1. Introduction

1.1. Late lessons from early warnings: an approach to learning from history

In 1898, Lucy Deane, a UK Factory Inspector, observed: *'The evil effects of asbestos dust have also instigated a microscopic examination of the mineral dust by HM Medical Inspector. Clearly revealed was the sharp glass-like jagged nature of the particles, and where they are allowed to rise and to remain suspended in the air of the room in any quantity, the effects have been found to be injurious as might have been expected.'* (Deane, 1898)

One hundred years later, in 1998, the UK government decided to ban 'white' asbestos, a decision that was echoed by the European Union (EU) the following year. The current asbestos-induced death rate in the United Kingdom is about 3 000 deaths per year, and some 250 000–400 000 asbestos cancers are expected in western Europe over the next 35 years, due to past exposures (Peto, 1999).

The hundred years between the 1890s and 1990s is the main focus of this report into the use, neglect and possible misuse of the concept of precaution in dealing with a selection of occupational, public and environmental hazards. The costs and benefits of the actions or inactions of governments and others in responding to 'early warnings' about hazards provide us with its content. The aim of this report is to see if something can be learnt from these histories that can help us prevent, or at least minimise, future impacts of other agents that may turn out to be harmful, and to do so without stifling innovation or compromising science.

The report is an example of the information needed to help the EU and EEA member countries to frame and identify sound and effective policies that protect the environment and contribute to sustainable development. Providing such information is the regulatory duty of the European Environment Agency (EEA), an independent Agency of the European Community established in 1993 to provide objective information to the policy-making bodies of the EU and its Member States (Council Regulations, 1210/90 and 993/99).

In trying to reduce current and future risks the lessons of history have rarely been used. The histories of a selection of hazards is therefore the subject matter of *Late lessons.* Fourteen case studies (arranged chronologically according to the first date of early warning) have been chosen from a range of well-known hazards to workers, the public and the environment, where sufficient is now known about their impacts to enable conclusions to be drawn about how well they were dealt with by governments and civil society. Such conclusions should be based on 'the spirit of the times' and not on the luxury of hindsight. There are other public health effects and environmental disasters that have not been looked at, such as thalidomide (James, 1965), lead (Millstone, 1997), and the Aral Sea (Small, 2001) These provide additional information about unintended consequences, and the conflict between economic and social interests, from which additional lessons from history can be drawn.

The authors of the case studies were asked to structure their chapters around four key questions:

- When was the first credible scientific 'early warning' of potential harm?
- When and what were the main actions or inactions on risk reduction taken by regulatory authorities and others?
- What were the resulting costs and benefits of the actions or inactions, including their distribution between groups and across time?
- What lessons can be drawn that may help future decision-making?

The case studies and authors have also been chosen with a transatlantic audience in mind. Three chapters are focused either on a North American issue (pollution of the Great Lakes) or primarily on the North American handling of issues that are also directly relevant to Europe (benzene, and DES administered in pregnancy) and authored by scientists from North America (Gilbertson, Infante, and co-author Swann, respectively). Three chapters cover issues of some conflict between North America and Europe (hormones as growth promoters, asbestos, and MTBE in petrol); and all other chapters are as relevant to North Americans, their public health and their environments as they are to Europeans.

It is sometimes said that the United States does not use the precautionary principle, but it is worth noting (see Table 1.1.) that the United States has helped to promote what could be called 'precautionary prevention', without necessarily calling it 'the precautionary principle'.

Table 1.1. **Some examples of 'precautionary prevention' in the United States**

Source: EEA

Issue	'Precautionary prevention'
Food safety (carcinogenic additives)	The Delaney Clause in the Food, Drug and Cosmetics Act, 1957–96, which banned animal carcinogens from the human food chain
Food safety (BSE)	A ban on the use of scrapie-infected sheep and goat meat in the animal and human food chain in the early 1970s which may have helped the United States to avoid BSE
Environmental safety (CFCs)	A ban on the use of chlorofluorocarbons (CFCs) in aerosols in 1977, several years before similar action in most of Europe
Public health (DES)	A ban on the use of DES as a growth promoter in beef, 1972–79, nearly 10 years before the EU ban in 1987

The precautionary principle has become controversial, not least because of the disputes between the EU and the United States over hormones in beef, genetically modified organisms (GMOs), global warming and other issues in which precautionary approaches have been invoked. There is now considerable debate (not to say terminological confusion, particularly between politicians on different sides of the Atlantic) as to what the precautionary principle means, and how it can be implemented. One aim of this report is to try to improve transatlantic understanding on the use of precaution in policy-making.

The authors of the case studies, who provided their services *pro bono*, were asked to keep their contributions brief, which obviously inhibits detailed treatment of the issues. However, we wanted to elicit key conclusions from the histories and not the detailed post mortems that others have produced: these can be accessed via the references in each chapter.

It has been pointed out that the case study authors are not without strong views, being for the most part active participants in the process of making the histories that are summarised in each chapter. Joe Farman, the author of the chapter on halocarbons, for example, discovered the 'hole' in the stratospheric ozone layer; Morris Greenberg helped to set up the first asbestos mesothelioma register; Michael Gilbertson has spent most of his professional life researching Great Lakes pollution and advocating its clean-up; and Peter Infante did the first cohort epidemiological study of benzene-exposed workers, and has worked for many years in the US Health and Safety Department to reduce workers' exposure to benzene and other pollutants. All other authors, to varying degrees, have had significant involvement in the subject of their chapters: indeed they would not have been approached if they had not already extensively studied the case that they were asked to write about. All of them, as respected scientists in their fields, were expected to be as objective as possible in answering the four questions put to them. This involvement of the authors in the histories of their case studies is therefore brought to the attention of readers.

The case studies are all about 'false negatives' in the sense that they are agents or activities that were regarded at one time as harmless by governments and others, at prevailing levels of exposure and 'control', until evidence about their harmful effects emerged. But are there no 'false positives', where action was taken on the basis of a precautionary approach that turned out to be unnecessary? It was felt necessary to include such examples, but despite inviting some industry representatives to submit them, and discussing these in some detail, no suitable examples emerged. Attention was drawn to a US publication, *Facts versus fears* (Lieberman and Kwon, 1998), which attempted to provide some 25 examples of 'false positives'. However, on closer examination these turned out not to be robust enough for those who recommended them to accept our invitation to use the strongest half dozen in this report. The challenge of demonstrating 'false positives' remains: possible candidates that have been mentioned include the ban on dumping sewage sludge in the North Sea, and the 'Y2K millennium bug'.

1.2. What is the 'precautionary principle'?

Albert Schweitzer (1875–1965) may have been pessimistic when he said 'Man has lost the capacity to foresee and forestall... he will end up destroying the earth'. However, being wise before it is too late is not easy, especially when the environmental or health impacts may be far into the future and the real, or perceived, costs of averting them are large and immediate. Forestalling disasters usually requires acting before there is strong proof of harm, particularly if the harm may be delayed and irreversible, an approach to scientific evidence and policy-making which is part of what is now called the precautionary principle.

Precautionary prevention has often been used in medicine and public health, where the benefit of doubt about a diagnosis is usually given to the patient ('better safe than sorry'). However, the precautionary principle and its application to environmental hazards and their uncertainties only began to emerge as an explicit and coherent concept within environmental science in the 1970s, when German scientists and policy-makers were trying to deal with 'forest death' (*Waldsterben*) and its possible causes, including air pollution.

The main element of the precautionary principle they developed was a general rule of public policy action to be used in situations of potentially serious or irreversible threats to health or the environment, where there is a need to act to reduce potential hazards *before* there is strong proof of harm, taking into account the likely costs and benefits of action and inaction. A precautionary approach, however, requires much more than establishing the level of proof needed to justify action to reduce hazards (the 'trigger' for action). The *Vorsorgeprinzip* ('foresight' or 'precautionary' principle), in the German Clean Air Act of 1974, as elaborated in the 1985 report on the Clean Air Act (Boehmer-Christiansen, 1994) also included elements such as:

- research and monitoring for the early detection of hazards;
- a general reduction of environmental burdens;
- the promotion of 'clean production' and innovation;
- the proportionality principle, where the costs of actions to prevent hazards should not be disproportionate to the likely benefits;
- a cooperative approach between stakeholders to solving common problems via integrated policy measures that aim to improve the environment, competitiveness and employment;
- action to reduce risks before full 'proof' of harm is available if impacts could be serious or irreversible.

Since the 1970s, the precautionary principle has risen rapidly up the political agenda, and has been incorporated into many international agreements, particularly in the marine environment, where an abundance of ecological data on pollution yielded little understanding but much concern: 'huge amounts of data are available, but despite these data... we have reached a sort of plateau in our understanding of what that information is for... This is what led to the precautionary principle' (*Marine Pollution Bulletin*, 1997). More generally, Principle 15 of the UN Rio Declaration on Environment and Development 1992 (see Table 1.2.) extended the idea to the whole environment.

The use of different terms in these treaties and agreements such as 'precautionary principle', 'precautionary approach' and 'precautionary measures' can cause difficulties for communication and dialogue on how best to deal with scientific uncertainties and potential hazards. The concluding chapters of this report attempt to clarify some of these ambiguities.

In Europe, the most significant support for the precautionary principle has come from the European Commission's Communication on the Precautionary Principle (European Commission, 2000) and the Council of Ministers Nice Decision, both in 2000. They have made significant contributions to the practical implementation of the precautionary principle, especially concerning stakeholder involvement and the avoidance of trade disputes. Some of the main issues raised by the case studies and by the European Commission's Communication are elaborated in the concluding chapters.

Table 1.2. **The 'precautionary principle' in some international treaties and agreements**

Source: EEA

Montreal Protocol on Substances that Deplete the Ozone Layer, 1987 'Parties to this protocol... determined to protect the ozone layer by taking **precautionary measures** to control equitably total global emissions of substances that deplete it...'
Third North Sea Conference, 1990 'The participants... will continue to apply the **precautionary principle**, that is to take action to avoid potentially damaging impacts of substances that are persistent, toxic, and liable to bioaccumulate even where there is no scientific evidence to prove a causal link between emissions and effects.'
The Rio Declaration on Environment and Development, 1992 'In order to protect the environment the **Precautionary Approach** shall be widely applied by states according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.'
Framework Convention on Climate Change, 1992 'The Parties should take **precautionary measures** to anticipate, prevent or minimise the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost.'
Treaty on European Union (Maastricht Treaty), 1992 'Community policy on the environment... shall be based on the **precautionary principle** and on the principles that preventive actions should be taken, that the environmental damage should as a priority be rectified at source and that the polluter should pay.'
Cartagena Protocol on Biosafety, 2000 'In accordance with the **precautionary approach** the objective of this Protocol is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements.'
Stockholm Convention on Persistent Organic Pollutants (POPs) 2001 Precaution, including transparency and public participation, is operationalised throughout the treaty, with explicit references in the preamble, objective, provisions for adding POPs and determination of best available technologies. The objective states: 'Mindful of the **Precautionary Approach** as set forth in Principle 15 of the Rio Declaration on Environment and Development, the objective of this Convention is to protect human health and the environment from persistent organic pollutants.'

1.3. An early use of the precautionary principle: London, 1854

The use of precautionary approaches to hazards began well before the 1970s, particularly in the field of public health. One early application in Europe was by Dr John Snow, who in 1854 recommended removing the handle from the Broad Street water pump in an attempt to stop the cholera epidemic that was then ravaging central London. Some evidence for a correlation between the polluted water and cholera had been published five years earlier by Snow himself (Snow, 1849). This evidence was not 'proof beyond reasonable doubt'. However, it was proof enough for Snow to recommend the necessary public health action, where the likely costs of inaction would have been far greater than the possible costs of action (see Box 1.1.).

The costs of Snow being wrong in getting the pump handle removed would essentially have been angry and inconvenienced citizens who nevertheless wanted cholera stopped. These costs were small in relation to the cost of being wrong in *not* removing the pump handle, once the evidence of the link between the Broad Street pump water and the cholera was available. His evidence that there seemed to be a link was reliable enough to help make a public policy decision that proved correct: the cholera was being caused by sewage-contaminated water and removing exposure helped to remove the risk.

The story of John Snow and cholera has sometimes been misinterpreted as an example of how very strong evidence of harm and its causes can be used in a relatively uncontroversial way. However, it was a classic case of precautionary prevention, containing several of the key elements of an approach to scientific uncertainty, ignorance and policy-making. These elements include the difference between 'knowing' about a hazard and its likely causes and 'understanding' the chemical and biological or other processes underlying the link; a focus on the potential costs of being wrong; and the use of minority scientific opinions in public policy-making. These issues are taken up in the concluding chapters of this report.

There are many differences between cholera, asbestos (which came into use at about the

Box 1.1. John Snow's 'precautionary prevention'

In a 10-day period from 31 August to 9 September 1854, there were about 500 deaths from cholera in the parish of St. James, which included the Golden Square area of Central London. John Snow, a London physician, investigated the outbreak, having previously written *The Mode of Communication of Cholera*, a pamphlet of 30 pages which he published at his own expense in 1849. Prior to the Golden Square outbreak, Snow was studying cholera and the water supplies from two different water companies in South London: one 'clean' and the other 'polluted' with sewage. This incomplete study was already producing data that supported his theory that cholera was caused by contaminated water when he went to investigate the Golden Square outbreak.

A short investigation revealed that virtually all of the 83 people who had died in the Golden Square area between 31 August and 5 September had drawn water from the popular Broad Street water pump, rather than from the available, and cleaner yet less popular, piped water supplies. On 7 September, Snow recommended the removal of the Broad Street water pump on the grounds that there was 'no... Cholera... except amongst persons, who were in the habit of drinking the water of the (Broad Street) water pump'. The authorities removed the pump handle the next day, thereby helping to speed up the declining cholera outbreak and preventing further infection from that source.

Snow later produced one of the first epidemiological maps of disease and possible causes at a presentation to the Epidemiological Society of London on 4 December 1854, which included a map of cholera deaths and the wells nearest to Broad Street.

Snow's views on cholera causation were not shared by the majority of relevant scientists. The Royal College of Physicians inquiry into the earlier 1853-54 cholera outbreak had considered Snow's thesis and rejected it as 'untenable', as had the General Board of Health in 1854: 'we see no reason to adopt this belief'. They believed that cholera was caused by airborne contamination.

The biological mechanism underlying the link between polluted water and cholera was unknown at the time of this successful 'precautionary prevention' in 1854: that came 30 years later, in 1884, when Koch announced his discovery of the cholera vibrio in Germany.

EEA, based on Brody *et al.*, 2000

time of Snow's action), and the other harmful agents in the case studies, not least being the time lag between exposure to the harmful agent and the health damage, which was hours in the case of cholera but decades in the case of asbestos and most of the other agents studied. Yet had governments adopted a similar approach to precautionary prevention as Dr Snow, once the early warnings on asbestos had been published, much of the tragedy and the huge costs of asbestos exposure could have been averted.

1.4. Forestalling disasters: integrating science and public policy

Snow was working, both as a scientist and policy-maker, in the conditions of scientific uncertainty and political stress shared by all who are charged with responsibilities for protecting the public and the environment from potentially harmful economic activity. Politicians today are working in similar conditions of scientific uncertainty and stress as Dr Snow, but now made more difficult by the higher risks and uncertainties (economic, health and ecological) of larger-scale activities (Beck, 1992) and by greater pressure from the mass media (Smith, 2000). They also work with more democratic institutions, and are accountable to a better-educated and involved citizenry which can have good access to information from the Internet. Globalisation and free trade issues add further complications, as does the emerging science of complexity and chaos, which can require more humility and less hubris in science. It is in these circumstances of trying to prevent potentially serious and irreversible effects, without disproportionate costs, that the precautionary principle can be useful. It helps policy-makers and politicians, in circumstances in which waiting for very strong evidence of harm before taking precautionary action, may seriously compromise public health or the environment, or both.

Achieving consensus on the history of accepted hazards, such as asbestos, chlorofluorocarbons (CFCs) and the other case studies, is not easy, but it is easier than achieving consensus on how to deal with current controversies such as climate change, mobile phones or GMOs. There are some well established criteria for helping scientists to move from 'association' to 'causation', in health hazard identification (Hill, 1965), but there are no generally accepted criteria for helping politicians to make sound public policy decisions in the face of scientific uncertainty, despite several good proposals (Raffensperger and Tickner, 1999; Gee, 1997).

There is already a large literature on risk assessment and hazard reduction which can assist decision-makers in certain circumstances, but an historical perspective might also help. There is a rich history of hazards covered in this report from which something of value can be learnt. In chapter

16 lessons are drawn that can help frame and identify sound and effective public policy measures. These may help minimise the future costs of being wrong about environmental and health risks. There is particular concern to see fewer 'false negatives' in the future, but the late lessons should also help reduce the smaller but commonly feared risk of 'false positives'.

Public trust in the politicians and scientists who are trying to protect people and the planet from hazards is very low, especially in Europe, where BSE in the United Kingdom and elsewhere, dioxins in Belgium, and the HIV-contaminated blood transfusion affair in France have contributed to a general sense of malaise. Governments are aware of this and are developing responses, such as the EU White Paper on European Governance (July 2001). This includes recommendations for improving public participation in managing the inter-reactions between science, technologies and society. This report aims to contribute to the debate on the emerging issue of democratising scientific expertise.

1.5. References

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