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The sun safety metanarrative: Translating science into public health discourse

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Abstract. A case study examining the relationship between ozone depletion, UV radiation and skin cancer shows how scientific uncertainty is reduced and, through consensus building, translated into certainty in public health messages. Using narrative analysis we examine Canadian consensus statements on the dangers of UV and reconstruct the supporting logical claims and scientific evidence. Though considerable uncertainty remains about the relationship between the environment and skin cancer, both public health messages and the UV-Index formalize uncertainty and risk; concern then shifts from the less-certain, scientific realm into the apparently more-certain arena of public health messages. In this process the distinctions between science and policy become blurred. The case can be interpreted in two ways: as the result of various players acting in their self-interests or as a moral drama based on the importance of simple, clear messages to allow 'correct' actions.

Introduction

Throughout the twentieth century science has been perceived as the most effective tool for problem solving. Scientists are seen as objective individuals searching for an extant 'truth' unsullied by influences and pressures from the outside world. Though this notion has been challenged for many decades (Kuhn, 1962; Mulkay, 1980; Tesh, 1993) popular conceptions have continued to see science and scientists as working outside the messy, politically-driven world of policy making. With its roots in the rationality project and Cartesian dualism, scientific knowledge was abstracted from the social and political context in which it took place. In this way scientists, particularly those involved in health and medicine, have been able to provide medical 'truths' that have, in turn, resulted in important public health achievements. The virtual elimination of smallpox, the polio vaccine and the identification of infectious diseases such as cholera and typhoid are all examples of how scientific investigations have translated into lives saved through public health initiatives.

However, these and many other public health successes have not solely been the result of capricious and unsolicited scientific exploration. In many cases, it was public health officials and policy makers, not scientists, who identified and articulated the public health problems for which solutions needed be found. These problems were then presented to scientists, who proposed potential solutions. These solutions were evaluated by policy makers and the potential outcomes were weighed against the option of doing nothing in order to determine what was best for the public's health. So we see that, in the arena of public health, the distinction between science and policy making has not been so clear as previously thought (Tesh, 1993; Albæk, 1995). If, as Brandon (1984) contends, public policymaking is a moral endeavor, so too is the mandated science (Salter, 1988) used to support and promote that policymaking. There has always been a social and political contextualizing of scientific knowledge. The nature of the scientific project with its rationality, experimentation, and search has answers has often allowed this reality to escape our attention.

The distinction between science and policy becomes even less clear in examining the complex relationship between the environment and public health. Over the past several decades a growing popular concern with environmental issues, specifically environmental contaminants, has called into question the ability of scientists to provide clear, unequivocal solutions to environmental problems (Tesh, 1993). As both the number and complexity of environmental issues increase, scientists are being asked more and more to make predictions based on uncertainty and equivocal evidence. Since scientists can no longer rely on scientific 'truths' to substantiate claims and positions, they have turned to other methods such as persuasion and storytelling – the tools of politics and policy – in an attempt to promote solutions to environmental health problems.

Once more, this is not surprising. The action-oriented nature of health policy means that values are necessarily embedded because all action is based on underlying values (Brandon, 1984). In this way environmental health problems approach Torgerson's (1986) 'third face' of policymaking where the relationship between science, politics and policymaking is not necessarily antagonistic. Instead the relationship is symbiotic – a necessary requirement for solving broad problems that are beyond the scope of the narrow, technocratic, problem solving methods of rational science (Torgerson, 1986).

Using the relationship between ozone depletion, ultraviolet radiation (UVR) and skin cancer as a case study, we show how the distinctions between science and policy making are being increasingly blurred over time. It is the aim of this paper to examine how scientific uncertainty over the ozone-UVR-skin cancer relationship is translated and transformed into a consensus about risk factors and 'causes' of skin cancer. Further, we hope to show how, in environmental health issues, Torgerson's (1986) 'third face' of policymaking is unfolding.

The following discussion is framed around Roe's (1994) concept of the metanarrative. A metanarrative is an agreed-upon 'story' or way of making sense of an issue that makes it more amenable to policy intervention. In particularly conflicting or intractable situations individuals and groups with differing interests and values develop contrasting stories to explain or make sense of the problem. A metanarrative is the dominant story that develops over time 'by one or more parties to the controversy as underwriting (that is, establishing or certifying) and stabilizing (that is, fixing or making steady) the assumptions for policymaking in the face of the issue's uncertainty, complexity or polarization' (Roe, 1994; p. 3). In short, a metanarrative is the dominant story or explanation of the controversy.

In our discussion, we start at the end with a description of the sun safety metanarrative. This metanarrative evolved primarily from the public health messages of Health Canada and the UV-Index from Environment Canada. Both the messages and the index purport to provide individuals with information about skin cancer risk and to promote preventive behavior. We then trace back the series of logical claims and assumptions with underscore the metanarrative by looking at the development of the messages and the index. Next, we compare the nature of the evidence used by both scientists and policy makers in the construction of the sun safety metanarrative. Finally, we present conflicting explanations of the success of the sun safety metanarrative and show how the explanation based on morality brings to light Torgerson's 'third face' of policymaking.

What will become increasingly evident in this discussion is that scientists and policy makers utilize similar tools – narratives, metaphors, persuasion and argumentation – to promote their interests and values. Since it is ever more difficult for scientists to make conclusive links between environmental contaminants and health (Tesh, 1993; Frank et al., 1988) they instead use persuasion and argumentation to promote the solutions that these scientist *believe* are right. With the move from absolute proof to persuasion and argumentation, concern in the sun safety metanarrative is concurrently shifted from the less-certain, scientific and medical realm into the more-certain public health message advocating individual control. By shifting responsibility, science is released from its burden of absolute proof and the problem instead becomes an issue of action, values and morality. The result is a public health message that resonates with what the public 'knows' – the importance of individual responsibility and the moral certitude of acting 'right' to prevent skin cancer.

Recast as morality, the sun safety metanarrative resonates with a message that links back to a traditional European heritage. As with most current environmental problems, this issue may be viewed as a modern morality play in which humankind acts in ignorance, falls from grace, and is redeemed through the collective pursuit of 'proper' and 'moral' decisions and through the appropriate execution of the power of freewill. Science and policymaking (or research and morals/values) then feed social action and we see the unfolding of Torgerson's 'third face.'

The sun safety metanarrative

Ask almost any person on the street and they will tell you, 'The ozone layer is thinning, more sunlight is getting through, we're all going to get skin cancer so you have to stay out of the sun.' This metanarrative is pervasive and is reinforced through the media each Spring with articles warning about the dangers of sun exposure and ozone depletion. In Canada there are two parts to these messages: one from Health Canada about health issues and one from Environment Canada about ozone levels. These two link together to form a public consensus reinforcing and perpetuating the sun safety metanarrative.

Health Canada's consensus statements

The Canadian Health Care System is actually a mosaic of systems. Since health care is a provincial responsibility, each province currently operates its own single-payer system while adhering to a set of national guidelines allowing transferability and comprehensive, universal coverage. Health Canada is the federal institution that oversees national health care, including public health, and often plays a guiding role in delineating important national public health issues and initiatives. In this, science tries to influence politics, and politics to interpret, select, or use scientific evidence. Torgerson's (1986) first two faces (science dominating politics and vice versa) become intertwined. In the past decade, one such intertwined issue has been sun exposure and how it increases the risk of contracting skin cancer.

In September, 1994 and more recently in May, 1996, Health Canada and Environment Canada, in collaboration with the Canadian Cancer Society, sponsored symposia on public health messages related to UVR. The meetings brought together Canadian and international experts to develop a consensus on consistent health messages about the risks of UVR exposure and strategies for disseminating those messages (Mills and Jackson, 1995). The meetings resulted in an agreement on four key strategies for reducing the health effects of ultraviolent radiation exposure. The workshop participants agreed that healthy outdoor activity could still be enjoyed if an individual reduced UVR exposure by adhering to four main strategies: minimizing exposure during midday, seeking shade, covering up and using sunscreen.

Based on the current scientific consensus on health risks associated with UVR, participants in the meetings also agreed to a common set of messages as the basis for all information to be presented to the public. The messages from the 1994 Symposium are displayed in Table I (from Mills and Jackson, 1995: p. 34), while the updated messages from the 1996 Symposium are pending. The workshops served as fora for translating scientific information into a set of health and prevention messages for public consumption. In the process of this translation, much of the scientific uncertainty surrounding the current knowledge of the ozone-UVR-skin cancer relationship was reduced and the base was laid for the construction of the metanarrative.

Environment Canada and the UV-Index

Key to the construction of the metanarrative was the development of a UV-Index, announced in May, 1992 by Environment Canada, the national institu-

Table 1. Public information messages on UVR exposure.

- The ozone layer has been thinning noticeably since 1980. As a result, there has been a slight increase in UV-B radiation at ground level.
- The intensity of UVR is determined by your geographic location, altitude, the time of year and day, cloud cover and reflection.
- In North America, UVR gets stronger as you move southwards. In general, UVR gets stronger as you move towards the equator.
- Travelers should note that UVR is stronger throughout the year in warmer climates than in southern Canada.
- UVR intensity also increases with altitude.
- UVR varies markedly throughout the year; it is noticeably more intense from April to September, with a strong peak in June and July. During the late spring and summer, UVR is moderate or stronger from 11:00 am to 4:00 pm, peaking in the early afternoon. More specific information is available from your local weather office.
- As a rule, UVR is moderate or stronger when your shadow is shorter than you are.
- In the winter, UVR intensity is low but can still be significant, especially with extended exposure and/or reflection of fresh snow.
- Clouds reduce, but do not eliminate, UVR exposure. Variable or light cloud cover allows most UVR to pass through, whereas thick, dark, overcast decks of cloud significantly reduce UVR intensity.
- UVR may be significantly enhanced by reflection. 85% of UVR is reflected off fresh snow, and other bright surfaces such as sand and concrete also increase UVR by 15%–20%,
- Water is a weak reflector of UV-B and most passes through the top layer of clean lakes or swimming pools. Those swimming or playing in the water need to maintain their UVR protection.
- The intensity of UVR (especially UV-A) can be significantly higher in tanning beds than in sunlight.
- UVR from the sun and from tanning lamps is a major contributor to skin cancer, premature aging of the skin and cataracts.
- Most skin cancers are caused by the sun.
- Injury to the skin and eyes can occur without sunburn. Although all skin types can be damaged, the fairer the skin, the higher the risk. Eye damage is independent of skin type or eye color.
- Damage can be immediate (e.g., sunburn) and long-term (e.g. premature aging of the skin). All exposure contributes to cumulative lifetime damage.
- Occasionally, some medications, cosmetics and other substances can interact with sun rays, and this can be detrimental to your health (ask your health professional for additional information).
- UVR can suppress the immune functions of the skin.

tion responsible for providing weather and environmental information to communities throughout the country. Like the Health Canada messages in Table I which form an action consensus, the UV-Index reduces much of the scientific uncertainty around the link between ozone depletion and ground level UV-B by presenting a simple numerical value to the risk associated with planned outdoor activity. The numerical value acts as a powerful metaphor for risk because it is easy to understand and precipitates an appropriate response through behavior modification.

The UV-Index was developed with funding from the Green Plan, a national environmental initiative implemented in the early 1990s. The Index now provides daily local area readings of predicted UV-B levels on a scale of 1 to 10. As shown in Table II, an extreme reading of 9 or higher is equivalent to the midday

Table 2. The UV-Index.

UV-Index	0–3.9	4.0–6.9	7.0–8.9	< 9.0
Category	Low	Moderate	High	Extreme
Sunburn context	More than 1 hour	About 30 minutes	About 20 minutes	Less than 15 minutes

sun in the tropics and means that a person with Type 2 skin (white skin, blonde hair and blue eyes) would probably burn in less than 15 minutes. A high reading of 7 to 8.9 means the same person would burn in about 20 minutes, while a moderate reading of 4 to 6.9 would allow the same individual about 30 minutes in the sun without burning. A low reading of zero to 3.9 suggests that it would take over an hour of exposure in the full sun for Type 2 skin to burn.

When it was announced, then Environment Minister Jean Charest hailed the new Index as a way to 'help people to make simple choices on a daily basis and avoid excessive sun exposure' (Vancouver Sun, May 28/92; p. A9). Thus the standard health promotion approach was adopted assuming that individuals, armed with sufficient information, would adjust their behaviors to reduce their risk of UVR exposure. The index translates complex scientific information into a readily-understood public health action plan geared to individual behaviors.

Certainty and uncertainty: The evidence supporting the metanarrative

Together the UV-Index and Health Canada's UVR public education messages present a coherent and believable metanarrative about what is 'known' about the relationship between our changing environment and its effects on skin health. However considerable scientific uncertainty underpins this metanarrative. The public health certainty in the Canadian metanarrative is based on the following logic and its embedded claims:

1. The ozone layer is thinning,
2. UV levels (specifically UV-B) are increasing at the ground,
3. Increasing exposure to UVR causes skin cancer, and
4. Knowing about UV levels will change individual behaviors and reduce an individual's risk of skin cancer

To explore each of these claims we now examine the degree of scientific certainty and consensus around each claim. We will also explore the nature of the evidence supporting each of these claims. Through this examination we will show how public concerns have shifted from the less-certain scientific realm into the more-certain public health arena in the metanarrative advocating personal preventive behavior. Table III presents a summary of this discussion.

Table 3. Summary of relationships.

Claim	Nature of the evidence	Problems with the evidence	Players in the debate	Degree of consensus	Degree of certainty
The ozone layer is thinning	Antarctic ozone hole; ground & satellite data	Incomplete global coverage; instrumentation problems; natural vs. anthropogenic changes	Meteorologists/chemists/atmospheric scientists/industry/government	Strong	Medium
UVR (specifically UV-B) is increasing at the ground	Ground-based readings (esp. from Toronto)	Conflicting evidence from U.S. and Europe	Meteorologists/physicists/atmospheric scientists/biologists	Weak but growing	Low
Increasing exposure to UV-B causes skin cancer	Retrospective epi studies; some lab experiments	Long latency; recall bias; self-selection problems	Epidemiologists/oncologists/dermatologists/health practitioners	MM-moderate; NMSC-strong	MM-low; NMSC-moderate
Knowing about UV-B levels will change behaviors	None	Too many extraneous variables & confounders, especially lifestyle issues	Public Health/epidemiologists/physicians/politicians	High	Low

Abbreviations: MM – malignant melanoma; NMSC – non-melanocytic skin cancers.

Claim #1: The ozone layer is thinning

There is a strong degree of consensus among meteorologists, chemists and atmospheric scientists that there has been a small but identifiable reduction in global ozone over the last two decades (Drake, 1994; Burrows et al., 1994). While the consensus on ozone reduction is quite high, there remains considerable uncertainty as to the exact nature of its causes. Many scientists conclude that the decline is the result of human activity (Drake, 1994), but others counter that the natural processes are not well enough understood and therefore natural variation could be at least partially responsible (Wildavsky, 1995; Bailey, 1993). Thus, despite a high consensus among scientists, considerable uncertainty remains due to the conflicting evidence that has been compiled over the years. This disagreement is not merely arcane science because its resolution shapes the nature of the policy response.

Ozone is a gas that is created through the interaction of sunlight and oxygen. It is found in the stratosphere between 15 and 40 kilometers above the earth and peaks in a thin layer of high concentration at a height of about 25 km. Through a continuous process of creation and destruction, sunlight (ultraviolet radiation) interacts with oxygen in the stratosphere. Sunlight continually breaks apart oxygen (O_2) into free oxygen molecules which then join other oxygen molecules to become ozone (O_3). When they are then exposed again to UVR (sometimes almost immediately) two ozone molecules split off to make three new oxygen molecules (Drake, 1994). In this photochemical process of continual creation and destruction, the ozone in the stratosphere absorbs much of the damaging UV rays before they reach the earth's surface. The ozone layer absorbs virtually all radiation below 298 nanometers (nm), which are the shorter wavelengths in the UV-B range of 280–315 nm (Drake, 1994). These shorter wavelengths are particularly important because they are capable of damaging DNA and human skin (Lloyd et al., 1994). The ozone layer, therefore, plays an important role in screening potentially damaging UVR and preventing lower wavelength radiation from entering the lower atmosphere and affecting our skin.

Concerns over ozone depletion first erupted in the early 1970s when Molina and Rowland (1974) discovered that chloroflourocarbons (CFCs) had a serious potential for depleting ozone in the stratosphere. They argued that free chlorine molecules from the CFCs would eventually percolate into the stratosphere and become a part of the ozone creation/destruction process. These chlorine molecules, however, would have the ability to continually break apart the ozone and, through a series of photochemical processes, remain untouched. As more and more chlorine moved into the stratosphere, Molina and Rowland predicted that the process of ozone destruction would increase at an ever more rapid rate (Roan, 1989; Litfin, 1994; Nance, 1991; Drake, 1994). Since the chlorine breaks apart the ozone, the stratosphere loses its capacity to absorb the UVR that would then pass through the stratosphere and reach the earth's surface.

Predictably, this theory was widely attacked by industrial users and producers of CFCs (Roan, 1989; Benedick, 1991; Litfin, 1994). The main argument of industry scientists was there was no conclusive proof that ozone depletion had, was, or would take place. The lack of historical data on ozone levels supported this position. This reaction began a decade-long debate over the validity of various predictive models, the accuracy of ozone measurement instruments and the economic implications of phasing out CFC production and use. On one side were chemists and atmospheric scientists that argued that the long-term effects of CFCs would not appear for decades; therefore precautions had to be implemented immediately. On the other side were industry officials arguing that the social and economic costs of abandoning CFCs were too great; they supported a theory that the stratosphere was self correcting and could adapt to the changes in chemical composition that resulted from CFCs. Caught in the middle were governments and the public. The media, particularly in North America, provided extensive coverage of the ozone debate amidst a general climate of increasing support of the precautionary principle in environmental issues. The precautionary principle states that where equivocal evidence exists that can neither support nor deny environmental effects, it is best to err on the side of caution to prevent potential environmental destruction (Virtual

Elimination Taskforce, 1993). During this era, the public was primed to the precautionary principle and it was they, in their role as consumers, that cast the deciding vote. The public boycotted CFCs in aerosol products and proved to industry that, despite the residual uncertainty, the public believed CFCs had to go.

The development of an international consensus on limiting CFC production was advanced by the discovery of the Antarctic 'ozone hole' in the mid-1980s (Farman et al., 1985). Yet there are conflicting analyses about the degree of scientific consensus leading up to the 1987 signing of the Montreal Protocol (an international agreement to limit CFC production and use and therefore 'protect' the ozone layer). Some analysts state that there was little dissension between experts that CFCs were the main cause of ozone depletion (Nance, 1991; Benedick, 1991). By comparison, Litfin (1994) suggests that considerable scientific uncertainty and disagreement remained, but the growing consensus that led to the signing of the Montreal Protocol represented a key international discursive shift toward precautionary action in environmental issues.

This shift toward precautionary action to 'save the ozone layer' continues into the 1990s and has promulgated a continuing scientific consensus that ozone reduction is a serious global problem despite conflicting data and considerable scientific uncertainties. In March, 1992 Belgian meteologists (DeMuer and DeBacker, 1992) found that the instrument that provided historical records on ozone – the Dobson Spectrophotometer – had probably mistaken reductions in atmospheric pollutants and produced fictitious ozone readings. They concluded that once these pollutants had been accounted for, there was actually an *upward* trend in global ozone over the past decades.

Other researchers point to the robustness of the models used to predict future ozone depletion to highlight the considerable scientific uncertainty. Models that predict a downward trend of, for example, 5% can have confidence intervals that result in predictions that should range between 2.5% and 9% (Wildavsky, 1995). Since these models are based on the chemical composition of the atmosphere, and our knowledge of that composition is constantly changing and growing, considerable variation exists in the reliability of these predictive models.

This is added to by problems with the representativeness of existing ozone records. Most of the historical record of ozone readings are from more developed countries that have the technology to make these measurements. For example, Canada has been recording ozone levels since approximately 1957 (Kerr and Wardle, 1993) but ozone records are still not available for many parts of the African continent. Thus the consensus on ozone depletion is based on measurements that exclude completely certain parts of the globe.

It was anticipated that gaps in global ozone data would be filled by the launching of the Nimbus-7 satellite in 1978. This satellite provides daily maps and data of the global distribution of total ozone. However this and other satellite information has been available only since 1978. During the two decades the earth has passed through a bottoming out of the eleven year solar cycle. Our sun experiences continuous eleven year cycles where it passes through maxima (where solar activity and UVR is very high) and minima (where activity and UVR are low). This flux in solar UVR significantly changes the ozone concentrations in our stratosphere as it affects the ozone productive process. The two most recent solar cycle took place between 1969 (maxima) and 1980 (minima). Measurements from the Nimbus-7 began just prior to the solar minima of the 1980s and low ozone levels measured during that time could be explained away by the solar minima. Therefore the global data supplied from 1978 may fill in some of the 'holes' by providing data for previously unmeasured parts of the globe. However global natural variation cannot be discounted as an explanation for minor fluctuations in global ozone.

Despite considerable scientific and public consensus that the earth's ozone layer is disappearing, there remains only moderate certainty in the scientific community as to the nature, cause and the extent of the decrease. Problems with measurement instruments, predictive models and natural variability all contribute to this continuing uncertainty.

Claim #2: UV levels (specifically UV-B) are increasing at ground level

Despite the uncertainty noted above, the scientific consensus remains that there has been a decline in global atmospheric ozone over the past decade (WMO, 1994; Burrows et al., 1994). The next step in the logic chain takes us to the claim that, as a result of decreasing ozone, more UV-B is reaching the earth's surface. Consensus on the UV-B claim is considerably weaker than the ozone claim though it is growing rapidly. The main reason for this weak consensus is that most of the UV-B ground data is conflicting and of a short duration, resulting in low scientific certainty.

The strongest evidence for UV-B increases comes out of the Atmospheric Environment Service (AES) located near Toronto, Canada. Researchers at the AES have a record of ground based UV-B readings going back to 1989. This is the longest historical record for UV-B, yet it provides insufficient data to establish whether or not there is a long-term relationship between ozone and ground based UV-B (Kerr and McElroy, 1993). It has provided, however, sufficient data to show that on a *daily* scale, UV-B levels in Toronto correlate with ozone levels. This means that ozone levels are low on those days that UV-B levels are high, and that UV-B levels are low on those days that ozone levels are high (Kerr and McElroy, 1993). Researchers are cautious to point out that 'attempts to detect long-term trends in UV-B radiation from existing data records have been inconclusive and controversial' (Kerr and McElroy, 1993; p. 1032). They add that confounding variables such as clouds, aerosols, pollutants, ground albedo (reflectivity) and difficulties in consistent measurement all can influence UV-B records. Kerr and McElroy also cautioned that their findings may not be representative of long-term UV-B trends.

Yet, despite these and considerable other potential confounding factors and assumptions, researchers concluded by equating correlation with causation and linking ozone with UV-B. In their concluding paragraph Kerr and McElroy speculate that since high UV-B levels were found with low ozone levels in 1993,

> 'It is likely that past UV-B values have never reached the 1993 levels, at least since the beginning of the Toronto ozone record (1960). It is also quite reasonable to extend this conclusion based on the Toronto data (where record high UV-B readings were recorded in 1993) to other places because record low ozone values are also being reported elsewhere.' (Kerr and McElroy, 1993: p. 1034).

It is not surprising that this process of equating correlation was causation was misread by the popular press. Canada's leading daily newspaper announced:

> 'Canadian researchers have proved what scientists have long suspected: The more the ozone layer in the atmosphere thins, the more cell-damaging ultraviolet radiation reaches the ground.' (Globe and Mail, Nov. 12/93: p. A8).

The consensus over ozone depletion appears to be used to reduce the uncertainty over the link between ozone and UV-B levels. Elsewhere, newspapers cite scientific 'experts' as confirming this claim when a scientist with the US National Oceanic and Atmospheric Administration said 'It's the best confirmation that we have' about a link between ozone and UV-B (Winnipeg Free Press, Nov. 12/93: p. A3). So despite the caution that Kerr and McElroy identified in their publication, scientific uncertainty on the relationship between ozone and UV-B levels was reported as not just certainty, but also as consensus.

Meanwhile other studies from the United States and Europe have been unable to find any correlation at all between UV-B and ozone – either on a daily basis or over the long term (Wildavsky, 1995; Harvey, 1995). Average UVR surface measurements from eight stations in the mainland U.S. have shown a −8% trend between 1974 and 1985 (Scotto et al., 1988).

Similarly, declines of between 5% and 14% were found in UV levels in the rural U.S. (Liu et al., 1992). Instead of increasing, UVR levels seem to be decreasing at the earth's surface. Scotto et al. (1988) also found that the kind of UV that affects human skin actually decreased at ground level at one European and nine U.S. monitoring stations over approximately the same time period in which decreased ozone levels were reported. In conflict, some recent reports show that UV-B has increased approximatly 10% between 1991 and 1995 in some European stations (Zerefos, 1996, see also Diffey, 1996).

More recently, scientists that model UVR levels speculate that US and European reductions could be the result of local industrial pollution that lowers local UVR readings despite increases at the global level (Crutzen, 1992). What remains is considerable debate at several levels. The growing consensus that ozone is depleting is still met with conflicting evidence about whether or not UVB levels are increasing. What is even more interesting is that for almost 25 years scientists have continued to *believe* in the ozone-UVB relationship and to search for evidence to support it despite conflicting measurements and considerable scientific debate (Diffey, 1996).

Short of installing a global network of UV-B monitoring stations and waiting several decades for conclusive data, there is no way of being certain that UVR levels on the surface of the earth are increasing at all, let alone as a result of ozone depletion (Wildavsky, 1995). This lack of evidence appears to have increased scientific uncertainty over the relationship and, as a result, has weakened the scientific consensus that otherwise might have been much stronger.

However that consensus continues to grow as more and 'better' science is accumulated. In the practice of normal science (Kuhn, 1962) researchers address those problems for which they think they already know the answer, and search for the answers that they believe they will find. In this way researchers will continue their search for the link between ozone and UVR on the strength of the simple progressive logic of the relationship: if ozone absorbs solar radiation before it reaches the earth, and ozone is decreasing, then more solar UV radiation is probably reaching the earth. Most likely, scientists will not stop their search until they find the data to support this intuited causal relationship.

Claim #3: Increasing exposure to UV-B causes skin cancer

The increasing incidence of skin cancers over the past 30 years is often cited as evidence that anthropogenic climate change is having health effects (Nance, 1991). By accepting the two previous claims, we 1) assume that the ozone in the stratosphere is increasing, and 2) assume that UV-B levels are increasing on the earth's surface. But once again we are faced with differing degrees of consensus and scientific certainty over whether these changes have increased skin cancer among the world's population.

There are three main forms of skin cancer: cutaneous malignant melanoma (MM), basal cell carcinoma, and squamous cell carcinoma (Harvey, 1995). These last two are considered together as non-melanocytic skin cancer (NMSC). Throughout most of the world, NMSC is about ten times more common than MM; yet MM causes about three to four times as many deaths (Harvey, 1995).

Over the past 40 years, incidence rates for both NMSC and MM have risen substantially (Glass and Hoover, 1989). In addition, mortality rates from MM have also been on the rise although some studies suggest that the mortality has leveled off over the past several years (Glass and Hoover, 1989; Bonett et al., 1989). Most importantly, however, many studies suggest that increases in skin cancer rates over the last few decades are likely attributable to changes in general lifestyle and behavioral practices and that stratospheric ozone depletion is unlikely to account for any observed increases (Moan and Dahlback, 1992; Amron and Roy, 1991; Wildavsky, 1995).

The degree of consensus around the causes of skin cancer varies. Epidemiological studies of NMSC have resulted in low uncertainty and a strong consensus around risk factors. Older age, blue eyes, light colored skin, red or blonde hair and high lifetime cumulative UVR exposure are all widely accepted as risk factors of NMSC. Almost without fail, epidemiological studies have shown a strong relationship between cumulative UV exposure and NMSC (Harvey, 1995).

However there is a greater debate around the risk factors for MM. There is considerable inconsistency between studies examining the association between MM and cumulative UV exposure (Harvey, 1995). Some studies show that MM has a strong positive correlation with high local UV flux (Aase and Bentham, 1994), while other studies suggest that moderate tanning may be protective among those in the population that tan well (Dubin et al., 1989). Finally, Harvey (1995) calls into question the importance of UVR for MM by pointing out that a large proportion of MM lesions occur on the trunk and lower limbs which are generally not exposed to consistently high levels of UV radiation.

One of the problems with epidemiological studies of skin cancer is that researchers must rely on retrospective studies that are based on the recall of subjects. As a result these studies can be influenced by many biases including self selection and recall bias (Hennekins and Buring, 1987). While laboratory experiments have indicated that UV-B is a major etiologic factor in skin cancer, melanoma has yet to be induced by UVR alone in laboratory test animals (Mukhtar and Bickers, 1993).

Lack of strong empirical evidence again seems to be highlighting the uncertainty behind the relationship between skin cancer and UV radiation. Consistent retrospective studies support the relationship between NMSC and cumulative UV exposure and a strong scientific consensus has developed. The uncertainty around UVR and MM is much greater and there remains a much weaker consensus around that relationship. Since NMSC is rarely, if ever, life threatening, and melanoma makes up only 2.4% of cancers in Canada (Canadian Cancer Statistics, 1996), questions can be raised about the efficacy of spending public health moneys on skin cancer education and prevention campaigns during an era of competing demands.

Claim #4: Knowing about UV-B levels will change individual behaviors and reduce that individual's risk of skin cancer

The main premise underscoring Health Canada's public messages and Environment Canada's UV-Index is that individuals will change their sun exposure behaviors if they are cognizant of the risk. Thus, if 1) the ozone layer is disappearing, and 2) UV levels are increasing, and 3) UV causes skin cancer, then it is only 'sensible' that individuals would try to reduce their risk.

This final claim enjoys a strong consensus among health professionals, politicians and the general public despite the high degree of uncertainty that lies beneath it. There is little, if any, evidence that widespread public health campaigns affect individual behavior without addressing important motivating and predisposing factors (e.g., smoking cessation and heart-health programs). Some researchers suggest that increasing skin cancer rates have less to do with physical exposure, and more to do with social and economic changes over the past 40 years that promote and reward sunbathing (Weinstock, 1993; Harvey, 1995; Glass and Hoover, 1989; Miller et al., 1990; Keesling and Friedman, 1987).

The bulk of community intervention studies in skin cancer have taken place in Australia. In the 1980s and 1990s, researchers there have managed to achieve an unprecedented change in public attitudes towards sun exposure (Marks, 1992). As a result of their work, Australia, which previously had the highest skin cancer rates in the world, has seen incidence rates begin to level off. This success was not achieved through a simple increase in the knowledge around sun protection and skin cancer (Borland et al., 1990). Instead it was successful because it targeted structural impediments as well as social and behavioral norms. By the early-1990s Australians reported a lower tolerance for those wearing brief clothes in public, a decreased desire for a deep suntan, a reduction in the equating of tan skin with health, and substantially increased sales in UV-resistant clothing and sunscreen (Marks, 1992).

Despite the lack of evidence supporting simple information campaigns (Steckler et al., 1995), the consensus remains strong around providing information to reduce sun exposure. It was this consensus that was behind the development of the UV-Index. However, as a measure, the UV-Index has many problems (Deslauriers, 1996).

The UV-Index presents time to burn for type 2 skin. This represents skin that burns easily on an individual with blonde hair and blue eyes, or red hair and a propensity to freckle. Therefore it represents those that are highly sensitive to UVR. At present there is no knowledge of how much of the Canadian population has this skin type (Deslauriers, 1996). No studies have been done to find out what percentage of the public corresponds to this sensitivity. It is quite possible that a country like Canada with an increasingly diverse ethnic composition contains less than 20% of the population corresponding to these characteristics (Deslauriers, 1996). As a result, the UV-Index itself could be presenting inflammatory information with two potential results. First, many individuals could simply ignore the warnings because the danger levels simply do not equate with their personal experience. Second, it may inflate public sentiment and precipitate concern that is out of proportion with the danger.

In examining the public health messages communicated about UV risk, we have moved cautiously from the realm of scientific debate into that of public policy debate and shown how this series of claims has contributed to the sun safety metanarrative. However, the degree of consensus on how to act about these issues still remains much higher than the degree of certainty based upon the scientific evidence. Experts, whether they are scientists or public health officials, continue to present a face of considerable certainty of action and understanding, despite very low certainty and substantial lack of scientific evidence.

Discussion: The bases of the claims

There are similar underlying assumptions in each claim in this metanarrative, regardless of whether the claim is based in the scientific realm or in the policy-making arena. Indeed, in both instances, claims are based on one or a combination of:

- professional expertise,
- powers of persuasion,
- the superiority of one among conflicting explanations or 'stories,'
- interests and values, and
- the use of metaphors and symbols.

At each stage of metanarrative construction claims of course compete. Yet in any argument – scientific or policy-related – claims are made, questioned, backed up and moved forward by debate. The outcome of debate then becomes the basis for developing a consensus around the issue and certainty is created by and for the winning argument. There are often similarities to developing normal science and implementing a policy consensus. The following discussion examines the five bases for claims identified above. It then explores how these bases have been used to further the logical claims in the sun safety metanarrative.

Professional expertise and powers of persuasion

The development of consensus and metaphor construction takes place in both science and policy. In the scientific realm, the developed consensus is similar to Kuhn's (1962) concept of normal science; in the policy realm it is labeled the 'craft' of policy-making (Majone, 1989) or the successful construction of the policy argument (Dunn, 1981). The practice of Kuhn's concept of normal science is evident in the search for the link between ozone and UVR. New ideas were produced by scientific practitioners about ozone depletion. These then become accepted as facts and become the building blocks for shaping new questions and pointing the direction for new answers: that UV-B *must* be increasing at ground level. As the process continues, 'the result of the *construction* of a fact is that it appears unconstructed by anyone' (Latour and Woolgar, 1979; italics in original). In this case, the result is the construction of the 'fact' that, despite equivocal evidence, many *believe* that UV levels are rising at ground level even though it cannot yet be shown to be so. Instead, based on expertise, persuasion is used to justify action. The considerable expertise of the scientists invokes sufficient cause for governments, the media and the general public to accept and act on this belief. This is especially true in a climate shaped by the precautionary principle and in a society in which anxieties and concerns expressed by the public demand a response from government and its representatives.

Similarly, the general public widely accepts the skin cancer prevention messages of public health specialists based on expert opinions that individual behavior will mitigate the perceived dangers. The equivocal nature of evidence supporting this kind of public health campaign is set aside and recast into the need for action. Thus in communicating risks about UV-B, the low to moderate certainty about the facts (as noted in the final column in Table III) is transformed and translated into a moderate to strong consensus on how to act. The messages resonate with our understanding of what works to improve things: individual action. Thus public employees and officials use the government's mandate to create an environment wherein uncertainty is reduced (and certainty is increased) through the uptake of specific scientific, often medical, expertise. With a mission to protect the public health, these public servants assist individuals in assimilating information so that individuals have the so-called facts and are compelled to act.

Conflicting explanations or 'stories'

Both science and policy development are processes in which order is created out of disorder. The ozone-UVR-skin cancer claims are good examples of how scientific research and policy development can coalesce around a single explanation, story or metanarrative. Latour and Woolgar (1979) argue that, in science, experts are constantly constructing information by weeding out important statements from the 'noisy' data. From this atmosphere of noise they constantly reassess and revise the developing storyline for public presentation. This storyline then becomes the *scientific* paradigm which, through social transformation and policy adoption, also becomes the *social* paradigm or ideology (Cotgrove, 1982). Hence, an atmosphere rife with noise and disorder becomes a coherent public message resonating with certainty.

With the claim that the ozone layer was thinning, there was considerable scientific noise, resulting in considerable scientific debate over the construction of the facts (Nance, 1991; Benedick, 1991; Litfin, 1994). Latour and Woolgar (1979) argue that facts are based on creating a statement for which equally plausible explanations are impossible. In the case of depleting ozone, any number of alternate plausible explanations have and continue to be available. Yet considerable scientific consensus has developed that the layer is indeed thinning. It could be that, over time, there has been an increasing cost to any scientist that tries to bring forward competing claims and contradict normal science (Latour and Woolgar, 1979; Kuhn, 1962).

Over the past decades there have been a number of international agreements on how to solve the problem of ozone depletion. These political and policy responses have made it increasingly difficult for competing scientific claims (those that might say that ozone depletion is *not* occurring) to come to public attention. Evidently science and policy (in particular forms) do indeed reinforce one another. An individual scientist would likely put her or his career in jeopardy with such a statement and could expect considerable confrontation and criticism for making such a claim. In this way a consensus has developed around thinning ozone. Instruments have been invented to measure ozone and thus reified the issue and turned concern over ozone into a 'fact' that it is thinning (Latour and Woolgar, 1979). In the Kuhnian sense, ozone depletion has become 'normal' science.

By contrast, scientific consensus around the growth of UV at ground level is much weaker, although it is growing. The strength of this growing consensus is also based on the search for order in both science and, through translation, politics and society. If the ozone layer is thinning, then UV levels *must* be increasing at ground level. Lack of evidence is seen as a problem of technology and skepticism is met with comments that 'it's probably there, we just can't measure it yet.' As Allen and Hoekstra (1992) comment, science is defined not by what we observe but what we are able to observe, with instruments being created to measure what scientists feel they know is already there. The preconceived idea is reified and moved toward the status of fact. Thus a growing consensus around a concept with low certainty can precipitate the generation of new facts to the exclusion of looking for and discovering competing facts or explanations (Latour and Woolgar, 1979).

Interests and values

The relationships between UV levels, skin cancers and risky behaviors embrace high consensus despite low to moderate certainty. In this situation, argument has moved from what Dunn (1981) would call a designative claim (based on fact) to evaluative and advocative claims based on values and actions. Although this portion of the UV risk debate has one foot in the scientific realm, it has the other very firmly planted in the public health realm. Actors in this arena are rewarded for positive action that is seen to protect the public. It is not surprising, therefore, that action is taken to develop policy despite low certainty. The raison d'être of public health is to protect the public. The ill-structured nature of the ozone-UVR-skin cancer issue opens the doors for competing interests and values to promote different interpretations of both the problem and potential solutions (Dunn, 1981). Yet the mandatory nature of public health protection and the application of the precautionary principle point to one course of action: public health messages as seen in Table I.

Metaphors and symbols

Both scientists and policy makers have made considerable use of metaphors and symbols in the construction of the sun safety metanarrative. Perhaps the greatest metaphor being used by atmospheric scientists is the use of 'health as a surrogate for the environment' (Burger, 1990). By framing the ozone depletion issue in terms of human health, scientists use an effective metaphor to tap into emotions. Policymakers may likewise justify their claims and actions by appeals to health. 'We are not talking about the environment' they say, 'by the very survival of future generations' (see how Colborn et al. (1996) address this around contaminants and reproductive health). By framing the issue in this way, scientists and policy makers heighten public apprehension and shift policy concern away from the power of the evidence towards the power of the potential outcome (Majone, 1989). This is one example of how scientific evidence is used in the craft of policy making.

Policy makers also use metaphors and symbols to expedite their agendas. A particularly interesting component of the UV risk policy development has been the implementation of the UV-index. This index provides a simple scientific symbol – a number – to make more concrete a very complex risk evaluation.

Stone (1988) identifies how numbers are symbols of certainty amidst the noise of scientific uncertainty. As the most elemental of languages, the public easily understands numbers. A decimal scale helps us to identify relative risk: six is twice the risk of three; four is twice the risk of two, and so on. Thus risk is clarified and the individual becomes the decision-maker. What was once a maze of confusing risk assessments now becomes a decided path guided by an evaluation of the numerical risk (Stone, 1988). When the individual becomes the decision maker, responsibility is where it should lie and s/he can initiate corrective actions and behavioral changes – a, if not the, foundation of Canadian health policy (Epp, 1986).

Thus the risk identified with a reading of 7 on the UV-Index appears to give a concrete definition of danger for an individual. Lost in the number are the multitude of qualifications that modify the risk: cloud cover, skin type, eye color, propensity to burn, history of sunburn, genetic predisposition, altitude, pollution levels. All of these disappear in the presentation of a single number. What is lost too is any scientific uncertainty or equivocation. Ambiguity is swamped by the public consensus supported by an understandable, individualized number.

Summary

To step back, we are left, in policy analytic terms, with competing stories or narratives vying for credibility in explaining ozone depletion and its relationship to UV-B and skin cancer (Roe, 1994). On one side are those that support anthropogenic influences. Their story asserts that human influences have affected the atmosphere, there is increasing danger to human health, and that the result (if the problem is left unaddressed) will be human and ecosystem illness, perhaps death. This is the sun safety metanarrative. By contrast those that suggest that the stratosphere is self-correcting and that ozone depletion is less of a problem have a much less compelling story. Theirs, in Roe's (1994) terms, is a 'non-story.' It merely claims that everything is all right: that humans and planet earth will survive. Further it is not vivid (Nisbett & Ross, 1980) and is thus less convincing in narrative terms. As a result it is less compelling and less believable.

The most compelling of policy stories are those portraying increasing control rather than increasing helplessness (Stone, 1988). This appeals to an individual's sense of liberty and is, therefore, very popular. The interests and values of the multitude of groups involved in the sun safety metanarrative set up a policy space demanding competition for attention from the public, media and governments. Playing out a drama of heroes (scientists, public health officials), villains ('them,' as in industry and big government) and potential victims (the public) in a clear narrative structure provides drama and interest. This attracts media attention, which fuels public concern and generates a response from elected officials. This response is often to generate more science (Salter, 1988) or clear science (such as a number), or science meaningful to the policy process to try to promote understanding of the issue and to show that officials are indeed doing something about the problem.

Analysis

In the case of the sun safety metanarrative in Canada, we see a close, almost symbiotic, relationship between public health policy and science. Science provides potential answers to questions about environmental degradation and human health impacts, policies are implemented based on those answers, and public concerns are both calmed and coalesced around this scientific explanation, thus generating a need for more science for better understanding and future policy decisions.

Contrary to the common view of science as being outside the political world of policy-making, it is an integral part of policymaking – particularly in the arena of environmental health. More importantly, scientists are increasingly adopting the 'tools' that have traditionally been used by policymakers. The scientists providing the evidence for the sun safety metanarrative themselves used narratives, metaphors, persuasion and argumentation to promote their *beliefs* about the importance of ozone depletion and its potential to affect human health. In return, this environmental problem is reframed as a human health issue, thus raising its importance in the public view and reasserting the need for intensified scientific research.

Ideally scientists are rational, logical and objective and policymakers are politically motivated, reactive and subjective. Yet, as we have seen from the sun safety metanarrative, both scientists and policymakers use numbers and symbols, narratives and metaphors, and persuasion and argumentation as tools of the trade. As Albæk (1995) notes, science and policy are not so different as they might appear. There is nothing inherently wrong with their synthesis but there must be explicit recognition of this coalescing of methods and purposes between science and policy. Neither must be given primacy, but their symbiosis must be recognized and appreciated. The two faces of power and knowledge are indeed closely intertwined.

This linkage stems from both pursuing related, if slightly different, incentives. Scientists are motivated to conduct research to obtain peer-reviewed acceptance through publications and grants. Administrators and program leaders use and discard evidence based upon its applicability to local situations and circumstances and to serve their own purposes of public office, community betterment and so on. Nevertheless, both scientists and policymakers possess incentive structures underlying many of their actions.

But it is possible to understand their beliefs and actions in another way. Instead of seeing their actions as the outcome of differing incentive structures, we might view scientists and policymakers as sharing a moral base and a moral history that underpin and motivate their actions. The moral and dramatic structure that develops in the sunsafety metanarrative is not a new one but draws on the European historical tradition of the morality play. In that genre, a single performer represents humankind in the eternal struggle between good and evil portraying the human condition as a spiritual process (Potter, 1989). The performer begins in a state of ignorance (innocence), and through experience (corruption) falls from grace. Finally the individual goes through a realization (repentance) and is redeemed. The fundamental allegory is easily applied to the core message of environmentalism: humans were once part of the natural cycle (innocence), humans manipulate and change that natural cycle (corruption) and humans must make right their environmental damage in order to survive (repentance and redemption).

However the importance of the morality play and its didactic allegory can tell us more than a simple salvation story. Historically, the morality plays developed in Europe in the sixteenth century on the cusp of the Renaissance. This was a time of great social, religious and political upheaval wherein the medieval order was being challenged and the morality play became the main public expression of competing theologies and ideologies (Potter, 1989). Traditional religious plays continued, but the morality plays concurrently portrayed Christian ideals and morals in a more intellectual manner by examining the forces at work in the individual during the span of a single person's life (Davenport, 1982). This process of innocence, corruption, and redemption suggested that each individual audience member viewing the performance was part of the process and that he or she, as an individual, had important choices to make about the future of the world. The thrust of the story was that the way to redemption was through the moral exercise of free will (Potter, 1975).

We live, it is argued, in a time similar to the end of the Medieval period and are in the midst of shifting social and political forces. Simply put, ours is a millennial culture (Kingwell, 1996). As the twenty-first century draws near we are seeing a qualitative transformation from an industrial to a risk society in which anxiety and insecurity are common themes to be addressed by creating certainty (Beck, 1992). The popularity of simple, clear explanations – such as the sun safety metanarrative – speak to that need for a created certainty amidst a rapidly-changing world.

Via the sun safety metanarrative, the importance of free will for salvation resonates from both environmentalism and the public health call for individual protective behavior. Individuals are exhorted to make important choices about the future of the world (through making environmentally 'friendly' lifestyle choices) and about personal salvation (behaving 'correctly' to reduce the risk of cancer). The public information upon which those choices are made is stripped of equivocation and uncertainty. Nevertheless dissenting stories emerge that dispute the primacy of scientific explanation and point to the inability of Cartesian rationality to explain some of the simplest cause-effect relationships (for example, what causes skin cancer?). Just as the religious world view was being called into question in the sixteenth century, so now is the scientific and medical world view being called into question at the end of the twentieth century.

It is through the questioning of that scientific world view that we see the distinctions between science and policy becoming increasingly blurred. The sun safety metanarrative shows how scientists use policy methods to develop narratives to support what they know but cannot scientifically prove. At the same time, policy makers use pseudo-scientific methods and numbers to justify decisions and proposed actions. The result is that scientific uncertainty dissolves and is replaced by action and, as Brandon (1984) argues, all action is value-based. By being certain about the uncertainty, impetus is given for acting to prevent unknown effects (Roe, 1994), which again resonates with both moral undertones of our culture and the precautionary principle of science in policy.

Conclusion

The authors of this paper do not dispute that the earth's ozone layer is disappearing. Nor do we know whether UVR at ground level is increasing or decreasing and whether or not there will be an epidemic of skin cancer as some predict. The validity of this specific case has not been the issue. Instead, this case study has been used to show how scientists and policy makers need to understand the similarities between their endeavors as they both play parts in unfolding social and political transitions. We also hope to have shown how environmental health policy has moved beyond Torgerson's first two faces of policy and has adopted his third face model wherein science and policy, as well as knowledge and power, work equally in our rapidly-changing world.

The sun safety metanarrative is not the only issue in which scientific evidence or knowledge has been used to propel public health policy. Over the past several decades it has been the uncertainty over direct cause-effect relationships that has driven the debate over health effects of smoking. Despite the inability to link smoking to lung cancer with absolute scientific certainty, the smoking metanarrative has shifted in favor of the public health consensus that smoking is dangerous. The debate of reproductive health is a current issue that also shows how some scientists are contesting the existing metanarrative (that human reproductive health is separate from environment) with a counterstory of considerable emotional appeal (that human reproductive health is intrinsically linked to environment, and specifically it is affected by environmental contamination). Colborn et al. (1996) effectively show how scientists rely on faith and belief when developing counterstories to existing, accepted narratives.

Using the sun safety metanarrative as a case study we have shown that public health messages about UV radiation, and particularly the UV-Index, serve several purposes. First, they formalize a perceived environmental danger and make that danger applicable to everyone by linking it to an individual's health. By making that link, public consensus is cultivated to support the scientific consensus defining ozone depletion as a problem to be solved. Second, these messages present a policy solution to the public and reassure the public that action is being taken. But, third and most importantly, these messages and the Index shift responsibility for action from government and society to the individual. Given the level of uncertainty that exists in each claim in the metanarrative, this is likely the only level at which action can be rationalized. Individual responsibility reinforces the certainty that action against the dangers of UV exposure is possible and supports the moral certitude of the exercise of free will. As in the morality play, whatever happens in the world, the responsible and moral individual will be safe and, by his or her actions, saved.

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