

HEALTH, ENVIRONMENT AND THE BURDEN OF DISEASE; A GUIDANCE NOTE



Sandy Cairncross
Dominic O'Neill
Anne McCoy
Dinesh Sethi

Contents

Executive summary	2
Water supply, sanitation and hygiene promotion	3
Indoor air pollution (IAP)	3
Injuries	4
Improving health through the environment	4
Part I: Introduction	6
1 Health, environment and the burden of disease	6
2 Setting priorities in environmental health	9
2.1 A sequence of questions	9
2.2 Illustration of the approach	13
2.3 Everyone is responsible and has a part to play	14
Part II: Three key areas of environmental health	15
3 Water supply, sanitation and hygiene promotion	15
3.1 Introduction	15
3.2 The other benefits of water supply	15
3.3 The other benefits of sanitation	16
3.4 Impact on diarrhoeal disease	16
3.5 Other health impacts	19
3.6 Policy implications and interventions	20
4 Indoor air pollution	24
4.1 Introduction	24
4.2 Association between IAP exposure and disease outcomes	25
4.3 Interventions to reduce IAP	27
4.4 Implementation of IAP reduction interventions	31
4.5 Conclusions	31
5 Injuries	35
5.1 Background	35
5.2 Road traffic injuries	37
5.3 Drowning	39
5.4 Falls	41
5.5 Burns	42
5.6 Conclusion	43
Part III: Implications	46
6 Improving health and environment	46
6.1 Health, environment and the Millennium Development Goals	46
6.2 The pathway to improve environmental health	48
6.3 Conclusion	52
Appendices	53

Executive summary

Good health is both an end and a means of sustainable livelihood. For poor households, health is an essential asset in the pursuit of their livelihood, but their home and work environment often threatens their health. Improving environmental conditions which affect health is therefore basic to the creation of sustainable livelihoods and the elimination of poverty.

Progress towards the key Millennium Development Goals (MDGs) will be accelerated through improved environmental health conditions, in particular the MDGs for child health, access to water and sanitation and environmental sustainability. While many other interventions may also accelerate progress, the multi-sectoral approach to environmental health offers cost effective and sustainable improvements.

Environmental risk factors account for 21% of the overall burden of disease worldwide, and

more in developing countries. Some 1.7 million young children die each year from diarrhoea associated with inadequate water supplies, sanitation and hygiene and a further 1.4 million child deaths from respiratory infections are attributable to indoor air pollution. Environmental improvements are often more cost-effective as health measures than curative health services. After all, prevention is better than cure.

This Guidance Note examines the conditions which determine whether an environmental hazard is responsible for a substantial amount of disease, and whether feasible measures are available to prevent it. It considers three problems which account for nearly three quarters of the environmental burden of disease:

- Water, sanitation and hygiene
- Indoor air pollution, and
- Injuries.

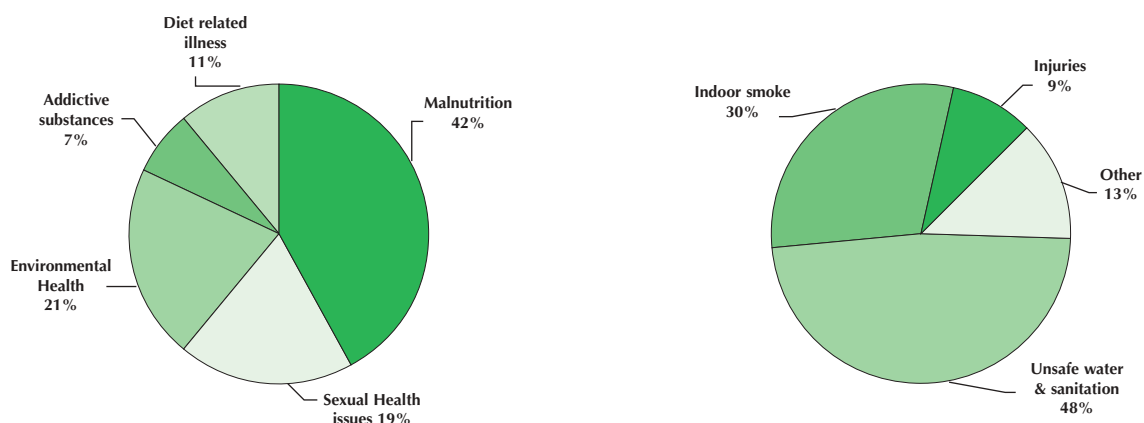


Figure 1. Global burden of disease according to (a) types of risk, showing the 21% associated with environmental health, and (b) the distribution of that environmental proportion (WHO 2002)

Water supply, sanitation and hygiene promotion

Water supply and sanitation contribute to various MDGs such as those for child mortality and urban poverty, but there are also MDGs to halve the proportion of people lacking water and sanitation by 2015. Water and sanitation are about much more than health. They offer substantial benefits, especially to women, who save time spent carrying water (or money spent paying vendors) and avoid the shame and danger of open defecation. Even poor people are willing to pay for these benefits. Using cross-subsidies, water and sanitation should pay for themselves.

Most endemic diarrhoea is not water-borne, but transmitted from person to person because of poor hygiene practices. Water supply hardware therefore needs to be accompanied by sanitation and hygiene promotion to realise its full potential as a public health intervention.

Sanitation's impact is greatest when children's excreta are also managed hygienically, and is probably greater in dense urban settlements. There is a health benefit to the individual, but also to the community as a whole; this means that there are externalities, which justify public intervention.

Hygiene promotion is particularly cost-effective, once the facilities are available for it to be practised; the promotion of washing one's hands with soap can reduce diarrhoea by over 40%.

Water and sanitation can also help to control other diseases, such as blinding trachoma, intestinal worms and dengue.

Providing water supplies is more an issue of governance than a technical one. In rural villages, the institutions of local government are often weak or non-existent, but they are needed to maintain community infrastructure.

In towns and cities, municipalities have few resources, less autonomy and little incentive to meet the needs of low-income groups. Private utilities also need financial or contractual incentives for them to provide services to the poor.

Sanitation offers a particular challenge because people must be persuaded to install and use it. This requires market research, affordable designs, consumer choice and probably a partnership with organizations experienced in marketing. Hygiene promotion also can benefit from a marketing approach.

Indoor air pollution (IAP)

Half the world's population burns low-grade fuels such as dung, wood and crop residues for cooking and heating. The levels of air pollution found in their houses are many times the maximum levels found or permitted with outdoor air pollution. This has serious health consequences, especially for women and children who are most exposed to the indoor smoke.

There is now good evidence that IAP causes an increased incidence of acute respiratory infections. The risk increases with the degree of pollution and the time spent in contact with it. There is increasing evidence to suggest that it also causes chronic obstructive lung diseases such as emphysema in adults, as well as various forms of cancer, some eye diseases, and possibly tuberculosis. Exposure to IAP in pregnancy also leads to low birth weight babies, which are more likely to die in infancy.

There are other benefits to improved use of energy in the home; open fires are dangerous, and collecting the fuel involves hours of drudgery. Their inefficient combustion wastes fuel and contributes to greenhouse gases.

However, the issues are very complex. A stove designed to save wood is not necessarily less

polluting, and it is not clear that improved stoves are the best way to improve health; a promising alternative is to install a ventilation hood over the existing stove or fire, or to improve house ventilation in other ways. Another option is to change to cleaner fuels, but these are often more expensive. No intervention has yet been implemented on a large scale and shown to reduce the health problems associated with IAP.

Like sanitation, the control of indoor air pollution will probably require a marketing approach, as people will need to be persuaded to modify their houses and their behaviour. Meanwhile, there is a need for more research into the health effects of IAP, and most importantly into developing appropriate and effective interventions to reduce it.

Injuries

Injuries cause nearly 6 million deaths a year, and the toll is increasing. Death and disability from injury occur disproportionately among children and the poor. Though they consume about 1-2% of GDP in many poor countries, they have been neglected and little done to prevent them. Part of the problem is that injuries, particularly non-fatal ones, often go unreported.

Excluding intentional injuries (such as those due to homicide, suicide and war), *traffic injuries* are the main cause of death, causing a million deaths a year, 85% of which occur in developing countries. While road traffic fatalities have fallen in the industrialised countries, they are increasing rapidly in the developing world. In South Africa, for instance, they are now the leading cause of death of children more than one year old.

Measures to reduce the toll of road accidents include infrastructure (such as kerbs to separate pedestrians from vehicles), legislation and its enforcement (e.g. vehicle

roadworthiness inspections, drunk driving legislation) and public education (e.g. of schoolchildren). The latter has been shown to work only if accompanied with environmental and legislative changes.

Drowning causes a further half million deaths. The death rate from drowning in children under five is highest in China, where it is more than ten times higher than in developed countries. Evidence from Europe and North America suggests that it is highest among the poor. Measures to prevent it include teaching children to swim, and safety barriers around drainage canals.

Falls are another important cause of injury. In fact, among children aged 5-14 years they are associated with more years of healthy life lost than any other cause. Falls often occur at home, though work-related falls are also important as a cause of death and disability in developing countries. Both can be reduced to some extent by legislation, such as building regulations and occupational safety legislation.

Burns usually occur in the home and are most common among women. They are associated with cooking stoves, and often with the ignition of loose clothing. Among children, they are most often associated with scalding by other hot fluids. Better design of cooking stoves, and their use on a raised surface are promising interventions.

However, in developing countries the need is for improved surveillance to show decision makers the importance of the problem, and research to improve the evidence base for of injury prevention strategies.

Improving health through the environment

The final part of this Guidance Note considers how DFID and its partners can act to improve the health of the poor through improving

environmental conditions. There are five main types of approach which can improve environmental health:

- Achieving effective behavioural change
- Improved governance, including regulation and legislation where appropriate
- Improved service delivery
- Appropriate infrastructure
- Finance and social marketing

Achieving behavioural change is not straightforward and should not be undertaken lightly; it should be preceded by thorough formative research to ensure the intervention is well designed. This is likely to take several months. There is a shortage of good evidence on its effectiveness, but we do know that it can be highly cost-effective.

Improved governance, in particular improved regulation and legislative frameworks, have excellent track records as environmental health measures, but they must be properly implemented. Often, all that is needed is the implementation of existing regulations. Nevertheless, it is more likely to be effective if it reflects a social consensus, and health promotion can help to achieve that.

Improved service delivery can ensure better access for the poor to essential environmental health services. This is required both in the urban and rural environments. Essential environmental health services include water and sanitation, solid waste management and drainage, food safety and occupational health and safety.

Appropriate infrastructure such as water supplies, home improvements and safety barriers often offers benefits beyond health, but such “hardware” needs to be accompanied by “software” such as health promotion, institution building and legislation to make it sustainable. This approach requires multi-sectoral collaboration if it is to succeed. Where the infrastructure is to be in the home (e.g. latrines, cooker hoods), a gender-sensitive marketing approach is required.

Finance and social marketing. As well as changing behaviour, improving environmental health often requires an improved or new product to be purchased at the household level e.g. a toilet, soap, hygienic water containers, improved stoves. In order to persuade people to use these products it is important to understand what people will like about them and how they will be able to pay for them.

Part I: Introduction

1 Health, environment and the burden of disease

Good health is both an end and a means of sustainable livelihood. For poor people, good health is an essential asset in the pursuit of their livelihood, but their home and work environment often threatens their health. Improving environmental health is a sustainable and cost effective means of improving people's health and is therefore basic to the creation of sustainable livelihoods and the elimination of poverty.

The World Health Organization has estimated (WHO 2000) that environmental health hazards account for 21% of the overall burden of disease worldwide. The vast majority of this is in developing countries, and the environmental proportion is greatest in the poorest regions of the world (Figure 1.1). Environmental improvements are often more

cost-effective as health measures than the curative efforts of the health sector. After all, prevention is better than cure.

This is illustrated by the analysis of a World Bank economist (Listorti, 1996), considering the urban environment, where most environmental health problems are man-made and therefore preventable. He calculated that infrastructure improvements, by improving urban environmental health, could prevent up to 44% of the burden of the disease in the cities of the developing world, compared with the estimate (World Bank 1993) that basic health services could have an impact on only 32%, and at greater cost.

The breakdown by disease type of the global disease burden attributable to the environment

Burden of Ill-Health by Region

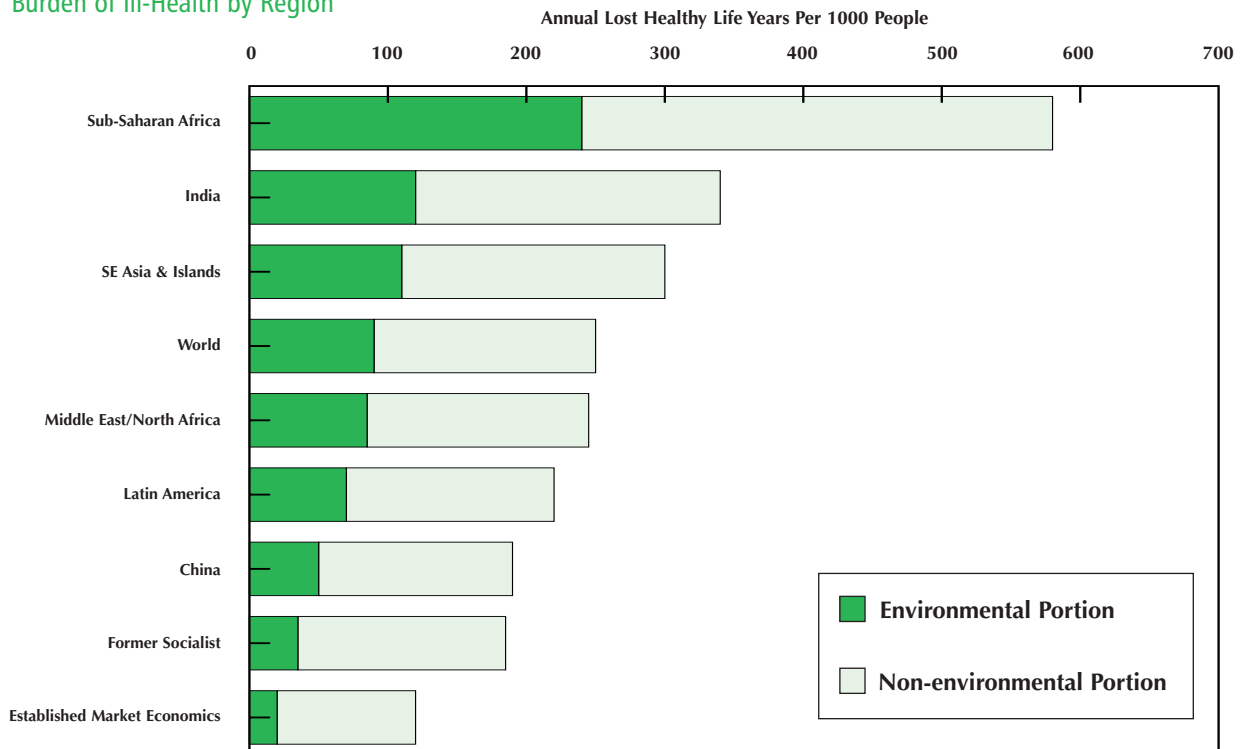


Figure 1.1. The burden of disease (in DALYs lost annually per thousand people: see Appendix 1) and its environmental component, by region.

What is environmental health?

The environment in which we live greatly affects our health. The household, workplace and outdoor environments can pose a variety of hazards to health, from contamination of the air we breathe, the water we drink and the food we eat, to the risk of accidental injury from vehicles or unsafe housing. Environmental health workers seek to control the risks to health by efforts to ensure that the natural and built environments are free of undue hazards, and by providing essential environmental services to households and communities. These services can include:

- Sanitation (in the narrow sense of excreta disposal)
- Water supply
- Hygiene promotion
- Air pollution control (indoor and urban)
- Storm water drainage (and flood prevention)
- Solid waste management
- Hazardous and clinical waste management
- Food management and inspection
- Implementation of building regulations
- Vector control (e.g. of rats, mosquitoes)
- Occupational health and safety management
- Road safety management

is shown in Figure 1.2. For the poor, the current environmental burden of disease comes mainly from “traditional” environmental health hazards such as diarrhoea due to lack of access to water & sanitation, and respiratory illnesses due to poor indoor air quality.

However, poor people in developing countries now face “modern” environmental health hazards such as industrial pollution and hazardous waste which are becoming alarmingly and increasingly significant. This means that they experience a double burden of disease, with exposure to both traditional and modern hazards occurring in the same place. This is the case in rapidly expanding urban areas where informal housing and industrialisation are increasing without appropriate planning and regulation.

With regard to the “traditional” burden of disease, more than a quarter of the total is associated with diarrhoeal disease, attributable to deficiencies in water supply, excreta disposal

and household hygiene. More than 99.8% of deaths associated with this risk factor are in developing countries, and 90% are deaths of young children.

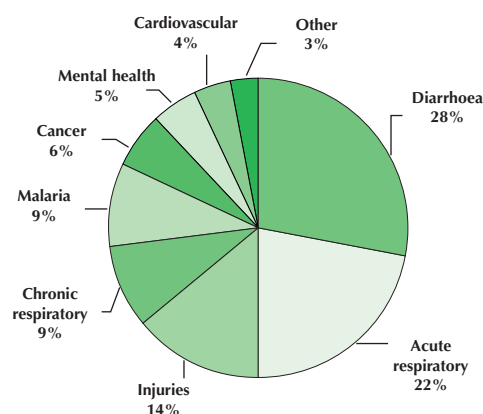


Figure 1.2. Breakdown of the global burden of environmentally related disease. Nearly three quarters is attributable to diarrhoea, respiratory disease, and injury

A similar proportion is represented by the acute and chronic respiratory disease caused more by indoor than outdoor air pollution. Nearly half the world cooks with solid fuels such as dung, wood or coal, and usually without a chimney. This includes more than 75% of the populations of China and India, and more than half in parts of South America and Africa. Studies suggest that indoor smoke causes about 36% of the lower respiratory tract infections which cause 3.9 million deaths each year.

A further 14% is due to injuries, of which the most common cause is road traffic accidents. Road traffic injuries were estimated to account for over 1.2 million deaths in 2000, of which

over 90% occurred in low and middle income countries.

Three problems therefore account for nearly three quarters of the environmental disease burden. They are:

- (i) water, sanitation and hygiene;
- (ii) indoor air pollution; and
- (iii) injuries.

These three categories are considered below in this Guidance Note. First, however, a few words are required about the evidence and the process for setting priorities in environmental health.

References

Listorti JA 1996. Bridging Environmental Health Gaps. AFTES Working Papers nos 20-22. Urban Environmental Management, Africa Technical Department. Washington DC: The World Bank.

WHO 2000. World Health Report 2000; Health Systems, Improving Performance. Geneva: World Health Organization.

World Bank 1993. World Development Report 1993: Investing in Health. Oxford: Oxford University Press for the World Bank. Table 2, p. 10.

2 Setting priorities in environmental health

2.1 A sequence of questions

Environmental health seeks to reduce people's exposure to environmental factors which cause disease. For the reduction of a particular factor

to be a high priority, there is a sequence of questions which must be answered in the affirmative. These are illustrated in Table 2.1 and discussed below.

Concept	Key question	Example
Hazard	Could exposure cause disease?	Irrigation with wastewater is a hazard, as faecal pathogens can get onto edible crops, but it may not cause any disease because of immunity, cooking, crop restrictions etc.
Relative risk	Does exposure cause disease?	People exposed to ionising radiation are more likely to contract cancer, but if hardly anyone is exposed, that may not be a high priority nationally
Attributable risk	How much disease is associated with exposure?	Heavy smoking increases the risk of death from lung cancer by 25 times, but only doubles the risk of heart disease. However, smoking kills more people by heart disease because heart disease is far more common.
Attributable risk	Who is most exposed or most vulnerable to the hazard?	Poor people are more likely to be run over and killed because their neighbourhoods lack kerbs to separate pedestrians from vehicles.
Disease burden	How important is this disease in the whole picture?	Diarrhoea in the UK is a minor nuisance, typically causing 2 days of lost work. In developing countries it kills 2 million children a year.
Intervention		
Available	Does the intervention reduce exposure?	It is not yet clear that improved cooking stoves reduce people's exposure to indoor air pollution.
Affordable	Can poor people afford to buy the product / service?	Latrines built to engineers' specifications are often too expensive for the poor.
Cost-effective	Is prevention more cost-effective than cure? More than other health interventions?	Fly control by insecticide can prevent 23% of diarrhoea, but costs hundreds of dollars per village per year. Promoting handwashing is cheaper, and prevents more than 40%.
Practically feasible at scale	Has the intervention been successfully taken to scale?	Solar disinfection of water has been introduced at community level by researchers and NGOs, but it has not yet been successfully promoted throughout an entire district or region.
Locally appropriate	Is the intervention acceptable in local conditions? Do local institutions have the capacity and will to implement it?	Composting toilets have been introduced at scale in Northern Vietnam where there is a culture of nightsoil use in agriculture, but have not worked in the South where latrines are built over fishponds.

Table 2.1. Concepts and the sequence of key questions which determine priorities in environmental health

Hazard.

This might seem the easiest question to answer, but historically the significance of many environmental exposures as hazardous to health has only been confirmed after extensive debate. The waterborne transmission of cholera in the nineteenth century, and more recently the impact of passive smoking and indoor air pollution, are examples of this. Other exposures (such as unpleasant smells, or miasmas), once considered hazardous, have subsequently proved to be innocuous.

Relative risk.

This epidemiological term refers to the ratio of disease rates between those who are exposed and those who are not. Epidemiologists can demonstrate an *association* between exposure and disease, but it is harder to prove that one *causes* the other.

This is particularly a problem with *observational studies*, in which people who happen to be exposed are compared with people who are not. The problem arises when exposure is associated with some other factor (such as poverty) which causes disease in other ways. For example, an epidemiologist might find that people with televisions suffer less disease; this does not mean that televisions protect our health, but that those with televisions are richer, better educated and for other reasons less likely to become ill. This phenomenon is called *confounding*. It is possible to “adjust” or “control” for confounding using multivariate regression models. This reduces, but *does not eliminate confounding*.

The only way to be sure of eliminating confounding and proving causality is an *intervention study*, in which the exposure is deliberately changed for one group of people, whose health is compared with a “control” group for whom exposure is not changed. However intervention studies are especially difficult in environmental health, because it is

difficult to alter the environment of a random group of individuals.

Attributable risk.

Even when a causal link has been established, it may not merit high priority if it does not cause a significant amount of disease. It may be that the exposure is fairly common but the disease extremely rare. For example, many rural households in Britain consume water with excess nitrates, which is known to cause methaemaglobinaemia (blue baby disease) in infants. However, on average there is less than one case per year in the UK, and the disease is treatable.

Vulnerability.

The poor are usually most exposed and also most vulnerable to environmental health hazards, especially women and children. They live in hazardous areas, such as neighbourhoods subject to flooding and infested with rats, mosquitoes and other disease vectors. They also work in hazardous jobs, which other people avoid, and their poor nutritional status renders them more susceptible to disease. Their livelihoods are also more vulnerable to the shocks of disease. If people are unable to work because they are ill or caring for those who are ill, they lose income and sometimes their jobs. It is therefore often desirable for preventive interventions to target the most vulnerable groups.

It may also happen that exposure is rare, although causing a high rate of attributable disease among a small group of people who are exposed. This is particularly true of occupational exposures. In such cases, an intervention targeted to that group is likely to be more cost-effective than one addressed to the whole population. For example, municipal sanitation and solid waste workers are likely to be exposed to intestinal worms, hepatitis, typhoid fever and plague, and would benefit from immunisations and regular de-worming treatments.

Disease burden.

Estimating the relative importance of different diseases is impossible without value judgements. Is the death of a two-year-old child a greater or lesser calamity than the permanent disability of a breadwinner aged 50? In an effort to reach a consensus on such questions, the Global Burden of Disease study (Murray & Lopez, 1996) developed the Disability-Adjusted Life Year, a common currency for the measurement of the burden caused by different diseases. For each disease, the total number of years of healthy life lost are estimated, and weighted by a factor ranging from 0 to 1.0 to express the degree of disability; they are also weighted to express a judgement that a year of childhood is worth less than a year of productive adulthood, which is worth slightly more than a year of old age. Further details are given in Appendix 1.

Given the design of the DALY, diseases causing death contribute more to the global burden

than those causing mild or temporary disability. Table 2.2 shows the leading causes of lost DALYs worldwide, from the Global Burden of Disease study. The groups of disorders most affected by the three types of environmental health intervention discussed below are highlighted:

- diarrhoeal diseases for water, sanitation and hygiene,
- lower respiratory tract infections for indoor air pollution control, and
- road accidents, falls, drownings and burns for injury prevention.

Of course, not all of the DALYs for a given group of diseases are necessarily preventable by environmental means. The figures in Table 2.2 have been updated from time to time in the World Health Reports issued by the WHO, although the evidence base for the adjustments made is not always clear.

Rank	Disorder	Number of DALYs (x106)	Rank	Disorder	Number of DALYs (x106)
1	Lower respiratory infections	112.9	16	War injuries	20.0
2	Diarrhoeal diseases	99.6	17	Self-inflicted injuries	19.0
3	Perinatal disorders	92.3	18	Tetanus	17.5
4	Unipolar major depression	50.8	19	Violence	17.5
5	Ischaemic heart disease	46.7	20	Alcohol use	16.7
6	Cerebrovascular disease	38.5	21	Drownings	15.7
7	Tuberculosis (not HIV)	38.4	22	Bipolar disorder	14.3
8	Measles	36.5	23	Pertussis	13.4
9	Road traffic accidents	34.3	24	Osteoarthritis	13.3
10	Congenital abnormalities	32.9	25	Cirrhosis of the liver	13.2
11	Malaria	31.7	26	Schizophrenia	12.8
12	Chronic obstructive pulmonary disease	29.1	27	Burns	11.9
13	Falls	26.7	28	HIV	11.2
14	Iron deficiency anaemia	24.6	29	Diabetes mellitus	11.1
15	Protein-energy malnutrition	21.0	30	Asthma	10.8

Table 2.2. Thirty leading causes of worldwide DALYs lost in 1990 (Murray & Lopez, 1997)

Intervention available...

Even if a substantial burden of disease has been shown to be attributable to an environmental factor, it does not always follow that we know how to reduce it. For example, it has long been known that airborne transmission of tuberculosis occurs in hospital wards, but it is only in the last few years that it has been shown that environmental improvements involving ultraviolet light can help to prevent it.

... affordable ...

Some of the environmental health improvements of the industrialised countries, such as flush toilets and refrigerators, are simply not affordable to poor people or to the governments of many poor countries. Where there is no chance of substantial subsidy, environmental health interventions (latrines, improved cookstoves or cooker hoods, etc.)

must be designed to suit the pockets of the poor, rather than the ideals of the engineers.

... cost-effective ...

Further work is required before a promising intervention can be shown to be effective at a reasonable cost in terms of dollars per DALY. Both cost and effectiveness are often context-dependent, so that there are dangers in picking only the interventions which are most cost-effective at global level. For example, water supplies are far cheaper in the Chinese coastal plain (where hand drilled wells can find water at shallow depth in the soft alluvium) than in the hard rock of West Africa. On the other hand, a new hand pump may have a far greater impact in an arid, guinea worm infested village in Nigeria than in rural China where 60% of households already have water in their yard, all drinking water is boiled, and few children die of diarrhoea.

Prevention can be as cost-effective as cure

A detailed modelling of the cost-effectiveness of water and sanitation hardware, and hygiene promotion software, as child survival interventions, was carried out by Varley (1996) for the USAID-funded Environmental Health Project. He concluded that whereas ORT cost typically \$24 per DALY saved and \$800 per death averted, the costs in the four environmental health scenarios were as follows:

Scenario	\$ / DALY	\$ / death averted
Software added to hardware	15.71	523
Hardware and software combined	320	10,655
Hardware alone	794	26,433
Software alone	29	966

... feasible ...

Interventions which are effective at experimental or pilot scale, or when implemented through the relatively intense involvement of an NGO, may not maintain this quality when implemented at a large scale. This is particularly true of measures involving behaviour change, or the acceptance of new equipment such as improved cooking stoves or latrines. The causes of this usually relate to human and institutional factors, rather than the technical characteristics of the intervention per se, but they still need to be taken into account as they are critical to success. Where large-scale implementation has already been achieved in other countries, there will be much to learn from that experience. Where it is being attempted for the first time, the exercise will be essentially experimental.

... and locally appropriate.

The importance of context in determining the cost-effectiveness of an intervention has been mentioned above. Culture is an important part of this - both the material culture of the population at risk, and the institutional culture of the institutions which will be called upon to implement preventive measures.

Bearing in mind that the evidence to respond to each of the key questions in Table 2.1 is often incomplete or imperfect, the order of priorities for environmental health in a given setting will often be unclear. In many countries, the most appropriate approach will be to look for areas where:

- there is a substantial attributable burden of disease
- proven and cost-effective interventions exist, but
- nothing is being done to implement them.

The first task is then to engage in advocacy to raise awareness that this is the case. Assessing all these factors in the context of a given country, and hence the priority to be allocated

to a specific environmental health intervention, will ultimately be a question of judgement. This Guidance Note seeks to support and inform that judgement.

2.2 Illustration of the approach

It was mentioned in the introduction that three areas of environmental health interventions are considered in detail below: water supply and sanitation, prevention of indoor air pollution, and prevention of injury. The position regarding these with respect to Table 2.1 can be summarised as follows.

Water and sanitation.

Lack of water supply, sanitation and hygiene is certainly a health hazard, and a substantial proportion of the global burden of disease is attributable to it. Well-tried preventive interventions are available. Hygiene promotion is a cost-effective intervention on health grounds alone, though water supply and sanitation are probably less so. Fortunately, the socio-economic benefits of water supply and sanitation are so significant that they are sufficient to justify the cost irrespective of the health impact. Water supply and sanitation programmes have successfully been taken to scale, but special attention is needed to ensure that sanitation is appropriate, and marketed appropriately, to elicit sufficient demand for it.

Indoor air pollution (IAP)

IAP is also a health hazard with a considerable attributable burden of disease. Some interventions are available which under experimental conditions reduce people's exposure, but it is not so clear that they would do so in the operational context of a large scale programme. No intervention has been taken to scale and at the same time demonstrated to reduce exposure, although a field trial and operational research is currently under way. There are good prospects for development of a workable intervention, because improved cooking stoves and

ventilation offer other benefits besides reductions in IAP.

Injuries

Injuries contribute to a substantial proportion of the burden of disease globally, and a number of hazards have been identified with which substantial attributable risks are associated. However, there is considerable uncertainty about the amount of disease burden in any specific country or setting, so that one priority is to improve surveillance. Moreover, the only evidence for the efficacy of the various possible interventions comes from industrialised countries and it is not clear which are likely to be the most cost-effective, or even most effective in developing countries.

2.3 Everyone is responsible and has a part to play

Some environmental health problems account for a huge burden of disease, but are largely intractable as it is not clear how best to address them. The magnitude of others may not be easily seen, as they only affect a minority of the population. This is especially true of occupational environmental health risks, such as work-related injuries, exposure at work to airborne particulates and carcinogens, and work-related noise. Only workers in

certain jobs are affected, but most of the risks, and the deaths and illness they cause, are easily preventable.

The three priority areas listed above account for much of the environmental burden of disease, but any project or programme which affects the environment is likely to have significant environmental health implications, for good or ill. These include roads and transport, energy, industrial development, urban infrastructure, dams, irrigation, and agricultural development. They all deserve an assessment of the opportunities and threats which they may present for environmental health as part of their environmental appraisal. Often a slight modification to an infrastructure project can enable it to make a major contribution to environmental health at negligible extra cost.

Similar opportunities also arise for promotional or legislative interventions whose beneficial impact on environmental health can be out of all proportion to their cost. An example is the recent introduction of unleaded petrol into Asian countries such as Thailand, where it has reduced the level of lead in urban children's blood (WHO 2002). That they are outside the three priority areas described above is not a reason to neglect them.

References

Murray C and Lopez A 1996. *The Global Burden of Disease*. Geneva: Harvard University Press, for the World Health Organization.

Murray C and Lopez A 1997. Mortality by cause for the eight regions of the world: Global Burden of Disease Study. *Lancet* 349:1269-76.

Varley R 1996. *Child Survival and Environmental Health Interventions; A Cost-Effective Analysis*, Environmental Health project, Applied Study No. 4. Washington D.C.:EHP for USAID

Part II: Three key areas of environmental health

3 Water supply, sanitation and hygiene promotion

3.1 Introduction

In contrast to the prevention of injuries and of indoor air pollution, discussed below, the technology for water supplies and sanitation is tried and tested, and its significance for public health is widely accepted.

In 2000, the percentage of people served with some form of improved water supply reached 82% of the global population, leaving 18% or 1.1 billion people unserved. Only 60% had access to basic sanitation facilities, leaving 2.4 billion unserved (WHO 2000). It has been estimated that 1.7 million deaths each year, or 3.1% of all deaths, are attributable to inadequate access to water, sanitation and hygiene (WHO 2002). Most of these are deaths of young children under 5 years old, from diarrhoeal diseases. The burden of disease attributable to unsafe water, sanitation and hygiene amounts to 54 million DALYs, or 3.7% of the worldwide total.

The team responsible for the above calculations used regional variations in water supply and sanitation coverage figures to estimate that the attributable burden amounted to about 230 DALYs/1,000 population in African Region of WHO, but less than 80 in the Americas and 22 in the Western Pacific, varying between 110 to 170 in different subregions of the Eastern Mediterranean and Southeast Asian Regions (Pruss et al. 2002).

Because of the health benefits, and other benefits of water supply and sanitation (discussed below), the twin targets of halving, by the year 2015, the proportion of people who are not adequately served by water supplies and by sanitation facilities have been adopted as Millennium Development Goals in their own right.

3.2 The other benefits of water supply

However, water supplies and indeed sanitation are about much more than health. They offer other benefits to which a money value can be attributed more easily than their health effect, and which often figure larger in the consumer's eyes. Some idea of the sustained transformation in a community's quality of life achieved by the simple provision of water can be gleaned from WaterAid's multicountry follow-up study (WaterAid, 2001) which found that social benefits as unexpected as improved marital relations were reported by the beneficiaries in so many settings and with such emphasis that they cannot be easily denied.

The saving in time spent by a household collecting water is typically half an hour to an hour per day. The time is mainly saved to women, and is a significant contribution to women's emancipation. It makes it possible for women to devote more time to child care, and there is evidence that this affects their children's nutritional status (Tomkins et al. 1978, Popkin & Solon 1976). Studies of how people decide whether to pay vendors for water to be delivered to their homes (Whittington & Roche 1990) have indicated that their implicit valuation of this time is of the same order as the local unskilled wage rate.

Some years ago, an analysis by the World Bank showed that, even if the health benefits of water supply were completely disregarded, the value of this time-saving benefit was enough to justify most investments in rural water supply, even at the relatively high level of service where each household had a piped connection (Churchill 1985).

It has been estimated that in urban areas, roughly 20 to 30% of the population purchase water from vendors. A multi-country study of water vending (Zaroff & Okun) found that the median household spent 20% of its income on this single item. The poorest of the poor pay the highest proportion of their income (Cairncross & Kinnear 1992). Households in this stratum would normally spend the vast majority of their income on food, so that money spent on water comes from their food budget. Providing water more cheaply than the vendors (which is not hard to do) can offer a substantial boost to their nutritional status.

Low-income groups are often unaware of the health benefits of improved water supplies, but they are acutely conscious of the time-saving benefit. As the widespread use of vendors shows, they are willing to pay for this time. This means that in all but the poorest communities, it is possible to charge for at least some of the cost of water supply. Indeed, using cross-subsidies it should be possible for the water supply sector to cover its costs at the level of each country.

3.3 The other benefits of sanitation

As in the case of water supply, people are often willing to invest in sanitation, even when they are very poor, but health rarely figures highly among their motives. For example, villagers in the Philippines gave the following responses when asked what they liked about their new toilets (Cairncross 1992). The responses are in descending order of frequency:

- Lack of smell and flies
- Cleaner surroundings
- Privacy
- Less embarrassment when friends visit
- Less gastrointestinal disease

There are also important gender-based

arguments in favour of sanitation, under three main headings:

Freedom from imprisonment by daylight.

In many cultures, the only time when women and girls can defecate, if they have no latrine, is after dark. Apart from the discomfort caused by the long wait until evening, this can cause serious illness.

Protection from harassment and rape.

The walk to the defecation field, often in the dark, is when millions of women run the risk of sexual harassment and assault.

School enrolment and attendance.

The lack of adequate, separate sanitary facilities in schools is one of the main factors preventing girls from attending school, particularly when menstruating. In Bangladesh, a Unicef-supported school sanitation programme increased girls' enrolment by 11%; what educational reform could achieve that? (Unicef 1999)

3.4 Impact on diarrhoeal disease

Ever since the sanitary reforms of nineteenth century England, water supply and sanitation have been widely acknowledged as essential components of public health. This is mainly because of their impact on diarrhoeal diseases, a major killer of young children. Two other facts are less widely known:

- Their impact at that time was largely on epidemics, particularly of cholera, and resulted largely from water quality improvements.
- However, the impact on the overall incidence of (and mortality from) endemic diarrhoeal disease was marginal.

In fact, child mortality rates in urban England throughout the nineteenth century were higher than in most developing countries

today. The pattern of diarrhoeal disease and death changed between the first and second World Wars, when increased access to in-house water supply and excreta disposal resulted in improved domestic hygiene.

Water supply

More recently, a number of studies from developing countries have pointed to the importance of ready access to water, and resulting increases in the quantity used for hygiene, rather than water quality improvements alone, in determining the health benefit. A complicating factor is that the quantity of water used is related in a non-linear and counter-intuitive way to the distance of the household from the water source. When water is provided closer to the home, water use increases until a plateau is reached at about 1 km. When water is provided closer than that, there is very little further increase

(Fig. 3.1) unless on-plot taps are provided, when water use doubles or trebles.

A number of studies in the last two decades failed to find any health benefit when water quality alone was improved (Feachem et al. 1978, Kirchhoff et al. 1982, Levine et al. 1976, Lindskog & Lundqvist 1989, Baltazar et al. 1988, Young and Briscoe 1988), while a large proportion of the classical studies which detected significant health benefits compared groups using in-house piped water with others using public taps or wells (Hollister et al. 1955; Wagner and Lanoix 1959). The negative studies usually surprised their authors, but the results were quite comprehensible when it came to be understood that most endemic diarrhoeal disease is not water-borne, but transmitted from person to person on hands, food and other fomites because of poor hygiene practices.

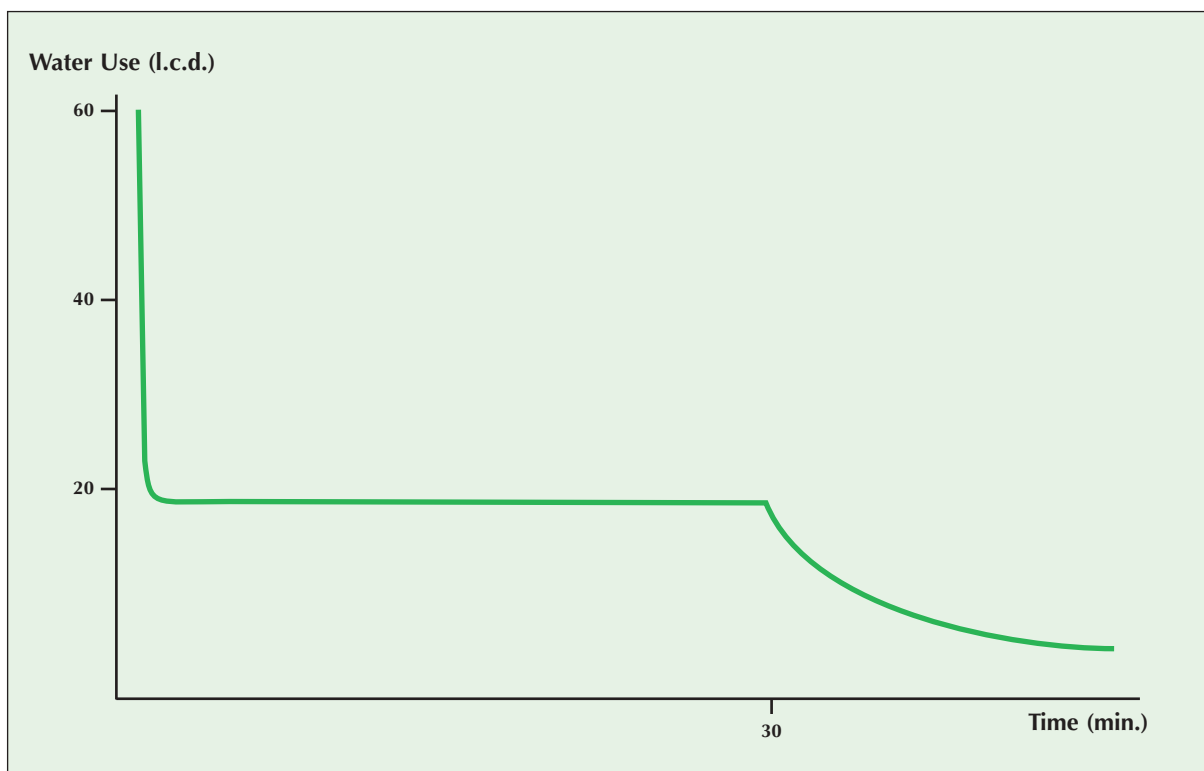


Figure 1. Typical relationship between water collection journey time and mean household water use.

Source: Cairncross & Feachem (1993) p. 63.

From this and other evidence, a consensus has gradually emerged that water supply hardware needs to be accompanied by measures to promote improved hygiene and sanitation if it is to realise its full potential as a public health intervention.

This consensus is not contradicted by the apparent emphasis in the World Health Report (WHO 2002) on the cost-effectiveness of disinfecting drinking water in the home as a diarrhoea prevention method. The studies on which it is based all involved hygiene education as an integral part of the package for promoting disinfection (WHO 2002, p 127). Of course, where water of doubtful quality is provided from a piped distribution system, disinfection can be effected more cheaply and usually more reliably at the water treatment works.

Sanitation

Similarly, the improved excreta disposal needs to be accompanied by measures to ensure it is used if it is to produce the optimal health benefits. In particular it is important to encourage the use of latrines by children, and for the disposal of toddlers' excreta. Children's excreta are more likely to contain diarrhoeal pathogens, but in almost every culture are regarded as less harmful than those of adults (Feachem et al. 1983).

It is also likely that sanitation has a greater impact on diarrhoea in dense urban communities where substantial faecal pollution is omnipresent, than in small rural settlements where defecation occurs far away from the residential area.

Moreover, sanitation bestows health benefits at two levels; there is a benefit to individual households which invest in a latrine, but a further and probably greater benefit to the community as a whole which collectively enjoys the advantages of sanitary infrastructure. This is illustrated in Fig. 3.2 by data from shantytowns in Salvador, Brazil (Moraes et al. 2002) showing that among children in households without toilets the incidence of diarrhoea is twice that among those who have sanitation; whereas among children in communities without sanitation infrastructure, it is three times greater than in otherwise similar, but sewered communities. Other studies (e.g. Baltazar et al. 1988) have found that, once community sanitation has reduced the level of faecal contamination in the environment, this increases the impact on child health of other measures such as improved water supply. This means that there are externalities in the health benefits of sanitation. Put another way, when a family installs a latrine, it not only protects them from their own excreta; it also helps to protect their neighbours. There is therefore a case for public measures (subsidy or regulation) to promote it. Individuals cannot be expected to pay for a benefit which others will enjoy.

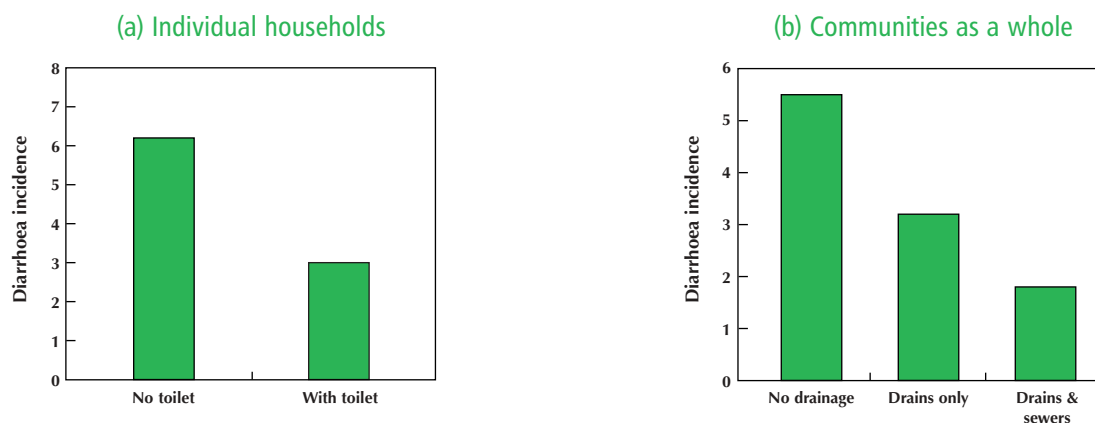


Figure 2 Impact on diarrhoea in young children of sanitation infrastructure, provided at (a) individual household level and (b) community level. Source: Moraes et al. 2002

The importance of context and hygiene behaviour

Thus, the health impact of a water and sanitation project depends closely on its context, and this can vary. It is likely that the health benefits of water and sanitation projects will be greater than the average when one or more of the following conditions is met:

- They provide on-plot water,
- The old water source was more than 1 km away,
- The setting for sanitation is a high density settlement,
- The sanitation is provided for the community as a whole,
- The facilities are used by all, especially by children,
- The provision of facilities is accompanied by improved hygiene practices.

There is some evidence that, where sufficient water is available to practice hygiene, the promotion of good hygiene can be a cost-effective intervention in its own right (Borghetti et al. 2002). It is even more so when it accompanies water supply and sanitation (Varley 1996)

Reviews of the literature on health impacts have normally treated "water supply" and "sanitation" as context-free black boxes and have not taken these factors into account (Esrey et al. 1985; Huttly et al. 1997; Prüss et al 2002). With that reservation, Figure 3.3 nevertheless shows how the reduction in diarrhoeal disease attributable to improved hygiene is likely to be greater than those to be expected from improvements in water supply alone. In particular, a recent literature review

(Curtis & Cairncross 2002) has found that the single hygiene practice of washing one's hands with soap is alone able to reduce diarrhoea incidence by over 40% and severe diarrhoeas (cholera, dysentery, and hospitalised diarrhoeas due to other causes) by over 50%.

This does not mean that only hygiene promotion is more cost-effective than water and sanitation, though it is cheaper. It is almost impossible to practise good hygiene without a ready supply of available water, and excreta disposal is hardly hygienic without sanitation. Water and sanitation are prerequisites for good hygiene. Besides, as mentioned above, water and sanitation have other benefits which can be offset against their cost.

3.5 Other health impacts

3.5.1 Water supply

Water supply improvements also help to reduce a number of other infectious diseases. For example, water supply is an essential element in the armoury of those currently engaged in the eradication of Guinea worm disease, now confined to a few countries in the Sahel and West Africa. There is also evidence that water availability helps to control skin and eye infections, including blinding trachoma (as these are prevented by washing of hands, face etc.), as well as schistosomiasis (caught when entering infected water to bathe), and dengue (transmitted by mosquitoes which usually breed in domestic water storage vessels). However, the majority - more than 90% - of the burden of disease attributable to water supply is associated with diarrhoeal disease (White et al. 1972).

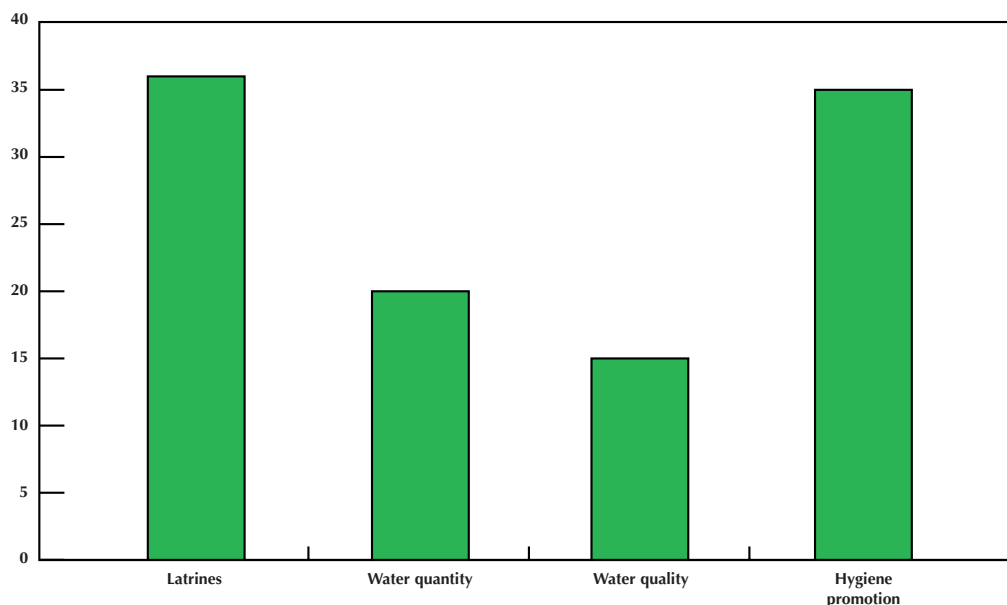


Figure 3.3 Reductions in diarrhoea risk from improvements in water quantity, water quality, sanitation and hygiene
Source: Esrey et al. (1985), Huttly et al. (1997)

3.5.2 Sanitation

Sanitation's role in preventing intestinal worm infections has been well documented since the research programme of the Rockefeller Foundation in the 1920s (Cort et al. 1930). In a typical poor community, more than half the population infected by one or more of four species of these worms; ascaris (known as roundworm), trichuris (whipworm) and the two hookworm species. They cause stunting of children's growth and impede their cognitive performance and development (Connolly & Kvalsvig 1993). A study in Lucknow, India (Srivastava et al. 1981) concluded that ascaris, through the damage its larvae do to the lungs, was responsible for 66% of the cases of childhood asthma in that city. Among adults the hookworms contribute to anaemia in pregnancy and hence to the toll of maternal mortality.

More recently, there has been a widespread initiative (Partnership for Child Development 1997), to support the control of these infections in school children by administering deworming drugs which kill the adult worms. This is not always a sustainable option,

however, as the children are quickly reinfected by the larvae which remain in the environment. The more sustainable option, adopted by Unesco, Unicef, WHO and the World Bank as the FRESH framework, includes school sanitation.

Other health benefits are less well known, such as the impact of sanitation on trachoma, the second leading cause of blindness worldwide. More than 70% (check) of this infection is caused by flies, of a species which prefers to breed in scattered human faeces. Latrines have been shown to reduce the population of these flies by depriving them of their breeding sites (Emerson 2002).

3.6 Policy implications and interventions

The programming and implementation of water supply, sanitation and hygiene promotion has been extensively described in the DFID Guidance Manual on Water Supply and Sanitation (WELL 1998). However, a number of key points deserve mention here.

One way to demonstrate the extent of the water problem for the poor is to document the extent of the water vending market. In general, though, the political pressure for water supply is already strong, so that advocacy can focus on the need for new approaches to the sector.

In rural areas and small communities, the construction of water supplies is a relatively simple affair, compared with the difficulty of organising a sustainable maintenance system. Maintaining community infrastructure is the task of local government, but in many rural communities, there is no local institution with legal powers needed to do this. Rural water supply is thus intimately bound up with the creation and empowerment of local government. Innovative solutions are needed, of the sort often developed by non-governmental organizations, to enable formal local government to collaborate with the more informal institutions likely to exist at village level.

Urban water supply is also a governance issue; the lowest income groups consume only a small proportion of the water supplied to a city, and its cost can usually be met by a modest surcharge on the tariff charged to the larger domestic consumers. Provision of a basic level of service, such as adequate public standpipes, to low-income groups is therefore not primarily a technical or financial problem, but one of political will to do so on the part of the municipality. Municipal water utilities can be given the dynamism of private companies

without necessarily privatising them, by giving them the autonomy to manage their own human and financial resources. Privatised utilities, on the other hand, need financial or contractual incentives for them to venture into the relatively high-risk and unprofitable business of providing services to the poor.

In some ways, sanitation is a complementary intervention to water supply, but for low-income groups it is unwise to implement it in the same way. Whereas water supply (a hand pump or public tap) is in the public domain and universally desired, a toilet (a pit latrine or pour-flush toilet) is installed on a family's private property, and householders may not always see one as a high priority. There is therefore a need to market sanitation, in much the same way as any other consumer product. This requires market research, affordable designs, consumer choice, and probably a partnership with private or voluntary sector organizations with more experience and capacity in this field.

Hygiene promotion also can benefit from a marketing approach. Government agencies may not be best suited to plan it, although government agencies which are in contact with the population (e.g. at schools and health centres) are important channels of communication. Formative research is an essential first step. This seeks to identify specific behaviour changes to promote, the motivational levers of change, the best communication channels, etc. It takes at least three months to complete.

References

- Baltazar J, Briscoe J, Mesola V, Moe C, Solon F, Vanderslice J, Young B 1988. Can the case-control method be used to assess the impact of water supply and sanitation on diarrhoea? A study in the Philippines. *Bull WHO* 66: 627-635.
- Borghi J, Curtis V et al. 2003. Is hygiene promotion cost-effective? A case study in Burkina Faso. *Bull WHO* (in press)
- Cairncross S 1992. *Sanitation and Water Supply: Practical Lessons from the Decade*. Water and Sanitation Discussion Paper No. 9. Washington DC: The World Bank.
- Cairncross S, Feachem R 1993. *Environmental Health Engineering in the Tropics; an Introductory Text*. 2nd edition. Chichester: John Wiley & Sons, p. 63.
- Cairncross S and Kinnear J 1992. Elasticity of demand for water in Khartoum, Sudan. *Social Science and Medicine* 34(2): 183-189.
- Churchill A. 1985. *Rural Water Supply and Sanitation; Time for a Change*. World Bank Discussion Paper No. 18. Washington DC: The World Bank.
- Connolly KJ, Kvalsvig JD 1993. Infection, nutrition and cognitive performance in children. *Parasitology* 107: S187-200.
- Cort WW, Otto GF, Spindler LA 1930. Investigations on *Ascaris lumbricoides* and the associated intestinal helminths of man in southwestern Virginia. *Am J Hygiene* 11: 1-55.
- Curtis V, Cairncross S 2002. Effect of Washing Hands with Soap on Diarrhoea Risk: a Systematic Review. *British Med J* (submitted).
- Emerson P 2002. PhD thesis, University of Durham.
- Esrey SA, Feachem RG, Hughes JM 1985. *Bull WHO* 63: 757-772.
- Feachem RG, Burns E, Cairncross S, et al. 1978. *Water, Health and Development: An Interdisciplinary Evaluation*. London: Tri-Med Books.
- Feachem RG, Bradley DJ, Garelick H and Mara DD 1983. *Sanitation and Disease; Health Aspects of Excreta and Wastewater Management*. London: John Wiley & Sons.
- Hollister AC et al 1955. Influence of water availability on *Shigella* prevalence in children of farm labor families. *Am J Public Health* 45 (3): 354-362.
- Huttly SR, Morris SS, Pisani V 1997. Prevention of diarrhoea in young children in developing countries. *Bull WHO* 75: 163-174.
- Kirchhoff LV, McClelland KE, Do Carmo Pinho M, Araujo JG, De Sousa M 1982. Feasibility And efficacy off in-home water chlorination in rural North-eastern Brazil. *J Hyg (Lond)* 94: 173-180.
- Levine RJ, Khan MR, D'Souza S, Nalin DR 1976. Failure of sanitary wells to protect against cholera and other diarrhoeas in Bangladesh. *Lancet* 2(7976): 86-89.

Lindskog P, Lundqvist J 1989. Why Poor Children Stay Sick; the Human Ecology of Child Health and Welfare in Rural Malawi. Research Report no. 85. Uppsala, Sweden: Scandinavian Institute of African Studies.

Moraes LRS, Cancio JA, Cairncross S, Huttly S 2002. Impact of drainage and sewerage on diarrhoea in poor urban areas in Salvador, Brazil. *Trans Roy Soc Trop Med Hyg* (in press).

Partnership for Child Development 1997. Better health, nutrition and education for the school-age child. *Trans Roy Soc Trop Med Hyg* 91: 1-2.

Popkin BM, Solon FS 1976. Income, time, the working mother and child nutrition. *Environ. Child Health* 8: 156-166.

Prüss A, Kay D, Fewtrell L, Bartram J 2002. Estimating the burden of disease from water, sanitation and hygiene at a global level. *Environmental Health Perspectives* 110: 537-542.

Srivastava VK, Malik GK and Agarwal SK. Ascariid infestation in asthmatic children. *Indian Journal of Parasitology* 1981; 5: 255-256.

Tomkins A et al 1978. Water supply and nutritional status in Nigeria. *Trans Roy Soc Trop Med Hyg* 72: 239-243.

Unicef 1999. Sanitation; a Right for Every Child. New York: United Nations Children's Fund.

Wagner EG, Lanoix JN 1958. Water supply for rural areas and small communities. Geneva: World Health Organization pp. 17-18.

WaterAid 2001. Looking Back. London: WaterAid.
www.wateraid.org.uk/site/in_depth/in_depth_publications

WELL 1998. Guidance Manual on Water Supply and Sanitation Programmes. Loughborough: WELL for DFID. www.lboro.ac.uk/well/resources/books-and-manuals/guidance-manual/guidance-manual.htm

White GF, Bradley DJ, White AU 1972. Drawers of Water; Domestic Water Use in East Africa. Chicago: University of Chicago Press.

Whittington D, Roche R. 1990. Calculating the value of time spent collecting water: some estimates for Ukunda, Kenya. *World Development* 18 (2): 269-280.

WHO 2000. Global Water Supply and Sanitation Assessment Year 2000 Report. Geneva: World Health Organization with Unicef for the WSSCC.

WHO 2002. World Health Report; Reducing Risks, Promoting Healthy Life. Geneva: World Health Organization

Young B, Briscoe J 1988. A case-control study of the effect of environmental sanitation on diarrhoea morbidity in Malawi. *J Epidemiol Commun Health* 42: 83-88.

Zaroff B, Okun DA. 1984. Water vending in developing countries. *Aqua* 5: 289-295.

4 Indoor Air Pollution

4.1 Introduction

In developing countries indoor air pollution (IAP) poses a significant threat to public health, particularly in rural communities (von Schirnding 2001). IAP results largely from the burning of low-grade fuels used for domestic cooking and heating. It is estimated that around half of the world's population and up to 90% of rural households in developing countries use unprocessed biomass fuels (animal dung, wood and crop residues) (World Resources Institute 1998). These fuels tend to be burnt indoors on open fires or low-efficiency stoves that are inadequately ventilated. This results in partial fuel combustion and the production of harmful pollutants and irritant gases, including carbon monoxide, particulate matter, sulphur dioxide, nitrogen dioxide, and various organic compounds (Zhang and Smith 1999).

Common levels of indoor exposure to IAP in Asia, Africa and the Americas are dramatically higher (Smith et al. 2000, Bruce et al. 2000, Ezzati et al. 2000a) than national standards set in industrialised countries. For example the average level of particulates measured in a developing country household over the course of a day is two to twenty times the US Environmental Protection Agency (USEPA) guideline maximum for ambient air pollution (USEPA 1997). The health effect sustained from biomass emissions is determined not solely by the pollution level but also as a function of the time individuals spend inhaling polluted air; that is, their exposure level.

The groups most vulnerable to the emission hazards associated with IAP are poor women and children (Boy et al. 2000). Biomass fuels are mainly used by the poor, who often cannot afford efficient stoves and chimneys. Typically, the women in exposed households are responsible for cooking and spend prolonged periods of time indoors close to the source of emission (Budds et al. 2001). Moreover, the most intense pollution occurs during short peaks when fuel is added or moved, the stove is lit, the cooking pot is placed on or removed from the fire, or food is stirred (Ezzati and Kammen 2002). Those doing the cooking are consistently closer to the fire at these moments. This means that the exposure of women and girls is underestimated by more than 50% when it is calculated from average pollution levels.

Infants and young children run increased risks because they tend to be cared for in the home close to where their mother is working (Bruce et al. 2000). In addition, infants and young children have heightened vulnerability due to their immature respiratory systems (Banerjee 2000) and physiological susceptibility (Boy et al. 2000). The detrimental effects of IAP are intensified by malnutrition, deprivation, poor sanitation and low standards of available medical services (WHO 2000a). Indeed, IAP is only one aspect of an interrelated complex of problems associated with household energy use by the poor (Figure 4.1).

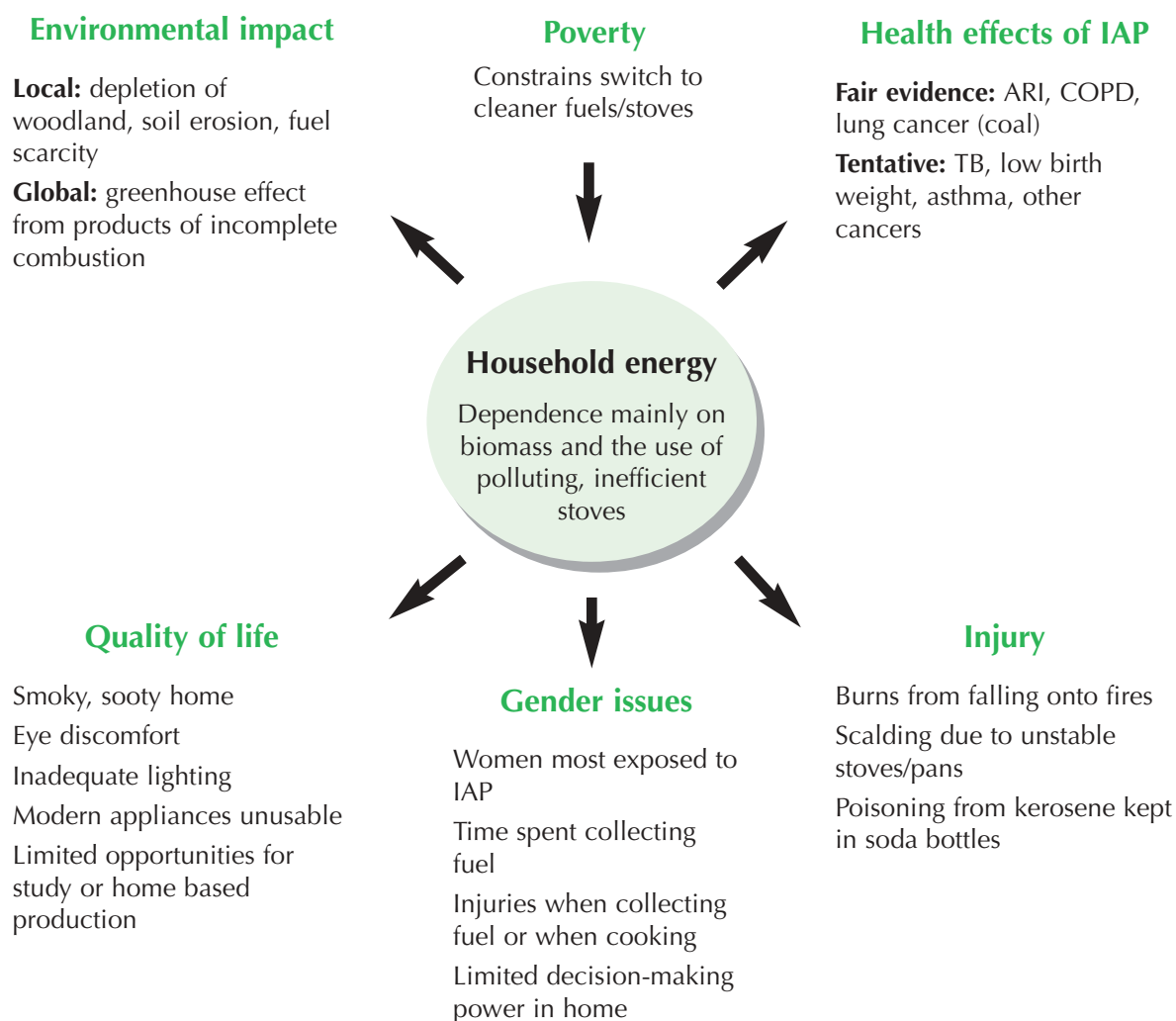


Figure 4.1 Summary of health and development issues associated with household energy use in developing countries (adapted from WHO 2000b)

4.2 Association Between IAP Exposure and Disease Outcomes

Exposure to IAP, especially to particulate matter can have a detrimental effect upon health in two principal ways (Budds et al. 2001):

1. Direct impact through specific substances released in biomass smoke (eg: carcinogens and toxins).
2. Indirectly these substances may damage the respiratory system's defences and thus make people more susceptible to infection by bacteria or viruses.

A growing body of evidence has established that exposure to biomass smoke is associated with an increased risk of a range of diseases to children and adults. It has been estimated that IAP is responsible for the loss of 53 million disability-adjusted life years (DALYs), around 4% of the global burden of disease (Smith and Mehta 2000). The specific disease outcomes are considered in turn.

4.2.1 Acute Respiratory Infections

The principal diseases attributable to IAP are acute respiratory infections (ARIs). WHO estimates that for all age-groups, ARIs were

responsible for 6.6% of the disease burden (DALYs) and 7.1% of mortality world-wide in 2000 (WHR 2001) and were the leading cause of death in developing countries (Stansfield and Shephard 1993). ARIs include minor upper respiratory infections (URIs) such as colds and sore throats; and the more serious, potentially life-threatening acute lower respiratory infections (ALRIs) such as pneumonia and bronchiolitis.

ARIs are the most important single cause of death in children aged under 5 years, responsible for 3-5 million deaths in this age-group every year. Around 75% of these deaths are attributable to pneumonia (Smith et al. 2000). Until recently, the evidence linking IAP exposure with ARI and ALRI was controversial, due to the use of proxies in the measurement of exposure and insufficient attention paid to confounding factors. However a recent study in rural Kenya linked longitudinal health data and demographic information with detailed monitoring of personal exposure over a 2-year period. This has enabled exposure-response relations to be determined for particulates produced from biomass combustion (Ezzati et al. 2000b, 2001a, 2001b). This study indicated that the risk of ARI and ALRI increased with average daily exposure to particulates; the risk of disease climbed steeply at relatively low levels of exposure, continuing to rise more gently for higher levels.

4.2.2 Other conditions

Chronic obstructive pulmonary disease (COPD) is an umbrella term used to describe a number of conditions including chronic bronchitis, emphysema and chronic asthma. The WHO estimates that indoor air pollution causes 22% of COPD (WHR 2002), although there is uncertainty about the precise figure (Bruce et al. 2000).

In industrialised nations tobacco smoke is the principal risk factor for lung cancer. However in developing countries, non-smokers, mainly

women, form a greater proportion of patients suffering from lung cancer. Studies in China indicate that women exposed to household coal smoke are 2 to 6 times more likely to develop lung cancer (Smith and Liu 1993, Mumford et al 1995). A study in Southern Brazil also estimated that around 33% of cancers of the mouth and throat were associated with the use of wood stoves for cooking and heating (Pintos et al. 1998).

There is also growing, but not yet conclusive evidence, particularly from India, for a link between biomass cooking fuels and active tuberculosis (Mishra et al. 1999a, Gupta and Mathur 1997).

Pollution associated with the use of biomass fuels causes eye irritation (Ellegard 1996) and may increase the risk of developing cataracts (Mohan et al. 1989, Mishra et al. 1999b).

The link between active or passive smoking and reduced birth weight has been extensively investigated, and a study in Guatemala found that pregnant women using wood fuel gave birth to babies with a lower mean birth weight than women using cleaner fuels (Boy et al. 2002). Low birth weight is itself a risk factor for ARI.

4.2.3 Other impacts; injuries and time

It is also important to consider the effect of injuries and the indirect health and social costs exacted as a consequence of biomass fuel use and IAP in developing countries. Children suffer burns as a result of falling into open household fires (Onuba and Udodiok 1987, Courtright et al 1993). Inferior indoor air quality, inadequate light, and limited choice of energy sources impose severe constraints upon patterns of household economic and educational activities (WEC 1999). This is illustrated by the time women spend collecting household fuel supplies, on average between 30 minutes and 2 hours per day, a time investment that rises in situations where local

environments are under pressure and fuel resources are scarce (WEC 1999).

Ideally, improved combustion efficiency should minimise exposure to harmful smoke while also improving safety and saving labour, fuel costs and natural resources. However, no affordable intervention has been demonstrated to achieve all these benefits. Projects to promote improved cookstoves or subsidise fossil fuels have aimed to save firewood, rather than to reduce IAP, and one does not follow from the other. Even their effectiveness in saving firewood is a subject of debate; one famous study of the topic (Foley and Moss 1983) is entitled, "How much wood would a woodstove save if a woodstove could save wood?"

4.2.4 Evidence issues

The strength and rigour of available evidence to date which links IAP to health outcomes, has been undermined by a number of methodological problems:

- Studies have lacked a systematic approach to the determination of IAP composition, measurement of pollutant concentrations, spatial distribution of pollutants and exposure patterns of individuals.
- Studies have tended to be observational in design and hence problems of confounding and bias may have been introduced into the results.
- The classification of disease outcome may have been inaccurate due to imprecise diagnosis and reliance upon self-reports in some studies.

However a significant advance has been made with a recent study in rural Kenya systematically examining the exposure-response relation between IAP and ARI (Ezzati et al. 2000b, 2001a, 2001b). It found that ARIs and ALRIs are increasing functions of mean daily emission exposure.

4.3 Interventions to Reduce IAP

The literature discussed above suggests that exposure to IAP has a detrimental effect upon health. Potential interventions should aim to minimise exposure to harmful combustion products, but the same time, in order to ensure effective uptake of interventions by households and communities, they should be cheap, available, accessible and acceptable (Budds et al. 2001).

A range of potential interventions may be instrumental in reducing IAP exposure (Ballard-Tremere and Mathee 2000):

1. **Emission source with a focus on stove type and fuel usage** - these interventions incorporate improved stove design to reduce smoke production; utilise chimneys, flues and hoods to maximise smoke removal; encourage fuel-switching by advocating (or subsidising) the use of cleaner fuels which produce less smoke and improve fuel efficiency.
2. **Household living environment** - to improve household ventilation; modify kitchen design; encourage the incorporation of separate kitchen space into housing design.
3. **Behavioural modification** - focus upon education to link exposure to disease; alteration of traditional cooking and childcare practices.

As yet, there has been little systematic evaluation of the effects, both direct and indirect, of these interventions upon health outcomes (von Schirnding 2001). Research has focused upon the impact upon patterns of fuel consumption and direct emission levels. Therefore the only way to assess the likely impact of interventions upon health is indirectly, by considering their effect upon IAP exposure.

4.3.1 Emission Source - Stove Type

Technical interventions in this field have primarily focused upon improved cook stoves, with the earliest stove projects dating back to the 1950s. In the 1970s, fuel-wood shortages, increased fuel efficiency and reduced costs became priorities. A variety of improved stoves have been designed in developing countries, for example the chula (India), plancha (Central America) and upesi (Kenya).

A recent report reviewed the findings of studies that investigated the effect of technological interventions upon indoor air pollutants (Budds et al. 2001). These studies produced conflicting results, which make it difficult to reach definitive conclusions about intervention recommendations. For example, some improved stoves which significantly reduced particulate emissions in rural Kenya (Ezzati 2000a) were found to produce higher CO and SO₂ emissions (Ballard-Tremeer and Jawurek 1996). Stoves will also fail to perform if they are poorly constructed, operated or maintained.

Flues to remove smoke should assist in reducing pollution levels, and many improved stoves integrate flues and chimneys in their design. However, flues are difficult to design, are fragile if constructed of asbestos or ceramic material and require careful and correct installation, whilst chimneys are expensive (RWEDP 1993). The specific contribution of flues to the reduction of IAP is difficult to determine because studies have tended to combine improved stove design with flues. However significant reductions (75% or better) in Total Suspended Particulates and CO have been recorded.

In a study in highland Guatemala, it was observed that a number of improved stoves had relatively high emissions due to the presence of holes and blockages in their metal chimneys, and that chimneys were reported to have a short working life of between 2-3 years. These are important design, construction and

maintenance issues that could have long-term financial and health effects upon stove users.

Hoods are free-standing units, independent of household stoves or fires, which operate on the same basis as flues and chimneys in the extraction of household smoke. They offer flexibility in their ability to work with traditional open fires or improved stoves but pose installation and operational problems in small traditional homes in developing countries (Budds et al. 2001). No peer-reviewed studies have measured emission patterns in households using hoods compared to those that do not. However a report from a recent field study in rural Kenya indicates that lower levels of IAP were measured in households that used hoods compared to those that relied solely upon windows for ventilation (Gitonga 2001).

4.3.2 Emission source - fuel switching

Use of cleaner fuels provides an alternative approach to IAP reduction. The reduction of IAP through changing fuel is unlikely to be a simple technical issue but will also involve considerations of policy at one level, and household practices at another. One lesson that has emerged from interventions to date however, is that the indiscriminate use of government subsidies to encourage fuel switching tends to bring the greatest benefits to wealthier urban households that consume more fuel (Ballard-Tremeer and Mathee 2000), and are unlikely to use biomass fuels anyway. For the majority of poor households, biomass fuels seem likely to remain important for the foreseeable future.

A number of cleaner fuels have been developed from biomass products, and emission levels summarised for a range of fuel types burnt under comparable conditions (Budds et al. 2001). The fuels, designed to be cleaner, include:

- **Briquettes**, which comprise fuel units (biomass, charcoal, coal) compressed into

more compact forms that result in lower emission levels and more efficient combustion due to their high-density structure. Briquette production is uncomplicated and may be undertaken locally.

- **Biogas** is rich in methane and burns cleanly with low associated levels of particulates and carbon monoxide. It can be produced locally from the anaerobic digestion of readily available biomass resources, principally crop residues and animal dung. However, a biogas digester is a substantial investment needing careful operation and a cow (or several pigs) per family. Biogas digesters are primarily built to produce fertiliser, and biogas will only be available as a fuel where such digesters are in use (Goldemberg 2000).
- **Producer gas** is a volatile substance composed principally of hydrogen (H₂) and carbon monoxide (CO), released during the gasification of wood. However due to its CO component, it carries a risk of CO poisoning unless production and combustion equipment are carefully designed and utilised (Ballard-Tremeer 1998).

No published data have been identified comparing emission levels in the field from “cleaner” fuels such as biogas and producer gas with traditional biomass fuels.

Another option is to switch to a completely different source of energy.

- **Solar power** has been utilised in the development of a number of stoves but these projects are still developmental (D’Sena 1999). Solar-powered stoves are difficult to use in practice. Cooking must be conducted outdoors, is slow and is not possible in the evening or in cloudy weather (Ballard-Tremeer and Mathee 2000).

- **Kerosene** is a relatively clean fuel. Its drawbacks are formal production and purchase costs; reliable supply; the cost of suitable stoves; and the risk of accidental poisoning caused when children drink kerosene stored in the home (Reed and Conradie 1997).
- **Liquid petroleum gas (LPG)** achieves almost 100% combustion, with negligible emission levels (Ballard-Tremeer and Mathee 2000), but usage is likely to be restricted by the cost of fuel and specialised burning equipment.
- **Electricity** use is governed by issues of access and affordability. A study conducted in a traditionally wood-burning area of South Africa investigated patterns of fuel-use following electrification. It was discovered that although electricity was adopted, biomass fuels continued to be burned for cooking and heating. The overriding reasons for not using electricity were the cost of electrical appliances; though other factors including fluctuating seasonal energy requirements and cultural beliefs were also involved (Luvhimbi 1997).

4.3.3 Household Living Environment

Consideration of housing design highlights two alternative strategies for IAP reduction (Murphy et al. 1997).

- **Improved Household Ventilation**
IAP concentration is raised by poor household ventilation, which may be altered by the strategic placement of window and door openings. Currently there is no information available to compare the effectiveness of ventilation modification with improved stoves and cleaner fuels (RWEDP 1993).

An informal report of an initiative in Kenya (Gitonga 2001) describes an intervention to modify housing design in order to maximise ventilation and reduce IAP. The initiative involved women in the community and aimed to combine their needs for better

light and air indoors whilst retaining privacy, security and warmth. The housing design intervention involved larger and more strategic location of windows, and the incorporation of eaves spaces between the walls and the roofs. Reduced levels of indoor smoke resulted in more light, greater convenience and household comfort. Indirect benefits were also observed with regard to improved visibility, resulting in fewer household accidents, reduction in kerosene use for lighting and a self-reported reduction in fatigue and headaches.

- **Kitchen/Cooking Area Design Modification**

The incorporation of simple design features (such as placing cookstoves next to windows or doors, or at waste height) might result in more effective pollutant dispersal and reduced exposure levels (Ballard-Tremeer 1998), though cultural and gender barriers may inhibit the acceptability and uptake of these modifications (Saatkamp et al. 1998). There is a lack of evidence supporting their effectiveness.

4.3.4 Behaviour Modification

A number of behavioural modifications may prove relevant in lowering people's exposure to high levels of household IAP - not as the core of intervention programmes but rather to complement their aims (Budds et al. 2001):

- **Educational Initiatives.** People are often unaware about the health risks associated with cooking smoke (McGranahan 1994), and health education to remedy this can enable individuals to make informed choices with regard to their behaviour.
- **Childcare Practices.** Keeping children away from cooking areas may lessen their exposure. However in practice this is difficult to achieve; placing children away from their mother's supervision may expose them to other dangers.

- **Cooking Practices.** Emission can be reduced by drying wood before use or cutting it into smaller pieces, or by the immediate extinguishing of fires after cooking (Budds et al. 2001). However these practices are more labour, time and space intensive, and require a covered area for drying the wood. Cooking outdoors maximises ventilation, but is beset by practical considerations.

4.3.5 Cost-effectiveness and feasibility

In a recent review, the World Bank considered results from preliminary studies to assess the comparative cost-effectiveness of different interventions to reduce IAP. It is reported that the introduction of improved biomass stoves cost between US\$ 50-100 per DALY averted (Smith 1998). Whilst the introduction and use of kerosene and LPG stoves in rural areas would cost US\$ 150-200 per DALY avoided (Hughes et al. 2001). Despite the need for more in-depth analyses of this nature, these results indicate that interventions to reduce IAP may be considered cost-effective in reducing disease burden. Evidence from India suggests that expenditure on cleaner fuels is cost-effective when compared to alternative strategies for lowering the burden of disease, based on any cost-benefit framework that attaches even modest values to the benefits of reducing child mortality and other negative health outcomes. The burden of disease averted by expenditure of this type is borne particularly by those in poverty or with below average household income (Hughes et al. 2001).

Nevertheless, *no intervention that has been proven to produce a significant reduction in IAP has yet been implemented successfully on wide scale.* Cost-effectiveness analysis is largely an academic exercise until there is a real programme to analyse.

Meanwhile, one randomised controlled trial of improved cookstoves is under way in

Guatemala (Smith, personal communication), but it has also been argued that other types of study may be more useful in establishing the characteristics required of any successful intervention (Ezzati & Kammen 2002). Only then will it be possible to offer guidance, based on practical experience, of how to design such a programme.

4.4 Implementation of IAP Reduction Interventions

Nevertheless, a few points are already clear. Any measures to reduce IAP will require people to alter their behaviour and, in many cases, their living environments. They will have to be persuaded of the advantages of this for them to accept it. That means the promotion of the intervention must be based on felt needs; establishing that will require formative research, sensitivity to the local context and to gender issues. A substantial social marketing effort will also be required. If stoves or hoods or other products are to be distributed, they must be affordable, but durable enough to survive with less than adequate maintenance. There will be numerous parallels with sanitation programmes, where a new product has to be introduced together with behaviour changes.

That such a programme is possible on a large scale is demonstrated by the Chinese National Improved Cook Stove Programme, which was established in 1980 by the Chinese government and which resulted in over 172 million chimney stoves being installed by the end of 1995 (Lin 1998). The programme promoted at least 20 different stoves, most for biomass combustion but some specifically for coal use. This programme has adopted a number of the implementation techniques outlined above. Through loan provision and technical support, the Government encouraged local manufacturing and the establishment of enterprises to produce, install and repair appliances, ensuring long-term sustainability. The quality, durability and effective pricing of

stoves also ensured their commercial viability. In addition users, particularly women, have been involved in the design and fieldwork phases of the programme, with particular attention paid to convenience and attractiveness in recent stove models. The programme also integrates regular monitoring and evaluation, whilst some degree of success can be attributed to novel national contests for improved stove design (Goldemberg 2000).

4.5 Conclusions

In summary, this review has presented evidence of the association between exposure to IAP and the development of disease, particularly acute respiratory infections. Research efforts are still needed to focus upon two areas:

- More systematic intervention studies, including randomised controlled trials which will accurately assess the impact of personal exposure to IAP and disease outcomes, whilst controlling for potential confounding factors. A particular area for research is to establish the specific characteristics of IAP which are responsible for each health outcome, and the levels to which they should be reduced for optimal impact.
- Operational research to identify, develop and evaluate operationally the best combination of feasible, replicable interventions which reduce IAP, especially particulates, while at the same time meeting the energy requirements of poor households.

Once such models have been developed, policy makers can envisage a long-term and a short term strategy for IAP reduction;

Short-term strategy (3-5 years)

Use of improved stoves, chimneys, hoods etc. to reduce harmful combustion emission (WHO 2000a). Especially promising opportunities arise where improved stoves are already being

promoted or purchased for other reasons, such as fuel economy. It is anticipated that even modest, well-focused resources and external funding could result in these interventions having a significant impact upon IAP-associated health burden and household energy use (von Schirnding 2001).

The most effective roles for external funds in this strategy would be product development,

quality assurance, the training of artisans and the stimulation of demand but not subsidising of the final purchase cost.

Long-term strategy (15-30 years)

Fuel-switching and transition to modern cleaner fuels, implemented within a comprehensive international and national policy and economic framework (Goldemberg 2000).

References

- Ballard-Tremere, G. 1998. How many of these improvements are in your stoves programme? *Boiling Point* 40: 25-27.
- Ballard-Tremere, G. and H.H. Jawurek 1996. Comparison of five rural wood-burning cooking devices: efficiencies and emissions. *Biomass and Bioenergy* 11(5): 419-430.
- Ballard-Tremere, G. and A. Mathee 2000. Review of interventions to reduce the exposure of women and young children to indoor air pollution in developing countries. In USAID/WHO International Consultation on Household Energy, Indoor Air Pollution and Health. Geneva: World Health Organization.
- Banerjee, L. 2000. Caution: children under threat. *Down to Earth*: 20-21.
- Boy, E., et al. 2000. Fuel efficiency of an improved wood-burning stove in rural Guatemala: implications for health, environment and development. *Energy for sustainable development* 4(2): 21-29.
- Boy, E., N. Bruce, and H. Delgado 2002. Birth weight and exposure to kitchen wood smoke during pregnancy in rural Guatemala. *Environmental Health Perspectives* 110(1): 109-114.
- Bruce, N., R. Perez-Padilla, and R. Albalak 2000. Indoor air pollution in developing countries: a major environmental and public health challenge. *Bulletin of the World Health Organization* 78(9): 1078-92.
- Budds, J., A. Biran, and J. Rouse 2001. *What's Cooking? A review of the health impacts of indoor air pollution and technical interventions for its reduction*. Loughborough UK: WELL - Water and Environmental Health at London and Loughborough.
- Courtright, P., D. Haile, and E. Kohls 1993. The epidemiology of burns in rural Ethiopia. *Journal of Epidemiology & Community Health* 47: 19-22.
- D'Sena, P. 1999. Indonesian sun-cooking: a social perspective. *Boiling Point* 43: 23-24.
- Ellegard, A. 1996. Tears while cooking: an indicator of indoor air pollution and related health effects in developing countries. *Environmental Research* 104: 980-985.
- Ezzati, M. and D. Kammen 2001a. Indoor air pollution from biomass combustion and acute respiratory infections in Kenya: an exposure-response study. *Lancet* 358(9282): 619-24.
- Ezzati, M. and D.M. Kammen 2001b. Quantifying the effects of exposure to indoor air pollution from

biomass combustion on acute respiratory infections in developing countries. *Environmental Health Perspectives* 109(5): 481-8.

Ezzati, M. and D.M. Kammen 2002. The health impacts of exposure to indoor air pollution from solid fuels in developing countries: knowledge gaps and data needs. *Environmental Health Perspectives* 110 (11): 1057-1068.

Ezzati, M., M.B. Mbinda, and D. Kammen 2000a. Comparison of emissions and residential exposure from traditional and improved cookstoves in Kenya. *Environmental Science & Technology* 34(4): 578-583.

Ezzati, M., H. Saleh, and D.M. Kammen 2000b. The contributions of emissions and spatial microenvironments to exposure to indoor air pollution from biomass combustion in Kenya. *Environmental Health Perspectives* 108(9): 833-9.

Foley G, Moss P 1983. How much wood would a woodstove save if a woodstove could save wood? *Improved Cooking Stoves in Developing Countries*. London: Earthscan.

Gitonga, S. 2001. *Smoke project activities*. Nairobi: Intermediate Technology Development Group.

Goldemberg, J. 2000. Rural energy in developing countries. In: *UNDP World Energy Assessment; Energy and the Challenge of Sustainability*. New York: UN Development Programme.

Gupta, B. and N. Mathur 1997. A study of the household environmental risk factors pertaining to respiratory disease. *Energy and environmental review* 13: 61-67.

Hughes, G., K. Lvovsky, and M. Dunleavy 2001. *Environmental health in India - Priorities in Andhra Pradesh*. Environment and Social Development Unit, South Asia Region, World Bank.

Lin, D. 1998. The development and prospective of bioenergy technology in China. *Biomass and Bioenergy* 15: 181-186.

Luvhimbi, J.H. 1997. Household energy in a recently electrified rural settlement in Mpumalanga, South Africa. *Boiling Point* 38: 30-31.

McGranahan, G. 1994. Energy and household environment in Accra. *Renewable Energy for Development* 7(2).

Mishra, V.K., R.D. Retherford, and K.R. Smith 1999a. Biomass cooking fuels and prevalence of tuberculosis in India. *International Journal of Infectious Diseases* 3(3): 119-29.

Mishra, V.K., R.D. Retherford, and K.R. Smith 1999b. Biomass cooking fuels and prevalence of blindness in India. *Journal of Environmental Medicine* 1: 189-199

Mohan, M., et al. 1989. India-US case control study of age-related cataracts. *Archives of Ophthalmology* 107: 670-676.

Mumford, J. et al. 1995. Human exposure and dosimetry of polycyclic aromatic hydrocarbons in urine from Xuan Wei, China with high lung cancer mortality associated with exposure to unvented coal smoke. *Carcinogenesis* 16: 3031-3036.

Murphy, H., B. Stanton, and J. Galbraith 1997. *Environmental Health Project Applied Study 3. Prevention: Environmental Health Interventions to Sustain Child Survival*. Office of Health and Nutrition, Bureau for Global Programs, Field Support and Research, US Agency for International Development under Activity No. 127-CC: Washington DC.

- Onuba, O. and E. Udoidiok 1987. The problems of burns and prevention of burns in developing countries. *Burns* 13: 382-385.
- Pintos, J., et al. 1998. Use of wood stoves and risk of cancers of the upper aero-digestive tract: a case-control study. *International Journal of Epidemiology* 27: 936-940.
- Reed, R.P. and F.M. Conradie 1997. The epidemiology and clinical features of paraffin (kerosene) poisoning in rural African children. *Annals of Tropical Paediatrics* 17: 49-55.
- RWEDP 1993. Improved solid biomass burning cookstoves: a development manual. Regional World Energy Development Programme in collaboration with Asia Regional Cookstove Programme and Energy Research Centre of Panjab University, Chandigarh, India.
- Saatkamp, B.D., O.R. Masera, and D. Kammen 1998. Fuels, stoves and indoor air pollution in Jaracauro, Mexico. *Boiling Point* 40: 16-18.
- Smith, K.R. 1998. Indoor air pollution in India: national health impacts and the cost-effectiveness of interventions. Mumbai, India: Indira Gandhi Institute for Development.
- Smith, K.R. and Y. Liu 1993. Indoor air pollution in developing countries. In J.M. Samet, Editor: *Epidemiology of lung cancer; Lung biology in health and disease*. New York: Marcel Dekker.
- Smith, K.R. and S. Mehta 2000. Background paper for US AID/WHO Global Consultation on indoor air pollution and household energy in developing countries, Washington DC, USA.
- Smith, K.R., et al. 2000. Indoor air pollution in developing countries and acute lower respiratory infections in children. *Thorax* 55(6): 518-32.
- Stansfield, S. and D. Shephard 1993. Acute respiratory infections. In D. Jameson et al., Editors: *Disease Control Priorities in Developing Countries*. Oxford, UK: Oxford University Press p. 67-90.
- USEPA 1997. Revisions to the National Ambient Air Quality Standards for Particulate Matter. Federal Register: 38551-38701.
- von Schirnding, Y., et al. 2001. Addressing the Impact of Household Energy and Indoor Air Pollution on the Health of the Poor - Implications for Policy Action and Intervention Measures. Geneva: Commission on Macroeconomics and Health.
- WEC 1999. The challenge of rural energy poverty in developing countries. London: World Energy Council.
- WHO 2000a. Guidelines for Indoor Air Quality. World Health Organisation: Geneva.
- WHO 2000b. Addressing the Links between Indoor Air Pollution, Household Energy and Human Health. WHO-USAID Global Consultation on the Health Impact of Indoor Air Pollution and Household Energy in Developing Countries (Meeting Report). Geneva: World Health Organization.
- WHO 2001. World Health Report 2001 - Mental Health: New Understanding, New Hope. Geneva: World Health Organization.
- World Resources Institute 1998. *World Resources 1998 -99: a Guide to the Global Environment*. Oxford UK: Oxford University Press.
- Zhang, J. and K.R. Smith 1999. Emissions of carbonyl compounds from various cookstoves in China. *Environmental Science & Technology*. 33(14): 2311-2320.

5 Injuries

5.1 Background

5.1.1 The Global Burden of Injury

It has been estimated that 5.8 million people die each from injuries; 16,000 every day. For every death, thousands more are injured, often causing long lasting disabilities. The toll is increasing, and is expected to reach 8.4 million, or 15% of all deaths, in 2020 (Murray and Lopez 1996). Much of the burden from injuries occurs in developing countries, where injuries are a leading cause of DALYs lost (Gwatkin 1998). Death and disability from injury also occur disproportionately among children (Bartlett 2002) and among the poor, (Baker et al. 1992, Roberts 1998). Injuries are a leading cause of premature loss of productive life, of high medical care costs, of significant degrees of disability and of large socio-economic loss to society (Baker 1992). In many low income countries, injuries consume about 1-2% of the GDP (Ariokoswamy 1994, Berger 1996). Despite this, little attention has been devoted to their prevention or management (Zwi et al 1996).

Intense media interest and public attention accompany the occasional massive crashes that take dozens of lives in a single event but in contrast, the relentless toll of injuries occurring daily, on the highways or in the home, receives far less attention. The few countries in the world which have made organised efforts to tackle this burden are mainly High Income Countries. This neglect is also true of many international agencies which influence health priorities and the allocation of resources in developing countries. The dramatic neglect in external assistance provided by international donors was highlighted by Michaud & Murray (1994) who showed that whereas donor aid for leprosy was US\$ 50 per DALY lost, \$4 for HIV and other sexually transmitted diseases, but only \$0.01 for injuries.

Historically, injuries have been neglected as a public health problem for a variety of reasons

(Sethi and Zwi 1999). The health and economic burden has been little documented, and there has been limited appreciation that injuries can be prevented through organised efforts of society. Powerful vested interests have also opposed safety promotion on the grounds of cost (Zwi 1996). More recently, influential studies such as the Global Burden of Disease Study (Murray and Lopez, 1996) have highlighted the scale of the problem and helped to focus attention on it.

Although the Global Burden of Disease Study has played a valuable role in drawing attention to the problem, it has been argued that for low income countries this information is of highly questionable reliability, based as it is on estimates and extrapolations (Mohan 1997). This is especially true of non-fatal injuries, many of which are never reported (Bangdiwala et al. 1990).

5.1.2 Types of injury

Injuries are often classified by intent. Most traffic related injuries, falls, drownings and poisonings are classified as unintentional. On the other hand homicides, suicides and war are classified as intentional. The term 'injuries' represents a wide range of different types of problem, each with a different set of risk groups, risk factors, and risk situations. The discussion below is mainly concerned with unintentional injuries and focuses on the role of the environment in the causation of injuries and how modifications can be used for the promotion of safety. Four types of unintentional injury - road traffic injuries, drowning, falls and burns - will be discussed in more detail below, together with potential courses of preventive action.

Among the 20 leading causes of global mortality in 1990, traffic injuries rank 9th causing one million deaths a year; and drowning ranks 20th, causing over half a million (Murray & Lopez 1997a). It is expected

that road traffic fatalities will continue to increase, while other important causes of death decline. Among the top causes of global DALYs lost in 1990, all four main types of unintentional injuries rank among the top 30: road traffic injuries 9th, falls 13th, drownings 21st and burns 27th (See Table 2.2 in Part I). Road traffic injuries ranked above malaria, and all four types ranked higher than HIV.

5.1.3 Injuries and children

A disproportionate share of injuries are among children. Children less than five years old constitute 10% of the population, but account for 22% of the total of injury-related DALYs lost worldwide (Murray & Lopez 1996). Data from Cuba, where statistics on deaths are reportedly very reliable, indicate that children under one year old account for 10% of all injury-related deaths of children (Jordan & Valdes-Lazo 1991). In countries where other health problems such as infectious diseases are well controlled, unintentional injury ranks as the leading cause of death for children, accounting for almost 40% of all deaths in the age group 1 to 14 years. In countries where communicable disease and malnutrition still kill many children, the percentage of injury-related deaths is lower, and as a result the problem is generally regarded as less significant. In fact, the number of injuries per capita is considerably higher, especially in the poorest communities. 98% of all child deaths by injury occur in low- and middle-income countries, and the rate of these deaths is five times higher than among higher income nations (Bartlett 2002).

There are several reasons why children are more susceptible to injury. Especially in young children, their desire to explore and experiment

is not matched by the capacity to apprehend or respond to danger. Often they are unattended by adults or cared for by siblings only a few years older. Not only are they more susceptible to injury; their injuries can also have more serious effects, for several reasons:

- The fact that children's bones are still growing means that fractures can cause permanent disfigurement;
- Children's thin epidermis increases the severity of burns;
- Their large head-to-body ratio increases the risk of head injuries;
- Smaller airway size increases the danger of choking (Berger & Mohan 1996)
- Larger body surface area in proportion to volume increases relative fluid loss after burns
- Relative immunological immaturity makes children more prone to secondary infection.

The following remarkable statement is made in a detailed review of children's injuries in low-income countries which cites nearly 90 studies (Bartlett, 2002); "There is no mention in any of the studies reviewed ... of abuse to children being presented as unintentional injury." In view of the widespread anecdotal evidence of child abuse in developing countries (and historically among low-income groups in today's high income countries) in the name of discipline or economic exploitation, and even mutilation for purposes of begging, this strongly suggests that a substantial amount of deliberate injury to children goes undetected and apparently unsuspected. It is an indication of the weakness of current surveillance of injuries and their causes in developing countries.

Injury control experience in Zimbabwe

In 1986 the Ministry of Health and Child Welfare (MOHCW) in Zimbabwe identified injury control as a priority; injuries were the leading cause of death in young adults and among the top 5 reasons for out-patient hospital attendances. They also imposed a heavy load on in-patient and rehabilitation services. The ministry took the following important steps:

- Recognise that injuries are predictable, and controllable
- Undertake detailed situation analyses
- Improve epidemiological surveillance
- Identify a 'lead' person within the ministry
- Establish intersectoral committees
- Stimulate research

This initial groundwork meant that when a series of bus disasters occurred with numerous fatalities, the opportunity was not lost and a task force was established to develop a national road safety plan.

Source: Zwi et al. (1996)

5.2 Road traffic injuries

Most of the road traffic injury deaths (85%) occurred in developing and transition countries and nearly half (44%) in the Asia and the Pacific region including large contributions from India and China. By the early 1990s there were more road accident deaths in India than in the USA, although India had less than 5% as many motor vehicles (Hardoy et al. 2001). Africa accounted for 11% of the global fatalities. The estimated annual cost of road crashes for the countries of the developing world was US\$ 65 billion, which is more than the total official development aid (multilateral and bilateral) which they receive from the OECD countries. Whereas mortality rates are highest in people over 60 years of age, the greatest burden is experienced by those aged 15-44, partly because of their greater exposure, but also because of the greater number of years lost and life lived with disability. In Thailand, traffic accidents were

found to be the most common cause of injury, and in South Africa the leading cause of death, for children more than one year old (Bartlett 2002).

The economic costs of road crashes - and the benefits of preventing them

Estimates of the economic costs of road crashes for some typical countries are given in the table below. It has been estimated from such data that road crash costs in developing and transitional countries amount to 1 to 3% of a country's GNP. A recent costing for Mauritius estimated the annual cost of road crashes at £20 million. A package of safety measures was proposed which was anticipated to reduce the total by 5%, or £1 million each year. This would cost £100,000 per year to implement over a five-year period, or a total of £ 500,000. The average first year rate return was thus 1,000%, and the benefit/cost ratio was 10:1.

Country	Study Year	Percent of GNP	GNP Value \$USD-1997	Source
Brazil	1997	2.00%	15,681	IADB Review of Traffic Safety
Bangladesh	1998	0.50%	220	IDC Economics Working Paper Accident Costs
Thailand	1997	2.30%	3,810	SWEROAD Road Safety Master Plan Report
Indonesia	1995	-	691- 958	Accident Costs in Indonesia: A Review June 1997 (Draft Copy), TRL/IRE
KwaZulu Natal	1996	4.50%	-	Kwazulu-Natal Road Traffic Safety Strategy (1996-2000)
Tanzania	1996	1.30%	86	1996 Road Safety Programme Tanzania Ministry of Works
Zambia	1990	2.30%	189	TOI Study
Egypt	1993	0.80%	577	Aly, 'Valuation of traffic accidents in Egypt'
UK	1998	2.10%	28,856	Road Accidents Great Britain: 1998 The Casualty Report
USA	1994	4.60%	358,022	NHTSA Technical Report

Table 5.2. Estimates of the Economic Cost of Road Crashes for a Range of Countries.

Road traffic fatalities have steadily declined in the developed countries to half their levels in the 1970s (Bruhning 1997). In contrast there has been an increase in the low and middle income countries, despite their lower vehicle densities. In these countries the victims of road crashes are mostly pedestrians or users of bicycles and motorcycles, as well as those involving buses, trucks and other public service vehicles. In Asia, Africa and the Caribbean, pedestrians typically represent over 40% of the fatalities. Bicycle and motorcycle fatalities constitute the highest proportion of road deaths in India (Mohan and Bawa 1985). In S. E. Asia and countries with substantial motorcycle traffic, motorcycles account for nearly 40 % of the deaths. A study of bus safety (Pearce and Maunder, 2000) indicated that in Nepal 65 % of all casualties came from crashes involving buses and 35 % in Tanzania. Most of the buses were privately operated.

Driver discipline, training, alcohol and the unsafe road environment contribute to the high fatalities (Berger and Mohan 1996). The

hazardous features of that environment include:

- the large ratio of pedestrians to vehicles,
- the mixture of pedestrians, motorised and non-motorised transport on roads,
- inadequate enforcement of vehicle roadworthiness legislation,
- overloaded public transport systems,
- inadequate illumination and sign posting,
- poor maintenance of roads.

5.2.1 Interventions and policy response to RTIs

The decline in road traffic mortality in high income countries is due to the development of a comprehensive policy comprising legislation (speed control, alcohol and driving, seat belt use, child restraints in vehicles, helmet use by motor cyclists), improved road design, traffic calming measures (especially in residential areas), health education, better car design and improved emergency medical systems. The greatest successes appear to be from multi-sectoral efforts.

A necessary starting point must be an appropriate injury surveillance system such as that promoted by WHO based on health and vital registration data and an appropriate traffic accident surveillance system such as those proposed by the UK Transport Research Laboratory (Holder et al 2001). The establishment of an effective national road safety body with multi-sectoral representation provides a useful avenue for formulating and implementing policy and programmes based on evidence of effectiveness. There is a lack of evidence from developing countries, settings and many of the effective innovations that have been developed in High Income Countries need to be assessed for their relevance to low income communities. This applies both to the effectiveness of interventions and also to programmes that implement them.

The interventions used in wealthy countries, which have focused on the safety of vehicle occupants, will only benefit the affluent in poorer countries, where other investments are needed to protect the poor. These involve protecting pedestrians and cyclists, as well as making improvements in the safety of public transport.

Forjuoh and Li (1996) have summarised some of the interventions which would be transferable from High Income Country to Lower Middle Income Country in terms of efficacy, affordability, feasibility and sustainability. Amongst those recommended are:

- separation of pedestrians from vehicles by kerbs, barriers etc.,
- pedestrian crossing signs,
- measures to make pedestrians and cyclists more conspicuous,
- the compulsory use of motor-cycle helmets and safety belts,
- alcohol sobriety checks.

Most of these are concerned with changes in the environment, whether this is physical or

societal. Public education has been shown to work only if it takes place in tandem with environmental, legislative and engineering changes.

Legislative changes and enforcement measures (e.g. speed limits, alcohol limits for drivers) tend to be cross-cutting, will protect everyone - drivers, passengers, riders and pedestrians, rich or poor. Measures are needed to enforce such limits and many middle income countries use radar speed checks and breathalysers. The latter are affordable and increasingly used in countries such as China, but confirming their results from blood samples may not be feasible in many developing countries because of resource constraints. Nevertheless, other measures such as banning the sale of alcohol in lorry parks would be affordable and reduce drunk driving. The lack of research to link risk factors to road fatalities in these settings has contributed to the failure of the governments and the public to recognise the magnitude of the hazards of drunk driving and the importance of such interventions. Even if not universally applied, therefore, breathalysing of some drivers involved in accidents would help to create awareness of the need for better enforcement.

5.3 Drowning

Drowning is the 20th leading cause of death world wide and in 1990 was responsible for about half a million deaths. It was ranked as the 21st leading cause of DALYs lost (Table 2.2). In 1998, drownings were the 11th leading cause of death in children under 5 years (125,301 deaths) and the 4th leading cause in children aged 5-14 years (157,573 deaths) (Krug et al. 2000). However the enormity of the problem is not widely appreciated, partly because drownings and near drownings are rarely seen at health facilities. For example, of 57,000 children seen over five years in a South African trauma unit, only 119 were victims of near-drowning (Kibel et al. 1990).

Figure 5.3 shows age-specific death rates by region. Drowning is a major cause of injury deaths in China, India, in the "Other Asia and Islands" (OAI) region and in sub-Saharan Africa. In boys and girls under the age of 5 years, China has the highest mortality (50 per 100,000 and 44 per 100,000 respectively) followed by the OAI region (44 per 100,000 and 28 per 100,000 respectively). In this age group the rate ratio between China and the Established Market Economies was 13:1 for boys and 22:1 in girls (Sethi 1998).

Examination at the country level helps show the wide variability and to appreciate the importance of the problem locally. For example in Malaysia drowning was the second most important cause of injury death overall (Department of Statistics, Malaysia 1997) and the same is true of rural Uganda (Kobusingye 2001).

There is a great diversity in the risk factors and circumstances in which drowning occurs in the

different areas and age groups. Evidence from Europe and North America suggests that the socio-economically deprived are at increased risk of drowning (Smith and Barss 1991). The location of the homes of poorer people on swampland or flood plains with many drainage canals and sewers, constitute drowning hazards, as shown by the experience of cyclones in Bangladesh. Drownings in bath tubs (infants), in swimming pools (especially of children under 5 years), and from sailing and water sports may be priority areas for concern in high income countries, but in low and middle income countries the causes for drowning are more likely to be wells, ponds and cisterns around the home, as well as streams, dams, lakes and while fishing. The environmental and behavioural circumstances are hugely different in the different areas, and scant attention has so far been given to the problem in developing countries. Unfenced ponds and wells are often found in the village environment, and appear to be a significant environmental hazard for toddlers (Smith and

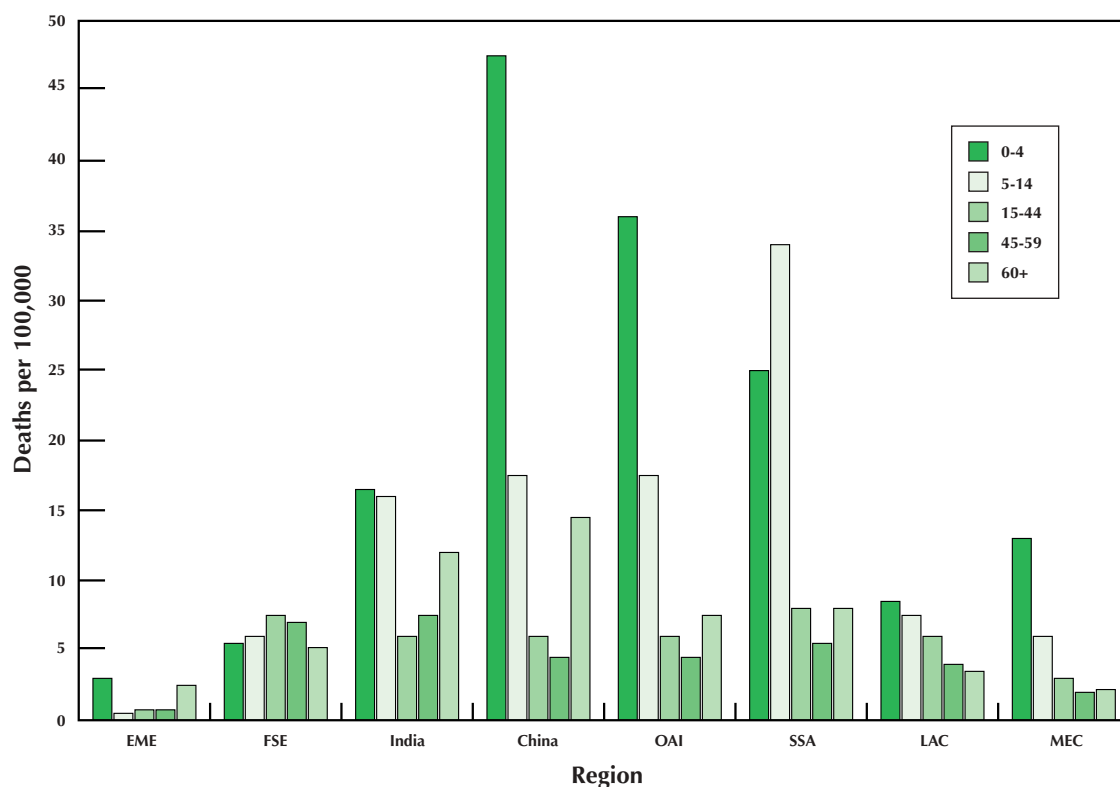


Figure 5.3: Age specific mortality due to drowning in 1990 by region (Source: GBD study)

Barss 1991). In low-income urban areas, open drainage channels present a similar hazard.

Comparison of childhood mortality between Western Europe and the transition countries of Eastern Europe and the former Soviet Union, showed that drowning was consistently a cause of a significant part of the difference in mortality in children under 15 years between these two regions (Koupilova et al 2002). It is unclear as to what extent drownings in these countries are due to unsupervised swimming in pools and rivers or exposure to expanses of water or wells. Several risk factors for childhood drowning in high income countries have been implicated, including large families and reliance on sibling supervision, practices which are common in low-income communities.

5.3.1 Interventions and policy response to drownings

The area of drowning prevention has been poorly researched and little is known about the circumstances of drowning in low and middle income countries. Most of the research is from developed countries, where there is evidence that:

- fencing of pools to limit access reduces drowning in children under 5 years old (Rivara FP et al 1998);
- that teaching children to swim would reduce the risk of their drowning;
- adults run a risk of drowning almost five fold greater after alcohol intoxication (Howland et al. 1988);
- the use of flotation devices reduces risk whilst boating.

The fencing of swimming pools, simple in high income countries, would be impractical if applied to waterways in developing countries where these may run into thousands of kilometres. It would nevertheless be feasible to enclose small ponds, wells and drainage canals

in residential areas, since toddlers are at greatest risk from sources close to home.

In spite of the different contexts, experts suggest that there is a commonality of approach, with education about risks, closer supervision and resuscitation skills as important first steps (Pless 1997). Researchers need to study the circumstances under which drowning occurs in the different settings, and data on good practice needs to be collated so that interventions can be applied in developing countries where the problem is more acute. Studies are needed to determine whether simple measures, such as enclosure of village wells and ponds, can lower the drowning rates of toddlers. There is clearly a need to get drowning higher on the agenda of both policy makers and researchers.

5.4 Falls

Overall, falls are the 13th leading cause of DALYs lost (Table 2.2). Among children aged 5-14 years they were associated with more than any other cause (nearly 11 million DALYs). The importance of falls in any community will be governed by the age structure, their livelihood and the environment. They often occur in the domestic setting, particularly among children and the elderly. In rural communities in some developing, where the products of tall trees are an important source of food and income, falls from tall trees are likely to be a leading cause of injury. Work-related falls are another important cause of death and disability in low and middle income countries where safety practices are inadequate.

5.4.1 Interventions to prevent falls

Whereas it may be impossible to prevent all falls, they can be reduced by simple interventions. Falls from rooftops, wells and windows can be prevented by the construction of appropriate barriers. The study of the circumstances of falls is needed in developing country settings in order to develop appropriate interventions.

5.5 Burns

In the population as a whole, burns are the 27th leading cause of DALYs lost (Table 2.2). In 1998 burns were the 11th leading cause of death in children aged 5-14 years (39,000 deaths) and adults aged 15-44 years (122,000 deaths) (Krug et al. 2000). Burns usually occur at home. Females have been identified as particularly at risk for burns, which occur most often in the kitchen or result from ignition of loose clothes. Rates are generally highest in the very young, the very old and in women of reproductive age. The Indian sub-continent is a particular area of concern, with higher mortality rates and numbers of DALYs lost in women than other parts of the world. (Mittal 1975) Official statistics under-report the problem as they depend on hospital data, which do not include deaths occurring in the home. The Global Burden of Disease study lists "fires" rather than "burns" as an injury category, but studies from Brazil, Ghana, Nigeria, Jordan, Iran and Hong Kong have all found that scalding water and other hot fluids are the most common source of burns for children (Bartlett 2002).

Open flames used for cooking and lighting are the most important source for burns in developing countries. Portable kerosene and

gas stoves are an important cause in many countries such as Egypt, where placement of stoves on uneven surfaces and poor maintenance were contributory to high death rates. House fires appear to be particularly common where indoor fires are used for cooking. In countries where poor families sleep around open fires there is an increased risk of clothing ignition and burns. Epilepsy can be a precipitating factor for burns if people fall into the fire during a fit. Hot substance burns and scalds are another important cause of disability; children seem to be particularly at risk.

5.5.1 Policy and interventions to prevent burns.

Many of the interventions from high income countries are for preventing house fires, such as smoke alarms and sprinkler systems. Clearly these are not applicable to most low income settings. Interventions in these settings need to be targeted to the risk factors and be cognisant of the circumstances of the injuries. For example better design of stoves and their use on a raised surface could help reduce the hazard from fires from stoves. Low pressure wick stoves are safer than high pressure ones. Closed stoves rather than open fires, can be cheaply manufactured from clay and are safer and also more fuel efficient. Such stoves were reported to reduce burns in Nepal by 70%. (Thapa 1990) The

National child accident week, South Africa

This event, organised in August each year, is an initiative of the Child Action Prevention Foundation of South Africa. It is supported by government, private and voluntary organisations including:

- The Department of Transport
- ESKOM, the state electricity corporation
- The Paraffin Safety Association
- Johnson & Johnson
- Cape Town Fire and Emergency Services

Activities organised include exhibitions at hospitals, educational activity days for school children, and distribution of safety leaflets. Content includes road safety instructions for pedestrians, fire prevention, and techniques for escaping from house fires.

Source: CAPFSA website www.altonsa.co.za/childsafe/capweek.htm

development of effective barriers around open fires and the use of closed stoves would greatly reduce the incidence of burns (Smith and Barss 1991). There are potential synergies here with measures to reduce indoor air pollution.

The use of a borax rinse after washing clothes or avoiding the use of loose flowing clothing whilst cooking would reduce injuries due to clothing ignition. A Ghanaian study recommended first aid management of burns and scalds with cold water and the implementation of 'safe kitchens' (Forjuoh et al. 1995). Some have suggested that burn admissions in Africa could be reduced by 90% by the introduction of closed stoves, although this has not been substantiated. (Authincloss and Grave 1976) Research is urgently needed to improve the evidence base for interventions in these settings, and to develop awareness that a public health approach could lead to a reduction in the burden from burns and scalds.

5.6 Conclusion

Injuries in low and middle income countries require a higher priority, both in research and policy terms. The ranking of injuries is rising in relationship to other causes of mortality and the absolute number of deaths and life years lived with disability is also increasing. Unintentional injury deaths in young people are increasingly represented among the top three causes of death throughout the world. The development of healthier environments, particularly safer dwellings and transport systems, are key to reducing the relentless toll from injuries. The first step is to identify injury control as a priority, and make systematic efforts to improve surveillance and to research and develop effective promotion strategies, as Zimbabwe did from 1986 (Zwi 1996). Some environmental improvements to reduce the toll of injuries in developing countries are suggested in Table 5.1.

Road traffic injuries	<ul style="list-style-type: none"> Recreational space for children Kerbs and other measures to separate pedestrians and cyclists from motor traffic Signed pedestrian crossings Traffic calming measures such as speed bumps Enforcement of vehicle roadworthiness legislation Speed limits and speed limit enforcement Drink-driving legislation and its enforcement Enforcement of motorcycle helmet legislation
Drowning	<ul style="list-style-type: none"> Fencing or covering of pools, wells, drainage channels Teaching children to swim Control of alcohol near swimming sites Life jackets and other flotation devices
Falls	<ul style="list-style-type: none"> Improved house construction Fences, roof rails, stair rails, window bars, well covers Settlement upgrading: street lights, covered or walled drainage channels Sanitation to prevent walks in darkness to toilets Fencing of construction sites
Burns	<ul style="list-style-type: none"> Cooking above floor level Electrification to reduce dependence on candles and kerosene More reliable power supply Safe stove design, particularly stove stability Barriers between children and kitchen safety hazards

Table 5.1 Environmental measures for injury prevention in developing countries

Source: Adapted from Bartlett (2002)

Injury prevention should be one of the cornerstones of DFID's strategy to improve environments. To this end there should be cross-sectoral working with health, environment and transport in order to develop effective strategies. This would be in keeping

with a strategy to target the principal diseases of the global poor, amongst which injuries are an important cause of death and disability. In order to do so there is a need for knowledge generation to find cost-effective interventions appropriate for low income settings.

References

- Arokiasamy JT, Krishnan R 1994. Some epidemiological aspects and economic costs of injuries in Malaysia. *Asia Pac J Public Health*. 7:16-20.
- Authincloss JM and Grave GF 1976 The problem of burns in Central Africa. *Trop Doctor* 6:114-17.
- Baker SP, O'Neill B, Ginsburg MJ, Li G 1992. *The Injury Fact Book*. Oxford: Oxford University Press.
- Bandiwala SI, Anzola-Perez E, Romere CC et al. 1990. The incidence of injuries in young people: 1. Methodology and results of a collaborative study in Brazil, Chile, Cuba and Venezuela. *Int J Epidemiol* 19: 115-124.
- Bartlett SN 2002. The problem of children's injuries in low-income countries: a review. *Health Pol Plan*; 17: 1-13.
- Berger LR and Mohan D 1996. *Injury control: a global view*. Oxford: Oxford University Press.
- Forjuoh SN, Guohua L 1996. A review of successful transport and home injury interventions to guide developing countries. *Soc Sci Med* 43:1551-60.
- Forjuoh SN, Guyer B, Stribino DM, Keyl PM, Diener-West M, Smithy GM 1995. *J Epidemiol Comm Health* 49:189.
- Gwatkin DR, Heuveline P 1997. Improving the health of the world's poor. Communicable diseases among young people remain central. *BMJ* 315:497.
- Haddon W 1980. Advances in the epidemiology of injuries as a basis for public policy. *Public Health Rep*. 95:411-421.
- Hardoy JE, Mitlin D, Satterthwaite D 2001. *Environmental problems in an urbanising world: finding solutions for cities in Africa, Asia and Latin America*. London: Earthscan.
- Holder Y, Peden M, Krug E, Lund J, Gururaj G, Kobusingye O 2001. *Injury surveillance guidelines*. Geneva: WHO, 2001.
- Howland J, Hingston R 1988. Alcohol as a risk factor for drownings: a review of the literature (1950-1985). *Accid Anal Prev* 20:19-25.
- Jacobs G, Aeron-Thomas A, Astrop A. *Estimating Global Road Fatalities*. TRL Report 445, Transport Research Laboratory, 2000.
- Jordan JR, Valdes-Lazo F 1991. Education on safety and risk. In: Manciaux M, Romer CJ (eds) *Accidents in childhood and adolescence, the role of research*. Geneva: WHO.
- Kibel SM, Bass DH, Cywes S 1990. Five years' experience of injured children. *SA Med J* 78: 387-391.
- Kobusingye O, Guwatudde D, Lett R 2001. Injury patterns in rural and urban Uganda. *Inj Prev* 7: 46-50.
- Koupilova I, Leon DA, McKee M, Sethi D, Zwi A 2002. Injuries: a public health threat to children and adolescents in the European Region. In (eds) Tamburlini G, Ehrenstein OV, Bertollini R. *Children's*

- health and environment: a review of evidence. WHO and EEA, 2002. (Environmental issue report No 29.)130-140.
- Krug EG, Sharma GK, Lozano R 2000. The global burden of injuries. *Am J Public Health* 90: 129-135.
- McKee M, Sanderson C, Chenet L, Vassin S, Sckolnikov V 1998. Seasonal variation in mortality in Moscow. *J Public Health Med* 20:268-74.
- Michaud C, Murray CJ 1994. External assistance to the health sector in developing countries: a detailed analysis, 1972-90. *Bull WHO* 72:639-51.
- Ministry of Health Malaysia 1997. Annual Report 1996. Kuala Lumpur.
- Mittal BN, Inrayan A, Sengupta RK et al. 1975. Epidemiological triad in domestic accidents. *Indian J Med Res* 63:1344-52.
- Mohan D Injuries in less industrialized countries: what do we know? *Injury Prevention* 1997; 3: 241-242.
- Mohan D, Bawa 1985. An analysis of road traffic fatalities in Delhi, India. *Accid Anal Prev* 17: 33-45.
- Murray C. and Lopez A 1996. *The Global Burden of Disease*. Geneva: Harvard University Press, for the World Health Organization.
- Murray CJL, Lopez AD 1997. Mortality by cause for the eight regions of the world: Global Burden of Disease Study. *Lancet* 349:1269-76.
- Pearce T, Maunder DAC (2000). The causes of bus accidents in five emerging nations. Paper presented at 10th REAAA conference 4-9 Spt 2000 Japan.
- Pless IB 1997. The challenge of drowning prevention. *Inj Prev* 3:237-9.
- Rivara FP, Grossman DC, Cummings P 1997. Injury prevention. *New England J Med* 337:613-8.
- Reichenheim ME, Harpham T 1989. Child accidents and associated risk factors in a Brazilian squatter settlement. *Health Pol Planning* 4: 162-167.
- Roberts I, DiGuseppi C, Ward H 1998. Childhood injuries: extent of the problem, epidemiological trends, and costs. *Injury Prevention* 4 (suppl) S10-16.
- Sethi D, Zwi A 1999. Accidents and other injuries. Eds Chamie J, Cliquet RL. *Health and mortality issues of global concern*. Brussels: CBGS.
- Sethi D, Zwi A 1998. Challenge of drowning prevention in low and middle income countries. *Injury Prevention* 4:162.
- Smith GS, Barss P 1991. Unintentional injuries in developing countries: the epidemiology of a neglected problem. *Epidemiologic Reviews* 13:228-266.
- Thapa NB 1990. Accidents and injury in childhood. In Wallace HM, Giri K eds. *Health care of women and children in developing countries*. Oakland CA.: Third Party Publishing Company 428-40.
- Zwi A, Murusingsampillay S, Msika B et al. 1993. Injury surveillance in Zimbabwe: a situation analysis. London School of Hygiene & Tropical Medicine, for the Ministry of Health and Child Welfare, Zimbabwe.
- Zwi AB, Forjuoh SF, Murugusampillay S, Odero W, Watts C 1996. Injuries in developing countries: policy response needed now. *Trans R Soc Trop Med Hyg* 90: 593-5.
- Zwi AB 1996. Injury control in developing countries: context more than content is crucial. *Inj Prev* 2: 91-92.

Part III: Implications

6 Improving health and environment

6.1 Health, environment & the Millennium Development Goals

Improving environmental health is essential if we are to make accelerated and sustainable progress towards achieving the MDGs. Environmental health contributes most directly

to the goals of reducing child mortality, extending access to water and sanitation and improving the lives of urban slum dwellers, but it makes significant contributions to others. Table 6.1 below shows how environmental health relates to key goals.

MDGs: Goals and Targets	Environmental Health Input
Goal 1: Eradicate extreme poverty and hunger	A healthy environment means healthy people, able to secure improved livelihoods and break the cycle of poverty and ill-health
Goal 2: Achieve universal primary education	Freedom from diarrhoeal disease and other environmental health hazards will result in increased attendance and participation in school. School sanitation is an important determinant of girls' attendance
Goal 3: Promote gender equality and empower women	As the burden of environmental health risks falls disproportionately on women, effective interventions help to improve women's lives and empower them through increased participation
Goal 4: Reduce child mortality	Appropriate environmental health interventions can significantly reduce the number of children under 5 who die as a result of indoor air pollution and unsafe water, sanitation and hygiene
Goal 5: Combat HIV/AIDS, malaria and other diseases	Preventive environmental health measures are as important and at times more cost-effective than health treatments (e.g. bed nets in the prevention of malaria)
Goal 6: Ensure environmental sustainability <ul style="list-style-type: none"> • Halve, by 2015, the proportion of people without sustainable access to safe drinking water • Halve, by 2015, the proportion of people without access to sustainable sanitation • By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers 	These goals are expressed in terms of environmental health improvements; environmental health measures such as water supply and sanitation contribute to the MDGs as described above, but also directly to these targets.

Table 6.1 Contributions of Environmental Health to the MDGs

The multifaceted effects of environmental health measures go beyond their impact on specific MDGs. They contribute to the assets of households and communities, and reduce vulnerability to the shocks caused by illness

and injury. Thus, environmental health improvements are important contributions towards the promotion of sustainable livelihoods (Figure 6.1).

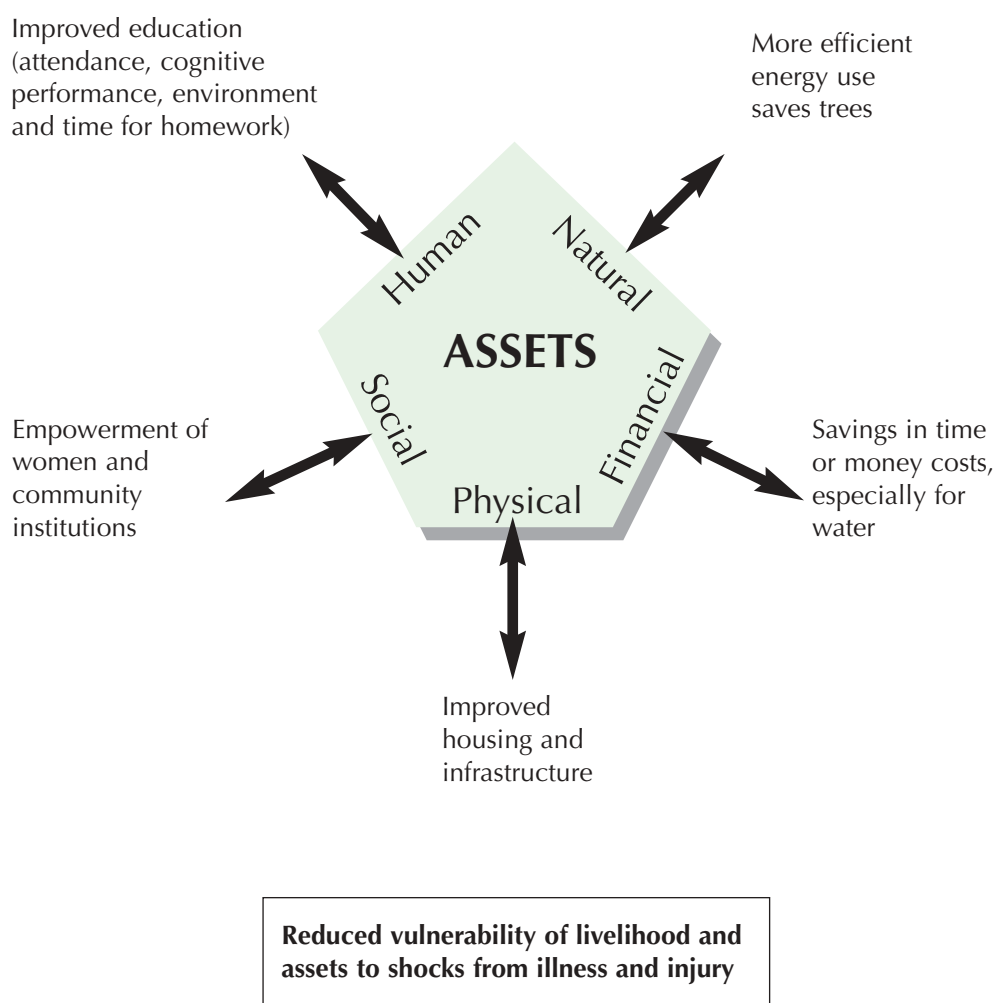


Fig 6.2 Contributions of environmental health to sustainable livelihoods

6.2 The pathway to improve environmental health

Environmental health initiatives produce important outcomes beyond health

improvements through a combination of approaches and by taking a multi-sectoral approach. The programming implications of this are illustrated according to DFID's three themes in the matrix in Appendix 2.

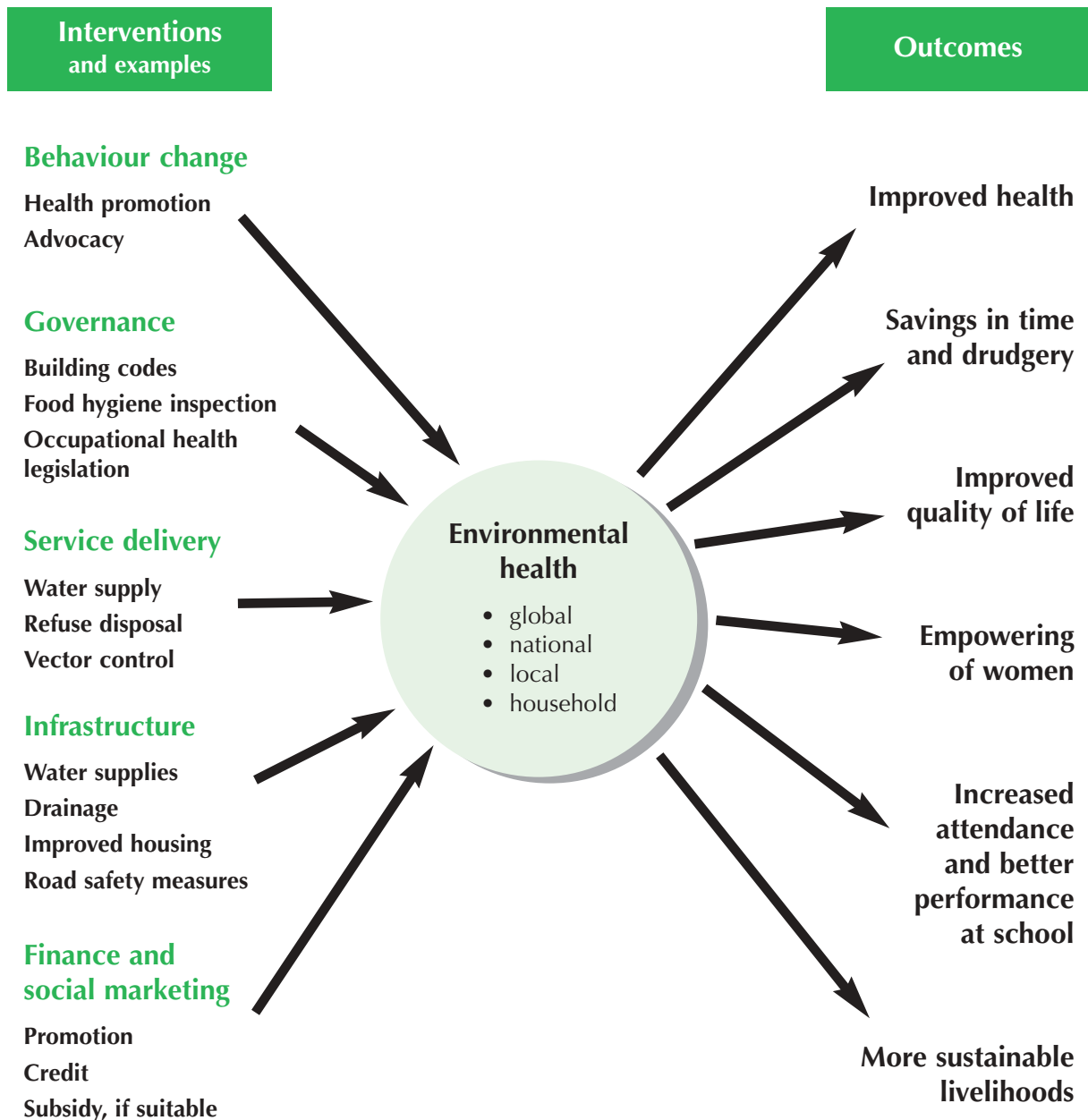


Figure 6.2 Multiple inputs and outcomes in environmental health

Figure 6.2 shows the five key types of intervention that form the critical pathway to achieving sustainable improvements in environmental health:

- Achieving effective behavioural change
- Improved governance, including regulation and legislation where appropriate
- Improved service delivery
- Appropriate infrastructure
- Financing and social marketing

These are discussed in turn below.

6.2.1 Behavioural change

In many cases, improvements to environmental health require interventions to change people's behaviour. For instance, they may require that people be persuaded to:

- Wash their hands with soap

- Install (and use) a latrine
- Place their rubbish in the right place for collection
- Buy and use an improved cooking stove
- Drive (and cross the road) more safely
- Wear protective clothing at work.

Lecturing people about their health is unlikely to achieve this. Paradoxically, people usually do things which are good for their health, for reasons which have nothing to do with health. Formative research (see Figure 6.3) is necessary to find out what people already know, do and want; in the process we can find out the "levers" which might motivate them to change their behaviour. Then an appropriate intervention can be planned, to use these levers. Men and women have different sources of information, resources and aspirations so these must be studied separately.

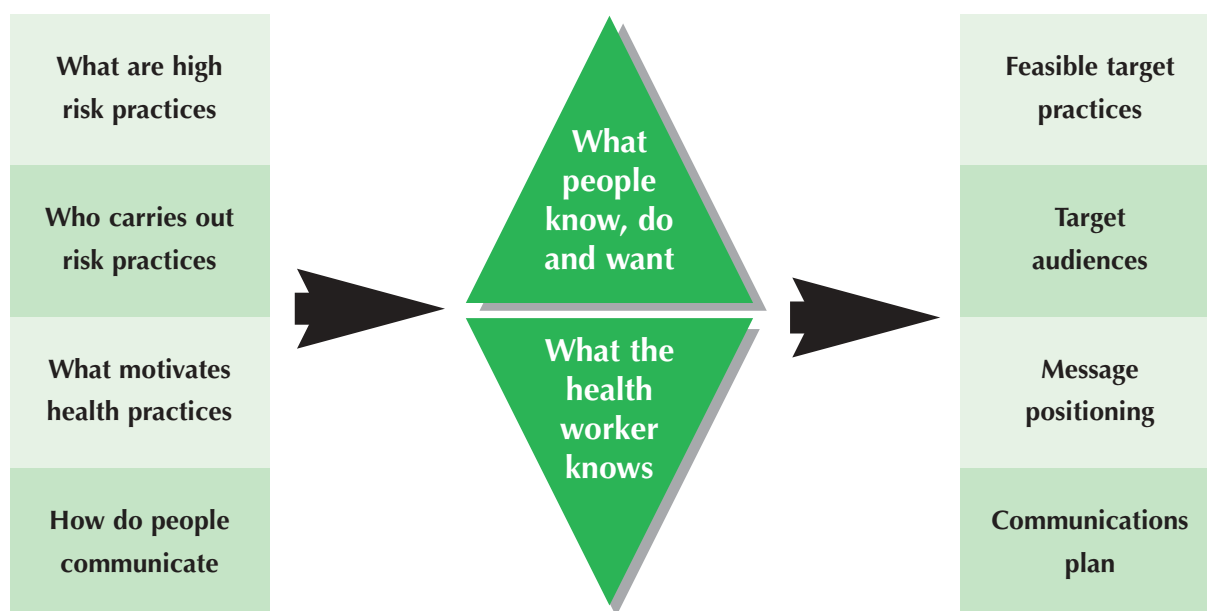


Figure 6.3 The process of formative research for environmental health promotion (Adapted from Curtis and Kanki 1998)

Health promotion is not a cheap option, requiring only a few posters. Experience from commercial marketing indicates that people need to be reached several times per month if they are to be persuaded to change their behaviour. Nor is it easily provided by health workers addressing patients waiting for treatment. Health campaigns in the UK, such as those against smoking or to promote seat belts, illustrate the intensity of contact with the message, and the long period of time required for it to bear fruit. Some successful promotional campaigns, such as the social

marketing of condoms, have been carried out independently of the health care system.

There is a shortage of good evidence for the effectiveness of behaviour change interventions in developing countries; many of the studies in the literature were evaluating interventions which were not based on proper formative research, and many studies were themselves methodologically weak (Cave & Curtis, 1999). However, there are good examples where such interventions have been shown to be effective at reasonable cost.

Behaviour change can be cost-effective

DFID funded the Community Health Clubs in rural Tsholotsho District, Zimbabwe which increased the proportion of households using a ladle to draw water from 3% to 93% and the proportion with an improved pit latrine from 40% to 80%, as well as improving other aspects of hygiene behaviour, at a cost of US\$ 3.33 per household (Waterkeyn 2002).

A recent hygiene promotion project in the town of Bobo Dioulasso (population 341,000) in Burkina Faso was found to have changed the hygiene practices of only 18.5% of mothers of young children, and to have cost \$292,000 to implement. Nevertheless, it has been calculated that the project could generate 394,000 in savings to the health system and in terms of lost productivity associated with child death (Borghi et al. 2003).

6.2.2 Improved governance

Poor governance at national and local level and within other governing bodies is a key cause of poor environmental health.

Environmental health issues are typically cross-sectoral, and therefore often fall through institutional "cracks" and are not given the political commitment they need. Local government institutional capacity is particularly important for environmental health, as this is the level where many environmental health services are provided or managed.

Many aspects of environmental health depend

on improved governance, both in delivery of essential environmental health services and in regulation and legislation. In many developing countries, better regulation and implementation - often of existing legislation - is all that is needed to prevent hazardous practices.

Of course, successful regulation requires monitoring, and where this has to be done locally it requires effective local government. Legislation is more likely to be enforceable if it reflects a social consensus, and accompanying promotion can help to ensure that.

Regulation can succeed where promotion has failed

In the 1970s, barely half the British population wore seat belts in their cars, although most vehicles had them and people were urged to wear them. Since the enactment of legislation to make the wearing of seat belts compulsory, supported by further campaigns to encourage their use, more than 95% now do so. This has contributed significantly to the reduction in fatal traffic injuries.

6.2.3 Improved service delivery

Equitable service delivery and environmental health management go hand in hand. The lack of access to fresh water, for instance, that much of the developing urban and rural populations face is not necessarily attributable to the scarcity of water, but the absence of proper mechanisms to deliver water effectively and equitably. Effective service delivery is dependent on all stakeholders (policymakers, service providers and citizens) interacting in well-structured institutional relationships. Broad-based participation is necessary, including local authorities, private and public sector, small-scale and non-profit service providers, consumers, and NGOs and CBOs to ensure proper programme design and implementation.

6.2.4 Appropriate Infrastructure

Water supply and sanitation is the most obvious example of how infrastructure can provide a healthier environment. It also illustrates the common experience of environmental health workers that the infrastructure is desirable not only on environmental health grounds, but offers many other benefits, such as savings in drudgery and improved quality of life.

On the other hand, the provision of infrastructure “hardware” often needs to be accompanied by educational and promotional “software” to ensure that it is properly used. For example, many externally-funded water supplies have been allowed to fall into disuse because no-one consulted the community to ensure that they were appropriate for local needs, or because the local institutions needed to maintain them were not established or adequately supported.

The Ministry of Health may not be the best arm of Government to build and operate water supplies, any more than it is best suited to market improved stoves or implement traffic safety improvements. This is the case with many important areas of environmental health, where a multisectoral approach is most likely to succeed. The health sector has an important advocacy role to play, however, in ensuring that the environmental health aspects are not forgotten. In practice, this advocacy role will often be to ensure that the needs of the poor are not dropped from the agenda. The health sector should also maintain a watching brief on the operation of the infrastructure; with water supply, this includes water quality surveillance. Environmental health

Even as a health measure, infrastructure can be cost-effective

The net cost of the 1991 cholera epidemic to Peru’s economy has been estimated at \$495,000 (Petraera and Montoya 1992). By comparison, the total cost of providing safe drinking water at public standposts for Peru’s 5.9 million people who are still unserved, at an average of \$41 per head, would be only \$242 million, or roughly half as much. As well as controlling the cholera epidemic, this would have saved millions of women from hours of drudgery collecting water, enabled the poor to avoid the exorbitant charges for water made by vendors, and improved people’s quality of life.

considerations often require a number of sectors to cooperate; here also the health sector can help to coordinate them.

It is important that any relevant infrastructure is gender sensitive. Water supplies, household sanitation and the cooking stoves which cause or prevent indoor air pollution are used more often by women than by men, though their improvement often needs the application of skills, tools and funds largely controlled by their husbands. This introduces an important gender dimension to environmental health. It is wholly wrong to think that physical infrastructure such as water pipes, pit latrines or chimneys is gender neutral.

6.2.5 Financing and social marketing

As well as changing behaviour, improving environmental health often requires an improved or new product to be purchased at the household level - such as a toilet, soap, hygienic water containers, or an improved stove. In order to market these products it is important to understand how people will prioritise them against other household needs. For example, when deciding whether to install a latrine, poor households weigh them against other home improvements, and health considerations are rarely significant in the decision.

It is also necessary to understand how people are going to finance the domestic investments required to improve their environmental health. This raises complex issues of willingness to pay which depend on affordability, reason for purchasing and other household priorities. Experience has shown that direct credit schemes are not always effective; either the loans are not recovered, or they do not reach the poorest. It is therefore important to identify and build on existing, traditional credit arrangements such as rotating credit associations.

6.3 Conclusion

Environmental health is an essential component of a sustainable livelihood. Measures to improve environmental health are no less cost-effective than curative ones, but they have often been neglected in the past as they require multi-sectoral interventions. Similarly, their benefits have often been underestimated as they go far beyond health and the health-related MDGs. They save the poor money and effort, while improving the quality of their lives. They empower women and community institutions. They do more than replace poor dead children by poor living children. Seen holistically, they are significant, sustainable and empowering steps toward the elimination of poverty.

References

Borghi J, Curtis V et al. 2003. Is hygiene promotion cost-effective? A case study in Burkina Faso. Bull WHO (in press)

Cave B, Curtis V 1999. Effectiveness of promotional techniques in environmental health. WELL Task No. 165. WELL for DFID; www.lboro.ac.uk/well/resources/well-studies/full-reports-pdf/task0165.pdf

Curtis V, Kanki B 1998. Happy, Healthy and Hygienic; How to Set up a Hygiene Promotion Programme. New York: Unicef.

Petrera M, Montoya A 1992. PAHO Epidemiological Bulletin 13 (3): 9-11.

Waterkeyn J 2002. Poster presentation, Royal Society of Tropical Medicine & Hygiene.

WHO 2002. Asia: experts call on governments to remove lead from gasoline. Press Release WHO/15. 7 March 2002

Appendix 1

The concept of the Disability-Adjusted Life Year (DALY)

The concept of the DALY (Disability-adjusted Life Year) was introduced in the Global Burden of Disease Study (Murray and Lopez 1996) in an effort to find a common currency by which they could assess priorities among different diseases and health problems. Inevitably, this involved the making of value judgements. Without these it would be impossible to compare the significance of a disease which (for example) kills children aged two with the public health importance of another disease which, say, seriously handicaps adults in middle age.

The authors had found major problems in trying to interpret national health statistics. Deaths data were not available by cause of death, and cause-specific data were incomplete; for example, in many countries cases treated by private practitioners are not included in the national figures. The burden of non-fatal disease, especially chronic disease which is often never presented to a health worker, is also unknown. On the other hand, research studies of specific diseases often mix science and advocacy, as the researchers are keen, for the best motives, to emphasise the public health importance of "their" disease. Because of this, if the global numbers of deaths apparently caused by every disease were added together, most of us would have to die twice over!

Murray and Lopez did not think it appropriate, or necessary, to put a money value on the burden of disease. They developed the DALY as an alternative. The values implicit in the

concept can be seen from the following design decisions which they took:

Ideal lifespan. This was needed in order to define the age before which death could be regarded as premature, and years of life considered lost. This was set at 82.5 years for women, and 80 for men, to correspond with the averages for Japan.

Value of a healthy year of life. Not all years of life were considered of equal value. This was taken as 0 at birth, rising steeply to a peak of 1.5 times the average at age 22, at, and then gradually declining to 0.5 at age 80.

Effect of socio-economic or ethnic status. None was allowed. A decision was taken to value all people's health equally, except for the age and gender effects mentioned above.

Value today vs. value in the future. A discount rate of 3% was applied to the data. This was needed to compare interventions with delayed effects. For example, hepatitis immunization helps to prevent deaths from liver cancer occurring 20 to 30 years later.

Value of life with disability. A system of weighting was devised for 22 indicator conditions, agreed by consensus at a meeting of a group of 8 to 12 health workers. The idea was that these weightings could be extended or interpolated to other conditions by analogy. The 22 indicator weightings are shown in the table below.

Disability class	Severity weight	Indicator conditions
1	0.00-0.02	Vitiligo on face, weight-for-height < 2 s.d.
2	0.02-0.12	Watery diarrhoea, severe sore throat, severe anaemia
3	0.12-0.24	Radius fracture in a stiff cast, infertility, erectile dysfunction, rheumatoid arthritis, angina
4	0.24-0.36	Below-the-knee amputation, Deafness
5	0.36-0.50	Rectovaginal fistula, mild mental retardation, Down's syndrome
6	0.50-0.70	Unipolar major depression, blindness, paraplegia
7	0.70-1.00	Active psychosis, dementia, severe migraine, quadriplegia

Table A1. Value of Life with Disability: System of Weighting

Murray and Lopez also performed some sensitivity analysis to assess the impact of changes in these design decisions. They classified diseases into three broad cause groups:

- I Communicable, perinatal and nutritional
- II Noncommunicable diseases
- III Injuries

They found that the distribution of the global burden between these three groups was largely unaffected by the age-weighting scheme

adopted, but slightly affected by the disability weighting method. A higher discount rate increased the relative burden in older age groups, and hence the proportion of non-communicable disease. The main effect of changing the discount rates and age weighting is to reduce the importance of several psychiatric conditions. The authors concluded that;

“Researchers’ efforts should be invested in improving the basic data rather than in spending excessive energy on analysing the effects of small adjustments to the measure itself.”

References

Murray C. and Lopez A 1996. The Global Burden of Disease. Geneva: Harvard University Press, for the World Health Organization.

www.hsph.harvard.edu/organizations/bdu/summary.html

Appendix 2

Matrix of practical programming implications identified by theme and the discipline

	HUMAN DEVELOPMENT	SOCIAL AND POLITICAL CHANGE	SUSTAINABLE ECONOMIC GROWTH
International Enabling Environment	<ul style="list-style-type: none"> Active engagement with international health institutions and initiatives to build commitment and coherence around environmental health improvement [health] Contribute, through funding of Knowledge Programmes, operational research etc to the international evidence base and the development of EH interventions. [health, engineering, energy, transport, economics] Build consensus among international organizations on including EH issues in school curricula and adult education programmes [education] Active engagement with international organisations to build support for school sanitation. [education, engineering] Support UNICEF/WHO initiatives including: <ul style="list-style-type: none"> - Joint monitoring programme on water & sanitation MDGs - Guinea worm eradication - School sanitation & hygiene education [health, engineering] 	<ul style="list-style-type: none"> Active engagement with international organisations and initiatives (e.g. NEPAD, SPA, DAC, World Bank) to build consensus around strategies for capacity building, particularly in local government, to foster the enabling environment for EH improvements [governance] Promote cross-country and cross-regional lesson-learning to build consensus around best practice for environmental health interventions in Public Service Reform, Public Expenditure Reform, and Security, Safety and Accessible Justice programmes [governance] Maintain active engagement in international fora on anti-corruption issues, particularly those related to reducing corruption in infrastructure contracts [governance] Support WHO and UNICEF in their work on human rights, gender equality and the rights of the child with respect to EH. [socdev, health] Support situation analyses to identify those with least access to EH services and understand the barriers to their access [socdev, livelihoods] Identify and support groups that have particularly high exposure to EH problems. Involve these groups in monitoring the delivery of EH services and uptake of preventive interventions. [socdev, health] 	<ul style="list-style-type: none"> Stay abreast of international work to cost investments necessary to achieve the MDG relevant to EH [economics] Work with international community on revenue implications of alternative approaches to financing and management of EH services [economics, engineering] Contribute to international thinking on Public Expenditure Management and development of financial systems, particularly for local government [economics, governance] Support more detailed analyses and monitoring of the real livelihood costs of EH-related illness and death, linking up with World Bank as appropriate [health, livelihoods] Work with international organizations to improve definitions, measurement and reporting of indicators in relation to water supply, sanitation, hygiene and indoor air pollution [engineering, statistics] Work with others to achieve better coordination of efforts to improve health information systems, especially in relation to accidents and environmental exposures [statistics, health, economic growth]

<p>DFID Enabling Environment</p>	<ul style="list-style-type: none"> • Capture and disseminate lessons and issues from investments in hygiene, sanitation, water supply, and other EH services. <i>[engineering, environment statistics]</i> • Where appropriate, make investments in promotion of hygiene, sanitation, IAP reduction and accident prevention measures through public, NGO and private (eg social marketing) channels <i>[health, socdev, PPP]</i> • Support development of national and local government policy, plans and budgets that explicitly address access to EH services <i>[engineering, economics, governance]</i> • Increase awareness of education's contribution to the EH agenda, through: a) school sanitation facilities; b) hygiene promotion in schools; and c) inclusion of EH issues in school curricula <i>[education]</i> • Develop post basic education policy to include EH issues connected with professional skill development (e.g. of health professionals, teachers, food handlers) <i>[education]</i> 	<ul style="list-style-type: none"> • Support measures to strengthen local government and endow it with the powers and resources to improve EH conditions <i>[governance]</i> • Develop guidelines on ways that local government can promote better access to water supply, sanitation and other EH services, particularly through regulation <i>[socdev]</i> • Support the networking and mentoring of water and sanitation sector regulators <i>[governance]</i> • Disseminate the technical implications of human rights conventions in relation to EH <i>[socdev]</i> • Ensure that EH issues are adequately addressed in PRSPs. <i>[health, economics, socdev, environment]</i> • Support strengthening of regulation of hazardous and clinical waste management by providing technical guidance and infrastructure for safe disposal. <i>[engineering, health, governance]</i> 	<ul style="list-style-type: none"> • Progress DFID thinking about appropriate instruments to achieve EH outcomes, particularly shift to less IAP-inducing fuels <i>[economics]</i> • Progress DFID thinking about appropriate mechanisms for Public Expenditure Management, including in water and sanitation the sector <i>[economics, governance]</i> • Mesh EH interests with other DFID initiatives to improve data systems <i>[health, engineering, statistics]</i> • Identify and support livelihood based approaches which lead to a demand for better EH, especially at household level (e.g. marketing support for artisan latrine builders). <i>[economics, livelihoods]</i>
<p>National Enabling Environment</p>	<ul style="list-style-type: none"> • Development of national EH policies and plans and support local government strengthening initiatives - use EH indicators as a marker of progress <i>[health, governance, economics, socdev]</i> • In budget support contexts, negotiate EH activities and outcomes into basic packages, into sector monitoring frameworks and annual review sessions etc. <i>[health, economics, governance, socdev]</i> 	<ul style="list-style-type: none"> • Support regulatory and legislative reforms to encourage affordable and good quality EH services for poor people <i>[governance]</i> • Support decentralisation programmes to enhance power of regional, district and sub-district institutions to promote EH interventions <i>[governance]</i> 	<ul style="list-style-type: none"> • Encourage programmes that monitor livelihoods to incorporate EH indicators <i>[livelihoods, statistics]</i> • Support development of public-private partnerships to promote hygiene, sanitation, road safety and other EH measures involving behaviour change <i>[economics, governance, health]</i>

- Promote appropriate legislative framework (national and by-law) for access to EH services and for regulation of private sector service provision **[engineering, environment, governance]**
- Support efforts to promote intersectoral collaboration in EH planning and budgeting, **[health, environment, engineering]**
- Financing strategies to address charges for sanitation and energy services; government to develop and advertise explicit tariff schedules and cross-subsidy policies where appropriate for water, sanitation and energy **[engineering, energy, economics]**
- Ensure relevant sector plans and PRSPs are informed by EH considerations and that the policy framework gives sufficient weight to effective preventive interventions; **[governance, health, environment, economics]**

- Promote the involvement of civil society and those advocating for EH in the monitoring of indicators of EH service coverage, disease exposure and morbidity/mortality **[socdev]**
- Encourage government to introduce or enforce existing legal and social rights to EH services and protection **[governance]**
- Regulate water and sanitation providers, including the private and informal sectors where appropriate, to decrease cost barriers to EH services **[governance, engineering, economics, enterprise]**
- Develop and assess instruments to promote interventions which reduce exposure to IAP including improved building design and switching to low pollution fuel **[governance, energy, economics]**.
- Implement regulatory interventions to reduce RTAs including vehicle inspection, safety belt and helmet requirements, and drink & driving legislation **[governance]**

- Support financial devolution and public expenditure management by local government **[economics, governance]**
- Explore means of protecting water supply, sanitation and housing from catastrophic shocks arising from emergencies, eg by advance warning and communication systems, and by requiring a risk management and disaster preparedness line item in municipal budgets. **[governance, engineering]**
- Assist in the selection of appropriate EH indicators in PRSP monitoring systems, and then support for improved methods of data collection and analysis. **(statistics)**
- Support communications networks to provide channels for EH messages through mass media, eg community radio **[engineering, socdev]**
- Support planning and budgeting of safer road design, especially for pedestrian security and at intersections **[engineering]**
- Support planning and budgeting for efficient and reliable water supply, sanitation and energy utilities **[engineering, energy]**

Appendix 3

Glossary

acute	Describes disease of short duration
attributable risk	The amount of disease in the population which can be attributed to a given risk factor
bias	Error in a statistical result
biomass fuel	Animal dung, wood or crop residues
burden of disease	The overall amount of disease in a population. To add the impact of different diseases, a common currency such as the DALY is required
chronic	Describes disease of long duration
confounding	An statistical error by which a disease appears to be associated with a risk factor although there is no causal connection
DALY	Disability-adjusted life year (see Appendix 1)
endemic	Disease which is habitual, often sporadic, in a given population
epidemic	An increase in the normal number of cases of disease in a given population
epidemiology	The study of patterns of disease in a population
epidermis	Skin and underlying tissue
excreta	Urine and faeces
exposure	The degree to which a person is subject to a given risk factor
dengue	An acute mosquito-borne disease occurring in urban epidemics; a complication known as dengue haemorrhagic fever (DHF) is often fatal

filariasis	A chronic mosquito-borne disease which causes disability in several ways including elephantiasis
fomite	An object on which a pathogen can be transmitted
formative research	Field research of local conditions and perceptions necessary to plan a behaviour change intervention (see fig. 6.3)
hazard	Something which could plausibly cause a risk (an increased probability) of disease
observational study	In epidemiology, a study in which no preventive or curative intervention is made, but those with disease are compared with those without
particulates	One aspect of air pollution, usually represented by the weight per cubic metre of air of solid particles less than 10 microns in size
pathogen	A micro-organism which causes disease
pour-flush toilet	A kind of toilet common in Asia which is flushed by pouring 1 to 3 litres of water into the bowl
respiratory tract	
lower respiratory tract	The trachea and lungs
upper respiratory tract	The mouth, nose and throat
risk factor	A characteristic or condition which is associated with an increased probability of disease
schistosomiasis	A chronic disease caused by bathing in infected water
social marketing	The application of commercial marketing techniques to promote goods or behaviour in the public interest
surveillance	The process of detecting, recording and responding to cases of disease with a view to controlling them
trachoma	A chronic eye disease common in arid environments and causing blindness

vector	An animal, such as a snail or mosquito, which transmits disease
vendor	A commercial distributor of water for domestic use
vital registration	Registration of births and deaths
water-borne	Describes the transmission of disease in drinking-water

The Department for International Development

The Department for International Development (DFID) is the UK Government department responsible for promoting sustainable development and reducing poverty. The central focus of the Government's policy, based on the 1997 and 2000 White Papers on International Development, is a commitment to the internationally agreed Millennium Development Goals, to be achieved by 2015. These seek to:

- Eradicate extreme poverty and hunger
- Achieve universal primary education
- Promote gender equality and empower women
- Reduce child mortality
- Improve maternal health
- Combat HIV/AIDS, malaria and other diseases
- Ensure environmental sustainability
- Develop a global partnership for development

DFID's assistance is concentrated in the poorest countries of sub-Saharan Africa and Asia, but also contributes to poverty reduction and sustainable development in middle-income countries, including those in Latin America and Eastern Europe.

DFID works in partnership with governments committed to the Millennium Development Goals, with civil society, the private sector and the research community. It also works with multilateral institutions, including the World Bank, United Nations agencies, and the European Commission.

DFID has headquarters in London and East Kilbride, offices in many developing countries, and staff based in British embassies and high commissions around the world.