Oxford textbook of public health

VOLUME 2

Processes for public health promotion

Edited by

Walter W. Holland, Roger Detels, and

George Knox

with the assistance of

Ellie Breeze

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Preface

It is not an easy task to follow in the footsteps of such a renowned editor as Bill Hobson. We were however very honoured when, on the retirement of Professor Hobson, the Oxford University Press approached us about taking up the challenge of revising Hobson's *Theory and practice of public health.* Since this work first appeared in February 1961 Professor Hobson was responsible for taking it through no less than five editions. Many eminent public health academics and practitioners have contributed to this book and it has been recognized as a standard textbook on the subject. Sadly, Professor Hobson died after a long illness at the end of November 1982. After an early training in public health starting as a medical officer of health and then as a specialist in hygiene and epidemiology in the army, he went on to be a lecturer in social medicine at Sheffield University, becoming professor in 1949. From 1957 until his retirement, he served in a variety of posts at the WHO, where his major responsibilities were always concerned with education and training. His interest in this and in the international aspects of health were well exemplified by the first edition of *Theory and practice of public health.* One of the major strengths of the book has been its international nature and its link to the WHO.

On accepting the daunting task of revising this major work our first step was to look dispassionately at its role within public health, a field which has evolved and changed greatly over the last 25 years. We decided that although this book is held in great esteem in the western world it was appropriate now to introduce major revisions and thus, increase its relevance to the problems facing us as we approach the twenty-first century. A particularly important advance has been the recognition in recent years that the problems in public health facing developing countries are quite different to those facing the developed world. The interests of WHO, quite correctly, have been focused on developing countries. We consider that this book should concentrate on presenting a comprehensive view of public health as it relates to developed countries. (Perhaps there is a place now for a comparable textbook concerned specifically with developing countries.) This is not to say however, that the content will not prove relevant and of interest to the student of public health from a developing country.

The *Oxford textbook of public health* attempts to portray the philosophy and underlying principles of the practice of public health. The methods used for the investigation and the solution of public health problems are described and examples given of how these methods are applied in practice. It is aimed primarily at postgraduate students and practitioners of public health but most clinicians and others concerned with public health issues will find some chapters relevant to their concerns. It is intended to be a comprehensive textbook present in the library of every institution concerned with the health sciences. The term 'public' is used quite deliberately to portray the dield. Public health is concerned with defining the problems facing communities in the prevention of illness and thus studies of disease aetiology and promotion of health. It covers the investigation, promotion, and evaluation of optimal health services to communites and is concerned with the wider aspects of health within the general context of health and the environment. Other terms in common use, such as community medicine, preventive medicine, social medicine, and population medicine have acquired different meaning according to the country or setting. This gives rise to confusion and we have avoided their use since this book is directed to a world-wide audience. Public health, we believe, is more evocative of the basic philosophy which underlies this book.

The first volume of the Textbook reviews the overall scope and strategies of public health. Volume 2 deals in depth with the processes of health promotion. Historically, public health has been primarily concerned with the identification and prevention of disease as the primary means to safeguard the health of a population. The need for this traditional approach still remains, but within the last decade public health has also come to incorporate a broader perspective as our understanding of the factors which determine the health of the public has increased.

This greater understanding of factors which enhance health has led to a reconceptualization of health as a condition which must be actively maintained. Thus public health has been able to adopt a proactive approach with health, rather than absence of disease, as a goal. This aim is reflected in the World Health Organization motto, 'Health for all by the Year 2000'. The agenda for public health in the 1980s will be to actively promote health and enhance the quality of life through a wide range of activities, both traditional and new.

Commensurate with this proactive approach is the assumption of new responsibilities. For example, public health is now also concerned with the quality of health care, adequate access to medical care by all segments of society, the health effects of the many chemicals and other agents which are released into the environment as a result of the many new technical advances, and promotion of healthy lifestyles. These responsibilities call for both new strategies and processes to promote the health of the public and innovative use of traditional strategies.

In this volume we present a discussion of the processes currently being used to promote the health of the public. These range from the scientific and regulatory strategies used to control the physical environment and the spread of infectious diseases to the involvement of national governments and international organizations in promotion of the public's health.

In the first two chapters of the volume, the control of the physical environment and the control of infectious diseases are discussed. Although these have been important traditional concerns of public health, there have also been new strategies developed as new health problems emerge and former health problems are resolved.

The next several chapters address more recent concerns of public health: modifying the social environment, intervening in population dynamics in order to limit growth, and providing more effective health services to include provisions for specialty care and for care of the mentally and emotionally handicapped.

The third section discusses the organization of public health services, the staffing of these services, and the training of personnel for public health. The volume concludes with a discussion of the co-ordination and development of strategies and policy on the national level and to some extent, on the international level.

In conclusion, this volume should give the reader some appreciation of the dynamic, evolving nature of public health and the diversity of approaches which are being used to assure the highest levels of public health in developed countries.

Volume 3 of this textbook is concerned with the investigative methods used in public health, and finally Volume 4 with a description of the specific applications of public health methods of controlling disease processess, and, with tackling the problems of disease in specific client groups.

The development of public health policy is dependent upon a series of scientific methods, and we do not attempt in this book to cover all the methods and their applications. However it is to be hoped that those examples that have been chosen will illustrate to the reader the way in which particular problems can be approached. Each chapter includes a comprehensive list of further reading which should equip the reader with the means of obtaining a deeper knowledge should he or she wish to pursue any theme further.

This is the first of what we hope will be many editions. As each chapter was submitted to the editors we have attempted to identify gaps and areas of overlap. There is no doubt however that some remain. It is only through feedback from readers that we will be able to adapt, modify, and improve further editions. If the book is successful it will be entirely due to the effort of the contributors who undertook with great patience a tremendous amount of work. They were bombarded with instructions, advice, reminders, and modifications and we would like to express our thanks and extend our apologies to all of them. Our gratitude also goes to our secretaries and assistants who coped so admirably with the enormous task of compiling this work. We hope that it will be widely read by all those concerned with the formulation and execution of public health policy and that it will provide a suitable framework for devising approaches to some of the problems challenging public health today.

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Abbreviations

AA	Alcoholics Anonymous
ACPM	American College of Preventive Medicine
ACT	Australian Commonwealth Territory
ADAMHA	Alcohol, Drug Abuse, and Mental Health Administration
AIDS	Acquired immune deficiency syndrome
AMA	Australian Medical Association
ANA	American Nurses Association
APHA	American Public Health Association
ASPH	Association of Schools of Public Health
ASTHO	Association of State and Territorial Health Officials
BPM	Best practical means (in environmental pollution control)
BMA	British Medical Association
CAT	Computer axial tomography
CDC	Centers for Disease Control
CDSC	Communicable Disease Surveillance Centre
CEHO	Chief Environmental Health Officer
CHC	Community Health Council
CLEAR	Campaign for lead-free air
COPES	Community-oriented programs environment scale
DHHS	Department of Health and Human Services
DHSS	Department of Health and Social Security
DMT	District Management Team
DRO	District Rehabilitation Officer
DWI	Driving while intoxicated offenders
EAP	Employee Assistance Programme
EEC	European Economic Community
EIS	Epidemic Intelligence Service
EMAS	Employment Medical Advisory Service
EPA	Environmental Protection Agency
ERC	Employment Rehabilitation Centre
FDA	Food and Drug Administration
FMECH	Foundation for Multi-Disciplinary Education in Community Health
FMP	Family Medicine Programme
FPA	Family Planning Association
GMSC	General Medical Services Committee of the British Medical Association
GP	General practitioner
HDL	High density lipoprotein
HEC	Health Education Council
HEO	Health Education Officer
HEW	Health, Education and Welfare
HRSA	Health Resources and Services Administration
HSA	Health Systems Agency
ICN	International Council of Nurses
IPPF	International Planned Parenthood Federation
JCVI	Joint Committee on Vaccination and Immunization
LHD	Local Health Department
LMC	Local Medical Committee
LSD	Lysergic acid diethylamide
MAFF	Ministry of Agriculture, Food, and Fisheries
MOEH	Medical Officer for Environmental Health
MOH	Medical Officer of Health
MRFIT	Multiple Risk Factor Intervention Trial
NHS	National Health Service
NIH	National Institutes of Health
NIOSH	National Institute of Occupational Safety and Health
NOPHN	National Organization for Public Health Nursing
NSW	New South Wales
OHE	Office of Health Economics
OPCS	Office of Population Censuses and Surveys
PHLS	Public Health Laboratory Service
PHN	Public Health Nursing Section of American Public Health Association
PHS	Public Health Service
PRO	Professional Review Organization
RACGP	Royal Australian College of General Practitioners
RAWP	Resource Allocation Working Party
RCGP	Royal College of General Practitioners
RCP	Royal College of Physicians
SAIT	South Australian Institute of Technology
SHA	State Health Agency
SHHD	Scottish Home and Health Department
VTP	Vocational Training Programme
WHO	World Health Organization

Contents

1 The control of the physical environment

H.A. Waldron

INTRODUCTION

The effects which the release of chemicals into the environment might have on human health is a matter which continues to attract a great deal of attention and there has been both national and international concern in response to suggestions that some forms of chemical pollution may be implicated in, for example, the aetiology of malignant disease or of congenital malformations, or that it may exacerbate chronic respiratory disease or induce subtle behavioural effects in children. Many of the untoward effects attributed to chemicals in the environment are accepted both by the general public and many scientists in a largely uncritical fashion. This is brought about by a desire to explain the changing patterns of mortality which have been observed during the last hundred years or so by the application of old concepts to new problems.

The great change in the pattern of mortality which has been observed during the past century and a half has been the virtual elimination of deaths due to infectious diseases. In the mid-nineteenth century, infectious diseases accounted for at least a third of all deaths whereas they now account for about 0.5 per cent. By contrast, cardiovascular and malignant diseases, which caused less than 2 per cent of all deaths in the nineteenth century are now the cause of three-quarters of all deaths (Table 1.1). The elimination of the infectious diseases came about, not by advances in medical treatment, but by improvements in hygiene of which the most important was the separation of sewage from drinking water. As McKeown (1979) has shown, specific medical measures did not contribute to the decline in the death rate from infectious diseases which was falling before the causative organisms were isolated and long before any effective treatment or prophylaxis (in the form of effective immunization) became available.

Table 1.1. *Changes in causes of death*

ICD Group	Deaths as a percentage of all deaths 1838–42	1969–73
Infectious disease	36.50	0.59
Malignant disease	0.76	20.43
Endocrine disease	–	1.18
Diseases of the blood	–	0.32
Mental disease	0.17	0.25
Neurological disease	14.25	1.10
Circulatory disease*	1.22	51.24
Respiratory disease †	9.34	14.28
Digestive disease	6.26	2.42
Urogenital disease	0.64	1.34
Others ‡	27.39	2.97
Accidents	3.39	3.88

*Includes cerebrovascular disease.
†Includes pneumonia.
‡Includes dropsy, debility, and old age.

The success which environmental manipulation had in the control of the infectious diseases, however, combined with a general disinclination to accept behavioural factors as being of importance in the causation of disease, has led to a search for the environmental agents which might be responsible for the modern epidemics. The most favoured candidates for this role are the chemicals which are to be found widespread throughout the environment.

The corollary of accepting chemical pollutants as important factors in the causation of human disease (and here I shall ignore the harm which they might cause to animals, to plants and the general amenities) is that adequate control of their dissemination should produce a general improvement in health. Pollution control, however, is extremely costly and can be undertaken only by directing resources away from other sectors of the economy. Thus it is important to have a rational basis from which to develop control strategies and priorities. To achieve this it is necessary to know the pollutants which are commonly present in the environment, to what extent (and under what circumstances) they are harmful to health, and what general measures would best keep environmental contamination below presumed toxic thresholds.

There is no doubt that man's activities have greatly enhanced the rate at which chemicals circulate through the environment. There is, of course, a natural rate of release of materials into the environment. The elements within the earth's crust enter the environment as the result of the erosion of soils and rocks and, to a lesser extent, by volcanic activity, by earthquakes and by the decay of organic matter. If elements were not released by these means then life would not be possible. As a species we have depended upon the metals which are naturally released into the environment and enter the various components of our diet. Because it is necessary to maintain the concentration of metals in the body to within relatively narrow limits, mechanisms have evolved which control their uptake from the gut. Non-essential metals, some of which may be toxic, become incorporated into food and drink and are able to take advantage of the various transport mechanisms by which the essential metals are absorbed from the gut, often in competition with essential metals (cadmium v. zinc, lead v. calcium, for example). Since non-essential metals are subject to none of the normal control mechanisms, however, their absorption continues irrespective of existing tissue levels. The widespread dissemination of toxic metals thus enhances the probability that tissue levels will exceed no-effect thresholds.

One other physiological mechanism which is important in the context of environmental pollution is that for most of man's evolutionary history he has breathed air which has contained very low concentrations of non-gaseous elements. Because the uptake of chemicals, other than gases, from the lung was insignificant, there are no mechanisms by which their uptake can be regulated; thus, particles which are sufficiently small ($< 7\ \mu m$ diameter) to enter the alveoli are readily absorbed. This fact has to be taken into account when deciding upon the action to be taken with respect to a metal pollutant. For example, the concentration of lead in air is much lower than it is in food and drink but a greater proportion is absorbed from the air (about 40 per cent) than from the gut (c. 10 per cent in adults). In adopting a strategy to reduce exposure to lead it *may* be more effective to reduce levels of lead in the air than in the diet.

Environmental pollution is associated with urbanization and industrialization and is by no means a new problem. There is a long history of concern about the effects of pollution on health. As early as 1273, legislation was directed against the use of coal in England because it was prejudicial to health whilst John Evelyn's tract, *Fumigigium, or the Smoake of London Dissipated* which was published in 1661 states that:

> in London people walk and converse pursued and haunted by the infernal smoake. The inhabitants breathe nothing but an impure and thick mist, accompanied by a fuliginous and filthy vapour, which renders them obnoxious to a thousand inconveniences, corrupting the lungs and disordering the entire habit of their bodies, so that catharrs, phthisicks, coughs and consumption rage more in that one City than in the whole earth besides.

In the following century, Ramazinni notes an interesting instance of industrial pollution in Finale, a town in northern Italy. A lawsuit was brought against a business man who owned a factory in which he manufactured sublimate by roasting vitriol. The citizen bringing the cases stated that the neighbourhood was poisoned by the fumes from the roasting vitriol and he produced the parish register of deaths from which it appeared that more people died annually in the immediate vicinity of the factory than in other localities. Moreover, a doctor gave evidence that the residents of that locality usually died from diseases of the chest which he ascribed to the vitriol fumes.

No one doubts that man's activities have greatly increased the rate at which many elements circulate through the environment and that this ra‹e has increased particularly since the industrial revolution. In some cases the rate has been increased by two or three orders of magnitude as may be seen from Table 1.2.

Table 1.2. *Comparison of natural and man-made circulation rates (10^3 tonnes per year) for some common elements*

Element	A Geological rate*	B Man-made rate†	Ratio B:A
Iron	25 000	319 000	12.8
Nitrogen	8500	9800 (NO_3 consumption)	1.2
Manganese	440	1600	3.6
Copper	375	4460	11.9
Zinc	370	3930	10.6
Nickel	300	358	1.2
Lead	180	2330	12.9
Phosphorus	180	6500 (consumption)	36.1
Molybdenum	13	57	4.4
Silver	5	7	1.4
Mercury	3	7	2.3
Tin	1.5	166	110.7
Antimony	1.3	40	30.8

*Calculated as the annual discharge of the element from rivers into the oceans.

†Expressed as the number of tonnes mined per year (except in the case of nitrogen and phosphorus).

For organic chemicals the position is even more striking. In 1950, the world production of organic chemicals was seven million tons, in 1970 it was 63 million tons and by 1985 it is expected to rise to 250 million tons. Many of these chemicals will find their way into the environment although most will be present in trace amounts only. As techniques of analysis become increasingly sensitive and sophisticated, chemical compounds can be found in almost all compartments of the environment; the precise route which most take in their wanderings through the environment are not generally known nor, for the most part, are the manipulations which they undergo during their passage. These facts in themselves present a strong argument against the thoughtless release of chemicals into the environment. The possibility that compounds of low toxicity may be transformed by, for example, bacterial activity into ones of high toxicity must always be borne in mind and much more work needs to be carried out to determine the environmental pathways of pollutants. (Some of the biological cycles of toxic elements in the environment are described by Wood (1974).)

On the other hand, the detection of a compound in the environment, even if its presence was formerly unsuspected, must not be considered as evidence that it is necessarily harmful. It is obvious that as detection limits are lowered, more compounds will be found but this does not mean that they are newly present in the environment nor that their presence constitutes a new threat to health.

SOURCES OF POLLUTION

There are four common and important sources of environmental pollution, the combustion (complete and incomplete) of fuels, especially of coal and oil, the discharge of industrial effluents, either into the air or to water, agricultural practices, and the disposal of wastes. The only route by which pollutants are dispersed on a wide scale (that is, on a global scale) is by dissemination into the atmosphere. Discharges to water may result in widespread dissemination if made into rivers, but discharges to the sea are less likely to do so because the oceans act as a sump of almost infinite capacity. (Discharge of pollutants to the sea can be harmful under special circumstances which I shall refer to below.) Agricultural practices, such as the spraying of pesticides are usually a local problem, but the application of fertilizers may result in a relatively widespread pollution of water by nitrates caused by run-off from treated fields. The disposal of toxic wastes almost always results in intense local contamination which may, however, present serious health problems at the disposal point.

The pollutants which arise from the burning of fuels vary depending upon the type of fuel used. Coal and oil give rise to sulphur oxides and to smoke which varies greatly in its chemical composition and its physical form, but which, as a rule, consists of a mixture of hydrocarbon droplets, mineral ash, carbon particles and acidic aerosols. Some fuels are rich in compounds of chlorine and fluorine and these cause the emission of hydrochloric acid and hydrogen fluoride; trace metals may be evolved from the combustion of some coals whilst vanadium may be given off from the burning of heavy fuel oils. By contrast, the burning of gas causes very little pollution except for the evolution of carbon monoxide if the combustion is incomplete, a fact taken advantage of by generations of suicides.

The combustion of petrol normally gives rise to a great deal of carbon monoxide (up to 11 per cent in the exhaust gases in some phases of the operation) because the fuel is burnt in a supply of oxygen which is not sufficient to complete the oxidation of carbon to carbon dioxide. The diesel engine, by contrast, burns its fuel in a large excess of air and under normal working conditions, should produce neither smoke nor carbon monoxide. Both the petrol engine and the diesel engine produce oxides of nitrogen (predominantly nitric oxide); this nitric oxide may combine with emitted hydrocarbons to form photochemical oxidants found in many urban areas. In addition, petrol contains anti-knock agents to prevent premature detonation in the cylinders. These additives are organic compounds of lead, tetra-ethyl and tetra-methyl lead, and during their combustion, inorganic lead compounds are formed which are emitted in the exhaust gases. The inorganic compounds are predominantly oxides or halides formed by combination with salts added to the petrol as scavengers; some of the volatile organic lead compounds also reach the atmosphere but in small quantities (less than 10 per cent of the total).

RELATIVE PROPORTION OF POLLUTANTS BY SOURCE AND SEASON

So far as air pollution is concerned, the proportion of pollutants found in any one location will depend upon the relationship between motor traffic and industry, and on whether or not the industry is exercising efficient control. In areas where the emissions of smoke and sulphur dioxide are controlled but the volume of motor traffic is high (as in many western cities), the bulk pollutants will be carbon monoxide and nitrogen oxides. When emissions from domestic or industrial chimneys are not well controlled, the bulk pollutants will be sulphur dioxide and smoke; this will be especially the case where motor traffic is also light. The proportion of pollutants from different sources will also be affected by seasonal changes. The most important change is the increase in pollution from the combustion of fuel during cold winter months and its decrease during the summer. (For further details on this point, see Rossano and Rolander (1976).)

The vagaries of climate also may have a profound effect on the local concentration of airborne pollutants. The efficient mixing and dispersing mechanisms of the upper atmosphere are made use of to dilute emissions and thus reduce ground level concentrations. These mechanisms, however, may (and often do) transform a local pollution problem into one which has international repercussions. (Air pollution meteorology is discussed in detail by Munn (1976).)

THE EFFECTS OF POLLUTION

The extent to which it is thought desirable to control the release of materials into the physical environment will depend upon the magnitude of the risk which they are seen to pose to the health of the population; this assessment of risk will also determine the maximum levels which are thought to be compatible with health, that is, the no-effect thresholds.

The view to be presented in this chapter is that there is very little evidence which suggests unequivocally that environmental pollutants have a deleterious effect on the general health in the concentrations in which they are *normally* found. There are, of course, exceptions. Thus, there is no doubt that the emission of sulphur dioxide and smoke may exacerbate the symptoms of chronic bronchitis. When atmospheric concentrations of sulphur dioxide and smoke particulates simultaneously exceed 200 $\mu g/m^3$ and 150 $\mu g/m^3$ respectively, ill-effects may begin to be noted, especially in elderly people with pre-existing lung disease and in some very young individuals (WHO 1979*a*). These concentrations were common in city air in the past but are now rarely exceeded in industrial cities and annual concentrations are generally well below these critical levels (Table 1.3).

In addition to the increased morbidity caused by the emissions of smoke and sulphur dioxide there have been some large scale outbreaks of deaths caused by exceptional circumstances. These episodes (Table 1.4) have occurred when a layer of stagnant air polluted from industrial or domestic chimneys has been trapped by an inversion layer of cold air. The episode in London in 1952 led to the passage of the Clean Air Act 1956 which, together with the increasing use of gas and oil-fired heating systems, has been followed by a significant decline in both the emission and the ground level concentration of smoke and by a decline in the ground level concentrations of sulphur dioxide.

Evidence such as that which can be presented against sulphur dioxide and smoke, however, is almost entirely lacking when considering general effects such as teratogenicity and carcinogenicity, or the particular effects of one pollutant or class of pollutants. The exceptions to this occur when there is a combination of circumstances which

Table 1.3. *Annual mean daily concentrations* of sulphur dioxide (SO_2), selected urban and industrial areas, 1970–76*

Urban or industrial areas	1970	1971	1972	1973	1974	1975	1976
Canada							
Montreal	100	69	57	38	37	36	29
Toronto	100	69	45	30	30	26	25
US†							
New England	100	90	78	69	71	75	65
Great Lakes	100	91	89	76	59	69	62
Japan							
Tokyo	100	62	55	64	55	49	47
Osaka	100	75	54	42	34	40	32
Nagoya	–	100	84	63	47	40	35
Belgium							
Brussels	–	100	91	79	67	62	63
Antwerp	100	95	94	101	81	75	58
Ghent	100	106	91	102	78	68	75
France							
Paris	100	105	119	128	95	99	100
Lyons	100	154	152	140	115	104	108
Marseilles	100	101	91	92	67	71	82
Germany							
Gelsenkirchen	100	76	79	78	76	78	66
Mannheim	100	55	25	25	40	–	–
Frankfurt/M.	100	125	97	97	96	95	88
Luxembourg‡	–	–	100	93	65	60	58
Portugal							
Lisbon	100	100	120	85	56	92	113
Spain							
Madrid	100	101	84	108	98	85	76
Barcelona	100	96	68	61	42	56	–
Bilbao	100	101	104	112	128	135	122
Sweden							
Gothenburg	100	43	38	67	62	62	–
UK§							
London	100	105	89	89	74	78	71
NW region	100	97	78	74	72	66	70

*Measured in $\mu g/m^3$, based 100 in 1970. In studying trends shown it is important to take into account the fact that annual changes in the weather pattern can easily mask the effect of a 25% change in the emissions.

†60 sites in six states in north-eastern US, 160 sites in six states surrounding the Great Lakes.

‡Average of measures throughout the country network.

§Data for different years do not necessarily refer to the same measurement sites; NW region includes Manchester and Merseyside.

results in exceptionally high exposures, either wide-spread or local.

As an example of the harmful effects which can arise due to exceptional exposures one might consider the case of mercury. There have been a number of important episodes of environmental mercury poisoning, the most notorious of which was the Minimata Bay episode which was first noted in the early 1950s. The disease was caused by the consumption of fish and shell fish which contained substantial amounts of methyl mercury. A second, but less publicized outbreak in Japan occurred in 1964 in Niigata. In both outbreaks the disease resulted from the discharge of industrial effluents to water with subsequent contamination of fish which formed the staple diet of the affected populations (WHO 1976*a*). The circumstance in these outbreaks which caused exceptionally

Table 1.4. *Major air pollution disasters*

Location	Date	Duration (days)	Deaths attributed to episode
Meuse Valley, Liege, Belgium	December 1930	3	60
Donora, Pa, US	October 1948	5	20
London, UK	December 1952	5	4000
	January 1956	3	1000
	December 1957	3	700–800
	December 1962	5	700
New York, US	January/February 1963	15	200–400
	November 1966	3	168

high exposure was that the population relied almost exclusively on fish from the polluted waters for their food.

In the Minimata Bay outbreak, the mercury was discharged from a factory manufacturing fertilizers, plastics, fibres, and a range of general chemicals. Mercury was used as a catalyst for two processes, the manufacture of acetaldehyde (from 1932–68) and the production of vinyl chloride (from 1941–71). It has been estimated that the total loss of mercury during this time was 81.5 t, of which 30 t was in the organic form. It was this organic mercury in the effluent which caused the disease. There is a general belief that the organic mercury in the bay resulted from the methylation of inorganic mercury by bacteria in the sediments; the rate of bacterial conversion, however, is much too slow for this to have been the case.

Organic mercury poisoning has also resulted from eating bread made from seed grain treated with alkyl mercury fungicides. Cases have been reported from Pakistan, Guatemala, and Iraq, the worst episode occurring in Iraq in 1971–72 with at least 6000 cases and 500 deaths (Bakir *et al.* 1973).

The lesson to be learnt from the episodes of mercury poisoning is that it is relatively easy for a set of circumstances to come about under which unusually high exposure to mercury can occur and precautions must be taken to prevent them. In the context of controlling pollution, it is important to prohibit the discharge of mercury into waterways from which the fish form the staple diet of the surrounding population. This is a lesson which still has not been learnt for there is concern that contamination of their fishing grounds may be having an adverse effect on the health of the Indians and Inuits of Canada (Charlebois 1978).

On a more local scale, examples of exceptional exposure can be taken from the harmful effects which can be produced by the disposal of toxic waste. There have been a number of misadventures arising from the inhalation of toxic gases which have been evolved when chemical wastes were inadvertantly mixed. Some fatalities have been recorded including some amongst drivers dumping in illegal sites where there was no prior knowledge of what might have already been disposed of there (Keen 1982).

The effects which arise as the result of pollution are generally pollutant-specific, that is to say, the typical symptoms of mercury poisoning, or hydrogen sulphide poisoning, or nitrate poisoning are produced. Public concern, however, is often directed more towards the role of chemicals in the aetiology of conditions which are not pollutant-specific; two which attract much attention are congenital malformations and cancer.

Although there is evidence that exposure to chemicals at work may be associated with reproductive anomalies (see for example, Hemminki *et al.* 1980) there is little evidence that chemicals encountered outside the workplace produce similar effects. Many of the supposed associations arise because there is a chance clustering of events. Not infrequently some external activity may serve as a cause to which the malformation or the stillbirth can be attributed; crop spraying or emissions from a factory are common examples. Unfortunately the atmosphere is usually so charged by the time the cluster has come to scientific notice that an objective assessment is difficult if not impossible to carry out. The understandable desire on the part of mothers who have given birth to malformed children to link this to an external cause in an attempt to alleviate a sense of personal failure makes it difficult to shake the belief that the putative teratogen was responsible even if there is no epidemiological evidence to support the belief.

So far as trends with time are concerned, there has been a slight increase in notification of all malformations in the UK since 1968 which is due to the more complete recording of minor abnormalities such as hypospadias and skin blemishes. There has been no increase in the rate of reporting major abnormalities and there is no suspicious increase in the rate of notification of any individual anomaly (Doll 1979). These data do not give any support to the idea that any increase in chemical pollution has affected the national rate of malformations.

An examination of the national trends in cancer mortality shows that (in the UK) the rates have decreased progressively (by more than 1 per cent per annum) since 1951 for 16 sites, have increased by the same amount for 13 sites, whilst for 25 sites, the rates have varied by less than 1 per cent per annum over the last 30 years (Doll 1979). Most of the decrease can be attributed to improved treatment, more precise diagnosis and changes in personal behaviour. The increase in rates for cancer of the pharynx and lung in women and cancer of the oesophagus in both sexes can be explained by increased alcohol consumption or cigarette smoking. The increase in the rate of breast cancer is likely to be due in part to decreased fertility and that of melanoma to more extensive exposure to sunlight. There is no evidence to link any increase with chemical pollution.

STRATEGIES FOR THE CONTROL OF POLLUTION

Strategies for controlling pollution vary from one country to another; some countries (especially the US, Germany, and the USSR) advocate setting air and water quality standards which are regarded as maximum allowable concentrations (WHO 1976*b*). In the UK, certainly so far as the control of air pollution from industrial premises is concerned, the approach has been that of 'best practical means'. (See also Hunt and James, Chapter 13.)

The best practical means (BPM) approach has its origins in the Alkali etc. Works Regulation Act 1906, Section 6 of which requires that works specified in the first schedule of the Act 'shall use the best practical means for preventing the escape of noxious gases by the exit flue of any apparatus used in any process carried on in the work, and for preventing the discharge, whether directly, or indirectly, of such gases into the atmosphere, and for rendering such gases where discharged harmless and inoffensive . . .' The philosophy of the 1906 Act is still adhered to although recent acts have encompassed many more processes than were originally covered.

The wording of the Act places a duty upon industrialists not only to reduce emissions as far as practicable, but also to see that unavoidable emissions are discharged in such a way as to render them harmless. In effect this means that discharges to atmosphere must be effected in such a manner that the resultant ground level concentrations are acceptable, and this is most often done by ensuring that chimney stack heights are sufficient to allow effluent to be carried away and diluted in the upper atmosphere. As the acceptability of ground level concentrations changes, however, so will BPM change and this has had the result, over time, of the building of more effective filtration plant or of higher and higher chimneys.

The adoption of BPM in the UK has been highly successful and industrial pollution has fallen considerably in the present century. Blake's 'dark satanic mills' are now things of the past. This approach, however, does not guarantee a uniformity of air quality since the BPM for a newly commissioned foundry will be different from those which apply to an old iron works built in the last century. It is in the best British tradition a pragmatic approach, the compromise between what might ultimately be desirable (minimal pollution) and what is practicable (given prevailing technical knowledge and the state of the economy).

Quality standards, by contrast, appeal particularly to the law makers because they appear somehow more scientific and because they are simpler to administer. The standard either is or is not being met and if not, then emissions must be reduced.

There are, however, objections to these apparent advantages. Although it may appear to be toxicologically sound to set limits for the concentrations of potentially harmful materials in the air or the water, there are precious few data on which to make the judgement of where such limits should be set.

For standards to have a rational basis it is necessary (or at least preferable) to know the shape of the dose–response curve for the material and the response in question, and the contribution made by the concentrations of the material in air, food and water to the total uptake in order to decide which tactic will best reduce exposure to acceptable levels (the ones closest to the no-effect thresholds). The rate of absorption will be another factor which will have to be fitted into the equation; is the form in which the pollutant is most commonly encountered biologically available? In 1972, Lawther and his colleagues showed that the lead emitted from motor vehicles was firmly bound to carbonaceous filaments and thus in a form which would greatly reduce its biological availability. This important observation has been persistently ignored by proponents of the removal of lead from petrol although it has a considerable bearing on the arguments concerning the effects of lead in the atmosphere.

The number of pollutants for which the data noted above are available is small and quality standards are (on this account) at best, educated guesses.

A less serious objection to the concept of adopting quality standards is that polluters would tend to work at the upper end of the standard; an industrialist would naturally choose to emit the maximum he was allowed and, unless the standard were lowered, there would be no pressure on him to do otherwise. With BPM, however, the tendency will always be to pollute less because the best practical means of controlling emissions will become more effective with time.

The imposition of standards may also impose unreasonable economic penalties on some industries. It is easier for a factory situated in a country district to meet quality standards than one which is in a heavily industrialized area where other works are contributing to the overall pollution. If the factories were similar, BPM would apply equally under both conditions.

TOWARDS A RATIONAL STRATEGY

All measures taken to reduce pollution incur a cost which has to be borne by society either directly through the increased cost of manufactured items or indirectly through taxation. There is little doubt that the risk to health from pollution will tend to zero as the corresponding levels of pollution also approximate zero. From this, it may be argued that pollution should not be tolerated at all. This view would imply that the mobilization of chemicals into the physical environment should not be allowed to rise above natural levels.

If the risks from increasing pollution and the cost of controlling pollution are plotted (Fig. 1.1) it can be seen that it will not be possible to achieve zero pollution in the foreseeable future because the costs become infinite if *all* pollution is to be prevented. From the appropriate cost and risk scales, however, a weighted sum (s) can be derived such that

$$s = \alpha_1 r + \alpha_2 c$$

where r and c are the points on the risk and cost scales respectively, and α_1 and α_2 are constants whose values are empirically determined. The minimum value for s in a particular case gives the optimum solution for the establishment of quality standards and should represent the compromise between risks to health and cost (Prinz 1976). This approach does presuppose that risk can be evaluated with some precision and this is the case for few pollutants. It is unrealistic to suppose that it will ever be possible (or even desirable) to establish standards for all the pollutants in the environment and effort should be directed towards establishing the risks for the most important; important in this context referring to their potential for harm or to those which occur in the highest concentrations.

The values to be given to α_1 and α_2 in the equation above are a matter of politics and not of medicine or toxicology, although one hopes that some note might be taken of medical advice when deciding a value to assign to them. If environmental considerations prevail above all others (and effects other than those on humans might have to be taken into account) then the value of α_1 will increase and the curve will shift to the left. If cost is paramount, then α_2 will increase and the curve will shift to the right.

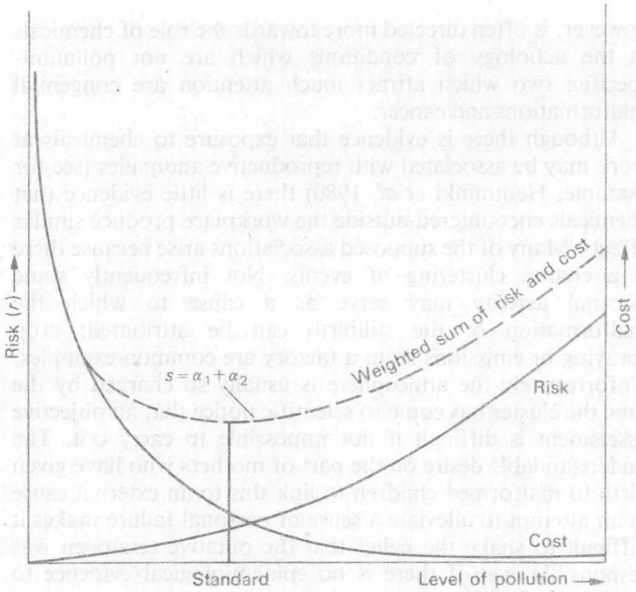

Fig. 1.1. Establishment of quality standards from cost and risk factors.

WHAT IS REALISTIC?

If the data can be provided to plot the risk curve in Fig. 1.1 then it would be possible to devise a series of standards which have some rational basis. I have suggested, however, that the data from which such curves can be constructed are available for few pollutants and much more research is required in order to provide the necessary information for others of importance. Even when the data are available, it will probably be many more years before there is any measure of agreement on their significance to health. For example, few pollutants have been investigated as extensively as lead but there is still no general agreement on the effects that present levels might have on behaviour (DHSS 1980).

A theme which runs through this chapter is that it is only under exceptional circumstances that ill-effects on a significant scale are likely to occur as the result of environmental pollution. Thus, it seems inherently more satisfactory to take steps to define these conditions and institute measures to prevent their occurrence. This is what happened in response to the London smog of 1952; the Clean Air Act enabled local authorities to ban the burning of coal on domestic fires, the concentrations of smoke and sulphur dioxide in the atmosphere fell and the smogs vanished into history. To protect against environmental mercury poisoning would require more stringent control of treated seed grain and the prohibition of the discharge of mercury into any waters which supported fish which were the staple diet of the local population. Knowing that the haphazard disposal of toxic waste may lead to circumstances under which toxic gases are produced should give the impetus to the framing of effective legislation for the control of waste disposal with the provision of severe penalties for those who break the law.

Such an approach would concentrate efforts on real problems and have some expectation of ameliorating them. It would also go hand in hand with the general improvements which are seen in the environment. In debates and discussions about the state of the environment, there is a tendency to overlook the fact that the surroundings in which we live are cleaner than they have been for many years in the past; they may be unaesthetic and inhuman in many other respects, but that is a different issue.

The control of the physical environment will not best be served by the introduction of a large number of air and water quality standards but by continuing with the approach of BPM. More use should also be made of environmental health impact assessment in granting planning permission for new projects or in allowing the introduction of new processes and new chemicals into agricultural and industrial use. In this way, potential threats to health would be anticipated and monitored. At present, the medical input into planning decisions is minimal (WHO 1979*a*).

The view to which I presently subscribe is that the role of environmental chemicals as a cause of ill-health amongst the general population is exaggerated. It is relatively easy to generate hypotheses about the harmful effects of pollutants which are plausible but not amenable to scientific testing. Much alarm may thereby be engendered and those who propagate such hypotheses should be aware of the consequences of their actions. Not only is alarm caused to those who appear most at risk and who are usually powerless to do anything to lessen the risk but expensive and unnecessary environmental adjustments may be set in motion which could themselves lead to unwanted effects and attention and resources may be taken away from other areas in which real improvements in public health could be made.

With millions of the world's population suffering from starvation and parasitic diseases, and other millions suffering from excess of eating, drinking and smoking, it seems inappropriate to devote a very great deal of energy to controlling the release of chemicals into the environment without the most pressing reasons to do so, particularly as this has to be done at the expense of other, more profitable approaches to the improvement of the health of the general public.

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2 The control of infectious diseases

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INTRODUCTION

Control of infectious disease continues to be a major public health priority throughout the world. For hundreds of years, control measures were formulated on the basis of incomplete knowledge of the epidemiology of the disease to be controlled and thus were directed at perceived factors of disease causation. Occasionally, these control measures did result in a decrease in the occurrence of a disease. Additionally, on occasions, either because of changes in relationships among the disease-producing factors or a natural cyclic variation in the occurrence of the disease, the incidence of certain diseases did decrease and credit was given to the applied 'control measures'.

In the eighteenth and the nineteenth centuries, epidemiological principles were incorporated into investigations, which resulted in more specific data being obtained concerning disease occurrence and the development of potentially more effective control measures. For example, in 1798, Jenner, in investigations of smallpox, noted that milk maidens did not develop smallpox. He associated this protection with their contact with cowpox and used secretions from cowpox lesions to vaccinate humans successfully against smallpox. In the 1840s, Snow identified by means of epidemiological studies contaminated water as the vehicle of infection for cholera. In subsequent outbreaks by preventing the use of contaminated water, the incidence of the disease was reduced. In 1861, Semmelweis studied the epidemiology of puerperal fever among new mothers and was able to make recommendations concerning decontamination of hands with chlorinated solutions that effectively reduced the incidence of this disease. In these examples, the recommended control procedures, based upon epidemiological data, were made years before the aetiological agents were identified. Nevertheless, they did have an effect on the occurrence of the diseases against which they were directed.

In the nineteenth and twentieth centuries, social and economic changes including improvements in nutrition, housing, medical care, and living and working conditions, also had a perceptible impact on the occurrence of infectious disease.

As scientific methods have continued to improve both in the field and laboratory, our knowledge of the epidemiology of diseases has also improved, and epidemiologists have been able to direct more specific control measures at factors related to the occurrence of particular diseases. In the twentieth century, major advances have been made in controlling most infectious diseases. However, unusual cases or outbreaks of selected diseases still need to be investigated to identify better and more effective control measures. Additionally, 'new' diseases do arise. These include diseases occurring for the first time and those that although occurring for years, have only recently been characterized and for which the appropriate control measures have not as yet been identified.

Control refers to reducing the occurrence of disease. Prevention refers to averting the occurrence of the disease in a population and is a more comprehensive goal in the practice of public health. The concepts related to control may also be applicable to prevention, however; the actual control measures implemented may need to be extended and modified, or new measures developed in order to be applicable to prevention. A more extreme goal is eradication, which implies the disease will no longer occur in a population. To date, only one disease, smallpox, has been eradicated. Other diseases have been proposed for eradication but so far these efforts have not been successful.

Control of a disease is dependent on identifying the many interactive factors related to its occurrence. These factors can be identified through disease surveillance and epidemiological investigations. The degree of completeness with which these factors are identified, and are susceptible to modification will govern the ability to implement control measures.

In this chapter, the broad concepts of surveillance and epidemiological principles as related to the chain of infection are discussed. The techniques of epidemiological investigations are reviewed elsewhere in this textbook (see Volume 3). Broad principles of control will be reviewed here but more detailed information concerning control appears in other chapters on specific diseases and disease-related topics.

SURVEILLANCE

Surveillance is the routine, regular accumulation of all pertinent data concerning the occurrence of disease in a defined population, the collation and analysis of those data, and the preparation and distribution of summary reports of the analysed data. Surveillance should be a dynamic activity since in order for it to assume its proper role in public health and preventive medicine, surveillance must lead to action. If data are used to prepare a report, but no further action is taken, the activity is primarily archival.

In the mid-1800s, the contributions of Farr, a British registrar of statistics, had a major impact on the practice of surveillance. His concept of surveillance included collecting and analysing morbidity data and publishing the analysis of these data in order to stimulate improvements in public health practice.

In the US, disease surveillance activities were initiated in 1878 when Congress directed the Public Health Service (PHS) to collect reports of the occurrence of the quarantinable diseases; that is, cholera, plague, smallpox, and yellow fever. Over the next 35 years, further direction was given to national surveillance in the form of requests that state and municipal health authorities report to the PHS certain health information obtained on reporting forms developed specifically for the surveillance programmes. Subsequently, states were also requested to report certain data on the occurrence of disease to the PHS by weekly telegrams. Initially, surveillance data were published each week in *Public Health Reports.* A separate report, the *Morbidity and Mortality Weekly Report* (MMWR), was begun in the early 1950s.

In 1960, PHS surveillance activities, including the publication of the MMWR, were transferred to the Communicable Disease Center (CDC – now called Centers for Disease Control). Surveillance at CDC actually was initiated in the 1950s when specific information concerning malaria in the US was needed in order to establish appropriate control and prevention programmes (Langmuir 1963). In 1955, poliomyelitis surveillance was initiated as an extension of an investigation of an outbreak of the disease related to contaminated vaccine (Langmuir *et al.* 1956). Over the next 15 years, special surveillance programmes were established for influenza, salmonellosis, shigellosis, hepatitis, hospital infections, and childhood immunizable diseases – in each instance because of a need to obtain specific data in order to institute disease control and prevention programmes. Surveillance activities in the US have always been a co-operative procedure involving the PHS and state and local health departments.

Surveillance may be general or disease-specific and may cover large populations or subsets of populations. The techniques of conducting surveillance activities depend upon the specific disease problems, the perceived cause(s) of the problem(s), the geographical area(s) involved, the type of information desired, and the support resources available (Thacker *et al.* 1983).

The geographical area involved is dependent on the disease and the objectives of the surveillance programme and can vary from a small area to a whole country or the entire world. For example, local surveillance may be initiated following an outbreak of Legionnaires' disease among patients at a hospital; intensive county surveillance of measles may be instituted following the occurrence of cases in a community; state-wide surveillance of influenza may be desired in order to develop an appropriate plan for allocating limited supplies of vaccine; regional surveillance may be appropriate in instances such as the occurrence of dengue fever in the south-eastern US; country-wide surveillance may be instituted because of the distribution throughout the country of a food contaminated with a particular *Salmonella* serotype; and cholera and influenza are under world-wide surveillance, through the World Health Organization (WHO), in order to develop data concerning the spread of these diseases so that effective control measures can be instituted.

An example of the important role of surveillance in a programme to eliminate disease transmission is provided by the current measles elimination programme in the US (Hinman *et al.* 1979; Hinman 1982). When a case of measles is reported, health personnel investigate all contacts for additional cases and vaccinate all susceptible contacts. Intensive surveillance is instituted in areas adjacent to the involved area in order to identify additional cases as soon as they occur. If the disease spreads to another area, the investigations, vaccinations, and surveillance activities are also instituted in that area. This technique parallels the successful WHO-directed smallpox eradication programme.

In addition to monitoring an unusual occurrence or an epidemic of a disease, surveillance may also be used to depict the natural history of disease, guide the development of research projects, evaluate hypotheses, portray changes in the properties of infectious agents, and provide data for planning purposes. Another important use of surveillance is in evaluating the effectiveness of instituted control measures. Unless the occurrence of a disease is monitored continuously, ineffective control measures may continue to be used.

Elements of surveillance

This discussion focuses on surveillance for infectious disease; however, with modifications, the techniques can be applied to non-infectious diseases or to almost any other health-related situation. There are ten basic data sources or elements that can be applied with various levels of intensity to the collection of disease surveillance data. Not all sources are necessarily used at the same time. Some are used routinely, whereas others may be used sporadically depending on the programme, objectives, and available resources.

Mortality registration. This is the oldest universally available data base used, but since cause of death may be determined subjectively rather than scientifically, this method of surveillance may not be accurate. Mortality reporting is not very useful for detecting epidemics because of the time-lag between onset of a disease and reporting of a related death. One example of a current application of mortality reporting is the weekly influenza surveillance programme in the US, in which observed deaths from pneumonia and influenza are compared with expected deaths as determined from analysis of data collected over the preceding years (Choi and Thacker 1981). Excess mortality is related to influenza deaths, providing a measure of the frequency and severity of influenza in a community.

Morbidity reporting. The reporting of individual cases of disease is the most common method of accumulating surveillance data and can be a prompt and simple system whose sensitivity and specificity vary by disease. Diseases that occur at high frequency are usually under-reported, whereas rare diseases are more accurately reported. Hepatitis is a relatively common disease, but it is estimated that only approximately 10 per cent of actual cases are reported, while poliomyelitis occurs so rarely that all diagnosed cases probably are reported. However, it is the *trend* in the occurrence of disease that is