels, even in developed countries. This is despite the efforts of food producers to ensure the safety of the food chain. Preventing food-related infections relies on a combination of good hygiene practices during food preparation, cooking and storage.

Whereas there has been a tendency to assume that the common gastrointestinal, respiratory and skin infections circulating in the community are a relatively minor concern, the burden related to these infections in terms of absence from work and school, together with increased pressure on health services, is considerable. In the USA, diseases caused by the major pathogens alone are estimated to cost up to US $35 billion annually (1997) in medical costs and lost productivity.[6] Data increasingly now shows that both intestinal and also respiratory pathogens can act as co-factors in diseases such as cancer and chronic degenerative diseases, or as triggers for the development of allergic diseases further supports the need to better control the spread of these diseases.

Across the world, healthcare-associated infections (HCAIs) are no longer seen as a “nuisance” but as a major barrier to delivering health. Alongside this there is acceptance that controlling infections such as MRSA, *Clostridium difficile* (*C. difficile*) and norovirus is a community as well as a hospital problem.[7] Hygiene is recognised as an important component of strategies to tackle the problem of antibiotic resistance. There is now, however, a second dimension to the problem, that of “community-acquired” strains such as community-acquired MRSA (CA-MRSA) strains which have emerged quite separately in the community and affect mainly young healthy people and children, rather than immune-compromised patients in hospitals. Although CA-MRSA strains have become a major problem in the USA, they are still relatively uncommon in Europe and there is still an opportunity to avoid the problem escalating to a similar scale in Europe.

A key contributory factor to our increased understanding of ID trends in the community has been the development of molecular and other improved technologies which can be used for detecting pathogens from human isolates and matching them against the possible source or vector. The application of these techniques now shows the extent to which viral agents such as the norovirus, rotavirus and adenovirus are a cause of community-acquired infections, not only IID, but also respiratory and other infections. Since viral infections are not treatable by antibiotics, this reinforces the need for prevention through hygiene.

The changing “hygiene climate” in the home and community not only reflects the constantly and rapidly changing nature and range of pathogenic micro-organisms to which we are exposed, but also the social, demographic and other changes which are occurring within the global population which affect home and community-based resistance to infection. Across the world, governments are under pressure to fund the level of healthcare that people expect. A solution to this problem is increasing care in the community, but the gains are likely to be undermined by inadequate infection control at home. Those at risk include the increasing elderly population, the very young, patients discharged earlier from hospital as a result of shorter hospital stays, as well as patients undergoing outpatient treatments such as chemotherapy or patients with indwelling catheters. Factors such as the globalisation of food supplies, mass travel, migration and refugee movements all serve to move pathogens rapidly around the world to areas where the population may have little resistance.

In the developing world, one of the main “drivers” for changing attitudes to hygiene has been the 2002 UN Millennium Development Goals, which have firmly established not only the issues of water, sanitation, but also more recently, hygiene, on the global agenda. For decades, universal access to water and sanitation has been seen as the essential step in reducing the preventable ID burden, but it is now clear that this is best achieved by programmes that integrate hygiene promotion with improvement in water quality and availability, and sanitation. In reality, it is hygiene (e.g. keeping faecal matter away from hands, food and water, preventing cross contamination etc) that reduces the burden of ID in countries where safe disposal of faeces is not practiced. The neglect of hygiene goes a long way to explaining why water and sanitation programmes have often not brought the expected benefits. An analysis, presented in the 2006 Disease Control Priorities Project (DCPP) publication “Disease Control Priorities in Developing Countries”[8] concluded that, for the “high burden” diseases such as HIV/AIDS, Malaria, diarrhoeal disease and TB, hygiene promotion is the most cost-effective intervention in terms DALYs (disability adjusted life years) averted (up to $10 per DALY averted due to diarrhoeal disease compared with, e.g. up to approx $1,000 per DALY averted by anti-retroviral treatment of HIV/AIDS).

IFH was established in 1997 in response to concerns about the need for an international body which could speak from a scientific/medical standpoint about home and community hygiene. One of the first projects which IFH undertook was a review of the evidence to establish whether there was a need to address this issue.[9] From this review, the IFH Scientific Board concluded “Epidemiological and microbiological data presented in this paper suggest an a priori need for an improvement in hygiene awareness and hygiene practices in the home”. Since the publication of this review, there have been significant changes in the “hygiene climate”, which indicate that the need to address the issue of home and community hygiene is increasing rather then decreasing.

The purpose of this unique report is to draw together data on the global incidence and prevalence of IDs, for which it is generally accepted that community-based hygiene interventions (safe disposal of faeces, provision of safe water, and hygiene practices such as hand washing and safe handling of food) play a significant part in reducing the burden of infection. The report also examines the social and demographic factors which have influenced trends in these diseases over the past 20-30 years. An important question however is “how do we know that these diseases are hygiene-related” and “to what extent i.e. which hygiene interventions have the greatest impact”. Although these are important questions, they are outside the scope of this report, which focuses on understanding the burden of hygiene-related diseases and the factors which influence current trends in these diseases. Evidence which demonstrates how and to what extent infectious agents are spread in the home and community, and the role of hygiene in breaking the chain of infection is reviewed in detail in two other IFH key reviews “The Infection Potential in the home and the role of hygiene”,[10] and “Hygiene procedures in the home and their effectiveness: a review of the evidence base”.[11]. This aspect is also addressed in our IFH special reviews on household water treatment and safe storage,[12] hand hygiene,[3] viral[13] and fungal[14] infections and a report on MRSA, *C. difficile* and ESBL-producing *Escherichia coli* (*E. coli*).[7] Section 7 contains a short summary of the key points from these reviews.

The report covers both developed and developing countries and compiles data from epidemiological and microbiological studies. The report is based on the 1997 IFH keynote paper. It also contains data from the database of peer-reviewed, published scientific literature on the "hygiene climate" which has been accumulated by the IFH since 1997 (see the reading rooms of the IFH website home hygiene library), together with contributions (peer-reviewed, published scientific literature) from the knowledge base of all the authors. In 1999, Professor Sattar published a detailed review paper on the impact of changing societal trends on the spread of infections in American and Canadian homes.[15] This IFH review paper also draws on, and develops the data presented in Professor Sattar's paper. Global patterns of IDs are also reviewed in 2 reports produced in 1996 and 2008 by the Rudolf Schulke Foundation.[1,2]

We anticipate that readers will sometimes prefer to use this review as a reference source for one of the individual issues which go to make up the report. For this reason, we have tried to make each section as internally comprehensive as possible; therefore, readers may find some repetition in the material presented.

2. GLOBAL PATTERNS OF HYGIENE-RELATED DISEASE IN THE HOME AND COMMUNITY

The WHO 2008 report on the global burden of disease,[16] based on data for 2004, assesses that, worldwide, infectious and parasitic diseases account for 9.5 million deaths a year (16.2% of all deaths). The report shows that, of the top 10 leading causes of death worldwide, lower respiratory tract and diarrhoeal infections rank 3rd and 5th respectively, accounting for 7.1% and 2.2% of all deaths. Of the 10.4 million deaths among children under 5 years old, diarrhoeal diseases and neonatal infections (mainly sepsis) account for 17% and 9% of deaths, respectively.

Although the reduction in ID mortality in the developed world represents one of the great achievements in public health in the last century, in these regions, it is the pattern of ID that has changed, rather than the overall incidence, e.g. with less typhoid and cholera than a century ago, but more viral infections and an increasing range of emerging infections, such as *Campylobacter* species, *Cryptosporidium parvum* and HIV.

The significant decline in mortality due to IDs is, however, predominantly an achievement of the developed world. The WHO 2008 report[16] assesses that, of the 10.4 million deaths in children aged under 5 years worldwide, 4.7 million (45%) occur in the African region, and an additional 3.1 million (30%) occur in the South East Asia Region. The death rate per 1000 children aged 0-4 years in the African region is almost double that of the region with the next highest rate, the Eastern Mediterranean and more than double that of any other region. The two leading communicable disease killers in all regions are diarrhoeal disease and respiratory infections. In Africa and the Eastern Mediterranean diarrhoeal diseases account for 8.9% and 5.8% of total deaths compared with 0.4% and 1.1% for Europe and the Americas, respectively.

In developing countries, although introduction of oral rehydration therapy has led to a marked reduction in deaths caused by diarrhoea and cholera among children, due to poor hygiene and lack of safe water, morbidity continues unabated. In the South East Asia region the annual diarrhoeal episodes range from 0.7 to 3.9 per child. Every year more than 10 million die before they reach their 5th birthday; 7 in 10 of these deaths are due to acute respiratory infection, diarrhoea, measles, malaria or malnutrition. On an average, children below 5 years of age suffer five episodes of ARI per child per year.[17]

A 2008 report prepared for the WHO by Prüss-Üstün et al[18] estimates that, globally, improving water, sanitation and hygiene has the potential to prevent at least 9.1% of the global disease burden (in disability-adjusted life years or DALYs, a weighted measure of deaths and disability), or 6.3% of all deaths. Children, particularly those in developing countries, suffer a disproportionate share of this burden, as the fraction of total deaths or DALYs attributable to unsafe water, inadequate sanitation or insufficient hygiene is more than 20% in children up to 14 years of age. Although a substantial proportion of this estimated reduction is made up, not only of diarrhoeal disease reduction but also conditions such as malaria, lymphatic filiariasis and schistosomiasis which are water source-related and would derive from public-funded improvements in sanitation and water supply, the report estimates that for diarrhoeal diseases whereas improvements in the provision of sanitation and water supply would produce, respectively, a 32% and 25% reduction in diarrhoeal disease burden, improvements in water quality (achievable by promotion of home water treatment and safe storage as well as better control of public supply) and the promotion of other hygiene interventions including, but not limited to, hand washing in the home and community could produce, respectively, 31% and 37% reduction in diarrhoeal disease burden. The inter-related roles of water, sanitation and related hygiene issues for diarrhoeal disease was demonstrated in a 2008 study in the in Khorezm province, Uzbekistan.[19]

In making their assessments, Prüss-Üstün et al gauge that the 9.1% of the disease burden attributed to unsafe water, inadequate sanitation or insufficient hygiene may be an underestimate. Diseases that are unquantifiable include some that are likely to be significant at a global scale including legionellosis, leptospirosis, conjunctivitis and otitis, which are mostly respiratory infections related to hygiene. The report also concludes that water, sanitation and hygiene interventions interact with one another, and that the impact of each may vary widely according to local circumstances, which means that prioritising investment in disease reduction needs to be based on local conditions and evidence from implementation rather than from pooled data, such as the average impacts defined above.

The WHO 2008 report on the global burden of disease,[16] contains region by region statistics on the incidence of specific IDs, using data for 2004. Current trends in communicable IDs in Europe are described in more detail in the "2008 Annual Epidemiological Report on Communicable Diseases in Europe" from the European Centre for Disease Prevention and Control (ECDC).[20]

In the following sections we give an overview of what is known about the incidence and prevalence of community-associated ID, including IIDs, respiratory tract diseases (RTs), skin and eye infections. The review focuses on IDs which predominate in the home and community, for which the evidence suggests that hygiene is a significant factor in preventing spread. In developed countries, whereas, in the past, research and surveillance largely focused on healthcare-associated and foodborne illnesses, increasing resource is now being allocated to generating data which gives a better view of the extent to which infections are circulating in the community, how they are being transmitted, and how this varies from one region, country or community to another. Although, the data in the following sections represent a useful overview, we note that the data collection methods differed significantly from one study to another, which means that comparisons from different geographical locations must be interpreted with care.

3. Infectious intestinal diseases

Despite significant progress, diarrhoeal diseases remain a principal cause of preventable death, in developing countries. One estimate[21] suggests that residents of developing nations may experience between 5 and 20 episodes of diarrhoea per year. Although the global estimate for the number of deaths from diarrhoea dropped from 4.6 million before 1980, to 3.3 million per year between 1980 and 1990, the figures for 1990–2000 remain at 2.6 million deaths per year.[22] The 2008 WHO report[16] on the global burden of disease reports a total of 2.16 million deaths per year for calculated for data gathered in 2004. The 2008 report by Pruss-Üstün et al[18] states that 80% of cases of diarrhoea worldwide are attributable to unsafe water, inadequate sanitation or insufficient hygiene. This 2008 report estimates that these cases result in 1.5 million deaths each year, most being the deaths of children. The category "diarrhoea" includes some more severe diseases, such as cholera, typhoid and dysentery – all of which have related faecal:oral transmission pathways.

Whereas, in developed countries there is a tendency to assume that most IID is caused by consumption of contaminated water and food, this is by no means the case, IIDs are also transmitted by direct hand-to-mouth contact and in low income communities faecal:oral transmission (either directly or via food and water) is the most common route of spread. In developing countries, where sanitation is poor, hands frequently become contaminated with enteric pathogens by contact with infected faecal material. In developed countries, community based studies increasingly show the extent to which diseases such as norovirus and rotavirus are spread by hand contact with contaminated surfaces, or the hands of someone who is infected. Obtaining reliable data on the extent (and relative extent) to which diarrhoeal infections are waterborne and foodborne, or are due to direct hand-to-mouth transmission, is difficult. This is particularly so in developing countries, where relatively little systematic data is available.

As far as water is concerned, up until 2004 the WHO/UNICEF joint monitoring group were reporting that up to 1.1 billion people were without access to "improved sources of water for drinking". They also estimated that, even for the remaining 5.2 billion people who have access to an "improved water source", a significant proportion were still drinking grossly contaminated water.[23] In 2008, WHO/UNICEF[24,25] report that in the last few years the situation has significantly improved and that for the first time since data were first compiled in 1990, the number of people globally who lack access to an improved drinking water source has now fallen below 1 billion. At present 87% of the world population has access to improved drinking water sources (including water piped into a dwelling, plot or yard, and other improved sources such as public taps, boreholes, protected dug wells, protected springs and rainwater collection), with current trends suggesting that more than 90% will do so by 2015. Overall 54% of the world's population now has piped water on the premises (piped household connection located inside the users dwelling, plot or yard). The report, however, highlights large disparities within national borders, particularly between rural and urban dwellers. Worldwide, there are four times as many people in rural areas – approximately 746 million – without improved water sources, compared to some 137 million urban dwellers. Real improvements in access to safe drinking water have occurred in many of the countries of southern Africa. According to the report, 7/10 countries that have made the most rapid progress and are on track to meet the Millennium Development Goal drinking water targets are in sub-Saharan Africa (Burkina Faso, Namibia, Ghana, Malawi, Uganda, Mali, Djibouti). Of the countries not yet on track to meet the sanitation target, but making rapid progress, five are in sub-Saharan Africa (Benin, Cameroon, Comoros, Mali and Zambia).

Drinking water quality however still remains a significant problem, not only in developing countries but also in developed countries, most particularly in Eastern Europe, but also in North America and elsewhere. The 2005 IFH review[12] on household water states that "Even in the European region it is estimated that 120 million people do not have access to safe drinking water. In European countries and North America, there are now fewer risks of epidemics related to drinking water contaminated with pathogens such as cholera and typhoid or viral hepatitis, but numerous instances of water-borne disease resulting from contaminated drinking water are still reported. In developed countries, as much as 15–30% of community gastroenteritis may be attributable to municipal drinking water, despite state of the art technology for water treatment and no evidence of unacceptable microbial contamination levels. With a current global population of 6.5 billion individuals this adds up to 5–60 billion IID cases annually". Although significant advances have been made in low-income communities, community water supplies often become contaminated during distribution or transport to the home, and during storage and handling within the home. One option for dealing with this is the promotion of point-of-use water treatment and safe storage in the home. A key argument for promoting hygiene measures related to water treatment and storage is that it can deliver safe water to underserved populations much more quickly and affordably than it takes to install piped community supplies, providing immediate benefit until the long-term goal of providing community supplies can be achieved. In the developed world household water treatment is important as a routine measure for households that do not have access to good quality water. It is also important as an emergency measure in controlling outbreaks which result from sporadic breakdowns in the system.

As far as food is concerned, as the data in the following sections show, even in developed countries, foodborne illness remain at unacceptably high levels, despite the efforts of food producers to ensure the safety of the food chain. Raw meat and poultry, fruits and vegetables, bought at retail premises may be contaminated with pathogens, which means that good hygiene practices during food preparation, together with thorough cooking and safe storage in the home is essential in preventing cross contamination of prepared foods from raw foods. Good hygiene is also key to preventing contamination of foods by household members or from domestic animals which are infected or who are carriers of foodborne pathogens. In a 1999 review,[26] Kaferstein assessed that during the early 21st century, foodborne diseases may be expected to increase, especially in developing countries. This is partly because of environmental and demographic changes including climatic changes, changes in microbial and other ecological systems and decreasing fresh water supplies. Kaferstein predicts that even greater challenges to food safety will come from changes resulting directly in the degradation of sanitation and the immediate human environment. Other changes which will impact the IID risks include ageing population, unplanned urbanisation and migration and mass production of food due to population growth and changed food habits. Mass tourism and the huge international trade in food and feed are causing food and feedborne pathogens to spread trans-nationally. Foodborne infections figure prominently among the new diseases and infections discovered in the last few decades including campylobacteriosis, Cryptosporidium, Cyclospora, enterohaemorrhagic *E. coli* infections and listeriosis. In addition, there are new strains of *Vibrio cholerae* and drug-resistant strains of several enteric pathogens, particularly *Salmonella* and, possibly, *H. pylori*. New foodborne diseases can be expected to appear in the coming millennium.

Worldwide, bacterial foodborne zoonotic infections (infections and diseases that are transmissible between animals and humans) are the most common cause of reported cases and outbreaks of human IID, with *Salmonella* and *Campylobacter* accounting for over 90% of all reported cases of bacteria-related food poisonings. These infections can be acquired directly from animals, through the ingestion of contaminated food, or from other environmental sources. It is estimated that one-third of populations in developed countries are affected by foodborne diseases every year.[27] In his 1999 review Sattar[15] states that, in the developed world, sporadic foodborne outbreaks pose the highest economic burden, but as many as 99% of these infections are unreported as a result of the relatively mild symptoms, so the true impact of foodborne illness is difficult to determine. Sattar states that "Between 6.5 million and 30 million infections per year are a result of foodborne spread, which burdens the economy for more than US $5 billion". The available evidence suggests that foodborne diseases are more prevalent in developing countries than in developed countries. Foodborne diseases such as cholera, typhoid fever and liver fluke infection, which are mostly attributed to the combined impact of unsafe water, inadequate sanitation and poor hygiene, have been virtually eliminated in developed countries, but are still common in the developing world.

3.1 Infectious Intestinal Disease – Developed Countries

3.1.1 Foodborne disease

The 1990s saw rapid increases in the incidence of food poisoning in the developed world, and finally a call to action to reverse this trend. Although this has largely been achieved, levels of foodborne disease remain unacceptably high. The 2007 annual Community Summary Report by the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention and Control (ECDC), based on data collected in 2006, gives an overview of the latest trends and figures on the occurrence of zoonoses and zoonotic agents in humans, animals and foodstuffs in the 27 European Union (EU) Member States and the four European Free Trade Association (EFTA) countries (Iceland, Liechtenstein, Norway and Switzerland).[27]
The 2003 WHO report[28] concluded that about 40% of reported foodborne outbreaks in the WHO European region over the previous decade were caused by food consumed in private homes. The report cites several factors as "critical for a large proportion of foodborne diseases" including use of contaminated raw food ingredients, contact between raw and cooked foods, and poor personal hygiene by food handlers. A key aspect as stated in the 2003 WHO report is that "foodborne illness is almost 100% preventable".

UK data (Table 1) give an example of food poisoning trends in Europe which shows how the number of food poisoning notifications reached a peak in 1997/1998 and has since declined, but remains in excess of 70,000 per year. Although the number of cases recorded is in the thousands, the true burden of food poisoning is likely to be millions of cases per year, as most cases go unreported. According to the UK Food Standards Agency,[29] up to half of the annual 9.4 million cases of IID are food poisoning, equating to 4.7 million cases per year.

Table 1 – Food poisoning notifications – annual totals England and Wales, 1982–2005 www.hpa.org.uk/infections/topics_az/noids/food_poisoning.htm

1990	52,145	1998	93,932
1991	52,543	1999	86,316
1992	63,347	2000	86,528
1993	68,587	2001	85,468
1994	81,833	2002	72,649
1995	82,041	2003	70,895
1996	83,233	2004	70,311
1997	93,901	2005	70,407

The 2008 (based on data for 2007) European Community Summary Report on foodborne infections[27] cites campylobacteriosis, as in previous years, as the most reported animal infection transmitted to humans with 200,507 confirmed cases reported. This was a 12% overall increase compared to 2006 (including the new Member States Bulgaria and Romania for 2006 to facilitate comparison) with most Member States reporting an increase, some as high as 27%, compared to 2006. It is predicted that about 1% of the inhabitants of Europe will be infected with *Campylobacter* every year.[27] Salmonellosis was the second most commonly reported zoonotic infection in the EU in 2007, with 151,995 human cases and a statistically significant decreasing trend in the notification rate in the EU over the past 4 years. In foodstuffs, *Campylobacter* was most commonly detected in fresh poultry meat where on average 26.0% of samples were found positive at the EU level. *Campylobacter* was also frequently found in animals and most often in poultry flocks and pigs although *Campylobacter* rates in pig (and bovine) meat typically decrease sharply following slaughter and remain low at retail. In food, *Salmonella* was most commonly found in fresh broiler meat and in pig meat, where 5.5% and 1.1% of samples, respectively, were found positive. The bacterium was very rarely detected in vegetables and fruit or in dairy products (although outbreaks involving such vehicles are known to occur). In animals, *Salmonella* was most frequently detected in poultry flocks but at lower levels than *Campylobacter*. Although these agents make up the overwhelming majority of all zoonotic infections they represent only a fraction of the true number of cases in the EU. For verotoxigenic *Escherichia coli* (VTEC), a total of 2,905 confirmed cases were reported in 2007, representing a 13.5% decrease compared to 2006. The notification rate was highest in children aged 0 to 4 years, and this group also accounted for almost 60% of the 103 reported cases with haemolytic uraemic syndrome (HUS). The HUS cases were mainly associated with infections with VTEC serogroup O157. VTEC was detected mainly in cattle and their products. In 2007 the European Community Summary Report[27] reported that, for the first time, foodborne viruses were the second most frequent cause of foodborne infections. The number of viral outbreaks is assumed to have been severely under-reported in the previous years.

In a 2008 review, Denny[30] and Goulet et al[31] evaluated the increase in reported cases of listeriosis from EU Member States over the past 5 years. In 2006, listeriosis was reported in 23 EU Member States and was the fifth most common zoonotic infection in Europe, after *Campylobacter*, *Salmonella*, Yersinia, and VTEC infections. In 2007 the number of confirmed cases of listeriosis was 1,558, thus remaining at the same level as in 2006.[32] Even though listeriosis occurs infrequently (0.3 cases per year per 100,000 of the population), it is characterised by a high case-fatality rate which can exceed 30%. It also carries one of the highest hospitalisation rates among known foodborne pathogens, 91%, with additional long-term sequelae in some patients. The risk groups for listeriosis are the elderly, immunocompromised individuals, pregnant women and neonates younger than four weeks Interestingly, Goulet et al report that "Extensive epidemiologic investigations of clusters in France have ruled out the occurrence of large foodborne disease outbreaks. In addition, no increase has occurred in pregnancy-associated cases or among persons <60 years of age who have no underlying disease. Increases have occurred mainly among persons >60 years of age and appear to be most pronounced for persons >70 years of age". Since it is reported that ready-to-eat food (mainly smoked fish, ready-to-eat meat products and various types of cheese) is the most important source of human listeriosis infections, it is unlikely that poor home hygiene plays a significant part in the spread of these infections.

In the USA, the Foodborne Diseases Active Surveillance Network (FoodNet) of CDC's Emerging Infections Program routinely collects data from 10 US states (45.5 million persons representing 15% of the US population) regarding diseases caused by pathogens commonly transmitted through food. The total incidence is then calculated by dividing the number of laboratory-confirmed infections by population for the preceding year. In 2007, Foodnet reported a total of 17,883 laboratory-confirmed cases of infection in the 10 FoodNet surveillance areas.[33] The number of cases and incidence per 100,000 population were reported as follows: *Salmonella* (6,790; 14.92), *Campylobacter* (5,818; 12.79), Shigella (2,848; 6.26), Cryptosporidium (1,216; 2.67), *E. coli* O157 (545; 1.20), *E. coli* non-O157 (260; 0.57), Yersinia (163; 0.36), Listeria (122; 0.27), Vibrio (108; 0.24), and *Cyclospora* (13; 0.03). In 2007, outbreak-associated infections accounted for 86 (15.8%) of *E. coli* O157 cases and 364 (5.4%) of *Salmonella* cases ascertained, similar to proportions in previous years. In their 2007 report, CDC assessed overall that, although significant declines in the incidence of certain foodborne pathogens have occurred since 1996 (see Table 2), these declines all occurred before 2004. Comparing 2007 with 2004–2006, the estimated incidence of infections caused by *Campylobacter,* Listeria, *Salmonella*, Shigella, STEC O157*, Vibrio,* and Yersinia did not decline significantly, and the incidence of *Cryptosporidium* infections increased. The incidence of *Campylobacter*, *Salmonella*, Shigella, and *E. coli* O157 infections remains highest among children aged <5 years. Interestingly, CDC identified risk factors for bacterial enteric illness in young children as: riding in a shopping cart next to raw meat or poultry, attendance at day care, visiting or living on a farm, and living in a home with a reptile which indicates that family hygiene practices, in addition to those associated with storage and cooking of food are important.

Table 2 – Number of reported foodborne disease outbreaks and cases in the USA: 1993–2005

	Outbreaks	**Cases**		**Outbreaks**	**Cases**
1993	489	17477	2000	1417	26043
1994	653	16234	2001	1265	25055
1995	628	17800	2002	1238	25035
1996	477	22607	2003	1072	22791
1997	504	11940	2004	1319	28239
			2005	982	20179

In Australia in 2006, OzFoodNet reported 115 foodborne disease outbreaks giving an overall rate of 5.6 outbreaks per million population.[34] These outbreaks affected 1,522 persons, hospitalised 146 persons but did not result in any deaths. This compares with rates of outbreak reporting in other developed countries. Using data from 200 to

2004, Hall et al estimated the annual community incidence rates per 100,000 population as 262, 1,184, and 23 for salmonellosis, campylobacteriosis and *E. coli* (STEC) respectively.[35] New Zealand reported a rate of 35 foodborne outbreaks per million population for 2006.[36] The most frequently notified aetiological agents were *Campylobacter* (15,492 notifications) and *Salmonella* (8,331 notifications). *Salmonella* notifications increased in 2006 by 5.2% when compared to historical reports. Other agents included Listeria, Shiga-producing *E. coli*, *Clostridium perfringens* intoxication, and one outbreak each of *Staphylococcus aureus* (*S. aureus*) and *Bacillus cereus,* outbreaks of Shigella and one outbreak of *Vibrio cholerae* (3 people) were also recorded. The most common settings where food was prepared in outbreaks were in restaurants (41%), and private residences (13%).

Increases in *L. monocytogenes* infections have not been confined to the European region. According to Sattar,[15] in the past 30 years, the worldwide incidence rate has gone from less than 0.1 cases/million persons to between 0.7 and 3.3 cases/million with a 20% case fatality rate. This increase has not been a result of higher numbers of Listeria in foods, but the higher number of immunosuppressed persons who are unable to combat the disease and changes in methods of food processing and preservation.[37]

3.1.2 Infectious intestinal disease – non-foodborne infections

From recent investigations, it is now recognised that a substantial proportion of the total IID burden in the community is due to person-to-person spread within households, particularly for viral infections. Person-to-person transmission in the home can occur by direct hand-to-mouth transfer, via food prepared in the home by an infected person, or by transmission due to aerosolised particles resulting from vomiting or fluid diarrhoea. Apart from transmission by inhalation of airborne particles, these infections are preventable by good hygiene practice.

The 2003 WHO report[28] stated that, of the total IID outbreaks (including foodborne disease) reported in Europe during 1999 and 2000, 60 and 69%, respectively, were due to person-to-person transmission. A study of UK outbreaks[38] suggested that 19% of *Salmonella* outbreaks and more than half of *E. coli* O157 outbreaks are transmitted by non-foodborne routes.

National surveillance systems vary in their methods of data collection but mostly focus on foodborne disease. Inevitably this means that data on gastrointestinal (GI) illnesses relates mainly to large foodborne outbreaks in restaurants, hospitals etc, whilst sporadic non-foodborne cases in the general community go largely unreported. In the UK, even where “household” outbreaks are reported they mostly involve home catering for parties and other functions and, are therefore, mainly foodborne outbreaks.[39] Since milder cases of GI illness often go unreported, this means that the overall GI infection burden, particularly that which is not foodborne, is unknown; the most informative data on the overall burden of infectious GI illness (both foodborne and non-foodborne) in the community comes from various community-based studies, which have been carried out in Europe and the USA and are reviewed below.

Two large community studies have been carried out in Europe, one in the UK and the other in The Netherlands. The UK study, carried out from 1993–1996 involving 460,000 participants in the community presenting to general practice, estimated that only 1/136 cases of GI illness is detected by surveillance. The study indicated that as many as 1 in 5 people in the UK population develop GI illness each year, with an estimated 9.4 million cases occurring annually of which about 50% are non-foodborne.[29,40] It was estimated that, for every one reported case of *Campylobacter*, *Salmonella*, rotavirus and norovirus, another 7.6, 3.2, 35 and 1,562 cases, respectively, occur in the community; based on the number of laboratory reports, it is possible to make an estimate of the true number of infections occurring in the community (Table 3).

Table 3 – Estimated number of cases of infectious gastrointestinal disease in England and Wales associated with *Campylobacter*, *Salmonella*, rotavirus and norovirus

Organism	Number of laboratory reports from faecal isolates in 2005	Ratio of actual reported cases	Estimated number of cases in the community
Campylobacter	42,679	7.6	324,360
Salmonella	11,191	3.2	47,763
Rotavirus	13,306	35	567,790
Norovirus	2,607	1562	4,072,734

From the community study carried out in The Netherlands between 1996 and 1999,[41] it was estimated that about 1 in 3.5 people experience a bout of infectious GI disease each year. *Campylobacter* was detected most frequently (10% of cases), followed by *Giardia lamblia* (5%), rotavirus (5%), norovirus (5%) and *Salmonella* (4%). Relative to the population of The Netherlands (16 million), 650,000 norovirus gastroenteritis cases occur annually.[42]

A 2007 report of ID outbreaks in Germany by Krause et al evaluated data from 30,578 outbreak reports captured 2001–2005.[43] These included foodborne as well as non foodborne infections. Of particular note is the fact that the most common settings among the 10,008 entries for 9,946 outbreaks in 2004 and 2005 were households (53%). Of these outbreaks, 90% were caused by pathogens of the intestinal tract (e.g. *Salmonella*, norovirus, rotavirus, hepatitis A virus, enteropathogenic *E. coli*, and *Campylobacter*). Whereas households were reported as the most frequent settings for outbreaks associated with *Salmonella*, rotavirus and *Campylobacter* (accounting for 38, 25 and 14% of total outbreaks, respectively) this was not the case for norovirus where hospitals and nursing homes were cited as the setting for 66% of reported outbreaks compared with only 13% for the household setting. It is possible that this reflects under reporting of norovirus infections in the home. Of 14,566 outbreaks for which there was evidence supporting association with named exposures 5,400 were indicated as person-to person transmission, 1637 to food, and 85 to water. Of the outbreaks caused by *S. enteritidis* spp., *Campylobacter*, norovirus and rotavirus only 14% (141/999), 8% (28/359), 1% (16/1,239) and 0.2% (2/940), respectively, were associated with food.

In 1999, Mead et al[44] reported on infectious intestinal illness in the USA, using data from a range of sources including national surveillance and community-based studies. The data indicated that the total number of cases of infectious GI illness annually is around 210 million (of which about 64% are non-foodborne). They estimated that the number of episodes of acute gastroenteritis per person per year is about 0.79. From the available data they were also able to estimate the proportion of total episodes which were non-foodborne. As shown in Table 4, by far the most frequently reported causes of GI illness were norovirus, rotavirus and *Campylobacter*. For *Campylobacter*, *E. coli* and norovirus, a significant proportion of cases were estimated as non-foodborne, whilst for hepatitis A (HAV), Shigella and rotavirus, almost all cases were estimated as non-foodborne. For *Salmonella* on the other hand, only 5% of cases were considered as non-foodborne. Davis et al reviewed outbreaks of *E. coli* O157 related to family visits to animal exhibits.[45]

Table 4 – Estimated annual infectious gastrointestinal illnesses in the USA

	Total infectious GI illnesses	Infectious illnesses (%) which are non-foodborne
Norovirus	23,000, 000	13,800,000 (60%)
Rotavirus	3,900,000	3,861,000 (99%)
Campylobacter	2,453,926	490,785 (20%)
Salmonella	1,412,498	70,624 (5%)
Shigella	448,240	358,952 (80%)
Hepatitis A	83,391	79,221 (95%)
E. coli O157	73,480	11,022 (15%)

Mead et al[44] estimated the number of cases of Shigella in the USA at around 448,249 per year, of which only about 20% are food-related, the remainder being person-to-person transmission. In the UK the number about 500–800 cases are reported annually, but this is probably a significant underestimate. A recent study[46] indicated that exposure to a family member with *H. pylori* gastroenteritis was associated with a 4.8-fold increased risk of infection in another family member and that infection most usually involved person-to-person transmission, associated with conditions of crowding and poor hygiene.

Using data from the 2006 *E. coli* O157 outbreak in the USA associated with contaminated spinach, Seto et al developed a model which showed that secondary person-to-person transmission was similar to that in previous *E. coli* outbreaks (≈12%). The model suggests that even a modestly effective hygiene promotion strategy to interrupt secondary transmission (prevention of only 2–3% of secondary illnesses) could result in a reduction of ≈5–11% of symptomatic cases.[47]

In Australia in 2006, OzFoodNet reported 24,598 notifications of diseases or conditions commonly transmitted by food, representing an increase of 2.5% over the mean of the previous 5 years. In all there were 1,544 reported outbreaks of GI illness which was the largest number reported since surveillance began in 2000. The majority of these outbreaks were due to person-to-person transmission of highly infectious norovirus. These outbreaks affected 34,916 people and resulted in 769 people being admitted to hospital and 27 deaths. Person-to-person transmission was the mode of transmission for 83% of outbreaks and accounted for 92% of all persons affected by outbreaks. Sixty per cent of reported outbreaks associated with person-to-person transmission occurred in aged-care facilities, while 20% and 13% occurred in hospital and child care settings, respectively. Fifty per cent of person-to-person outbreaks were caused by norovirus, while 29% were of unknown aetiology and 10% were suspected to be due to a viral pathogen. *Cryptosporidium* and rotavirus were each responsible for 3% of person-to-person outbreaks.

Indications are that norovirus is now the most significant cause of infectious GI illness in the developed world, both outbreak-related and endemic.[48,49] In the winter of 2006/2007 Japan reported the highest number of outbreaks of norovirus since 1981.[50] A large increase in norovirus outbreaks in Hungary, Germany and England and Wales was reported to European national health authorities via the Foodborne Viruses in Europe (FBVE) network in 2006.[51] Institutes charged with the surveillance of norovirus outbreaks in Ireland, Germany, The Netherlands and Sweden also reported high norovirus activity to FBVE in late 2007. In these countries, the number of reported norovirus outbreaks exceeds that of October and November of the previous record seasons, 2004 and 2006.[52] A similar situation has been reported in the UK.[53] Expert opinion is that norovirus strains now circulating are more "virulent" and more easily spread from person-to-person via hands and surfaces or during food-handling.[48] Norovirus infections are reviewed in more detail in a 2008 IFH review.[54]

More recently a systematic review of studies that used RT-PCR for detection of norovirus in faecal specimens further demonstrates the important role of these viruses in both mild and severe gastroenteritis worldwide.[55] Among all reported studies that used conventional RT-PCR, noroviruses were detected in ≈12% of children <5 years of age with severe diarrhoea, which suggests that these viruses are the second most common cause of severe childhood gastroenteritis, following rotavirus. Although some studies suggest that norovirus infections in the community are slightly less severe than rotavirus infections, data also exist to suggest that these childhood infections may be similar in severity, which may particularly apply to hospitalized children. On the basis of the pooled detection rates, it was estimated that in the USA alone noroviruses account for >235,000 clinic visits, 91,000 emergency room visits, and 23,000 hospitalizations among children <5 years of age. A US report on norovirus activity comparing frequency of norovirus outbreaks for the period October to December 2006 and January to June 2007.[56] The report describes a significant increase (254%) in frequency of outbreaks which was associated with the emergence of two new co-circulating strains of norovirus GII.4.

Rotavirus infections cause a considerable disease burden throughout the world and is the leading cause of gastroenteritis in children under 5 years of age. Parashar et al[57] estimate that, globally, each year, rotavirus causes approx 111 million episodes of gastroenteritis in children under 5 years. Rotavirus infection also results in 15 million visits to a clinic/doctor, 2 million hospitalisations and up to 592,000 deaths each year. The incidence is similar in developed and developing countries, although the majority of deaths are in lower income settings. A 2006 study estimated annual rotavirus disease burden in the (at that time) 25 countries of the European Union at 231 deaths and nearly 90,000 hospital admissions.[58] In the World Health Organization (WHO) European Region (53 countries) there is some evidence that the burden of acute gastroenteritis is higher in some countries in the eastern part of the region.[59,60] However, there are fewer published studies of rotavirus disease burden in these areas.

Infection with hepatitis A virus is common world wide,[61] whilst adenovirus is also a frequent cause of gastroenteritis.

3.1.3 Waterborne disease

In general, it is assumed that treated community water supplies in developed countries are safe with respect to waterborne microbial disease risks. This is not necessarily the case, particularly in regions of Europe where political and economic upheaval have led to infrastructure deterioration, but also in areas where communities rely on small water supplies. Also of significance is data which showed increased risks of waterborne IID from a community water supply in Quebec, Canada, where the water was extensively treated by modern methods and met all microbial quality requirements.[62,63] These findings suggest that bacterial indicators were inadequate or that pathogens, at levels below detection but high enough to cause IID, penetrated treatment barriers or entered treated water in community distribution systems or household plumbing. This suggests that even extensively treated community drinking water which according to current standards and detection methods and limits is considered of high quality may still be contributing significantly to community IID.

The following is a summary of available data on waterborne IID. IID related to water quality and water coverage is also reviewed in more detail in a 2005 IFH report.[12]

3.1.3.1 Europe

In 2002, WHO published a report entitled "Water and Health in Europe".[64] The following section summarises some of the key findings from this report. Although water quality standards are high in most European countries, outbreaks of waterborne disease continue to occur. For 1986–1996, data from 17 countries in the European region indicated a total of 2,567,210 cases of IID, 2% of which were linked to drinking water (see Table 5). These 17 countries (estimated population 220 million), on average, reported 233,383 cases of IID per year. It appears that the number of outbreaks of waterborne diseases has been increasing in countries which have experienced recent breakdown in infrastructure, although reliable data on drinking water quality and the incidence of disease in most countries are lacking.

For 1984–1996, 710 waterborne disease outbreaks were reported. Of these, 55% occurred in rural and 45% in urban areas; 36% of outbreaks were associated with public water supplies, 18% with individual water systems, 6% with standpipe public supplies and 41% with unspecified supplies or recreational water. Remarkably, no outbreaks were reported in Germany, Lithuania or Norway, whereas 208, 162 and 53 outbreaks, respectively, were reported for Spain, Malta and Sweden. These differences are most likely due to differences in detection and reporting rather than real differences.

Table 5 – Reported cases of gastroenteritis or other possibly waterborne diseases linked to drinking water in 17 European countries 1986–1996

Causative agent	**Total number of cases reported**	**No (%) of cases linked to drinking water**
Bacteria: bacterial dysentery, cholera, typhoid fever, *Salmonella*, *Campylobacter*	534,732	15,167 (2.8%)
Viruses: hepatitis A and norovirus	343,305	6,869 (2.0%)
Parasites: amoebic dysentery, cryptosporidiosis, Giardiasis, meningoencephalitis	220,581	4,568 (2.1%
Unspecified cause: gastroenteritis and severe diarrhoea	146,171	22,898 (1.6%)
Total	**2,576,210**	**5,2304 (2.0%)**

Table 5 shows that waterborne diseases attributable to bacteria include bacterial dysentery (*Shigella* spp.), cholera, typhoid fever, *Salmonella* and *Campylobacter*. *Campylobacter* is considered as one of the predominant foodborne pathogens, but waterborne outbreaks are also quite frequently reported, which usually occur when surface water becomes contaminated with sewage from farm animals and wildlife. Six outbreaks were recorded in Sweden between 1986 and 1996. *Campylobacter* outbreaks are most often associated with wells providing private supplies which are most likely to be contaminated with animal waste. For the same reason *E. coli* 0157 outbreaks may also be found in rural situations.

The number of cases of amoebic dysentery in countries which maintain records is generally low; in 1996 the number of cases per 100,000 population ranged from <1 in countries such as Hungary, Lithuania and Austria to between 1 and 5 in the UK, Sweden, Norway and Finland. By contrast, outbreaks of Shigella dysentery are regularly reported, the number of cases per 100,000 population ranging from <10 for countries such as the UK, Austria, Norway, Germany and Belgium to between 10 and 70 for Romania, Estonia, Lithuania, Slovakia and Albania. Cholera epidemics have re-emerged since 1991 in traditional cholera-free areas, although the number of reported cases is low, and all are estimated to be imported from elsewhere. In 2005, 34 cases were recorded by 20 countries.[20] According to the ECDC 2008 Annual Report on Communicable Diseases in Europe,[20] in 2006, 111 cholera cases were reported by 28 EU/EFTA countries. Most reported cases were in adults. The fact that most cases occur in intermediate age groups could be associated with the large numbers of people of that age who travel to countries where cholera is endemic.

Waterborne disease outbreaks attributable to viruses such as hepatitis A and norovirus are quite frequently recorded in the European region, although the incidence varies widely between countries. Outbreaks due to norovirus have been a significant concern in Norway and Sweden. Of 41 waterborne outbreaks reported in Finland during 1998–2003, samples from 28 outbreaks suggested that noroviruses caused 18 of these outbreaks. In 10 outbreaks, the water sample also yielded norovirus which was identical to that recovered from the patients.[65]

Inadequate removal of *Cryptosporidium*, and less frequently Giardia and Toxoplasma, from the public water system have led to outbreaks. In 2005, 7960 cases were reported by 16 countries.[20] Outbreaks related to Giardia are also reported, although the contribution of waterborne infection to the total disease burden varies significantly between years and between different countries. In 2005, 15,301 cases were recorded in 18 EU countries.[20]

Towns and cities of Europe are generally well supplied with running water, but rural populations may have to rely on small private non-piped supplies, where the risks of contamination are higher. In Iceland and Norway, all the rural population is connected to a public supply compared with as few as 5% and 12% of the rural population of Turkmenistan and Ukraine, respectively. In Romania 84% of the urban population is supplied by the centralised system vs. 32% of the rural population.

3.1.3.2 North America

Despite the fact that most US citizens expect to have low cost, high quality water available in their domestic water tap, waterborne disease outbreaks still occur. Table 6 summarises the number of reported outbreaks of disease associated with drinking water for the years 1999–2002.[66,67,68] In addition, Olsen et al[69] reported that, of 5/18 waterborne outbreaks of *E. coli* O157 infections reported to the Centre for Disease Control and Prevention (CDC) from 1982–1998, were caused by contaminated drinking water from small water systems or wells supplying rural areas or camps. Olsen et al maintain that, because of under-reporting and under-diagnosis, reported outbreaks probably represent only a small fraction of the true number of *E. coli* O157 outbreaks associated with drinking water in the USA.

Table 6 – Infectious disease waterborne outbreaks caused by contaminated drinking water systems in the USA

Etiological agent	1971–1994	1999–2000	2001–2002
Total outbreaks	579	36	20
Total cases	560,421	2,068	1,020
% outbreaks for which organism was isolated	325/579	56.4%	13/20
Salmonella	13	2	-
Shigella	40	0	-
Campylobacter	15	2	2
E. coli O157	-	4	1
Cryptosporidium	10	1	1
Giardia	113	6	3
Hepatitis A	28	0	-
Norovirus	20	4	5
Naegleria fowleri	-	-	1

In a 2005 review,[70] Shuster reported that 288 known outbreaks occurred during the period 1974–2001. Ninety-nine, 138 and 51 of these outbreaks occurred in municipal, semi-public (facilities with own supply, e.g. schools, hotels, nursing homes, etc) and private supplies, respectively.

In the USA and Canada, a number of outbreaks have been reported which have resulted from a breakdown in the system. In the spring of 2000, residents of Walkerton, Ontario, were exposed to contaminated drinking water after heavy rains compromised the municipal well and the water treatment process. In all 23,000 cases of *E. coli* O157 and *Campylobacter jejuni,* and seven deaths, were recorded.[71] *Cryptosporidium parvum* was not recognised as a human pathogen until the 1970s. One of the largest recorded waterborne outbreaks occurred in Milwaukee, USA, during 1993. The outbreak occurred because one of the city's water treatment plants failed to filter out the parasite from the untreated water. The outbreak affected some 400,000 people with 54 deaths.[72] In early 2008, an outbreak of *Salmonella* infections affecting more than 300 people was reported in Alamosa, Colorado. Some 85 *Salmonella* cases were confirmed, with 12 people requiring hospitalisation. Of the people sickened, about half were children under age 11. Investigations of local tap water indicate this was the source of infection and it was further determined that the particular strain that caused the outbreak was one found in the faeces of local deer, birds and other warm-blooded animals, although there were no indications as to how the water became contaminated.[73]

Most waterborne outbreaks in the USA are due to systems with inadequate treatment, vulnerable watersheds and aquifers, distribution system deficiencies and serving smaller communities. In the USA most of the population receive their water from community systems, but these vary considerably in the number of people they serve.[74,75] A particular problem in the USA arises from "small water systems" (i.e. systems serving 10,000 or fewer people) for which the IID risks from faecal and other contamination is considered to be greater. Small communities face the greatest difficulties in supplying water of adequate quality and quantity because they have small customer bases and often lack the resources needed to maintain and upgrade water supply facilities. Olsen et al[69] maintain that small water systems collectively serve approximately 40 million people, or 15% of the US population. Although the problems of small systems are well known, the number of these systems continues to increase. Issues related to small water systems are further reviewed in a US National Research Council Report.[74]

Approximately 27.5 million Canadians (87% of the population) have access to safe drinking water provided by centralised treatment plants or systems whose construction and operation are subject to regulatory requirements. The remaining 3.8 million Canadians rely on private supplies, typically groundwater. The vast majority of these are First Nation communities.[70]

3.1.3.3 Pseudomonas aeruginosa and Stenotrophomonas maltophilia

Pseudomonas aeruginosa (*P. aeruginosa*) is widespread in the environment and is often isolated from soil, water, plants and some vegetables. It is one the most frequently isolated gram-negative pathogens causing nosocomial infections.[76] A number of studies have shown that sinks and tap water outlets in hospitals are often colonised with *P. aeruginosa* and may represent a source of endemic infections on ICUs.[77] Evidence of aerosol transfer of *P. aeruginosa* from hospital toilets, which can also become reservoirs of *P. aeruginosa*, was reported by Scott and Bloomfield.[78]

P. aeruginosa is an opportunist pathogen which represents a risk to patients with increased susceptibility to infection who are cared for in the home. However, whereas this organism is quite frequently found in the hospital environment, indications are that it is not commonly found in the home.[79] The infection risk for cystic fibrosis patients is illustrated by two studies. Schelstraete reported a study of 50 newly infected patients attending a cystic fibrosis centre.[80] *P. aeruginosa* could be cultured from 5.9% of the environmental samples (mainly in the bathroom), corresponding to 18 patients. For nine of these, the genotype of the environmental isolate was identical to the patient's isolate. Denton et al reported contamination with *Stenotrophomonas maltophilia* in 36% of homes of colonised children and 42% of homes of non-colonised children, from sites which included dishcloths and sponges, washing up bowls, washing machines and a kitchen work surface.[81]

3.1.4 *Clostridium difficile*

Toxin-producing strains of *C. difficile* have now been established as the leading cause of hospital-acquired infectious diarrhoea. *C. difficile*-associated intestinal disease now also occurs with increasing frequency in the community, where it most usually affects home-based patients undergoing antibiotic or other treatment, but occasionally affects otherwise healthy individuals.[7] *C. difficile*-associated disease (CDAD) can occur both in individuals that carry the organism in their gut and those who are exposed to the organism in their home or community. *C. difficile* colitis occurs primarily among individuals who have undergone treatment with antibiotics, immunosuppressants, antacids or surgical intervention. These exposures may cause *C. difficile* to transform into its active toxin-producing form that inflames the colon causing diarrhoea. The elderly are particularly at risk and over 80% of cases are in the over-65 age group.

Carriage rates in healthy people in the community may be around 3 up to 5%, perhaps higher in those connected with hospitals, and this may lead to community-acquired infection.[82,83] Rates of colonisation and infection increase markedly beyond the age of 65, such that for England and Wales *C. difficile* is the predominant enteric pathogen among people in this age group.[84] Up to two-thirds of infants carry *C. difficile* asymptomatically during the first few months of life (thought to reflect acquisition from hospital). There are no data, however, to indicate what proportion of carriers are carrying toxin-producing strains, but although isolation rates for *C.*

difficile have decreased since 2000, the proportion of those isolates which are toxin producers has increased.[85,86]

In the past 3/4 years a new type of *C. difficile* (type NAP1/027) has emerged which appears to be more virulent, with an ability to produce greater quantities of toxins. In addition, unlike many previous *C. difficile* strains, it is resistant to floroquinolone antibiotics. At present there is insufficient data to assess how prevalent this strain might be. However, it is known that type 027 now accounts for 28% of all isolates from hospital patients in England, which has risen from practically zero in the last 2 years. In the USA in 2005, a number of cases of community-acquired CDAD were reported in previously healthy individuals in the community where there was minimal or no exposure to healthcare settings and no history of recent antibiotic prescribing. These various reports reflect the rapidly changing epidemiology that appears to be taking place with *C. difficile*.

In the UK, 55213 cases of *C. difficile* reported in 2006.[87] Starr estimates that, more than 13,000 cases of community-acquired cases occur each year in the UK, three-quarters of which have not been in hospital during the previous year.[83] In the USA, it is estimated that 20,000 infections with *C. difficile* occur in the community each year. Data from Sweden indicate that 42% of cases of *C. difficile* infection present in the community, half of whom do not have a history of hospitalisation within the previous month.[88] In Ireland, 11% of cases presenting with cytotoxin-positive *C. difficile*-related diarrhoea had no hospitalisation within the previous 60 days.[89] The Intestinal Infectious Disease (IID) Survey in England identified *C. difficile* as the third most common cause of IID in patients aged >75 years seen by GPs.[29]

Domestic pets can also be a source of *C. difficile*. This aspect is reviewed in section 10.

3.2 INFECTIOUS INTESTINAL DISEASE – DEVELOPING COUNTRIES

The most recent estimates of mortality and morbidity associated with diarrhoeal diseases come from population data presented in the WHO 2008 report on the global burden of disease,[16] based on data for 2004, from the 2004 World Health Report,[23] and from Pruss-Usstin et al,[90] who used risk estimates from intervention studies to calculate the diarrhoeal disease burden. Data for 2002 and 2004 from the WHO, as shown in Table 7, indicate that the highest levels of diarrhoeal disease occur in Africa and the Eastern Mediterranean region.

Table 7 – Disease burden from diarrhoeal disease: total deaths and DALYs for 2002 and 2004

		Global	**Africa**	**Americas**	**South East Asia**	**Europe**	**Eastern Mediterranean**	**W. Pacific**
% of total deaths due to diarrhoeal diseases	2002	3.2%	6.6%	0.9%	4.1%	0.2%	6.2%	1.2%
	2004	3.7%	8.9%	1.1%	4.4%	0.4%	5.9%	0.8%
% of total DALYs lost due to diarrhoeal diseases	2002	4.2%	6.4%	1.6%	4.8%	0.49%	6.2%	2.5%
	2004	4.8%	8.5%	1.8%	5.2%	0.9%	5.8%	1.9%

As far as water quality in the home is concerned, the WHO/UNICEF joint monitoring group[24,25] assess that the percentage of people served with an “improved water supply” (including water piped into a dwelling, plot or yard, and other improved sources such as public taps, boreholes, protected dug wells, protected springs and rainwater collection) worldwide has now reached 87% while 70% have access to basic sanitation. The quality of these water supplies, however, varies widely and depends on many factors including the quality of the raw water source, the extent and type of treatment and disinfection used, the integrity of the distribution system and the maintenance of positive pressure within the network. Access to improved water supply varies considerable with some regions making considerable progress in the past 16 years, and others less so (see Table 8).

Table 8 – Drinking water supply coverage (figures for 1990 and 2006)

	Percentage coverage															
	Common-wealth of independent states		**Latin America/ Caribbean**		**N. Africa**		**W. Asia**		**E. Asia**		**S. Asia**		**SE Asia**		**Sub-Saharan Africa**	
	‘90	‘06	‘90	‘06	‘90	‘06	‘90	‘06	‘90	‘06	‘90	‘06	‘90	‘06	‘90	‘06
Unimproved source	7	6	16	8	12	8	14	10	32	12	26	13	27	14	51	42
Improved source	22	31	17	12	30	14	17	20	17	15	54	65	57	54	33	42
Piped water on premises	71	73	67	80	58	78	69	80	51	73	20	22	16	32	16	16

Although it is well established that IIDs are one of the major causes of morbidity and mortality in developing countries, there is relatively little systematic data available on the incidence and prevalence of disease in different areas, what proportion of this disease is waterborne, foodborne etc, what are the causative agents and how these factors vary from one region and one country to another. In his reviews of IID in developing countries Todd[91,92] reported that relatively few countries in the developing world have surveillance programmes which publish data on food and waterborne disease. Although very few countries in Africa and the Middle East have surveillance programmes which publish data on outbreaks, all central, South American and Caribbean countries have some form of notifiable disease system.[91,92] Kaferstein estimates, however, that this situation is improving, and that, by 2020 a surveillance network will cover most countries.[26]

In developing areas, it is often difficult to establish whether a disease outbreak is waterborne or foodborne or involves direct faecal:oral transfer. Most disease that is spread by water is also spread through faecal contamination or person-to-person contact and in contaminated food. In rural areas where sanitation facilities are often inadequate, once a pathogen gets into a community, faecal:oral spread can be rapid and extensive.

It is likely that the proportion of infections which are foodborne (relative to other modes of spread, e.g faecal oral transmission not involving food) is lower in developing compared with developed countries because of the frequent and more varied opportunities for other modes of transmission, and because the zoonotic agents (particularly *Salmonella* and *Campylobacter*) which are especially associated with foodborne infections in developed countries are less important relative to other enteric pathogens in low income communities, where sanitation and water are inadequate. The overall rates of foodborne infection, however, are likely to be higher in developing compared with developed countries. Because keeping food hot or cold is usually not practical, pathogens may be able to grow in home-prepared foods and those sold in food service operations and street vendors. A major concern in developing countries is babies and young children. Although breast feeding is recommended and has been shown to reduce enteric infections, women in low income families may not produce enough milk making supplemental weaning foods necessary.[91]

In the following section some of the available data on diarrhoeal disease in developing areas of the world is reviewed. Data on diarrhoeal diseases in developing countries is reviewed in more detail by Todd, although these reviews were prepared in 1997 and 2001.[91,92] Epidemiological studies on waterborne disease are also reviewed by Payment et al.[93] Todd estimates that Enterotoxigenic *E. coli*, Enteropathogenic *E. coli*, Shigella, Vibrio cholera and parasites are the main problems in developing countries, but it is uncertain how many cases are attributed to food, water or to person-to-person transmission. Todd assesses that, in respect of foodborne disease in developing countries, *Salmonella* is still the most important agent, with *S. enteritidis* and *S. typhimurium* being of most concern.

In a recent review, Coker et al[94] reported that *Campylobacter* is one of the most frequently isolated bacteria from stools of people infected with diarrhoea in developing countries. Table 9 shows isolation rates for some countries from studies of diarrhoea in children <5 years old ranging from 5–20%. The survey found that the major sources of *Campylobacter* were food and environmental contamination, and a survey of retail poultry in Bangkok and Nairobi revealed *Campylobacter* contamination rates of 40 and 77%. Campylobacteriosis is considered to be a particular burden in the developing world, partly because *Campylobacter*-associated diarrhoea and bacteraemia occur in HIV/AIDS patients.

Table 9 – Isolation rates of *Campylobacter* from diarrhoea specimens from <5 year olds in selected developing countries

Country	Isolation rate	Country	Isolation rate
Algeria	17.7%	Guatemala	12.1%
Cambodia	7.7%	Egypt	9.0%
Ethiopia	13.8%	Jordan	5.5%
Nigeria	16.5%	Bangladesh	17.4%
Tanzania	18.0%	Thailand	13.0%
Zimbabwe	9.1%	Laos	12.1%
Brazil	9.9%		

In a 2004 review of the burden of ID in South Asia, Zaidi et al[95] reported that, although interventions targeted at diarrhoea and acute respiratory infection have resulted in a substantial decline in deaths in South Asian children, these diseases still account for almost half of all deaths (see Table 10). *Salmonella* is reported to be the most common bacterial pathogen identified from blood stream infections.[96,97] Millions of cases of typhoid infections occur each year, but reliable data of the annual number of cases are not available because laboratory identification is not routinely undertaken Sattar[15] assesses that whereas the annual incidence of *E. coli* O157 is 8 cases per 100,000 in the USA, it could be as much as 5–10 times higher in South America.

Table 10 – Selected indicators of diarrhoeal disease in South Asian children

	Afghanistan	Bangladesh	India	Nepal	Pakistan	Sri Lanka
No of annual deaths*	60,240	82,320	576,480	18,240	135,600	<1,000
% of children <5y affected by diarrhoea in previous 2 weeks*	20	6	19	27	26	5
% receiving fluids plus continued feeding	33**	61**	27**	11	19	34**

*extrapolated from Black et al 2003[98]
**Data for oral rehydration therapy only

In India, despite the implementation of massive programmes aimed at supplying potable water to both urban and rural areas, morbidity and mortality due to waterborne diseases have not declined to an extent commensurate with increased availability. In the last 10 years, reported cases of diarrhoea, cholera, viral hepatitis and enteric fever have continued unchecked.[99] Community studies show that every child under 5 years of age has two or three episodes of diarrhoea each year, and 400,000 to 500,000 children under 5 years die from diarrhoea. Viral hepatitis is estimated at 12 cases per 100,000, although studies in urban communities have shown that the actual incidence may be as high as 100 per 100,000. Rates of typhoid as high as 980 per 100,000 population have been reported from urban slums in Delhi.

Evidence suggesting that a significant proportion of infant diarrhoeal disease burden in developing countries is associated with contaminated infant weaning foods has been reviewed by Todd[91,92] and Lanata.[100] Lanata reports that the first recognition that there was a correlation between the point at which infants were introduced to weaning foods and began to suffer from frequent bouts of diarrhoea came in the 1960s. It was also noted that the timing of the peak periods of diarrhoea coincided with ages when greater amounts of weaning foods were consumed. However, although a range of studies have shown that weaning foods are quite frequently contaminated with enteropathogenic micro-organisms, attempts to link this to rates of diarrhoeal disease have yielded conflicting results, some studies showing a positive correlation whilst others do not. Contamination of weaning foods may result from use of contaminated raw foods or contaminated water, but may also be associated with poor standards of hygiene during preparation of the food. This may include handling of foods with unwashed hands, inadequate cooking or re-warming, the use of contaminated feeding utensils, or storage of prepared foods at ambient temperature for prolonged periods. Lanata assessed that the available data suggests that levels of contamination may be higher in weaning foods than in drinking water. Since there is a need to reach a critical level of enteropathogenic contamination in order to cause an infection, Lanata postulates that weaning foods, which are often stored at ambient temperatures for several hours which encourages microbial growth may in some communities be more important than drinking water for transmission of diarrhoeal diseases in infants.

The most recent global cholera report for 2005[101] documents a total of 131,943 cases, including 2,272 deaths, notified from 52 countries. Overall, this represents a 30% increase compared with 2004. The year was marked by a particularly significant series of outbreaks in West Africa, affecting 14 countries and accounted for 58% of all cholera cases reported worldwide. The total number of countries reporting cases declined slightly (from 56 to 52), but there were a number of countries where cholera re-emerged after having been absent for several years. Globally, the number of deaths decreased from 2,345 to 2,272, reflecting an overall case-fatality rate (CFR) of 1.72%, compared with 2.3% the previous year. Globally, the actual number of cholera cases is known to be much higher; the discrepancy is the result of underreporting and other limitations of surveillance systems.

Table 11 – Cholera cases and deaths notified to WHO in 2005

Region	Cases	Imported cases	Deaths
Africa	125,082	0	2230
Americas	24	15	0
Asia	6824	40	42
Europe	10	10	0
Oceania	3	3	0
World totals	**131,943**	**68**	**2272**

In addition to endemic levels of IID, large scale outbreaks attributable to contaminated water are sometimes reported, such as the hepatitis outbreak in India[102] and the outbreak of cholera in Latin America.[103] The effect of extreme conditions on water quality which may be seasonal or related to natural disasters is also a significant factor which may be underestimated.[102] In a 2007 review, Zuckermann et al[104] estimated that the scale of the problem in relation to cholera is uncertain because of limitations in existing surveillance systems, differences in reporting procedures, and failure to report cholera to WHO; they believe that official figures are likely to greatly underestimate the true prevalence of the disease and have identified, literature searches, additional outbreaks of cholera to those reported to WHO, many of which originated from the Indian subcontinent and southeast Asia.

As stated previously a 2008 systematic review of studies that used RT-PCR for detection of norovirus in faecal specimens highlights the important role of these viruses in both mild and severe gastroenteritis not only in developed, but also in developing countries and suggests that these viruses are the second most common cause of severe childhood gastroenteritis, following rotavirus.[55] Limited data from developing countries are available to make firm estimates, but norovirus disease may cause >1 million hospitalizations and 200,000 deaths each year among children <5 years of age.

4. Respiratory tract infections

Respiratory tract (RT) infections are largely caused by viruses. In the USA, it is estimated that viruses account for up to 69% of respiratory infections.[105] The common cold is reported to be the most frequent, acute infectious illness to humans.[106] Data from the USA, suggest that the mean number of respiratory illnesses experienced per year in adults is around 1.5–3.0, and in children under 5 years it is around 3.5–5.5.[105] Until quite recently, it was generally thought that transmission of RT infections was almost entirely by the airborne route, involving aerosols (small <10u check droplet nuclei) or droplets generated by coughing and sneezing.[107] Although, supporting data related to colds has been available for some time, it is only in the last 5/6 years that there has been any real awareness that hands and surfaces may also be a significant transmission route for influenza viruses.

4.1 COLDS AND OTHER UPPER RESPIRATORY TRACT INFECTIONS

About 80% of upper RT infections are caused by rhinoviruses. Other species causing acute rhinitis are coronaviruses, parainfluenza viruses (PIV), respiratory syncytial viruses (RSV) and adenoviruses.[108] Although colds are generally mild and self-limiting, they represent a significant economic burden due to loss in productivity and medical costs. Furthermore, secondary infections produce complications, such as otitis media, sinusitis, or lower respiratory infections such as pneumonia, with its risk of mortality, particularly in the elderly. Several studies have demonstrated that colds are also a trigger for asthma.[109] RSV is the major cause of viral RT infection in young children worldwide. Child day care attendance in North America carries with it a very high risk of RSV infection within the first 2 years of life, and accounts for 0.5–1.0% of hospitalised infants in the USA.[110]

4.2 INFLUENZA

4.2.1 Seasonal influenza

Influenza, is a more serious RT illness which can cause complications that lead to increased physician visits, hospitalisation and death, the risks being highest among persons aged >65 years, children aged <2 years, and persons who have medical conditions (e.g. diabetes, chronic lung disease).[110,111,112] Influenza must also be considered in terms of days absent from work and school, and pressure on healthcare services.[112] An important aspect of influenza is the threat associated with the emergence of novel subtypes capable of causing an influenza epidemic or pandemic.[113] Since new strains arise every 1 to 2 years and new variants are able to elude human host defences, there is no lasting immunity against influenza, neither after natural infection nor after vaccination.[113] According to Bridges et al,[114] influenza epidemics in the USA result in an annual average of 36,000 deaths and 114,000 hospitalisations; among those with influenza, who belong to an “at risk” group, a significant proportion develop pneumonia, whilst up to 1 in 10 can die of related complications. In Europe, the 2004–2005 influenza season annual report[115] showed that, of 25 countries assessed, two reported low activity of <50 influenza-like or acute respiratory illnesses (ILIs or ARIs) per 100,000 of population, whilst 15 countries recorded high activity (150 up to 3000 ARIs or ILIs per 100,000 population). The incidence of influenza in EU countries is further reviewed in the 2007 ECDC communicable diseases report.[20]

In a 2005 CDC review, Scott et al[116] report that the global burden of influenza epidemics is believed to be 3–5 million cases of severe illness and 300,000–500,000 deaths per year. Among those with influenza, who belong to an “at risk group”, a significant proportion develop pneumonia, and may require hospitalization whilst up to 1 in 10 can die of influenza-related complications.[117,118,119,120,121]

4.2.2 Pandemic influenza

Across the world, preparations for the next influenza pandemic started in 2005. WHO is confident that there has been no reduction in the threat of a pandemic since this time and that although unpredictable, it can be considered as inevitable. In a 2007 report on the state of pandemic preparedness in the EU and EEA countries (available from http://ecdc.eu.int) ECDC concludes that although much has been done, more still needs to be done. Health sectors in all countries have developed preparedness plans and, at national level, these plans are becoming operational. ECDC estimates, however, that even if a developed European country works hard and commits considerable additional resources, it will take Europe another 2–3 years of hard work and investment to achieve the necessary state of preparedness.

Compared with previous flu pandemics, the armoury of countermeasures has never been greater and includes antivirals, human H5N1 vaccines, evidence-based public health measures and modern business continuity planning. ECDC recognises that although, in the event of a flu pandemic, there are various measures that could be used to reduce peak levels of flu transmission and delay transmission towards the decline that occurs naturally in summer months, and/or until pandemic vaccines start becoming available, it is unlikely that "one size will fit all countries and communities" except for the few measures that are at the "relatively easy" (hand washing and personal respiratory hygiene) or "very difficult – don't do it" (border closure) extremes. A WHO global influenza preparedness plan has been drawn up to assist WHO member states and those responsible for public health, medical and emergency preparedness to respond to threats and occurrence of pandemic influenza.[122]

4.2.3 Acute lower respiratory tract infections

Acute lower respiratory tract infections (ALRIs) include infections such as pneumonia, bronchiolitis and bronchitis. Causative organisms may be bacterial (most commonly *S. pneumoniae* and *Haemophilus influenzae*) or viral. The major burden of ALRI disease falls in developing countries. The WHO 2008 report on the global burden of disease[16] estimates that globally, lower respiratory infections cause up to 4 million deaths annually, mostly of children. Lower respiratory infections rank number 3 in the leading causes of death globally, accounting for 7.1% of the total mortality. Acute respiratory infections (mainly pneumonia) account for around 12.4% of the 10.4 million deaths among children under 5. There is little data however to show whether hygiene plays any significant role in the spread of ALRIs. Data from intervention studies discussed later in section 7.2 suggest that hand washing can produce a significant reduction in the risks of transmission of respiratory infections, but most of these studies were carried out in developed countries and concerned upper RT infections, such as colds and flu. As also concluded by Rabie and Curtis,[123] this means that, extrapolating the results of these studies to developing countries, and to the severe pneumonias which are responsible for most ALRI deaths in those settings is uncertain. However, in a 2005 study Luby et al evaluated the impact of handwashing with soap on pneumonia in over 600 households in children under 5 in squatter settlements in Karachi, Pakistan.[124] Pneumonia was defined according to the WHO clinical case definition – cough or difficulty breathing with a raised respiratory rate. The results indicated a 50% reduction in pneumonia in the intervention compared with the control group.

4.3 LEGIONNAIRES' DISEASE

Legionellosis is a serious and sometimes fatal form of pneumonia caused by *Legionella pneumophila* and other legionella species which are normally found naturally in the environment and thrive in warm water and warm damp places. Legionellosis and its prevention is reviewed in detail in a 2007 publication.[125]

Legionnaires' disease is believed to occur worldwide, but the incidence varies widely. Since many countries lack appropriate methods of diagnosing the infection or surveillance systems capable of monitoring the situation, the real magnitude of the problem is unknown. For the period 2005-6 11,980 cases were reported by 35 European countries.[126] Based on findings from Denmark where a high level of testing for legionella in patients with pneumonia is developed, a more realistic incidence would be closer to 10,000 cases a year for the same 36 countries. The majority of reported cases are either community-acquired (in public settings), nosocomial (acquired in a healthcare setting) or travel associated, but a small number of cases are domestically acquired. During August 2006, there was an increase in non-travel related legionella cases throughout England and in The Netherlands, possibly associated with the fluctuating weather conditions in July. In August and September, eight cases were reported to a local health authority in eastern England. No common source for this cluster could be established. Legionella was isolated from the home of two patients (two showerheads in one home and a hot tub in the other) but unfortunately clinical isolates were not available for genetic typing. The incident control team concluded that multiple sources (both domestic and environmental) may have caused the cluster.[127] In Germany 47% of notified legionella infections are estimated to be acquired at home.[128] In Italian houses, Legionella contamination of domestic hot water ranges from 22.6% of 146 samples from a multi-centre investigation around the country[129] to 41.9% of samples obtained from 59 apartments in Bologna.[130]

Infection results from inhalation of contaminated water sprays or mists which can occur in the home in association with showers, spas and hot tubs. An infected source can disseminate sprays or droplets of water containing legionellae. When this occurs, most or all of the water in the droplet evaporates quickly, leaving airborne particulate matter that is small enough to be inhaled. Particles of less than 5 μm in diameter can be deeply inhaled, and enter the respiratory airways to cause legionellosis. Risk factors for community or domestic-acquired legionellosis include: over 40 years, smoking, immunosuppression, and chronic debilitating illnesses. There is no evidence of person-to-person transmission. Severe legionella infections have been reported among previously healthy people, including young people without underlying disease, and those without other known risk factors.[131] The case fatality rate may be as high as 40–80 per 100 in untreated immunosuppressed patients. For persons able to develop an immune response the death rate is usually within the range of 10–15%.

5. Skin, wound and eye infections

5.1 Skin and wound infections

Skin and wound infections are common in the home and community, but most are self-limiting. Since these infections, apart from *S. aureus* infections, go unreported, this means that little or no data is available on the burden of these infections in the community.

S. aureus is the most common cause of infection of skin and soft tissue, which, in a small proportion of cases, lead to severe invasive bacteremias or pneumonia.[132] A study by Kluytmans et al suggests that up to 60% of the general population,[133] carry *S. aureus* as part of their normal body flora, although a 2006 USA study[134] suggests that the carriage rate is much less (31.6%).

Serious *S aureus* infections usually occur in healthcare facilities, in patients who are immuno-compromised or have other predisposing factors, where it is mostly usually associated with wounds and intravenous devices. Of particular concern are the antibiotic resistant strains of *S. aureus* referred to collectively as methicillin resistant *Staphylococcus aureus* (MRSA). A US study, representing the first nationwide estimate of the burden of invasive MRSA infections (using data from the Active Bacterial Core Surveillance/Emerging Infections Program Network) covering July

2004 to December 2005 was reported in 2007.[135] Based on these data, it was estimated that there were a total of 94,360 cases of invasive MRSA in the USA in 2005, and 18,650 deaths, although the researchers could not establish that MRSA was the cause in all cases. The researchers estimated that, if these deaths were all related to *S. aureus* infections, the total would exceed other better-known causes of death including AIDS which killed an estimated 17,011 Americans in 2005. These data, however, relate only to invasive infections.

In the past 10–15 years, it has become apparent that problems related to MRSA are by no means confined to the hospital setting. Infected patients discharged from hospitals may continue to carry MRSA, even after their infection has healed, and pass it on to other healthy family members who become colonised, thereby spreading the organism into the community and facilitating circulation of these strains. Healthcare workers caring for MRSA-infected patients in hospital may also bring MRSA back into the home on their hands or uniforms etc. MRSA has the same potential to infect the elderly and immuno-compromised in a home setting, which means that family members, e.g. with post-operative and other wounds or with urinary catheters, are at risk of acquiring MRSA from healthy family members who are MRSA carriers. In the same way, family members who are carriers of MRSA are at increased risk of infection following hospital admission or outpatient treatments that increase their susceptibility to infection. A number of studies (as reviewed in section 10) show that domestic pets as well as family members can be a source of *S. aureus* infections (including MRSA and PVL-producing strains) in the home.

Of perhaps greater concern in the community is the emergence of new "community" strains of MRSA (community-acquired MRSA or CA-MRSA). Whereas healthcare associated (HCA) strains of MRSA are mainly a risk to vulnerable people being cared for in homes and the community, for CA-MRSA any family member is at risk, although US experience suggests that CA-MRSA strains present a threat mainly to those engaging in activities involving close skin contact and abrasion such as sports clubs and schools. Data from the USA indicates that CA-MRSA is more prevalent among children and young adults. One of the main reasons for concern is that, unlike HCA-MRSA, some *S. aureus* strains circulating in the community (both CA-MRSA and methicillin sensitive *S. aureus* strains (MSSA)) strains have also acquired the ability to produce Panton-Valentine Leukocidin (PVL) toxin. These strains can lead to skin and soft tissue infections, which in some cases leads to severe invasive infections such as septic arthritis, bacteraemia, or necrotising pneumonia. If the bacteria get into the lungs, a devastating pneumonia that kills more than 40% of patients can result. Although CA-MRSA strains have become a major problem in the USA, they are still relatively uncommon in the UK and elsewhere, and there is thus still an opportunity to avoid the problem escalating to a similar same scale.

The data, as further discussed in section 7, suggests that good hygiene is key not only to protecting at risk groups cared for at home, but also containing the circulation of both CA-MRSA and HCA-MRSA in the total community.

The risk for transmission of MRSA amongst family members in the home environment is illustrated by a number of studies. The US nationwide study covering July 2004 to December 2005[136] reported that, of the 8,987 cases of invasive MRSA identified, although most were found in hospitals or community healthcare settings, 13.7% were identified as infections not associated with healthcare facilities. To determine the role of healthcare workers (HCWs) in the spread of MRSA in the community, Albrich et al did a literature search covering January, 1980, to March, 2006, to determine the likelihood of MRSA colonisation and infection.[137] In 127 investigations, the average MRSA carriage rate among 33/318 HCWs was 4·6%;

5·1% had clinical infections. Risk factors included chronic skin diseases, poor hygiene practices, and having worked in countries with endemic MRSA. Both transiently and persistently colonised HCWs were responsible for several MRSA clusters. Transmission from personnel to patients was likely in 63 (93%) of 68 studies. MRSA eradication was achieved in 449 (88%) of 510 HCWs, but subclinical infections and colonisation of extranasal sites were associated with persistent carriage.

A study of nasal colonisation among 100 HCWs in a UK hospital showed that 31 were colonised with *S. aureus,* including six with MRSA; two of the MRSA isolates belonged to CA-MRSA strains, and soft-tissue infections were reported in one of the HCWs and in the family member of the other HCW colonised with these strains.[138] Hicks et al showed that 69% of carriers were still colonised with HCA-MRSA 4 weeks after contact,[139] while another study estimated the MRSA colonisation can persist for up to 40 months.[140] In a reported outbreak of community-associated MRSA which occurred in a beautician and two customers, eight other persons, who were either infected (n = 5) or colonized (n = 3), were linked to this outbreak, including a family member, a household contact, and partners of customers. [141] Data et al describe a retrospective cohort study to evaluate the risk of subsequent MRSA infection and death among patients known to harbour MRSA for at least 1 year.[142] Among 281 prevalent carriers, 65 (23%) developed a total of 96 discrete and unrelated MRSA infections in the year after their identification as prevalent carriers. Common infections were pneumonia (39% of MRSA infections), soft-tissue infection (14%), and central venous catheter infection (14%). Twenty-four percent of infections involved bacteremia. Thirty-eight MRSA infections occurred during a new hospitalisation, and 32 (84%) of these infections were the reason for hospital admission. MRSA contributed to 14 deaths, with 6 deaths attributable to MRSA.

Establishing the overall incidence and prevalence of MRSA circulating in the general community is extremely difficult. Surveillance data now coming from the USA suggests that the prevalence of, e.g. CA-MRSA strains can vary significantly from one area to another. Most of the available data comes from surveillance studies of hospital patients and hospital admissions, whilst community-based studies relate to patients presenting to general practice with local or invasive *S. aureus* infections. Establishing which cases are healthcare associated strains (HCA-MRSA) and which are “true” *de novo* community-acquired strains (CA-MRSA) is difficult. If the evolution of MRSA continues, the concepts of hospital and community MRSA strains may become blurred.[143]

In the UK, indications are that the proportion of the general population carrying antibiotic resistant strains of *S. aureus* (either HCA or CA-MRSA) is somewhere between 0.5–1.5%. Most of this carriage is concentrated in the elderly and those recently in healthcare institutions.[144] The relative prevalence of CA-MRSA to HCA-MRSA carriage is unknown. Although cases of CA-MRSA and PVL-producing MRSA have been reported, indications are that the prevalence of MRSA and PVL-producing strains circulating in the UK community is currently small.[145] There have been no systematic studies to establish how common C-MRSA infection is in the UK, although through surveillance of *S. aureus* isolates, the Health Protection Agency has identified approximately 100 cases over the last 3 years.[146] Though data is limited, perhaps around 2% of UK MRSA strains are PVL-positive, but the figure may be much higher.

Whereas CA-MRSA infections are currently rare in the UK, other countries, particularly the USA, have encountered more serious problems; CA-MRSA strains have been detected in the USA, France, Switzerland, Germany, Greece, Ireland, the

Nordic countries, Australasia, The Netherlands and Latvia.[147,148,149,150,151] Vandenesch and Etienne[152] concluded that, for countries where CA-MRSA cases have been identified, even though some data are available from isolates collected at hospitals, it is possible that these represent only the tip of the iceberg in relation to the number of healthy carriers in the community.

In the USA CA-MRSA is now a significant concern. Again it is concluded that the rates of colonisation in the community are still low but is thought to be increasing.[153,154,155,156,157,158] Graham et al[134] report on an analysis of 2001–2002 data from the National Health and Nutrition Examination Survey (NHANES) to determine colonisation with *S. aureus* in a non-institutionalised US population. From a total of 9,622 participants, it was found that 31.6% were colonised with *S. aureus*, of which 2.5% were colonised with MRSA. Of persons with MRSA, half were identified as strains containing the SCC*mec* type IV gene (most usually associated with CA-MRSA), whilst the other half were identified as strains containing the SCC*mec* type II gene (most usually associated with HCA-MRSA). Several other investigators have examined the epidemiology of MRSA in the US community; differences in the data suggest a sporadic distribution of CA-MRSA, with carriage rates ranging from 8–20% in Baltimore, Atlanta and Minnesota,[157] up to 28–35% for an apparently healthy population in New York.[159] These data are similar to those reported in a more recent (2008) study of 1300 sick and well children in the St Louis area recruited from a practice-based research network.[160] Prevalence of MRSA nasal colonisation varied according to practice, from 0% to 9% (mean: 2.6%). The estimated population prevalence of MRSA for the two main counties of the St Louis metropolitan area was 2.4%. Of the 32 MRSA, 9 (28%) were healthcare-associated and 21 (66%) were community-acquired types. Children with MRSA colonisation had increased contact with healthcare, compared with children without colonisation. MRSA colonisation ranged from 9–31% among practices. The estimated population prevalence of Methicillin-sensitive *S. aureus* was also determined and found to be 24.6%. Risk factors for MSSA colonisation included pet ownership, fingernail biting, and sports participation.

Whereas the major concerns at present relate to antibiotic resistant strains of *S. aureus*, the UK study by Hayward et al[161] indicates a major general increase in pathogenic community-onset staphylococcal disease over the past 15 years. These workers found that hospital admission rates for staphylococcal septicemia, staphylococcal pneumonia, staphylococcal scalded-skin syndrome, and impetigo increased >5-fold. Admission rates increased 3-fold for abscesses and cellulitis and 1.5-fold for bone and joint infections. They postulate that this trend may result from altered virulence or transmissibility of *S. aureus* in general or of particular strains; changes in the host that affect vulnerability (e.g. increasing levels of obesity and diabetes or of intravenous drug use) or transmission dynamics (e.g. increasing use of preschool child care); or changes in the environment, such as widespread use of antimicrobial agents or changes in hygiene behaviour. They conclude that this change is worrisome, particularly in view of the international concerns about the emergence of CA-MRSA and serious invasive PVL-related disease.

These and other studies on the prevalence of MRSA in hospital and community settings are also reviewed in other IFH reports.[3,7]

5.2 Eye infections

Conjunctivitis is a very common eye condition in the community, and is an inflammation of the conjunctivae, the mucous membranes covering the white of the eyes and the inner side of the eyelids. Bacterial conjunctivitis is caused by strains of staphylococci, streptococci or haemophilus which may come from the patient's own skin or upper respiratory tract or from another person with conjunctivitis. Viral conjunctivitis is often associated with the common cold and may be caused by adenoviruses. This type of conjunctivitis can spread rapidly from person-to-person, between people and may cause an epidemic of conjunctivitis. Chlamydia trachomatis may also be a cause of conjunctivitis. Babies and small children are particularly susceptible to infective conjunctivitis and can develop severe forms of the condition. One of the most important pathogens in kerato-konjunvctivitis associated with contact lenses is *P. aeruginosa* where unhygienic behaviour is a risk factor.[162,163]

A number of studies carried out in ophthalmology clinics have demonstrated the role of hand hygiene in preventing the transmission of adenoviral keratoconjunctivitis.[164,165] Interestingly, Jernigan et al[166] showed that the hands of physician and patients remained culture-positive for the incriminated adenovirus even after washing hands with soap and water and drying them with a paper towel. Azar et al[167] recovered infectious adenoviruses from the hands of 46% (12/26) of the patients with epidemic keratoconjunctivitis indicating the potential for virus transfer to hospital personnel through casual hand contact.

5.3 Trachoma

Trachoma is the world's leading cause of blindness, but is completely preventable through hygiene (face washing breaks the infection cycle). Up to 600 million individuals live in endemic areas and are at risk for contracting trachoma. WHO estimates that approximately 6 million people worldwide are blind due to trachoma and more than 150 million people are in need of treatment.[168,169] Prevalence of active disease in children varies from 10–40% in some African countries to 3–10% in several Asian countries. The overall incidence is unknown.

Trachoma is the result of infection of the eye with Chlamydia trachomatis. Infection spreads from person-to-person (particularly in the elderly), and is frequently passed from child-to-child and from child-to-mother, especially where there are shortages of water, numerous flies, and crowded living conditions.

6. Fungal infection

Fungi in indoor environments are a potential health problem. Not only can they be responsible for infections, they can cause an allergic response, they can deteriorate/damage surfaces and cause unpleasant odours. Moulds produce millions of spores, which, due to their small size (average size 1–5 μm) easily stay airborne and may be breathed deep into the airways. Fungal spores cause respiratory allergies, in both the lower and upper respiratory tracts.[170] When larger fungal spores are inhaled, they are deposited in the nasopharynx and are associated with nasal and/or ocular symptoms usually referred to as hayfever. Spores of <5 μm can penetrate the lower airways,[171] where allergic reactions will usually manifest as asthma. Some fungi produce mycotoxins including *Aspergillus, Stachybotrys, Fusarium* and *Trichoderma.* Exposure may take place through inhalation or skin contact. Mycotoxins associated with inhaled spores may be absorbed via the respiratory epithelium and translocated to other sites, possibly producing systemic effects.[172] Numerous fungi, e.g. *Aspergillus*, *Penicillium* and *Fusarium* have been found to produce volatile organic compounds (VOC) with unpleasant odours.[173,174,175]

Some fungi are pathogenic to healthy humans, causing superficial infections (mycoses), where the fungus grows at the body surface such as the feet, skin, hair and nails, as well as the oral or vaginal mucosa. Causative agents include the dermatophyte fungi of the genera *Epidermophyton*, *Microsporum* and *Trichophyton*. They are spread by direct contact and are highly contagious and easily spread to other individuals. *Candida albicans* can also cause superficial infections such as thrush and nappy rash. Candida infections are usually the result of antibiotic therapy that suppresses the normal resident bacterial microflora allowing Candida to flourish.

Infections within the body (deep mycoses) involve internal organs and are usually life-threatening. They are rare in healthy humans. However, people with impaired immune functions (e.g. cancer patients receiving chemotherapy or people with AIDS) are at significant risk of opportunistic fungal infections. They are acquired by inhalation of spores or by entry through wounds, whilst some exist as part of the normal body flora (e.g. Candida) and are innocuous unless the body's defences are compromised in some way. Other opportunist fungi include *Aspergillus, Penicillium*, *Cryptococcus neoformans* and *Histoplasma capsulatum.* Infections caused by common indoor environmental moulds, such as *Aspergillus, Penicillium, Fusarium, Rhizopus* and *Alternaria*, are increasing in HIV-infected patients.[176] In addition, oral candidiosis is often the earliest infectious complication encountered. Cryptococcosis has become a major cause of illness in AIDS patients.[177]

Airborne fungi are often associated with damp conditions, poor ventilation or closed air systems. The primary sites of fungal growth are often inanimate surfaces, including carpets and soft furnishings.[178] The predominating fungal contaminants recovered from upholstered furniture include *Cladosporium, Alternaria, Penicillium, Aureobasidium* and cream yeast. Other fungi recovered include *Aspergillus versicolor, Rhodotorula, Aspergillus fumigatus, Aspergillus flavus, Paecilomyces, Trichoderma, Phialophora, Rhizopus, Ulocladium, Fusarium,* and *Stachtbotrys*.[179] Levels of fungal contamination in carpets and upholstery can approach or exceed 100,000 CFU/g and include potential aeroallergens such as *Cladosporium, Alternaria,* and *Penicillium* (Cole et al).

Fungal infections in the home and community and the role of hygiene in preventing the spread of fungal infections are described in more detail in a 2004 IFH review[14] and a review by Scott.[180]

7. THE LINK BETWEEN HYGIENE AND THE SPREAD OF INFECTIOUS INTESTINAL, RESPIRATORY AND SKIN DISEASES

The aim of this report is to review infectious diseases (IDs) that are generally regarded as "hygiene-related". This however raises the question "how do we know they are hygiene-related?" and "to what extent? i.e. which hygiene interventions have the greatest impact on the total burden of these diseases?" This data is key to understanding what the health benefits could be, if we could motivate people to take more responsibility for preventing ID transmission in their own home through better hygiene practice. Understanding the strength of the association between hygiene and the spread of IDs is reviewed in detail in two further IFH reviews "The Infection Potential in the home and the role of hygiene"[10] and "Hygiene procedures in the home and their effectiveness: a review of the evidence base".[11] This aspect is also covered in a number of other IFH reviews[3,7,12,13,14] and reviews by other researchers.[181] The following is a short summary of the key points from these reviews.

Data assessing the strength of the association between hygiene and the prevention of specific diseases or groups of diseases comes from a range of sources including epidemiological data (surveillance data, data from intervention studies, case control studies, etc) and microbiolgical/biological plausibility data (data showing how and to what extent infectious agents are introduced into the home, how and to what extent they survive and spread such that family members are exposed to an infectious dose).[181] Other data which should be taken into account include factors such as time dependency (did the outcome occur after the cause), biological gradient (is there a relationship between the number of infectious agents to which the population is exposed and the occurrence of infection), consistency of the association (has the same association between a hygiene practice and a health outcome, or health-related outcome, been shown in a range of different studies. Currently, there is a tendency to demand that data from intervention studies should take precedence over data from other sources in formulating public health policy. Although there are those who still adhere to this, it is increasingly accepted that, since transmission of pathogens is highly complex, involving many different pathogens each with multiple routes of spread, infection control policies and guidelines must be based on the totality of the evidence including microbiological and other data. This is particularly important for home hygiene, for which little or no intervention data is available and where it is virtually impossible to isolate the effects of specific hygiene procedures (hand washing, surface hygiene, laundry, washing and bathing etc. This shift of opinion is supported in a recent document produced by the UK Health Development Agency.[182] Based on a literature review there was general agreement from the authors who concluded “Although the randomised controlled trial (RCT) has the highest internal validity and, where feasible, is the research design of choice when evaluating effectiveness, however, many commentators felt the RCT may be too restrictive for some public health interventions, particularly community-based programmes. In addition, supplementing data from quantitative studies with the results of qualitative research is regarded as key to the successful replication and ultimate effectiveness of interventions”.

7.1 THE LINK BETWEEN HYGIENE AND THE SPREAD OF INFECTIOUS INTESTINAL DISEASES IN THE HOME

For IIDs the link between poor hygiene and spread of disease is well established and is supported by a wealth of epidemiological as well as microbiological and other data. These data are summarised in various IFH and other reviews.[3,10,11,12,181]

Data on the reduction in risk of diarrhoeal disease by ensuring safe faeces disposal comes from intervention studies that assess the impact of improved sanitation. Based on analysis of intervention studies in developing countries published in 1991 (Table 12), Esrey et al estimated that the risk reduction associated with provision of improved sanitation was between 22% and 36%.[183] Based on a study that included more recent data, Fewtrell et al calculated a risk reduction of 32%.[184]

Table 12 – Estimated relative reduction in risk of diarrhoeal disease associated with water and sanitation interventions

Intervention	Esrey et al. (1991)	Fewtrell et al. (2005)
Sanitation	22-36%	32%
Water supply	19-22%	25%
Household water treatment		39%

With regard to water quality, the 2005 systematic review by Fewtrell et al (Table 12) concluded that diarrhoeal episodes can be reduced by 25% through improving water supply and by 39% via household water treatment and safe storage. A more recent (2006) Cochrane review of randomised controlled trials confirmed the key role that point-of-use water quality interventions could play in reducing diarrhoea episodes, reporting a reduction in diarrhoeal disease morbidity by roughly half, on average, with some studies resulting in disease reductions of 70% or more.[185] The link between household water storage, handling and point-of-use treatment and its effectiveness in reducing the burden of diarrhoeal diseases is also reviewed in the 2005 IFH review which focuses on household water treatment and safe storage[12] and, more recently, in a 2008 report issued by the WHO.[186]

Although, there is good evidence that handling of food by the family (either during preparation in the kitchen, or at mealtimes), with hands contaminated by faecal pathogens, is a frequent cause of IID, infection can also arise from pathogens which enter the food chain from animal and other sources during preparation for retail sale to the public. The 2003 WHO report[28] concluded that about 40% of reported foodborne outbreaks in the WHO European region over the past decade were caused by food consumed in private homes. The report cites several factors as “critical for a large proportion of foodborne diseases”, including use of contaminated raw food ingredients, contact between raw and cooked foods, and poor personal hygiene during food handling. A key aspect as stated in the 2003 WHO report is that “foodborne illness is almost 100% preventable”. However, there is relatively little data which indicates the importance of hygiene practice in food preparation relative to cooking and correct storage, and how this might vary from one region to another according to local conditions.

In low income communities in developing countries, limited access to sanitation means that rates of direct hand-to-mouth transmission from faeces are likely to be very high relative to other routes of transmission. In developed countries settings on the other hand (and probably also in higher income groups of developing countries), where there is adequate water and sanitation, transmission is more likely to involve person-to-person transmission and transmission via food (including zoonotic infections), rather than direct faeces-to-hand-to-mouth (or food or water). In developed countries, surveillance of IID tends to focus on outbreaks of foodborne disease. Although there is a tendency to assume that IIDs in developed countries are mostly foodborne, and result from inadequate cooking and inadequate storage of food, in reality, as discussed in section 3, a large proportion of IIDs in the home (mainly norovirus and rotavirus infections but also, e.g. *Salmonella*, Shigella and E. coli O157) result from person-to-person spread via hands and surfaces, and in some cases, e.g. norovirus may involve airborne transmission.

Indications are that the hands are probably the single most important route for transmission of intestinal pathogens in the home and community, since they come into direct contact with the mouth and are thus a, or the, key last line of defence in preventing exposure to intestinal pathogens. They can also come into contact with food or water which is then consumed. From a systematic review of hand washing intervention studies carried out in 2007 (Table 13), Bloomfield, Aiello et al estimated that the range of reduction in the incidence of IIDs was between -13% to 79% for developing countries and between -10% and 57% for developed countries.[3] Of the studies that were statistically significant (7/11 and 3/5), reductions in gastrointestinal infections ranged from 26–79% and 48–57% for developing and developed countries respectively.

Table 13 – Summary of data from intervention studies on the impact of hand hygiene on respiratory and gastrointestinal infections (from Bloomfield, Aiello et al[3])

Type of infection	**Area of study**	**Risk reduction from hand washing with soap**	
		Range	**No of statistically significant studies (range)**
Gastrointestinal	Developed	-10 to 57%	3/5 studies (48 to 57%)
	Developing	-13% to 79%	7/11 (26% to 79%)
Respiratory	Developed and developing	5% to 53%	2/6 studies (20%-51%)

The strong causal relationship between hand hygiene and gastrointestinal disease risk has also been demonstrated by meta-analysis studies of community-based interventions. Curtis and Cairncross[187] estimated a 42–47% reduction in diarrhoeal diseases associated with hand washing. Fewtrell et al showed a 44% reduction in diarrhoeal illness associated with hand washing.[184] In a more recent 2008 study, Aiello et al, estimated that hand washing with soap combined with education could produce a 39% reduction in gastrointestinal illness.[188] All three of these meta-analysis studies were carried out using data from studies conducted in both developed and developing countries.

The link between poor hygiene and the spread of IIDs is supported not only by epidemiological data, but also by a whole range of microbiological studies, many related specifically to the home. The micobiological data are summarised in various IFH reviews[3,10,11,12,13] and reviews by other researchers.[181] The following is a short summary of the key points from these reviews. The data show the extent to which infectious agents responsible for GI diseases such as *Salmonella*, *Campylobacter* occur and are spread in home and community settings during normal daily activities. Although most intestinal pathogens are unable to find a permanent home outside the human or animal body or food, field studies show that most gastrointestinal pathogens can survive for significant periods, not only on hands but also on environmental surfaces; survival times can be relatively short (minutes to hours) for some pathogens (e.g. *Campylobacter*), whilst for others (e.g. norovirus, *C. difficile*) survival times may be days or months. Microbiological data shows that pathogens from infected or contaminated sources are readily spread around the home via contaminated surfaces such that family members are regularly exposed to these organisms in numbers which may be sufficient to cause an infection. The data indicates that, in some cases, the hands alone may be "sufficient cause" for transmission of infection, whilst in other cases transmission may involve a number of "component causes" (e.g. from contaminated food, to a food contact surfaces, to hands, to the mouth of a recipient). Risk assessment indicates that the most important "critical control points" or "component causes" of infection transmission in the home are the hands, together with hand and food contact surfaces and cleaning cloths. Clothing and household linens may also be involved. Although the data overall indicate a strong link between hygiene and transmission of gastrointestinal diseases in the home, defining the risk reduction associated with hygiene practices such as surface and cloth hygiene relative to hand washing other hygiene practices is much more difficult because of the close interdependence of these factors. The microbiological data is however consistent with the view that, although there is a tendency to assume that GI infections in developed countries are mostly foodborne, in reality, a large proportion (mainly norovirus and rotavirus infections but also e.g. *Salmonella*, Shigella and *E. coli* O157) result from person-to-person spread via hands and surfaces, and in some cases, e.g. norovirus may involve airborne transmission.

7.2 The link between hygiene and the spread of respiratory diseases

For respiratory diseases the link between poor hygiene and spread of disease is also supported by both epidemiological and microbiological data. The data indicate three possible routes of transmission of respiratory viruses, namely droplet transmission (droplets of size > 5µm of infected mucous generated by coughs and sneezes which propels the droplets onto conjunctiva of the eye or the lining of the nose, where the virus infects the mucous membrane), airborne transmission (droplet nuclei (size < 5µm) which are drawn down into the lungs where they infect the lung tissue) and contact transmission (individuals become infected if they rub their eyes or nose with contaminated hands). It is probable that colds and flu are transmitted by all three pathways, but there is considerable disagreement as to the relative importance of each pathway, which may differ for different viruses.

The link between poor hygiene and the spread of respiratory diseases is supported not only by epidemiological data, but also by a whole range of microbiological studies, many related specifically to the home. These data are summarised in various IFH and other reviews. [3,10,11,13,181]

A range of intervention studies have been carried out which indicate a significant link between hand washing and transmission of respiratory infections. In 2007 Aiello et al did a systematic review of hand washing intervention studies carried out to assess the impact on respiratory diseases.[3] Based on these studies, Table 13 summarises the results of community-based interventions (excluding healthcare-related and military settings) on RT illnesses. Most studies were conducted in economically developed countries (83%, 5/6). The range of reduction in illness was 5–53%, but only 33% (2/6) of the studies were statistically significant. Rabie and Curtis in 2006 also published a review of hand hygiene studies involving RT infections.[123] They reported that hand hygiene (hand washing, education, and waterless hand sanitizers) can reduce the risk of respiratory infection by 16% (95% CI: 11-21%). These investigators have now updated their estimate with two further, more recent, studies which, when all studies are taken together, give a pooled impact on respiratory infection of 23%.[189] In a more recent 2008 study, Aiello et al, estimated that the reduction in respiratory illness associated with the pooled effects of hand hygiene (hand washing with soap, use of alcohol handrubs) was 21%.[188]

A significant part of our understanding of the association between hygiene and the transmission of cold and flu viruses comes from microbiological and clinical studies. Investigations carried out during the 1970s and 1980s to understand better the mode of transmission of cold viruses are reviewed in other IFH reviews. These data show that although the commonly held belief is that colds are spread by particles of infected mucous generated by coughs and sneezes, increasingly, there is evidence that infection can spread when fingers become contaminated by contact with the infected nose, or when surfaces such as handkerchiefs and tissues, tap and door handles or telephones become contaminated by droplets of infected mucous shed from the nose. The virus is passed onto another person either by handshaking or when contaminated surfaces are touched by that person. Individuals then infect themselves by touching their nose or eyes with contaminated hands. The data show that cold viruses are shed in large numbers in mucous and are deposited on surfaces where they can remain viable, in large numbers, for several hours and the "infectious dose" (the number of viral particles required to cause infection) may be very small (for rhinovirus the infective dose may be less than 10 particles). Whilst some investigators maintain that inoculation of the eyes or nose by contaminated hands is of paramount importance, others maintain that the evidence favours airborne transmission as the most important mode of spread. For RSV, there is general agreement that the hands are the primary route for the spread of infection.

For influenza viruses, microbiological investigations show that the virus is shed in large numbers from an infected person. Survival times for aerosolized virus vary between 1 and 24 hours. The virus can also survive on surfaces such as stainless steel and plastic for 24–48 hours, and for up to 12 hours on soft surfaces such as cloth, paper and tissues. By contrast the virus survives only short periods of time on the hands; investigations suggest that, after transfer to hands from surfaces, viable virus falls to a low level within 5 minutes. Whereas some investigators believe that droplet transmission is the major pathway for spread of flu and airborne transmission is of minor importance, others maintain that the role of droplet transmission has been overrated and that airborne transmission is a potentially important transmission pathway in indoor environments. Like colds, flu can also be spread via the hands by contact with objects that an infected person has contaminated with infectious nose and throat secretions, although there is less supporting evidence for this mode of spread than for colds. It is possible however that influenza is less transmissible via hands and surfaces compared with rhinovirus etc, because of its lower ability to survive outside a human or animal host. To some extent, airborne droplets and droplet nuclei probably cause infection as a result of settling on hand contact surfaces. This means that surface hygiene, particularly the hygiene of hand contact surfaces may contribute to preventing the spread of influenza.

The role of hygiene measures such as hand washing is stressed in a recent literature review of 51 intervention studies, carried out by Jefferson et al.[190] They found that hand washing and wearing masks, gloves and gowns were effective individually in preventing the spread of respiratory viruses, and were even more effective when combined. Indirect evidence that personal protective measures and other broader community public health measures (social distancing measures, school closures) can be quite effective comes from the SARS outbreaks in Hong Kong in 2003, which coincided with the latter part of influenza season, when it was observed that as extensive personal and community public health measures took place, reported influenza case numbers fell significantly, more so than usual for the time of year.[4] In a recent publication, Chun-Hai Fung and Cairncross[191] examined data on the effectiveness of hand washing as an intervention against SARS transmission; 9/10 studies showed that hand washing was protective, but only in three studies was this result statistically significant.

As discussed in section 4.2.3, globally, acute lower respiratory infections such as pneumonia, bronchiolitis and bronchitis cause up to 4 million deaths annually, mostly of children, the major burden of ALRI disease falling in developing countries. There is little data to show whether hygiene plays any significant role in the spread of ALRIs. Data from intervention studies discussed later in this section suggests that hand washing can produce a significant reduction in the risks of transmission of respiratory infections, but most of these studies were carried out in developed countries and concerned upper RT infections such as colds and flu. However, in 2005 Luby et al reported a study of the impact of handwashing with soap on pneumonia in children under 5, in squatter settlements in Karachi, Pakistan.[192] The results indicated a 50% reduction in pneumonia in the intervention compared with the control group. Luby et al assess that a link between hand washing and the prevention of pneumonia in developing countries is plausible on the basis that, in developing countries it is known that viruses commonly cause pneumonias. It is also known that some of the viruses that infect the respiratory tract are readily transmitted from person to person via hands. Additionally several viruses that cause RT infections predispose children to bacterial pneumonia.

7.3 The link between hygiene and the spread of *Staphylococcus aureus* (including MRSA) in the home

Although skin, wound and eye infections are common in the home and community, and are transmitted from person-to-person, other than for *S. aureus* infections, there is little relatively little data available on the routes of transmission in the home and the role of hygiene.

In two studies carried out in Pakistan, Luby et al[192,193] studied the health impact of hand washing with soap on impetigo. Impetigo is a skin infection caused by *S. aureus* which is frequently found as part of the normal body flora and is carried harmlessly in the nostrils, throat, and skin. In the 2002 study,[193] involving 162 households, it was found that, children had a 25% lower incidence of impetigo (-52% to -16%) compared with controls (no hand washing promotion). In the 2005 study involving 600 households, it was found that, compared with controls, children younger than 15 years in households with plain soap had a 34% lower incidence of impetigo (-52% to -16%).

The link between poor hygiene and the spread of *S. aureus* (including MRSA) is supported by a whole range of microbiological studies, many related specifically to the home. These data are summarised in various IFH and other reviews.[3,7,10,11] The data show that the organism is shed both by infected people, and by asymptomatic carriers into the home environment, mainly from the skin surface (usually on skin scales) though also from the nose. Household pets can also act as carriers and shedders of MRSA. The studies also show that *S. aureus* is a robust environmental survivor and is readily transmitted between hands, surfaces, cloths and fabrics. For *S. aureus* it has been shown that although up to 10^6 cells may be required to produce pus in healthy skin, as little as 10^2 may be sufficient where the skin is occluded or traumatised.[194] In studies[195,196,197] in the homes of HCWs colonised with MRSA, the HCW was treated to eradicate the organism, but subsequently became re-colonised. In each case, MRSA was isolated from environmental surfaces in the home. Contaminated surfaces included pillows, bed linen, brushes, cosmetics and hand contact surfaces, as well as household dust. In each case the problem was finally terminated only after thorough cleaning of the home environment. In other studies where persistent carriage of MRSA was reported, the source of colonisation was found to be a domestic dog.[198,199] A number of other cases are reported where family members in the home of an infected person have become colonised.[200,201,202,203,204]

Most recently, Turabelidze et al[205] reported a case-control study, involving 55 culture-confirmed cases MRSA in a prison in the USA which was carried out to examine risk factors for MRSA infection with a focus on personal hygiene. It was found that the risk for MRSA infection increased with lower frequency of hand washing per day and showers per week. In addition, patients were also less likely than controls to wash personal items (80.0% vs. 88.8%) or bed linens (26.7% vs. 52.5%) themselves instead of using the prison laundry. When personal hygiene factors were examined for cases and controls, patients were more likely than controls to share personal products (e.g. cosmetic items, lotion, bedding, toothpaste, headphones), especially nail clippers (26.7% vs. 10%) and shampoo (13.3% vs. 1.3%), with other inmates. To evaluate an overall effect of personal hygiene practice on MRSA infection, a composite hygiene score was created on the basis of the sum of scores of three individual hygiene practices, including frequency of hand washing per day, frequency of a shower per week, and number of personal items shared with other inmates. A significantly higher proportion of case-patients than controls had lower hygiene scores (≤6) (46.7% vs. 20.0%). Sharing of towels and soap was also identified as significant risk factors in recurrent outbreaks of CA-MRSA in a football team in the USA.[206]

Experience in the USA, on the other hand, suggests that PVL-positive CA-MRSA is easily transmissible not only within families but also on a larger scale in community settings such as prisons, schools and sports teams. For CA-MRSA, those at particular risk appear to be younger, generally healthy people who practice contact sports or other activities that put them at higher risk of acquiring skin cuts and abrasions.[207] Skin-to-skin contact (including intact skin) and indirect contact with contaminated objects such as towels, sheets and sport equipment are the primary vehicles of transmission. Johnson[208] cites risk factors for spread of CA-MRSA as close skin-to-skin contact, cuts and abrasions, shared contaminated items or surfaces, poor hygiene and crowded living conditions.

8. The emergence of new pathogens and re-emergence of existing pathogens, and their significance in the home and community

The emergence of new pathogens and re-emergence of existing pathogens remains a significant concern. Experience now shows that as soon as we begin to get one pathogen under control another emerges. The 1996 Rudolf Schulke Report shows that over the period 1972–1996, at least one new pathogen per year was reported.[2] Many of these emerging infections have been caused by species which are normally present in the environment, but have become pathogenic to humans as a result of changes in technology (food technology, building design and operation etc) or societal changes. Others have resulted from the emergence of new strains of already known and well-established pathogens. Some are strains which have developed altered or enhanced virulence properties (e.g. they have acquired the ability to produce a specific toxin, or enhanced levels of toxin). Others represent a problem because they have acquired the ability to resist the action of antibiotics. The problem of antibiotic resistance is considered in section 9.

International and national agencies such as WHO, CDC as well as the UK HPA, now recognise that, where there is emergence of a new pathogen, good hygiene may be a first line of defence before other measures can be put in place. The threat posed by emerging diseases such as avian influenza and SARS which demand an immediate response, has prompted the realisation that, in the event of a pandemic, hygiene will be a first line of defence during the early critical period before mass vaccination becomes available.

These issues were reviewed in two papers published in 1997. In their review paper, Morris and Potter[209] evaluated the emergence of new pathogens as a function of changes in host susceptibility, whilst Sattar[15] evaluated the impact of changing societal trends on the spread of infections in American and Canadian homes. In a

2008 review, Jones et al[210] evaluated the impact of socio-economic, environmental and ecological factors on the emergence of infectious diseases between 1940 and 2004. They demonstrated that EID events have risen significantly over time, with their peak incidence (in the 1980s) concomitant with the HIV pandemic. EID events are dominated by zoonoses (60.3% of EIDs): the majority of these (71.8%) originating in wildlife (e.g. SARS virus, Ebola virus), and are increasing significantly over time. It was concluded that tropical countries are the regions where new EIDs are most likely to originate in the future.

9. ANTIBIOTIC RESISTANCE AND THE ROLE OF HYGIENE IN REDUCING THE IMPACT OF ANTIBIOTIC RESISTANCE

Antibiotic resistance represents a major that severely undermines our ability to control IDs. The implication from this is that greater emphasis must now be placed on preventive strategies such as hygiene, rather than reliance on antibiotic therapy, and that these strategies need to be developed not only in hospitals but also in the community. The need for improved hygiene to reduce the spread of antibiotic resistance was addressed in the 1999 report of the EU Scientific Steering Committee in its document entitled "Opinion on Antimicrobial Resistance".[211] The report stated that "there should be action to reduce the risk of infection in individuals and in the population as a whole by encouragement of uptake of immunisations, education regarding home hygiene, attention to public health issues, and by the maintenance and/or improvement of housing and social conditions". The relationship of antibiotic resistance, specifically MRSA, to hygiene is reviewed in more detail in an IFH report prepared in 2006,[7] which indicates that there are a number of aspects to consider.

Firstly, hygiene is recognised as a strategy *per se* for reducing antibiotic resistance. Good hygiene means fewer patients with infections demanding antibiotics from their GP, thereby reducing the selective pressure that drives the ongoing emergence of antibiotic resistant strains. The benefits of this approach have been demonstrated in clinical settings. Reduced rates of infection and antibacterial resistance have been demonstrated where an approach combining good hygiene and reduced prescribing has been evaluated.[212,213] Educating primary and secondary school pupils about antibiotic resistance and hygiene is the fundamental aim of the EU-sponsored e-Bug project.[214] This is a Europe-wide project to disseminate an antibiotic and hygiene teaching resource for 9–16 year olds. The aim of the project is to ensure that all children will leave school with knowledge of prudent antibiotic use and how to reduce spread of infections for themselves and their children through hygiene.

The second aspect relates to the increasing spread pathogens such as MRSA and *C. difficile*, in the home and community. Across the world, governments are under increasing pressure to fund the level of healthcare that people expect. One solution to this problem is increasing care in the home. Although most MRSA and *C. difficile* infections arise in hospitals, the organism has the same potential to affect the elderly and immuno-compromised in a homecare setting. Good hygiene is key to protecting at risk groups cared for at home from infection including infection with antibiotic-resistant strains of opportunist pathogens such as HCA-MRSA and ESBL-producing *E. coli*.

Although, as discussed in section 5 "healthcare-associated" strains (HCA-MRSA) which mainly affect those with reduced immunity have until recently been the major concern, there is now a second dimension to the problem, that of "community-acquired" strains (CA-MRSA) which have emerged quite separately in the community and affect mainly young healthy people and children. For CA-MRSA any family member is at risk, although US experience suggests that CA-MRSA strains present a threat mainly to those engaging in activities involving close skin contact and abrasion such as contact sports.

The circulation of antibiotic-resistant (and related) strains in the community also has important implications for delivering infection control in hospitals and care facilities. Hospital managers now realise that managing healthcare associated infections is hampered by people (new patients, visitors and healthcare workers) who are "silent" carriers of antibiotic-resistant organisms such as MRSA, ESBL-producing *E. coli,* and also *C. difficile* that walk into their facilities, and that one of the key measures is containing the spread of these organisms in the home and community. By preventing the spread of these organisms in the home by promoting better hygiene, we can reduce the reservoir of antibiotic resistant strains such as MRSA and *E. coli* circulating in the community which means that the opportunities for their introduction into hospitals via new patients, HCWs and hospital visitors is reduced.

10. Pets and domestic animals as a source of infection in the home

The home is frequently a shelter to a range of different pets; more than 50% of homes in the English-speaking world have cats and dogs, with 60 million cats and dogs in the USA. The increasing popularity of exotic pets increases the risk of humans acquiring zoonotic infections.[15] A number of studies have shown that domestic cats and dogs can act as reservoirs of *Salmonella*, *Campylobacter* and other enteric pathogens.[215,216,217,218] In the USA, up to 39% of dogs may carry *Campylobacter*, and 10–27% may carry *Salmonella*;[219] cats are also carriers of these organisms. Wall et al reported that 36% of all *Salmonella* isolates from cats in the UK corresponded to multiresistant *S. typhimurium* DT104.[216] Harrison found that, from 100 specimens of faeces obtained from a London cattery, 19 species of *Campylobacter* spp. including *C. upsaliensis* and *C. jejuni* were isolated.[220]

Indications are that staphylococci are commonly carried by animals, but tend to be host-adapted varieties. *S. intermedius* is the most common isolate from dogs, but human strains may be isolated. Data showing that domestic pets can also be a source of *S. aureus*, including MRSA and PVL-producing strains, comes from a number of studies, although little information is available on the prevalence of these species in domestic pets.[198,199,221,222,223] Rankin et al[221] carried out a study to determine the presence of *S. aureus* PVL toxin genes in MRSA strains isolated from companion animals. Eleven MRSA isolates from 23 animals were found to be positive for the PVL toxin genes, as well as for methicillin resistance (mecA) genes. A survey conducted at a veterinary hospital on one day in February 2004 by Loeffler et al[224] identified MRSA carriage in 17.9% of veterinary staff, 9% of dogs, and 10% of environmental sites. The available evidence suggests that MRSA is most likely acquired in animals by transmission from humans, although this is by no means proven.[225]

Borriello et al[226] reported that carriage of *C. difficile* in household pets is common. Although carriage appears to be transient and not associated with GI disease, they report that up to 23% of household pets are affected. Although carriage was reportedly higher in animals that had previous antibiotic treatment (31% compared with 19%), the differences were not statistically significant. In most cases non-cytotoxigenic strains were identified. Both cytotoxigenic and non-cytotoxigenic strains were also isolated from the animals' surroundings. Al Saif and Brazier[227] report that the organism is also widespread in the environment. A study in a group of 102 dogs from a variety of sources across Ontario, Canada showed that the most frequently isolated pathogen was *C. difficile* which was isolated from 58 (58%) faecal specimens. Seventy-one per cent (41/58) of these isolates were toxigenic, i.e. disease-causing strains.[228] The authors also reviewed other reports from the USA and Australia, which indicated asymptomatic carriage in the general canine population between 0 and 37%.

A number of studies are reported which show the risks of infection transmission of infections in the home from domestic animals to humans. Such studies suggest that hands and other surfaces can play a role in the transmission of infection if hygiene practices are not observed. In Canada, outbreaks of salmonellosis from pets have been reported by Plaut et al.[229] Schutze et al[230] described a study of 50 US homes in which children under 4 years were known to be infected with *Salmonella* spp. In 34% of homes there was also found to be illness in other family members at the time of illness of the index patient. The data indicated that environmental sources, infected family members and also pets, were more significant risk factors for development of salmonellosis in these children than contaminated foods.

Two further studies describe discharged hospital patients and healthcare workers who were successfully treated to eradicate the MRSA organism, but subsequently became recolonised.[198,199] In each case the evidence suggested that the source of re-colonisation was a domestic dog. It is possible, however, that the domestic animals were “innocent bystanders” rather than true carriers, i.e. the organism originated from contaminated dust and skin scales trapped in the animal fur. In 2006, 35 homes of health care and non–health care workers, each with a child in diapers and either a cat or dog in the home, were recruited from the Boston area. *S aureus* was found in 34 of the 35 homes (97%) MRSA was isolated from 9 of 35 homes (26%), and was found on a variety of household surfaces, including the kitchen and bathroom sinks, countertops, kitchen faucet handle, kitchen drain, dish sponge/cloth, dish towel, tub, infant high chair tray, and pet food dish. A positive correlation was indicated for the presence of a cat and the isolation of MRSA from surfaces.[231]

Although there is a significant amount of evidence to show that domestic pets have the potential to act as a source of infection in the home, there is little data indicating the extent to which this may or may not occur. In 2008 the CDC Foodborne Diseases Active Surveillance Network reported that the incidence of *Campylobacter*, *Salmonella*, Shigella, and *E. coli* O157 infections is highest among children aged <5 years. In this report, CDC identified that risk factors for bacterial enteric illness in young children included visiting or living on a farm, and living in a home with a reptile.[33] By contrast, in a 2008 study in which the results of the UK community IID were reviewed[232] the investigators found no evidence of an association between self reported diarrhoea and pet ownership although there was no attempt to evaluate the impact of age, or to identify the pathogens involved.

The potential for transmission of pathogens from domestic animals to humans via hands and surfaces is further demonstrated by a study of the nature and frequency of contacts between dogs, and between dogs and people. The study involved a questionnaire survey of 260 dog-owning households in a community in Cheshire, UK. Contacts were very variable depending on the size, sex and age of the dog, individual dog behaviour, human behaviour and human preferences in managing the dog. However, a number of situations were identified that may be important in relation to transmission of zoonoses, including sleeping areas, playing behaviours, greeting behaviours, food sources, walking, disposal of faeces, veterinary preventive treatment and general hygiene.[233]

11. CLINICAL SEQUELAE OF INFECTIOUS DISEASES

In addition to the threat posed by acute infections, pathogens are increasingly implicated as causative or co-factors in cancers and degenerative diseases.[234,235,236,237] Because these may manifest at a later date, the link to infectious disease may go unrecognised. Examples include *Campylobacter jejuni* (Guillain Barré syndrome)[238] and *H. pylori* (cancer).[239] Clusters of *Campylobacter* infections are known to arise in family households, and complications (Guillain Barré syndrome) which require ongoing treatment are a real concern.[240,241] Foodborne illness has been estimated to result in chronic sequelae in 2–3% of cases.[242] A report from the European Commission[243] cited evidence of chronic disease, such as reactive arthritis, following 5% of *Salmonella* cases, with 5% also of *E. coli* O157 cases progressing to the serious and often fatal complication of uraemic syndrome.

Viral respiratory infections, even mild infections, can be important predisposing factors to more severe and possibly fatal secondary bacterial infections.[244] There is also growing evidence that respiratory viruses may exacerbate attacks of asthma.[245,246,247] Recurrent wheezing in children has been associated with respiratory infections early in life, RSV being one of the main viral agents thought to be responsible.[248]. In 2008, Jackson et al reported a study of 259 children that demonstrated a significant relationship between viral illnesses and asthma development.[249] Viral etiologies were identified in 90% of wheezing illnesses. From birth to age 3 years, wheezing with RSV, rhinovirus, or both rhinovirus and RSV was associated with increased asthma risk at age 6 years. In year one, both rhinovirus wheezing and aeroallergen sensitisation independently increased asthma risk at age 6 years. By age 3 years, wheezing with rhinovirus was more strongly associated with asthma at age 6 years than aeroallergen sensitization. Nearly 90% of children who wheezed with rhinovirus in year three had asthma at 6 years of age. Bossios et al also review epidemiological studies which suggest that human rhinoviruses and house dust mites can synergize in inducing asthma exacerbations.[250]

To examine the influence of childhood respiratory infections on adult respiratory health Dharmage et al examined around 9000 adult participants, initially at the outset of the study and then again after around 10 years.[251] Of these participants, 10.9% reported serious respiratory infections before 5 years (SRI) and 2.8% reported hospitalisation for lung disease before 2 years (HDL). SRI was associated with current wheeze (OR 1.9) and asthma (OR=2.5). Childhood respiratory infections were also associated with new asthma (OR 1.5), new wheeze (OR=1.5), and persistent wheeze (OR 2.2) but not with decline in lung function. Similar findings were observed for HDL. The impact of early infections was larger in subjects exposed to maternal or active smoking. The authors concluded that the impact of childhood respiratory infections on respiratory system may not only last into adulthood but also influence development and persistence of adult respiratory morbidity.

Buez et al describe an animal model study which suggests that over the lifetime of an individual, picornavirus-related infections could have a permanent effect on memory late in life.[252] Picornaviruses infect more than one billion people worldwide each year. In the study, mice were infected with Theilers murine encephalomyelitis virus. Mice that contracted the virus had difficulty learning to navigate a maze designed to test various components of spatial memory, the degree of impairment, ranging from no discernable damage to complete devastation and correlated to the number of dead brain cells in the hippocampus region of the brain. Clinical studies indicate that picornavirus infections in humans may be associated with inflammation of the brain and damage to the hippocampus, the part of the brain responsible for forming, storing and processing memory.

Richardson et al present evidence which suggests that enteroviruses may be a trigger for type 1 diabetes. They found evidence that pancreatic cells of human patients with type 1 diabetes can be infected with enterovirus, although it remains unclear whether such infections occur at high frequency and are important in the disease process.[253]

A number of new studies show that infection may be more significant in sudden unexpected death in infancy (SUDI) than previously thought.[254,255,256,257] Weber et al[254] report a UK retrospective study of post mortem data on 546 cases. The cases were grouped by whether the autopsies revealed no obvious cause of death, evidence of bacterial infection as a likely cause, or evidence of another cause that was not bacterial. Bacterial samples taken at autopsy were also grouped by whether the bacteria were associated with obvious causes of death by infection or whether the bacteria could cause rapid death without an obvious infection. Two bacteria in the latter group *S. aureus* and *E. coli* were found to be more common than expected in babies whose deaths could not be explained. Sixteen percent of samples from infants whose deaths remained unexplained after autopsy were positive for staphylococci, compared with 9% of infants whose deaths were explained but not related to infection; and 6% of samples from the former group contained *E. coli*, compared with just 1% of samples from the latter. Prtak et al[256] carried out a retrospective investigation of 116 cases of SUDI of which 104 (90%) of cases had an organism identified, of which 52 were found to have at least one significant result. *Streptococcus pneumoniae* was the most frequently cultured organism, followed by *Haemophilus* spp and *Staphylococcus aureus,* among other bacteria.

12. DEMOGRAPHIC AND SOCIAL CHANGES WHICH INFLUENCE POPULATION SUSCEPTIBILITY TO INFECTIOUS DISEASE – "AT RISK" GROUPS IN THE HOME

Changes in microbial virulence and resistance to antibiotics, as reviewed in sections 8 and 9 of this review, are not the only factors that are contributing to changing global ID trends. Other factors are the social and demographic changes which are occurring within the global population that impact on host resistance to infection (i.e. how well the host can defend itself against a pathogen). The following data suggest that these changes not only affect our resistance to "established pathogens", the increases in the number of persons susceptible to specific micro-organisms can contribute to the emergence of new pathogens. Increased susceptibility to hygiene-related infections may relate to the fact that, for risks groups (as compared with "normal" individuals), exposure to smaller numbers of infectious particles is sufficient to cause clinical infection. These issues were reviewed in two papers published in 1997. In his review paper, Morris et al[209] evaluated the emergence of new pathogens as a function of changes in host susceptibility, whilst Sattar[15] evaluated the impact of changing societal trends on the spread of infections in American and Canadian homes.

The largest proportion of people in the home who are at increased risk of infection are the elderly. These groups have generally reduced immunity to infection that is often exacerbated by other basic illnesses like diabetes mellitus, malignant illnesses, etc. Risk groups in the home also include the very young, patients discharged recently from hospital, and family members with invasive devices such as catheters. It also includes people whose immuno-competence is impaired, either as a result of chronic and degenerative illness (including those who are infected with HIV/AIDS), or because they are undertaking certain drug or other therapies. This includes those undergoing irradiation or chemotherapy for cancer, and organ transplant recipients. Immunosuppressed persons are often also on other medications such as antibiotics, which can further increase their susceptibility to infections.[209]

Data collected from the USA and three European countries, Germany, The Netherlands and the UK, suggests that at up to 1 in 5 of the population belongs to an "at risk" group (Table 14). The data suggest that between 12 and 18% of the population of these countries are >65 years of age.

Table 14 – Prevalence of "at risk" person in the domestic setting.

	US (2005)	UK (2002)	Germany (2002)	Holland (2002)	Russia (2003)	Ukraine (2003)
Total population	*290 million*	*60 million*	*82 million*	*16 million*	*145 million*	*50 million*
Over 65 year old	35.6 million	9 million	13 million	2 million	16 million	14 million
Living with cancer – significant proportion undergoing chemotherapy	2 million	1 million		160,000		
Under 1 year old	4 million	600,000	800,000	100,000	1.3 million	400,000
Discharged from hospital within previous 2 weeks	1.25 million	200,000		60,000		
Hospital outpatients at home	-		1, 270,000			
HIV cases*	40,000	50,000			177,000	500,000
AIDS cases		15,000				
People in homecare	0.5 million					
Total "at risk" persons	**>1 in 7**	**>1 in 6**	**>1 in 5.6**	**>1 in 6.3**	**>1 in 8**	**>1 in 3**

*This does not include those who are HIV positive who may also have lowered resistance to infection

Morris et al[209] review data indicating that the elderly are at increased risk of death from foodborne and diarrhoeal disease. Between 1979 and 1987, 28,538 persons in the USA had diarrhoea as an immediate or underlying cause of death; 51% of these persons were more than 74 years of age, 27% were adults age 55–74, and 11% were children under the age of 5. For the elderly, communal living environments, combined with problems of faecal incontinence, create an environment in which enteric and foodborne pathogens are easily spread. Incidence of salmonellosis and *Campylobacter* diarrhoea appears to be higher among the elderly. It is estimated that by 2025 there will be more than 800 million people over 65 years old in the world, two-thirds of them in developing countries.[258]

Hereditary diseases associated with immunosuppression are present in a small proportion of the population. The most common of these diseases, a selective immunoglobulin A deficiency, has been found in as many as 0.3% of some blood donor populations and may be associated with recurrent diarrhoea; infections with Giardia, in particular, have been noted to be more common among such immuno-compromised patients.[259] In a 2008 study,[80] the origin of *P. aeruginosa* isolates in cystic fibrosis (CF) patients was investigated by comparing the *P. aeruginosa* genotype(s) from 50 newly infected patients with genotypes of *P. aeruginosa* isolates from the home environment and from other patients from the same CF centre. *P. aeruginosa* could be cultured from 5.9% of the environmental samples (mainly in the bathroom), corresponding to 18 patients. For 9 of these, the genotype of the environmental *P. aeruginosa* isolate was identical to the patient's isolate.

The population of people in the community with HIV/AIDS-related immuno-deficiencies is rapidly increasing. In the past 20 years, *Toxoplasma gondii*, *Mycobacterium tuberculosis*, *Cryptococcus neoformans*, *Cryptosporidium parvum, Yersinia enterocolitica,* and *Listeria monocytogenes* have all made comebacks, initially in the AIDS population.[209] Globally, the number of people living with HIV/AIDS is now 40 million, the majority living in developing countries. In sub-Saharan Africa alone there are 25 million cases; 11 million children are AIDS orphans of which 90% are infected. In South East Asia region there are more than 4 million HIV affected people in the South East Asia region. India has the 2nd highest number of people estimated to be living with HIV, which is next to South Africa[17]. These people are not only more vulnerable to infection but, once infected, they are also a source of infection for other family members. In an intervention study of 148 patients with AIDS, it was found that patients assigned to the intensive hand washing intervention group developed fewer episodes of diarrhoeal illness (1.24+/-0.9 vs. 2.92+/-0.6 new episodes of diarrhoea, respectively, during a 1-year observation period).[260] Morris et al[209] reviewed data showing that persons with AIDS show increased susceptibility to infection with *Salmonella* species. Data suggest that risk for non-typhoidal *Salmonella* infections is increased 20- to 100-fold among AIDS patients with increased risk for septicaemia. In the USA increases in bacteraemia in states with high AIDS incidence are associated primarily with infections due to *Salmonella enteritidis* and *Salmonella typhimurium*. While these data are for non-typhoidal *Salmonella*, studies outside the USA suggest that AIDS patients have a similar increase in risk for infection with *Salmonella typhi* in areas endemic for typhoid fever. In Lima, Peru, the risk for typhoid increased 25-fold in HIV-infected persons 15–35 years of age. Morris et al[209] caution, however, that while the data suggest increasing salmonellosis in conjunction with increasing AIDS prevalence, anecdotal data from AIDS clinicians do not support this view.

Fewer data are available on susceptibility of AIDS patients to other acute bacterial foodborne infections. According to Morris et al,[209] a 35-fold increase in the *Campylobacter* case rate among persons with AIDS was noted in a study from Los Angeles, whilst a study in the San Francisco area suggested that AIDS patients have a 280-fold increase in incidence of listeriosis, as compared with the general population. *Toxoplasma gondii* is now seen as a leading cause of cranial lesions in AIDS patients; data from the 1980s suggest that 5–10% of AIDS patients get toxoplasmic encephalitis. In an estimated 50% of cases, *Toxoplasma* is transmitted by food. An estimated 10–20% of cases of AIDS-associated diarrhoea are due to *Cryptosporidium* which is a major waterborne pathogen.[261]

Padoveze et al, evaluated a total of 111 HIV/AIDS patients for nasal carriage of *S. aureus*. It was found that 70 (63.1%) had at least one positive culture. Patients in clinical stages of AIDS were more likely to be colonised than non-AIDS patients (p=.02). Among the patients with *S aureus* nasal carriage, 25.2% were transient carriers and 39.4% were persistent carriers.[262]

The number of new cancer cases has steadily increased over the past 20 years.[15] Patients are also surviving longer. There is evidence that cancer patients undergoing immunosuppression therapy have higher risk rates of septicaemia and foodborne infections by more common antibiotic-resistant bacteria.[209] According to Sattar,[15] the number of people in the community who are living with organ transplants is also increasing. In the past 45 years, there have been more than 500,000 transplants of various organs worldwide, with increasing success rates as a result of advancements in suppression of graft rejection. A factor in the increased survival rates of recipients has been the use of cyclosporine and other immunosuppressants. These drugs aid in the suppression of graft rejection but also prevent the immune system from reacting to infectious agents. According to the USA United Network of Organ Sharing, approximately 15% of all deaths are a result of infection in the first 3 months.[263] However, little data exists on the rate of infection and morbidity as a result of the use of immunosuppressive agents.

Increasingly, all of these “at risk” groups are cared for at home by a carer who may be a household member. This is illustrated by data for North America[15] which indicates the dramatic decrease in the number of acute care hospital admissions in North America; Sattar reported that, over the period 1978–1998, the number of days per capita spent in the hospital dropped from 12 days to just more than 5. This means that the burden of care and the impact of any infections in such patients are being shifted more and more to the community.[15] Ensuring that homecare is not accompanied by increased ID risks is key, otherwise cost savings gained by current policies of shorter hospital stays are likely to be overridden by additional costs of re-hospitalisation.[264]

13. THE IMPACT SOCIAL DETERMINANTS ON THE SPREAD OF INFECTIOUS DISEASE

Across the world, but most particularly in developing countries, there is an inequitable distribution of communicable diseases, sub-populations with poor educational attainment, low income, or other socio-economic factors carrying the highest burden of disease.

The impact of social determinants on the incidence and prevalence of communicable diseases in the newly expanded European community is discussed in a 2008 review by Semenza and Gieseke.[265] These workers carried out a systematic review of more than 200 publications on socio-economic factors and infections which suggests that populations at high risk of infection in Europe coincided with those with a low level of education, low occupational class, or low income level; other marginalised groups included migrants or people engaged in high-risk activities. These sub-populations suffer disproportionately from a range of infections, including *H. pylori,* respiratory infections, sexually transmitted diseases, and nosocomial infections. It is evident that not all communicable infections are associated with inequalities, but some, such as tuberculosis, HIV, or vaccine preventable infections, are more implicated than others. For many communicable diseases, social and ethnic groups within European countries differ not only in incidence and prevalence rates, but also treatment and cure rates, and access to health services.

Semenza and Gieseke[265] outline how the societal, political, and economic contexts which are the structural determinants of health, in turn give rise to the distribution of income, education, professional prospects, and the like among certain societal groups as defined by specific cultural, gender, or race/ethnicity norms. This process drives social stratification, which gives rise to intermediary determinants of health (e.g. living and working conditions), and behavioural factors (e.g. high-risk health behaviours, drug use) that generate potentially harmful exposures. A self-perpetuating cycle leads to adverse health effects in marginalised groups with differential consequences because of poor access to care. The "vicious cycle" can result in a descent down the socio-economic ladder, because healthcare costs and loss of work disproportionately affect disadvantaged groups. They conclude that “these avoidable differences can and should be addressed; however, unless the fundamental causes of disease, namely the social determinants of health, are not improved, disparity in health outcomes will not be ameliorated”.

In low income populations, malnutrition is an important contributor to increased population susceptibility to infection. While accurate data on the prevalence of malnutrition are difficult to obtain, problems are accentuated in developing countries, in areas of political unrest, and among marginalised populations in the USA, Europe and other affluent nations. As reviewed by Morris et al,[209] malnutrition increases host susceptibility through a number of mechanisms. Firstly, it weakens epithelial integrity which in turn may affect cell-mediated immunity leading to functional deficiencies in immunoglobulins and defects in phagocytosis. Malnutrition can also initiate a "vicious cycle" of infection predisposing to malnutrition and growth faltering, which in turn leads to increased risk for further infection. In studies in Bangladesh, malnourished and well-nourished children had the same number of infections with diarrhoeal pathogens such as enterotoxigenic *E. coli*; however, diarrhoea in malnourished children was of longer duration and had greater potential long-term nutritional consequences.[266] Overall, malnutrition appears to result in a 30-fold increase in the risk for diarrhoea-associated death.[267]

The demographic and epidemiological situations in many developing countries, particularly in the South Asian region, are marked by rapidly increasing population, with the attendant problems of poverty, illiteracy and lack of hygiene and sanitation. The population of the South Asian region is expected to reach 1.75 billion by 2010 and 2.06 billion by 2025.[268] With the continuing increase in the life expectancy and the decline in fertility, the age structures in most countries have changed reflecting an increase in the productive and elderly population. The demographic scenario in most Asian and African countries is also marked by rapid growth in urban population and rapid migration of people from rural to urban areas. This has influenced socio-cultural habits, quality of life and issues related to home hygiene.

With improvements in GDP and standards of living, there has been significant improvements in the health status of the community. In India, since independence in 1947, death rate per thousand of population has been brought down from 24.7 to 9 during the late 1990s. Life expectancy has increased from 32.7 to 63.5 years during the same period, while the rate of infant mortality has been reduced from 162.0 to 62.0.[269] But despite this impressive achievement, the demographic and epidemiological situations in countries like India, Bangladesh, Pakistan, Nepal, Afghanistan, Bhutan, Vietnam, Cambodia, Laos, etc are causing serious public health concern. Unabated growth of population coupled with the burden of poverty and illiteracy and lack of access to safe water, sanitation and hygiene are resulting in a huge burden of communicable diseases.

Data from India (Table 15) illustrates the very marked differences in the epidemiological and health status between the poor and the rich in developing countries

Table 15 – India 1992–1993: Health and epidemiological status of population[270] by socio-economic status

	Socio-economic status		
Indicator	**Most poor**	**Most rich**	**Average**
IMR/1000 births	109.2	44.0	86.3
< 5 Mortality rate	154.7	54.3	118.3
Total fertility rate	4.1	2.1	3.4
Immunization			
for all vaccines (%)	17.1	65.0	35.4
not immunized (%)	48.4	Not known	30.0
Delivery attended by a trained person	11.9	78.7	34.3
Use of contraceptive by married women	24.9	50.6	36.5

14. Changes in social habits, and cleaning and hygiene practices in the home and community

In addition to the "societal" and other changes, as reviewed in section 12, a number of other trends in social behaviour, eating habits, availability and use of home appliances etc can be identified which are also shaping the risks of ID transmission in the home and community. These trends, as they apply in the USA, and Canada were previously reviewed by Sattar.[15]

In the past 20 years, the variety of foods available for purchase from retail premises has increased dramatically. All foods, but most particularly raw foods such as meat, poultry, fish and vegetables, are a potential source of gastrointestinal infections in the home. As stated previously, although most domestic foodborne outbreaks probably relate to improper cooking or storage of food, poor hygiene can also lead to infection outbreaks originating from contaminated foods. These can occur during handling of the food, either by direct hand-to-mouth transfer, or by cross contamination to ready to-eat-foods such as snacks and sandwiches. The demand for different and "exotic foods" has stimulated increasing movement of foodstuffs from one region or country to another, but has created problems in controlling microbial quality. From data published in 1997, Sattar assessed that, in the USA more than 50% of fresh fruits and vegetables are now imported;[15] in 1997, Tauxe published a review of outbreaks ascribed to imported pathogen-contaminated items of food.[271]

In "westernised" homes, knowledge and skills in food handling and preparation have declined with increasing reliance on refrigerators, freezers, microwave ovens, and dishwashers.[15] In some cases, misuse of these appliances contributes to the risks of infection. The threat of listeriosis has increased with increasing use of refrigerators; *L. monocytogenes* is a psychrophile and can multiply on certain types of foods even at refrigeration temperatures.[272] In the past few years, there has been a steady increase in the use of microwave ovens in the home. This technology has been readily accepted without proper appreciation of the fact that microwaving may not make foods safe for consumption.[273,274] Evans et al review examples of foodborne infections contacted from items processed in microwave ovens.[275]

Although, hygiene of dishes and utensils has improved with the use of dishwashers, they are not universally used and water temperatures for washing dishes have declined. Although manually washed eating utensils are normally wiped dry or left to air dry, which can inactivate microbial pathogens or discourage their growth,[276] cross contamination of eating utensils can however occur if contaminated water is used for washing or when contaminated dish rags or sponges are used for washing or drying.[276] Mattick et al reported a study highlighting the potential for survival and cross contamination of foodborne bacteria during a typical washing-up process. Some dishes remained contaminated with bacteria after washing-up. *E. coli* and *Salmonella* survived towel or air-drying on dishes and after towel-drying the cloth became contaminated on every occasion. Some sterile dishes washed after contaminated dishes became contaminated.[277]

Clothing, bed linens, towels and other items which are in contact with the body may be a vector for transmission of infection, particularly for "at risk" groups. Although data are relatively limited, the risk for cross contamination by household laundry has been demonstrated by a number of studies as reviewed by Sattar[15] and by the IFH.[7,11] Of current concern is the potential for spread of *S. aureus*, particularly community-associated MRSA strains, which have the potential to infect the healthy as well as the immune compromised.

Domestic clothes-washing practices have changed in the past three decades to achieve energy conservation, environmental protection, and the changing nature of fabrics, but with little attention to the possible implications for hygiene. In homes where there is a carrier, MRSA has been isolated from laundered items (personal communication from Martin Exner, May 2001). Kniehl et al[197] described a study in Germany, of HCWs who had regular close contact with MRSA-colonised patients. MRSA was identified from nasal swabs of 87 workers Environmental sampling detected contamination in 7/8 home environments. Contaminated surfaces included pillows, bed linen, brushes, cosmetics and hand contact surfaces, as well as household dust. Changes in domestic clothes-washing practices are reviewed by Terpstra.[278] At one time, laundry was performed with hot water or bleach. However, with the advent of low-water temperature washing the availability of detergents active at ambient water temperatures and avoidance of bleaching with chlorine became commonplace, detergents had to make up for the lack of assurances. These changes may promote the survival of pathogens on clothes, whilst changing composition of fabrics may have on the retention and release of viable micro-organisms. Little is known about how well low temperature washing techniques eliminate pathogens from clothing and prevent cross contamination between laundered items. A few decades ago, it was common to dry laundry outdoors, where an added germicidal effect was achieved from sunlight. Clothes and linens were ironed damp so that steam penetrating the fabric caused significant reductions of microbial load.[279] These days, ironing the practice of ironing has almost disappeared in many households with the use of wrinkle-resistant fabrics.

The first novel detergents were designed in the mid-1970s, when phosphates were first introduced as more effective cleansing agents[278] at both low-water temperatures and high-water temperatures. Their negative environmental impact has since led to their removal from detergent systems. However, non-bleaching oxidising compounds, introduced as "low-water temperature bleaches" or colour-safe bleaches can compensate for this with their microbiocidal activity. Use of clothes dryers add an extra margin of safety because it can, depending on the temperature and time of drying, further reduce the microbial load.

The popularity of fitted carpeting in homes has increased significantly in the past 3–4 decades. The ability of carpets to sequester dust and permit the growth of micro-organisms, especially when damp, demands that these are regularly cleaned and

maintained, if the risk from airborne microbes and allergens is to be contained. Previously, carpets were regularly taken outside and beaten to remove dust and residues, and hard surface floors were brushed and damp-mopped. The reduction in the amount of time spent on housekeeping also has implications for home hygiene.
Climate control of indoor air through heating and air conditioning systems has led to the development of buildings with windows that are often sealed, air that is recycled, and ducting that can accumulate dust or act as a site for microbial growth. Mechanical heating or cooling of indoor air alters its relative humidity, which can influence the airborne survival of pathogens.[280] Allergens and endotoxins produced by some bacterial and fungal agents are increasingly implicated as causes of disease in humans.[281] Legionnaires' disease is an example of how conditioning of indoor air has turned an environmental bacterium into a human pathogen. *Legionella pneumophila*, is widely distributed in the environment and is generally harmless to persons unless it is introduced into hot-water tanks, air conditioners, and cooling towers; if aerosols from such water are subsequently inhaled they can cause infection.

In most developing countries during the last 2 or 3 decades there has been a shift of population to urban areas. Amongst the urban rich and middle class, there have been significant improvements in the standard of living and quality of life. This has been reflected in the hygiene practices like cooking food, cleaning and washing of clothing and utensils, floor cleaning, handling and storage of food and drinking water, etc. Use of refrigerators and microwave ovens has become common in the homes of urban middle as well as upper classes. Vacuum cleaners are also becoming increasingly popular. In the Indian sub-continent, in traditional homes, activities such as eating, cooking, etc, used to be performed at floor level which meant that cleanliness of the floor was an important factor. Dry sweeping was very common in most households which resulted in indoor dust pollution contributing to respiratory infections such as pneumonia and tuberculosis. In the last decade, dining tables have become common features of the homes in urban rich and middle class, even in rural homes. A significant portion of the rural population now have access to water, and use of soap for hand washing is universal not only among the urban rich and middle class but also an increasing percentage of the rural population. A comparison of a recent survey conducted by Sulabh International Academy of Environmental Sanitation in collaboration with IFH SEA in five Indian states, with the findings of the sample surveys conducted by IFH about 10 years ago'in Kolkata suggests significant improvements in the perception and practice of home hygiene.[282,283] However, the problem of poverty and illiteracy is inextricably related to the problems of hygiene and sanitation. Amongst the urban and rural poor the standards of home hygiene continues to be extremely poor. Unless the problems of poverty and inequality are effectively resolved risk of infectious diseases will continue to persist in the homes of the millions of poor of the developing countries.

15. Developing a risk-based approach to home hygiene

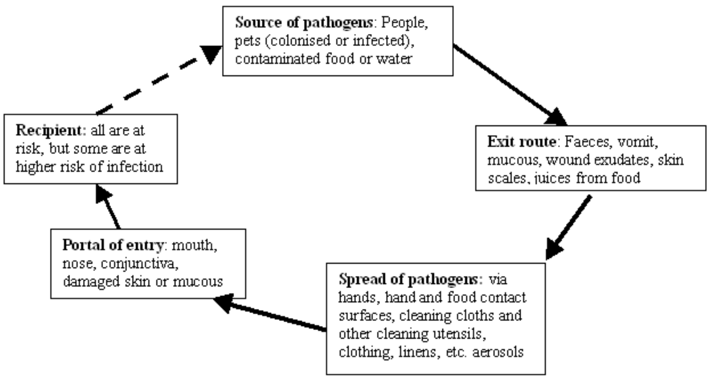
As stated previously, following a review in 1997,[9] IFH concluded that there was a need for an improvement in hygiene awareness and hygiene practices in the home. In response, the next step for IFH was to develop policies and guidelines etc for home hygiene, taking advantage of the significant database of published microbiological and other data relevant to the home, which has been generated since the 1980s. This data was reviewed in two IFH reports first published in 2002,[10,11] and more recently in IFH reviews of hand hygiene,[3] of MRSA, *C. difficile* and ESBL-producing *E. coli*,[7] and in this report.

The approach which IFH adopted for developing home hygiene policy is based on risk management.[3,7,284] This involves identifying the "critical control points" for preventing the spread of ID in the home. Risk management is the standard approach for controlling microbial risks in food and other manufacturing environments, and is becoming accepted as the optimum means to prevent such risks in home and hospital settings.[285] A risk-based approach has also been adopted in developing the WHO Global Patient Safety Challenge to promote hand hygiene in healthcare facilities. The central concept "My five moments for hand hygiene" focuses, not just on getting people to wash their hands, but getting them to do it at the right time and in conjunction with other critical control measures.[286]

Applied to the home, the risk-based approach has come to be known as "targeted hygiene". Targeted hygiene starts from the principle that pathogens are introduced continually into the home, by people (who may have an infection or may be asymptomatic), contaminated food and domestic animals, but also sometimes in water, or via the air. Additionally, sites where stagnant water accumulate such as sinks, toilets, waste pipes, or items such as cleaning or face cloths readily support microbial growth and can become secondary reservoirs of infection; although species are mostly those which represent a risk to vulnerable groups.[287] In many homes, there will also be at least one family member who is more susceptible to infection for one reason or another.

Within the home, there is a chain of events, as described in Figure 1 that results in transmission of infection from its source to a new recipient. Limiting the exit and entry of pathogens from and into the human body involves a whole range of activities such as good respiratory hygiene, care of wounds, etc. Thorough cooking and safe storage of food and household water treatment and safe storage are also part of targeted hygiene. In low income communities where sanitation is inadequate, it is necessary for the family and community to take responsibility for safe disposal of faeces. Safe disposal of household waste may also be the responsibility of the family. In communities where public water supplies are unsafe and/or inadequate, provision of safe water for the family through "household water treatment and safe storage" also becomes the responsibility of the family.

Fig 1 – The chain of infection transmission in the home.



Breaking the "spread of pathogens" link in the home depends on carrying out a risk assessment using the microbiological data related to each stage of the infection transmission cycle in order to identify the "critical control points" for preventing spread. This suggests that the "critical points" are the hands, together with hand and food contact surfaces, cleaning cloths and other cleaning utensils, which form the "superhighways" for spreading pathogens around the home, such that healthy family members or the food they eat become exposed. Toilets, baths, basins etc were invented for the purpose of dealing with human waste, but this does not mean that they are zero risk; they still have risks associated with them, particularly where someone in the home has sickness, diarrhoea, or other contagious infections. Although floors, however "dirty" they may appear, are assessed as relatively low risk, the risks increase where a pet animal and a small child share a floor area, or where a floor surface is contaminated with vomit or faeces.

Targeted hygiene also means applying a suitable hygiene procedure at appropriate times to interrupt the chain of infection transmission. Since the "infectious dose" for many common pathogens such as *Campylobacter*, norovirus and rhinovirus can be very small (1–500 particles or cells),[3,10] one must argue that, in situations where there is risk, a "hygienic cleaning" procedure should be used which eliminates as many organisms as possible from critical surfaces. Hygienic cleaning can be done in one of two ways, either by detergent-based cleaning with rinsing or by using a disinfectant/cleaner which inactivates the pathogens in situ. In many situations (e.g. hand washing) a "hygienically clean" surface can be achieved by soap and water alone, but recent studies suggest that this process is only effective if accompanied with thorough rinsing.[288,289,290] Wiping a surface with a cloth (or mop) will merely move organisms around the surface and onto the cloth and hands to be transferred to other surfaces. This means that in some situations we should not be afraid to recommend the use of a disinfectant. Waterless hand sanitizers should also be recommended for situations where access to soap and water for hand washing is limited. To ensure the elimination of pathogens from clothing and household linens, ideally they should be laundered either at 60ºC or at 40ºC using a bleach-containing laundry product.[291] Methods for household water treatment and safe storage are reviewed in a 2005 IFH report.[12]

The key to targeted hygiene is that it recognises that good hygiene is not a "once weekly deep down clean", it needs to be an ongoing part of our daily lives where hygiene measures are targeted where and when necessary. Targeted hygiene makes sense in that it offers the means to address issues such as the hygiene hypothesis because it maximises protection against infectious microbes, whilst otherwise allowing normal exposure to non-harmful microbes.

As part of our work in promoting hygiene, the IFH has produced a set of "Guidelines for Home Hygiene" together with "Recommendations for Selection of Suitable Hygiene Procedures".[283,292,293] These are based on the risk-based approach, and cover all aspects of home hygiene including food hygiene, general hygiene, personal hygiene, care of pets etc. IFH has also produced teaching resources on home hygiene,[291,294] which present home hygiene theory and practice in simple practical language which can be understood by community workers with relatively little infection control background.

16. RESPONDING TO THE CHANGING HYGIENE CLIMATE – THE WAY FORWARD

There is no doubt that preventing the spread of infectious diseases is a serious global concern. At the global level the WHO 2007 World Health Report elected to focus on the need for collective international efforts to face emerging diseases.[295] The document analyses threats to public health from previous centuries and examines how new threats can be managed. Since the 1970s, 39 new diseases have emerged in the world, a rate of one a year. The report states that it would be "extremely naïve and complacent to assume that there will not be another disease like AIDS, another Ebola, or another SARS, sooner or later". The report examines lessons learned from these and other diseases, as well as pandemic preparedness to avian flu and potential new threats. The document concludes with recommendations which it says are vital to head off future threats to global public health. These recommendations include open sharing of knowledge, technologies and materials, global responsibility for capacity building within the public health infrastructure of all countries, and increased global and national resources for prevention campaigns.

In the 2007 ECDC report on the state of infectious diseases,[296] the authors concluded that, although EU countries are generally doing well in the fight against infectious disease, there is no room for complacency particularly in areas such as healthcare associated infections, antibiotic resistant bacteria and the threat posed by influenza and pneumococcal infections.

Although international, regional and national authorities are now recognising that infectious disease prevention must be a responsibility which is shared by the family and community, and are beginning to invest in programmes to develop and promote hygiene, IFH believes that, if these programmes are to be successful in achieving behaviour change, a number of issues need to be addressed.

16.1 THE NEED FOR A FAMILY-CENTRED APPROACH TO HYGIENE

Across Europe, public health is currently structured such that the separate aspects of hygiene – food hygiene, personal hygiene, hand washing, pandemic flu preparedness, patient empowerment etc – are dealt with by separate agencies. This means that the information which the family receives is fragmented and largely rule-based. If things are to change we must recognise that fragmented knowledge is not enough to meet the challenges we currently face. Hand hygiene, e.g. is a central component of all hygiene issues and it is only by adopting a holistic approach that the causal link between hands and infection transmission in the home can be properly addressed. There is a need for the various agencies to work in partnership in order to promote an approach to hygiene that is family-centred rather than issue-oriented. At the very least we need to ensure that the principles of infectious disease transmission and the role of hygiene are part of the school curriculum. In line with this the EU funded e-Bug project is working to roll out education on antibiotic resistance and hygiene at primary and secondary school level across Europe.[214] We also need to work more closely with the private sector who make considerable investment in communicating with consumers about hygiene and hygiene products, in order to ensure continuity of information.

Although we are seeing increasing emphasis on “patient empowerment” as part of strategy to reduce healthcare-associated infections, the evidence suggests that “patient” empowerment is not enough, the need is for family empowerment. In response to the need for education on respiratory hygiene, ECDC has produced an “Influenza Communication Toolkit”[297] for use by health communicators in devising campaigns to tackle seasonal influenza. In November 2007, the UK launched a winter communications campaign to encourage the public to practise correct respiratory and hand hygiene when coughing and sneezing.[298]

16.2 ENGAGING THE FAMILY AND CHANGING ATTITUDES AND BEHAVIOURS

In recent years, hygiene has had a somewhat negative image in the developed world and has come to be seen as old-fashioned and disciplinarian. We need to make hygiene more appealing to the public by realigning it alongside positive attributes of health and well-being. Persuading the public of the need to share responsibility without being accused of shifting blame may however be a significant challenge.

At global, regional and national level, because the separate aspects of hygiene (e.g. food hygiene, hand washing, care of those who are infected or who are at increased risk of infection) are promoted separately, this means, as stated above, that the family tends to receive information which is fragmented and largely rule-based. This in turn means that knowledge cannot be adapted to meet new situations as they arise – rules about food hygiene are hardly applicable to preventing transmission of flu in a global pandemic situation. At local level, there is urgent need to build capacity for hygiene promotion; community workers who understand their community are best placed to develop hygiene programmes, but need leadership and support to achieve this.

In recent years, a significant amount of research has been done to identify strategies for changing hygiene behaviour. Whereas those who manage hygiene improvements often choose to promote hygiene by educating people on the links between hygiene and health, one of the lessons which has been learnt, is that traditional approaches can raise awareness, but do not necessarily change behaviour. If practices such as hand washing etc are to become a universal norm, a multi-dimensional promotion which engages the public is needed to persuade people to change their behaviour. Whilst we recognise that this aspect is fundamental, it is outside the scope of this report and is reviewed elsewhere.[299,300,301, 302,303]

16.3 A RISK-BASED APPROACH TO HOME HYGIENE

In the healthcare system, disease reduction is considered as the gold standard for assessing the effectiveness of clinical and other health interventions. By contrast, in the industrial field, it is now well accepted (and well proven) that the cost-effective means to achieve quality (absence of microbial contamination) in products is by a risk management approach which ensures that "critical control points" within the process are "under control". Currently, there is a tendency to demand that data from intervention studies should take precedence over data from approaches such as risk assessment. Although there are those who still adhere to this, it is accepted increasingly that, since transmission of pathogens is highly complex, involving many different pathogens each with multiple routes of spread, infection control policies and guidelines must be based on the totality of evidence including microbiological and other data. This is particularly important for home hygiene, there is little or no intervention data available and the size and thus cost of intervention studies is prohibitive.

This approach is supported in a recent document produced by the UK Health Development agency.[304] Based on a literature review there was general agreement from the authors of this report who concluded, "Although the randomised controlled trial (RCT) has the highest internal validity and, where feasible, is the research design of choice when evaluating effectiveness. However, many commentators felt the RCT may be too restrictive for some public health interventions, particularly community-based programmes. In addition, supplementing data from quantitative studies with the results of qualitative research is regarded as key to the successful replication and ultimate effectiveness of interventions".

16.4 INTEGRATING HYGIENE INTO WATER AND SANITATION PROGRAMMES IN DEVELOPING COUNTRIES

In developing countries, the danger of emerging infections like AIDS, SARS, etc, not withstanding, the huge burden of hygiene and sanitation-related infectious diseases (diarrhoeal, vector-borne and respiratory diseases) continue to be the most critical public health threat. It has been amply demonstrated however, that the installation of water supply and provision of toilets, go only part of the way towards improving the health status of a community. If the full benefits are to be realised, changes in attitudes must be achieved, and programmes of health and hygiene education must be implemented in conjunction with improvements in water supply and sanitation. In prevention of diarrhoeal diseases, it is improved hygiene – keeping faecal matter away from hands and food and from water itself when it is stored in the home – that transforms health. In developing countries almost all water-borne, water-based and water-washed diseases are spread through exposure of food and drinking water to human faeces. In reducing the burden of respiratory diseases, it is act of hand washing with soap and water which breaks the chain of infection transmission.

In translating water quality and sanitation improvements into a reduced burden of skin, eye and respiratory as well as diarrhoeal infections, we need a "holistic" approach which addresses all of the inter-related issues of hygiene behaviour in the home including hand washing, food and water safety (point of use treatment, storage and handling of water etc), personal hygiene, laundry, safe disposal of refuse etc.

The implementation for the International Decade for Water Supply & Sanitation in the developing countries during the 1980s and subsequent programmes on community water supply and sanitation during the 1990s was conspicuous by an unbalanced approach with investment on water supply hardware far outweighing the same on sanitation and hygiene. Efforts for improvement of hygiene education and promotion of behaviour change were extremely inadequate. The decade was for most of the developing countries in Asia and Africa was a story of misplaced priority, lost opportunity and unfinished agenda.

Even now, in most developing countries of Asia and Africa, public health concerns still focus on municipal services, hospitals, environmental sanitation, etc. There is a reluctance to acknowledge the home as a setting of equal importance in the chain of infectious disease transmission in the community. Managers of home hygiene and community hygiene need to act in unison to optimise return from efforts to promote public health. Promotion of hygiene behaviour in the domestic setting is possibly the most cost-effective among all preventive public health measures in developing countries today. A cost-effective analysis, commissioned by the International Scientific Forum on Home Hygiene (IFH)[305] revealed that hygiene improvements can prevent the death of a child at only a fraction of the cost of community water supply and sanitation in the developing regions of the world. A hygiene education programme that reaches household with children under the age of 5 years, with illiterate mothers, and without safe sanitation, i.e. at least 30 million households worldwide, is estimated to prevent about 0.6-1 million deaths per year. In a 2008 study conducted by Sulabh International Academy of Environmental Sanitation in collaboration with IFH SEA, it was observed that the perception and practice of hygiene in the homes of the community have a stronger coefficient of correlation with the burden of infectious diseases of community compared to that of community water supply and provision of toilets.[282]

Much of the focus in developing countries at the present time is on investment in community water supply and sanitation in order to meet the Millennium Development

Goals, but if the health benefits from achieving these goals are to be realised, sector professionals must look beyond provision of water supply hardware and toilet facilities. The IFH concept of holistic and targeted hygiene together with the implementation of hygiene behaviour change programmes at community and family level, in conjunction with the Community Water Supply and Sanitation (CWSS) programme could be the key to future progress.

16.5 BALANCING THE RISKS AGAINST BENEFITS OF HYGIENE

In recent years, increasing attention has been given by the media to risks associated with hygiene. These include the perceived risk of being too clean, concerns about toxic and environmental effects of cleaning and disinfectant products, and the possibility of links between disinfectant use and antibiotic resistance.

Although media coverage of the hygiene hypothesis has declined, a strong "collective mindset" has become established that dirt is "good" and hygiene somehow "unnatural". Although there is good evidence that microbial exposure in early childhood can protect against allergies, there is no evidence that we need exposure to harmful microbes or that we need to suffer a clinical infection.[306,307] There is also no evidence that hygiene measures such as hand washing, food hygiene etc are linked to increased susceptibility to atopic disease.[306] A consensus is now developing amongst experts that the answer lies in more fundamental changes in lifestyle that have led to decreased exposure to certain microbial or other species, such as helminths, that are important for development of immuno-regulatory mechanisms.[308, 309] There is still much uncertainty as to which "lifestyle" factor/s are involved. There is also no evidence to suggest, as often stated in the media, that we need to get regular infections to boost our general immunity to infection. Another key question is whether use of disinfectants is encouraging the emergence of "superbugs". Although laboratory experiments demonstrate links between exposure to biocides and increased resistance to antimicrobials, as yet there is no evidence that use of biocides in the community is linked to emergence and spread of antibiotic resistance.[310] Although it is vital that we continue to research these issues, it is important to avoid overemphasising them at the expense of ensuring that the public understand the risks of not doing hygiene properly.

17. CONCLUSIONS

Overall the data presented in this paper indicates that infectious disease is a continuing and significant burden on the health and prosperity of the global community. Indications are that the burden of ID could be significant reduced by better standards of hygiene practice, although in many cases it is difficult to assess which are the key interventions and it is likely that this varies between and within different local or global, areas, regions and communities.

It is now apparent that controlling infection needs to be addressed, not just in healthcare settings or in association with food hygiene, but right across the community. If efforts to promote hygiene at community level are to be successful in changing behaviour, we need a concerted family-centred approach to ensure that a basic understanding of infectious disease agents and their mechanisms of spread, together with an understanding of a risk-based approach to hygiene is promoted, as part of the school curriculum and as part of public health campaigns. Alongside this we also need unambiguous communication with the public on issues such as the hygiene hypothesis and environmental issues.

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