Getting strategic about the environment and health

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Introduction

The belief that our health is greatly influenced by our physical environment has seen efforts to control and regulate the environment become primary strands of public health policy throughout the world. This relationship between the physical environment and human health has also been prominent amongst the concerns of international organizations including the World Health Organization (WHO), the World Bank, the United Nations, the Organization for Economic Co-operation and Development and the European Union (EU). This

Summary

Historically, the physical environment has been a target for public health policy across the globe. This remains the case in developing countries where the enduring infectious and toxic challenge posed by the environment is tangible and its health impact is manifest. However, in Western societies, the relevance of the environment to health has become obscured. Even when this is not the case, the perspective is usually narrow, centreing on specific toxic, infectious or allergenic agents in particular environmental compartments. It is rare for importance to be given to a health-determining role for the environment acting through broader psychosocial mechanisms. The result is that environmental manipulation is seen as a cornerstone of the public health response for comparatively few health concerns. This paper considers how public health policies and action on the physical environment may be pursued more optimally. The need for a more strategic approach, which employs a new conceptual model that recognizes the complexity and contextual issues affecting the relationship between the environment and health but retains sufficient flexibility and simplicity to have practical application, is identified. Building on recent work, a model is proposed and pointers are given for its use in a practical context.

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paper argues that, despite sustained effort and visible commitment amongst many of the players involved, manipulation of the physical environment has become an underexploited option in addressing contemporary health challenges. A number of factors are proposed that have diminished the perceived role of the environment. Prominent amongst these are adherence to traditional approaches in environmental health and the lack of strategic thinking. If a more progressive and strategic approach is to be adopted, a new conceptual model is needed. Such a model must adequately represent the relationship between the physical environment and human health whilst taking cognisance of other influences. It should be a framework for the assembly of evidence, and should facilitate interpretation and translation of evidence into effective policy and action. The physical environment, as discussed here, is an inclusive concept defined in relatively simple terms as the universal set of all things external to the individual but excluding the social environment with which there is, of course, perpetual interaction. Thus, the physical environment comprises the full spectrum of biological, physical and chemical entities, whether natural or man made.

Role of the physical environment in human health

Both early Chinese and subsequent Hippocratic traditions pursued health through the creation of an equilibrium between environmental factors and aspects of the individual’s way of life, such as work, recreational behaviour, sexual habits, and food and water consumption. Central to the maintenance of internal balance or health was an external balance between humans and their environment; a paradigm underpinned by what was essentially an ecological perspective. Although a more mechanistic world view (the Cartesian paradigm) emerged in the 16th Century, it took a while for medicine and its attendant modes of enquiry to supplant the ecological perspective and effectively limit the definition of knowledge to the products of reductionist investigation. Although productive in many areas, the reductionist approach served to promote the primacy of biological plausibility when appraising health and its determinants, and to portray health and disease as attributes of individuals as opposed to populations. The result was a narrower perspective for policy and action.

In any era, the prevailing public health paradigms can limit thinking by dictating the areas that are deemed appropriate for investigation. A succession of paradigms can be seen to have dictated the importance accorded to the physical environment within causal processes. For example, in the early 19th Century, a miasmic paradigm that attributed disease to the inhalation of noxious vapours provided justification for environmental control as a public health measure. The subsequent development of the germ theory in the 1860s as a paradigm for a new ‘era of infectious disease epidemiology’ still accorded an influential role to the physical environment in health and disease that, in practice, were still seen as attributes of populations as opposed to individuals. With the passage of time and the emergence of immunization and isolation as weapons against infectious disease, the objective remained population health but the focus for intervention shifted increasingly to the individual. The boost to curative medicine that accompanied the discovery of antibiotics impacted dramatically on infectious disease in the developed world, whilst serving to further individualize health and undermine the ecological perspective.

Increasing individualization of health, disease and their determinants is nowhere more evident than in the unremitting growth of the healthcare industry during the 20th Century, giving it primacy amongst health-related activity, first call upon physical and intellectual resources, and a near monopoly of political debate around health. Paradoxically, despite its acclaimed population focus, much of the conduct of disease-centred epidemiology, particularly in the latter half of the 20th Century, seemed scarcely less individualistic in that its role was increasingly one of re-inforcing the insights of clinical medicine. Targeting, as they do, the determinants of health at societal level, the traditions of environmental health were somewhat out of kilter with the new orthodoxy. Manipulation of the physical environment did not disappear from the portfolio of public policy in the latter part of the 20th Century, but the primary drivers of intervention were often concerns external to public health. A contributory role for the physical environment in the headline chronic non-infectious epidemics of the day was only seriously countenanced where this could be demonstrated through reductionist modes of enquiry. This inevitably led environmental health policy to focus only on those areas where a direct and biologically plausible toxic, infectious or allergic mechanism could be substantiated, with no important role for the environment acting through psychosocial mechanisms. In effect, environmental health became a narrow activity wherein the approach was primarily the statutory enforcement of environmental
standards for single agents in specific environmental compartments. Reflecting the prevailing ethos, epidemiology's descriptive trawls for risk factors found them, most commonly, in individual behaviour or life style. Change in life style would then become the very direct target for policy and action. In a truly ecological perspective, health-damaging behaviours would be seen to exist within a wider social and environmental context, and the targets for public health and environmental health policy would be commensurately wider.

The perspective was not without challenge. As early as 1974, the Canadian Government White Paper, 'A new perspective on the health of Canadians', articulated a growing interest in looking beyond an infinite expansion of the healthcare industry and taking a wider view. It presented the environment as one of four health fields in which to group the determinants of health status. The others were lifestyle, human biology and healthcare organization. Articulated as policy, such an overt challenge to a healthcare-dominated orthodoxy provided focus for an increasingly disaffected public health constituency and a stimulus to debate. Indeed, the author of this White Paper identified a consequence of the health field concept as being the elevation of human biology, environment and life style to a status equal to healthcare organization, rightly claiming this to be a radical step. More soberly, some commentators have seen the White Paper, despite its laudable intentions, as a precursor to a debate characterized by a selective emphasis on lifestyle issues and a downplaying of the role of life circumstances. Thus, the importance of processes operating at societal level was arguably obscured if not lost in the debate. The perceived importance of the physical environment in health remained that of a setting in which individuals were exposed to a narrow range of toxic or infectious agents linked to specific pathologies.

This article will consider what the authors regard as a more enduring legacy of the Canadian White Paper, and will discuss the development of a conceptual model for a strategic approach to the environment and health.

**Current challenges in environmental health**

In earlier work, a simple framework was proposed for public health professionals to apply to conduct a gap analysis in relation to any accepted or hypothesized relationship between the physical environment and human health. The concept of a protective envelope (Fig. 1) is based on the idea that the systems which maintain a healthy physical environment demand attention to four key areas. Two areas are concerned with evidence. Firstly, there is the type of evidence from which one draws inference about the biological plausibility of relationships between the environment and health. Initially labelling this 'empirical or scientific evidence', a more appropriate term may be 'biological evidence', although it is assembled from the insights of a wide range of players across the field of science and medicine, such as toxicologists, immunologists, microbiologists and immunologists. Secondly, there is epidemiological evidence from which one can develop a view about the health impact or otherwise at population level of both an exposure and any intervention targeting its reduction or removal. In practice, biological evidence may act as a stimulus to epidemiological investigation, just as an observation from epidemiology can be the spur to scientific investigation.

The remaining elements of the protective envelope relate to the levers for changing or controlling the physical environment for health. The first concerns the mode of intervention. Is there an intervention that can remove an exposure or reduce it to safe levels? Pasteurization (in the control of milk-borne pathogens) or emissions control (in relation to air pollution) are examples, but so too are measures that can optimize environments for health, for example by creating environments that facilitate or encourage participation in exercise. The final area for consideration is all those factors that influence whether or not an intervention, however effective, can be applied in practice, i.e. they relate to the means of the intervention. This is a very wide set of issues, including the legislative, fiscal and administrative structures through which environmental control is pursued, and resources, not only financial but also the workforce, and its knowledge, skills, attitudes and priorities.

Conceived for use in the field of health protection and primarily a linear single-agent, single-outcome model, the protective envelope also provides headings under which to group generic

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**Figure 1** The protective envelope. Adapted from Morris and Robertson.19
challenges across the discipline of environmental health in the 21st Century.

Challenges relating to biological evidence

Biological evidence is central to the business of developing and maintaining environments consistent with population health. Those attempting to differentiate between causality and mere statistical association in any relationship between the environment and health draw on such evidence to assess biological plausibility. For example, putative links between overhead power cables and childhood leukaemia may have some support from descriptive epidemiology but lack evidence for a clear biological mechanism, so the links remain unproven.

Extrapolation from animal studies represents another contentious area. Here the challenge lies in evaluating the risk to health from exposure in, for example, a domestic or community setting to concentrations far lower than those in the situation where the toxic, carcinogenic, etc. potential was originally demonstrated. Extrapolative challenges frequently exist in relation to air pollutants and health. Radon and asbestos exposures are illustrative. In each case, extrapolating the dose–response curve from the documented carcinogenic potential amongst highly exposed individuals back towards the origin can lead to a conclusion that there is no safe limit. Such interpretations are often barely sustainable given the lack of data points on the graph at very low levels of exposure.

Extrapolations from animal studies to derive risks to humans introduce a further set of problems. At the time of writing, newspapers are reporting that six healthy volunteers are critically ill following 'first in man' studies of a monoclonal antibody that had proved to be safe in animal models. A further topical challenge involving issues of biological plausibility concerns the physiology of deprivation. In the developed world, it can be difficult to sustain an argument that less well-off individuals live in environments that are consistently more toxic, infectious or allergenic. A role for the physical environment in socio-economic health inequalities is more sustainable if unsatisfactory environments can be shown to impact in more subtle ways. The capacity of life circumstances to impact on physical and psychological health and wellbeing is, of course, widely discussed in the literature, where the term 'psychosocial' has been commonly adopted to capture what is a somewhat diffuse concept. Medical science is increasingly directing its attention to exploring the biological plausibility in the contention that exposure to the myriad stresses of poverty may mediate pathological processes that are more common and strike earlier amongst the poor; a differential that is maintained even when comparative behaviours are taken into account. For the environmental health community, success in this branch of enquiry may confirm the health relevance of environments that do not present an obvious toxic, infectious or allergenic threat, but which are tangibly unsatisfactory due perhaps to an aggregation of environmental 'bads', sometimes termed 'incivilities', and an absence of 'goods', such as open spaces. On this latter point, it may be considered that one reason why environmental manipulation is sometimes perceived to be less relevant to the health improvement agenda is its tradition of expressing environmental aspirations in terms of what it wishes to prevent as opposed to what it aspires to create. Pursuit of biological plausibility in the relationship between stress and physical pathology may, on one level, be seen as a medicalization of poverty, and the evidence around this is still accruing. Nevertheless, the authors believe that an inability to fulfil the full suite of contemporary evidential criteria should never be considered as an insurmountable barrier to adopting reasonable and intuitively appropriate actions on the basis of the strong suspicion that they will deliver a beneficial outcome. There are circumstances too where the case for action may be as much moral and philosophical as it is evidential. Public health can often find itself in this territory. This said, an understanding of causal processes rooted in conventional science can only benefit efforts to tackle the problem and evaluate progress.

Challenges relating to epidemiological evidence

Reference to environmental epidemiology rarely takes place without alluding to complexities in study design, statistical analysis and causal inference. These are abiding challenges for environmental epidemiology and, because they have the potential to influence the quality of the evidence base, they present difficulties for the discipline of environmental health. However, the contribution of epidemiology has been remarkable since, in the immediate post Second World War era, it first
focused on the new epidemics of chronic non-communicable disease. Development has been characterized by a process of continual methodological refinement as epidemiology confronted the multicausal nature of much chronic disease.\textsuperscript{10} Misclassification of exposure, confounding, social complexity and bias were each identified as challenges, and addressed through innovative study designs that introduced terms like 'odds ratios' and 'risk ratios' to the field of public health.\textsuperscript{10,34}

Susser and Susser identified an influential underpinning paradigm for much of this 'era of chronic disease epidemiology'.\textsuperscript{10} This relates 'exposure to outcome without any necessary obligation to interpolate either intervening factors or even pathogenesis...'.\textsuperscript{10} They appropriately term this the 'black box paradigm', and its relevance to discussion of the contemporary challenges in environmental health is that, whilst efficiently identifying individual risk, it is largely incapable of elucidating any factor that impacts at the level of society such as the environment. Still less can it identify potential points of intervention further back in what is invariably a chain of causality.

Thus, the dominance of the black box paradigm is inextricably linked to both individualization of health status and risk, and to the diminution of the ecological perspective. It must be confronted in any strategic approach to the environment and health.

### Challenges around the levers for change

The central theme of this paper is the optimization of the ways in which we pursue a physical environment consistent with human health. Interventions that will work have two important components. First, the desired change should represent meaningful progress towards a desired goal and, second, there needs to be a process of change whereby the intervention can be applied. For example, prevention of the burning of bituminous coal in domestic premises, a demonstrably effective mode of intervention to cut dangerous smoke and sulphur dioxide levels, demanded a means of implementation in the form of smoke control areas that were designated in the 1956\textsuperscript{35} and 1968 Clean Air Acts. Also central to success were appropriate alternative fuels and grant aid for the conversion of appliances to burn these fuels.

Thus far, this paper has reflected on the role of biological and epidemiological evidence in developing our understanding of interventions. Notwithstanding the trend towards a more precautionary approach,\textsuperscript{36} strong evidence of causal association remains the single most important criterion for intervention, particularly where this is to carry the force of law. This is understandable given the resource implications, opportunity costs and potential for curtailment of individual freedom implicit in many interventions targeting the environment.

Viewed in this context, it is unsurprising that priorities have been skewed towards those agents amenable to quantitative evaluation where evidence appears to strongly support prescription of a defensible health-based standard. It follows too that once standards are established, compliance is perceived as synonymous with achievement of a healthy environment.\textsuperscript{3}

Thus, the way in which evidence is applied within the process of environmental manipulation and the way in which change is pursued through regulation have led to what the Commission of the European Community\textsuperscript{5} have identified as a concentration of effort on 'single pollutants in single environmental compartments'. Such an approach takes little account of the additive effects of exposures from a number of environmental compartments (such as soil, air or water), or of the interactive effects between different agents within the environment (antagonistic, additive or synergistic). In addition, the regulation of emissions acts at the level of the individual source (such as a factory or farm), often without reference to the effects of emissions from other sources within the same area. Finally, the control of single agents in single compartments cannot take account of the mitigating or exacerbating influences of behavioural or societal influences on exposure and outcome. Thus, the original aim of the intervention, to protect and improve human health by limiting total exposure, can be lost within the traditional regulatory process with its concentration on the environmental state and individual emissions.

Regulation is generally best suited to a situation where an exposure or at least concentration of an agent within an environmental carrier can be quantified, and a distinction drawn between those that are acceptable or unacceptable in health terms. These criteria exclude many exposure situations and almost all but the most direct relationships. Another factor critical to success in regulating the environment is an adequately resourced enforcement agency, staffed by people with the knowledge and inclination to give priority to the issue in question, often in the face of competing demands. Indeed, considerations of priority impinge at every stage from the processes governing which topics are chosen for
epidemiological or biological investigation, to the legislative process and the allocation and deployment of enforcement resources. Unsurprisingly, many plausible interventions offering a potential health dividend are not, and perhaps cannot be, undertaken through a regulatory approach.

One conclusion may be that environmental health must embrace not just new ways of gathering, arranging and interpreting evidence, but more innovative intervention strategies that place less emphasis on legislation, and embrace new modes and means of intervention within an evaluative culture. The authors consider that such changes are more likely to emerge within a carefully structured strategic framework for the environment and health in which goals are clearly articulated, evidence informs priority and evaluation is embedded within the culture.

A strategic approach

The purpose of presenting an account of the recent history and contemporary challenges in environmental health is to provide the context in which to consider a way forward. In addressing determinants of health principally at the level of society, the traditions of environmental health are at variance with an individualistic view of health and disease. Rooted in an ecological perspective, they sit uneasily with a reductionist ethos in medical science and epidemiology. Further, the aims of environmental health are almost invariably expressed in terms of the environments that are to be prevented rather than those that are to be pursued, creating a conceptual barrier to full engagement in the health improvement agenda. Specific problems around the evidence base and its use to promote effective change for health have been highlighted. Some of these are scientific and methodological, but others owe much to a disarticulation between the health and environmental communities. A new approach is needed if manipulation of the physical environment is to regain status amongst policy options and attract resources.

A strategic approach would offer a real opportunity to develop and exploit the potential of environmental manipulation as a force for health. A predicted early outcome would be a much greater coalescence of the environmental and the health communities around a set of shared objectives. A strategic approach could dispel the overarching impression that, at its best, environmental health is a worthy activity nested within health protection and not wholly relevant to the headline health issues of the day, or, worse still, a reactive ad hoc activity lacking in clear priorities or direction.

A strategy is a plan to achieve a long-term goal.37 For environmental health, the long-term goal for strategy could be seen as the creation and maintenance of a physical environment consistent with, and promoting, human health (broadly defined). The strategy would be the structured plan to deliver this outcome. More pragmatically, the goal for strategy aligns closely with the pursuit and maintenance of integrity in the protective envelope.19,20 By implication, strategy is not delivered with the presentation of a 'once and for all' plan. An emphasis on systems is also fundamental, indicating that the elements of strategy ought to be assembled and connected in coherent inter-related sets that, when integrated, will constitute a single strategic and ongoing framework.

Expressing the goals of strategy in the environment and health in relation to the protective envelope has the advantage of simultaneously emphasizing the central role of evidence whilst making it overt that effective manipulation of environments for health is about more than just the right evidence appropriately assembled. Thus, once operational, a well-considered strategy should inform and evaluate the policies and actions necessary for beneficial change. It should also highlight gaps and shortcomings, not just in evidence but also in relation to the levers of change determining their effectiveness.

Like other branches of public health activity, environmental health relies on inputs from many players operating in a variety of institutional settings for its success. A thoughtfully conceived model would then offer a common point of reference and a framework for co-operation for these disparate constituencies.

A new conceptual model

In the introduction and the subsequent references to causal paradigms for health and disease, it has been implied that the way in which the health challenge is 'framed' has the greatest significance for how we 'do' public health. Continuing this theme, the role of an underpinning conceptual framework for strategy in the environment and health is now considered.

In 1974, the Canadian White Paper’s17 health field concept offered a new conceptual framework
representing the principal elements affecting health in Canada. The author made some important claims for the framework.

First, the chosen health fields were presented as the outcome of an examination of the causes and the underlying factors of health in Canada. The scope was such that thousands of ‘pieces’ relevant to health and its determinants were organized in ‘an orderly pattern’. Any problem, it was claimed, could be traced to one or more of the four elements, i.e. lifestyle, environment, human biology and healthcare organization. In turn, all those who contributed either collectively or alone could understand their roles and influence.

Second, the White Paper was also promoted as a tool for analysis. Any question could be examined in terms of the four fields to assess their significance and interaction. Importantly, individual fields were themselves amenable to subdivision. What was being proposed was no less than ‘a map of the health territory’, allowing the most direct links between health problems and their underlying causes to be identified. The White Paper was not concerned with the presentation of actual evidence to elucidate the causal pathways. It was, in some senses, more important and ubiquitous than that because it tried to show how the relevant pieces may be assembled in a useful way. By extension, only when the health fields were populated by information in a variety of forms would the evidential implications for policy emerge. Despite containing only a description as opposed to a diagrammatic representation of the health fields concept, the authors are in no doubt that the White Paper is a philosophical forerunner of the conceptual model needed to underpin strategy in the environment and health. Just as the health field concept aspired to map the health territory, the present model must map the environmental health territory.

In 1990, recognizing precedent in the 1974 White Paper and its health field concept, Evans and Stoddart elegantly documented the intellectual steps in assembling a somewhat more intricate conceptual model of health and its determinants. Again, the stated aim was not to present actual evidence but rather a framework for its assembly. Their socio-ecological model of health (Fig. 2) used a set of boxes to represent various conceptualizations of health and the factors that bear upon it either directly or in joint interaction. The boxes, whilst more numerous, mirror the spirit of the health fields, in that each is amenable to expansion to reveal complex content. Evans and Stoddart made a facility to present evidence in a way that would make its implications more apparent; a test of the usefulness of the model. By implication, useful application of the model in any setting would necessitate linkage to systems capable of generating and refreshing the information to populate the model. Only then could its evidential value be exploited. However, of particular relevance to this discussion of strategy, they observed that ‘there is much more to policy than evidence’. Logically, then, an appropriate conceptual model to underpin strategy on the environment and health must provide the framework for the assembly of the relevant evidence, but must have the utility to support all the components of strategy.

![Figure 2](image_url)
If people and organizations are to understand their role and influence, a map of the environmental health territory must be able to represent not only causal pathways and networks but also the interventions (policies and actions). A model restricting its scope to causal processes, providing no place for interventions in the form of policies and actions, has restricted analytical capacity and cannot support strategy in a meaningful way.

A very important challenge in developing a useful model is how to represent the key variables and the interaction between them without becoming burdened by complexity. There seems little point in illustrating complexity at the expense of utility. However, if a model excludes key elements bearing on the relationship between environment and health, it can never be truly fit for purpose. Ostensibly, a model to underpin strategy on the environment and health may avoid some of the complexity of, for example, the socio-ecological model, which must address a much wider set of determinants. It may be legitimate, for example, to exclude health care from the present model. In short, partiality is not, in itself, inadmissible.

In reality, the nature of the physical environment is hugely influenced by a range of external drivers. These may be policies on agriculture, transport or land use, but may also have their roots in the economic or cultural context or in societal norms, particularly where these influence behaviour. As these higher-level external drivers may become, or indeed may already be, targets for policies to influence the environment for health, a model representing this hierarchy is indicated. A hierarchy is also indicated in the transition between the state of the environment and population health. Here, self-evidently, a transitional step must be exposure. Thus, an appropriate model must avoid conflating the concepts of environmental state and exposure. Health-motivated interventions may target either or both. Furthermore, failure to represent environmental state and exposure separately denies a useful opportunity to properly represent contextual factors such as behaviour, demography, socio-economic circumstance and other environmental stressors that mediate the transition from state to exposure and on to health status. For example, behavioural traits may render young children more likely than adults to be exposed to lead in soil. Similarly, the likelihood of developing disease following a specific exposure is influenced by contextual factors. For instance, people who smoke tobacco and are exposed to radon have a much higher risk of lung cancer than the additive risks of exposure to one or the other.

A further criterion that may relate more to how the model is used rather than its configuration is an ability to map positive health states to positive characterization of environmental state. For example, where there is consensus to support a link between positive aspects of the environment, such as biodiversity or access to green space and psychological wellbeing, this relationship and factors that bear upon it should be equally amenable to representation.

In the search for an appropriate model, the socio-ecological model of health as proposed by Evans and Stoddart stands close scrutiny as a map of the health territory envisaged in the earlier Canadian White Paper. It reminds one that health is created and destroyed within a complex interactive system, and illustrates the fact that to define health as merely an absence of disease is often quite inappropriate. The model has the capacity to inform organizational structures across the field of public health, and many players can identify their position. Perhaps, however, because it so stridently emphasizes that everything matters, the authors are obliged to conclude that it is unsuited to the present purpose. Unquestionably elegant and comprehensive, it fails the test of simplicity yet lacks the detail, where required, to map the environmental health territory adequately.

A subsequent search for a more suitable model has led the authors to consider a model now being used by the WHO as a basis on which to devise indicators appropriate to measuring goals within its European Region-wide Children’s Environmental Health Action Plan for Europe. The DPSEEa model (Drivers, Pressures, State, Exposure, Effect, Actions) provides a simpler illustration of the way in which the environment influences health and how environmental state is influenced by higher causes (Fig. 3). Expertly conceived for its intended role underpinning an information system at European level, the DPSEEa model gains simplicity from linearity. It fulfils many of the authors’ stated aspirations for a model to underpin strategy on the environment and health. Most obviously, it is hierarchical, representing a chain of causation stretching up from the interface between health and exposure (which, pleasingly, is separated from environmental state), through those pressures that act to modify state and up to high-level external drivers. Importantly too, it allows actions or interventions to be directly mapped on to the chain of causation with the implicit advantages for analytical capacity and sectoral convergence which that confers. Through its linear representation, it appears to be well suited to the application of standard risk management protocols such as the Hazard Analysis and Critical Control Point.
approach already familiar to many environmental health practitioners. Thus, the DPSEEA model has the potential to extend beyond its intended role as a framework for developing an environmental information system. However, by excluding reference to factors influencing the transition from environmental state through exposure to effect, the model fulfils the criterion of simplicity at the expense of utility as an underpinning model for strategy. The authors believe that the model must incorporate all modifiable factors and, if not, the problem would be inappropriately framed. However, it is proposed that the map of the environmental health territory required in this study can be represented by a modified version of the DPSEEA model (Fig. 4). Here, the contextual importance of the external influences in determining whether the physical environment does indeed lead to positive or negative health outcomes for the population or sectors within it can be appropriately represented. The contextual ‘bubble’ surrounding exposure and outcome and extending to include the transition from state to exposure is particularly suited to representing the local or regional dimension in the relationship between the environment and health at a population level. Thus, effective local actions may be directed not only at the chain of causation but also to external factors that can act upon it.

By the simple expedient of developing further chains, the utility of the model can be extended to acknowledge more than a single aspect of the physical environment leading to a specific health outcome, and indeed several health outcomes may result from a specific exposure. Thus, exposure to environmental tobacco smoke may increase the risk of both cancer and cardiovascular disease (Fig. 5), or the environmental condition conducive to exercise may impact positively on obesity and cardiovascular disease.

By addressing certain limitations in the basic model, the modified DPSEEA model can become a useful basis for strategy in environmental health. It is, in a very real sense, a 'map of the environmental health territory'. Strategy will not automatically emerge merely from a recognition that the model is an acceptable representation. Positive action will be required if it is to be applied successfully in any setting. The following text considers the type of actions that are likely to be necessary to move from a conceptual model to application of the strategy.

**Getting started**

Thus far, key generic challenges for the discipline of environmental health in the 21st Century have been set out. It has been suggested that only a clear strategy can relocate environmental health at the heart of the health agenda. In proposing...
modifications to the DPSEEA model\textsuperscript{39,40} to underpin that strategy, the authors have sought to frame the 'problem' with reference to all determinants of outcome. This is regarded as essential if the model is to perform its role as a proper basis for strategy as opposed to solely a framework for assembling information within a causal hierarchy. Critically, the modification is also intended to allow the model to be applied at different geographical and administrative levels. Thus, whilst the broad contours on the map of the environmental health territory will always be familiar irrespective of setting, the specific features vary with locality. This is because of differences in the nature of the environmental health problems, in the social, economic or behavioural context, and in the local policy and institutional framework. Developing strategy and taking it forward requires an understanding of local context and engagement of local constituencies. One size will undoubtedly not fit all. Although it is believed that a coherent foundation has been set out from which a strategic approach can be pursued in any setting, it is perhaps useful, in closing, to offer a few observations concerning process.

![Figure 4: The modified DPSEEA model.](image-url)
Choosing priorities

An abiding concern in implementing strategy, and particularly in establishing the information systems to support it, relates to the scale of the task. A strategy so ambitious that it is never seriously implemented or crashes under its own weight serves no purpose and wastes resources that may be beneficially deployed elsewhere.

An obvious way of addressing this problem is to choose a manageable set of priority issues from which to develop strategy in the initial phase. It is not possible to be prescriptive about the process through which the priorities will emerge. However,
to achieve and maintain the necessary commitment, priorities should be based on broad local and intersectoral consensus. The authors are unconvinced that there is any scientifically robust method through which to identify initial health priorities for a strategic approach on the environment and health. However, one important consideration, particularly if the priorities are to lend status and political support to the strategy, is to align with those already articulated as priority targets for health policy and where other approaches, for example relating to life style, have proved ineffective. The strategy would seek to identify and address the environmental contributors to these outcomes. Thus, cardiovascular disease may be amongst the initial priorities, simply because it is frequently a target for health policy and can be causally linked to different aspects of the physical environment.

Including both positive and negative health outcomes amongst the initial priorities is advantageous. This sends out a powerful message that manipulation and control of the environment is relevant not solely to health protection issues and disease prevention but can also be used to promote positive health. A positive health outcome such as psychological wellbeing may be associated with a positive aspect of the environment, such as green space of sufficient quality or biodiversity.

Reference to the wider policy context beyond health or the physical environment may identify health targets contained within cross-cutting policy documents or articulated in various ways in the policies related to, for example, transport, planning, sustainability or inequalities. A capacity to address shared concerns across disciplines and sectors may be relevant to the choice of priorities. An example may be concerns over global warming and climate change, which may have profound effects on human health. It can be argued that this issue would feature on any list of priorities.

The choice of priorities to initiate strategy is central to the process as it offers the opportunity to give status and profile to the work whilst containing the work within manageable boundaries.

Constructing the chains and developing a map of the environmental health territory

Throughout this text, conflict has been implied between an understandable desire for robust evidence on the relationship between the environment and health as a basis for policy and action, and a desire to act positively where a broader way of thinking may dictate. Arguably, part of the evidential problem for the discipline derives from seeking to apply evidential criteria that are inappropriate to the complex dynamic relationship between humans and their environment. The process of building the chains leading from health effect through exposure and environmental state and ultimately to high-level drivers of necessity takes place within an evidential context. However, it is ultimately a pragmatic exercise that should not necessarily be wholly impeded by evidential deficits. A protocol is proposed through which the map of the environmental health territory can be produced for specific health priorities, which takes cognisance of the concerns around evidence and its application.

As the process constructing the causal chains and developing the maps is so central to the success of the process, it must be conducted with care. Facilitated workshops operating according to agreed guidelines may be an appropriate vehicle. The task for each workshop would be to produce a map of the environmental health territory based on the modified DPSEEA model for the relevant geographical area and environmental health issue. Workshop participants would need to include key stakeholders and embrace relevant scientific, epidemiological and technical expertise. Also represented would be those who could supply operational and, as appropriate, enforcement skills relevant to areas under consideration. Finally, members of the public who are affected should be represented.

The authors believe that the modified DPSEEA model has particular application in community planning for which improved health and wellbeing and greater equality in health are key targets. Through embracing complexity in the relationship between the environment and health, and framing health issues with reference to environmental, behavioural, social, economic and other factors, the model can be a basis for sectoral and institutional convergence, an antidote to silo working and a stimulus for meaningful integration in pursuit of health and reduced inequality.

In many cases where the environment is believed to contribute to a health effect, there is sufficient information and evidence to achieve broad consensus on causal processes, the contextual factors bearing upon the health outcome, and the existing policies. In short, the information exists to create a map of the environmental health territory based on the modified DPSEEA model. It is anticipated that many areas where specific air pollutants impact on human health in the UK would fall into this category.
In other situations, the task of producing such a map may prove markedly more challenging, and consensus would be sought around a notional and perhaps rather imperfect map of the environmental health territory. This could be subsequently refined and developed as the strategy rolls out, informed by an appropriately structured information system as discussed below. There are also likely to be situations where the knowledge and evidence deficit is such that even a notional map of the territory cannot be constructed, indicating a need for research.

**The core systems of a strategic approach**

When discussing the meaning of a strategic approach above, it was observed that the elements of strategy ought to be assembled in coherent inter-related sets or systems that, when integrated, would form the strategic framework. In considering how strategy may be operationalized at a national level, it is appropriate to think in terms of three core systems.

**System 1: an intelligence system**

An intelligence system is the first ‘core’ system of strategy, but this is not in itself synonymous with having strategy. It is suggested that a functioning intelligence system must be made up of three elements. The first is an information system, ideally configured to reflect the modified DPSEEA model. The authors believe that is neither practicable nor necessary for the information system to produce a constant flow of information elucidating all points on the DPSEEA chain, monitoring all actions, and tracking and updating every contextual factor. Instead, the role of information in strategy is to assist the process of evaluation and to point to promising interventions. Such a system may assist hypothesis generation in relation to causal processes, but it is not primarily about providing a forensic understanding of these processes. An information system, linked to other supporting systems, permitting a better understanding of what is happening in the dynamic environmental health territory and which could inform evaluation of interventions would be genuinely new.

The second element of the intelligence system requires the capture of research evidence (in its broadest sense) that can inform environmental and other policies and actions to tackle the strategic priorities. The third and final element requires the capture of relevant experience and knowledge from the operational level (i.e. what works). The creation of the intelligence system and particularly the information element must be carefully managed and focused to avoid it becoming overburdened.

**System 2: an evaluation system**

The authors regard an evaluation system as necessary to ensure the proper interpretation of the outputs from the intelligence system and to produce recommendations for: (a) further evaluation; (b) research; or (c) policy and action. A key output must be statements of the anticipated outcome from any course of recommended action. This is necessary in order to develop appropriate sensitivity and specificity within the information system.

**System 3: levers of change system**

The authors propose that the third and final core system of a strategic approach could be termed a ‘levers of change’ system and is concerned with securing beneficial change in practice. It is one of several mechanisms within the strategic approach where stakeholder input can be secured. Such a system recognizes that success is only possible with input at different levels and from many disparate constituencies whose capacity to implement change may be variously constrained. The function of the levers of change system must be one of identifying impediments and, where possible, making recommendations for lubricating the process of change. Where this cannot be achieved, it may be a mechanism through which to generate imaginative alternative solutions. In a sense, the levers of change system is about identifying bottlenecks and making recommendations for breaking them.

Each of the three core systems of strategy outlined would be distinct in character, but together they would be the elements of strategy linking together in a virtuous circle of activity. The whole can be greater than the sum of the parts.

**Conclusion**

This paper has articulated, in generic terms, the key challenges for environmental health, tracing these to a variety of causes. However, the overarching challenge lies in offering a response to an entrenched perspective that sees the physical
environment as a rather narrow activity with only limited relevance to human health. A schism has emerged between the health and environmental sectors to the detriment of each. Such is the gap culturally, institutionally and aspirationally in many countries that the justification for bridging it has become obscured or lost. Recently, however, there are signs that the situation may be changing. Developments at international level have pointed to a need to reduce the burden of disease attributable to the physical environment. Specifically, the WHO-led Ministerial Conferences on Environment and Health and the EU’s Environment and Health Strategy (SCALE) have offered new purpose and direction to this important area of public health policy.

This is undoubtedly an opportunity for those who believe in the potential of manipulation of the physical environment to impact on health status and reduce health inequalities. On the other hand, the discipline has become atrophied and reactive, information systems are fragmented and poor, and there has been limited attention to building the evidence base. This paper has proposed a solution in the development of a strategic approach and presented a flexible template on which it may be developed.

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References

Getting strategic about environment and health

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The paper advocates that to improve environment and health it will not be sufficient to merely embrace new ways of gathering, arranging and interpreting evidence but that more innovative intervention strategies should be developed which place less emphasis on legislation and which embrace new modes and means of intervention.1

How the health challenge is framed is considered to govern how Public Health is practised. A new conceptual model is, therefore, proposed to underpin strategic thinking. This must map the Environmental Health territory in a way which represents not only causal pathways and networks but also the interventions (policies and actions). A strategic approach demands that an information system is linked to other systems which exploit the information but having an information system is not synonymous with having a strategy.

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Interventions relating to health may target environmental state and/or environmental exposure. Failure to represent environmental state and exposure separately denies an opportunity to address contextual factors such as behaviour, socio-economic circumstances and other stresses which mediate the transition from state to exposure and on to health status. Similarly the likelihood of developing disease following a specific exposure may be influenced by contextual factors.

It is proposed that a modification of the DPSEEA model can provide a basis for strategy in environment and health. This must not just assemble relevant evidence but must be capable of supporting components of strategy. It is, therefore, proposed that contextual factors (social, economic, demographic, behavioural) are included in the consideration of state—exposure—outcome. In this way effective local actions may be directed not only at the chain of causation but also to external factors which can act upon it.

To develop strategies it is suggested that priorities are identified which are aligned with those already articulated as priority targets for health policy and in particular where other approaches have provide ineffective. Thus cardiovascular disease might be prioritized since it is a target for health policy and can be causally linked to different aspects of the physical environment.

The WHO led Ministerial Conference on Environment and Health and the EU’s Environment and Health Strategy (SCALE) have offered an impetus to this important area of public health policy. The model and strategy proposed is a useful template to further environmental health protection and promotion.

Reference

COMMENTARY 2

Getting strategic about environment and health

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Morris et al should be congratulated for ‘getting strategic about environment and health’. Their historical perspective sets the scene for a modified model of how the physical and social environment could influence individual behavioural or health outcome. The World Health Organization Drivers, Pressures, State, Exposure, Effect, Actions (DPSEEA) model represents the classical epidemiological linear paradigm of exposure (with its antecedent factors) and outcome. Actions, or interventions, can be implemented to reduce Exposure and Effect at any of the linked stages in the model. In developing their modified DPSEEA model, Morris et al. have recognized the role that the physical and social environment might play in mediating and/or modifying the pathways between Exposure and Effect.

They argue that a broader perspective is needed than is usually employed when investigating environmental effects on health. Most investigations in the past have concentrated on specific hazards or events, such as the risk of congenital malformations from living near a landfill site or the risk of leukaemia from living near a nuclear plant. Indeed, as Morris states, the Commission of the

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European Community have identified that there has been 'a concentration of effort on single pollutants in single environmental compartments'. While acknowledging the importance of such work they are concerned more with the effect of the environment acting through psycho-social mechanisms. This can occur following a specific incident, such as the Sea Empress disaster, but their special interest is in more general exposures arising from the physical environment.

Their modified model is based on the evidence that the context, or the physical and social environment, or the places where people live, is an important determinant of the health of individuals, over and above personal risk factors for poor health. Over the last 10 years or so there has been a resurgence of empirical interest in contextual effects on health and it is now generally accepted that the places where people live are an important factor in determining and sustaining inequalities in health outcome between individuals. But although a wide range of features of the local physical and social environment that may be health promoting or health damaging have been proposed, there is little evidence of research that tests theoretically specified causal models of the mechanisms that might link these contextual factors to health.

Why is this the case? One particular difficulty lies in the definition and measurement of context. Hierarchical or multi-level statistical modelling of contextual effects on health requires places to have a geographical boundary so that individuals can be assigned to a defined area of putative exposure. Here researchers are hampered by having to use 'off the shelf' administratively defined boundaries and their associated administratively collected data, most often from the census in the UK. These may bear little resemblance to the concept of neighbourhood, used in the sense that this is where contextual exposures are operating, and therefore may misclassify individuals into an incorrect context in the analysis. In order to move away from the convenient but rather non-specific nature of administrative data, newer and more specific measures of context have recently been developed, for example, based on a theorized hierarchy of human needs, and measures of social cohesion and social capital. Two directly observable measures of the built and social environment recently developed in the UK are the Built Environment Site Survey (BESSC), a measure of the built environment and the Residential Environmental Assessment Tool (REAT), a measure of neighbourhood quality. There is some limited evidence for cross-sectional associations between these directly observed measures of place and mental health, but the jury is still out, awaiting more definitive research.

The modified DPSEEA model implies causal pathways between Exposure, Context and Effect and the lack of evidence to support this contention is its main limitation. Almost all studies of places, people and health have used cross-sectional designs and some have demonstrated associations between context and health outcomes. Investigating the influence of context on the individual-level Exposure Effect association can be done in cross-sectional multi-level analyses by allowing the coefficient measuring the association between the outcome and contextual measure to vary randomly between areas. Allowing these 'random slopes' in the analysis is one of the advantages of the multi-level modelling technique and in a previous paper we have shown that the association between individual mental health status and economic inactivity was stronger in more deprived electoral wards in Wales—that is, a feature of the local social environment was modifying the association between Exposure and Effect. However, although this finding is plausibly causal, it is simply not known whether reverse causality is at play; that is because people may become economically inactive as a result of poor mental health, and a parallel selection effect whereby people with poor mental health are selectively concentrated in areas of high overall economic inactivity. The temporal association between Exposure and Effect also cannot be assessed in a cross-sectional study which measures both at the same point in time. There is little, if any, evidence from longitudinal studies of change in contextual and individual risk factors for a health outcome in which it can be assessed whether contextual factors are either mediating a causal pathway between Exposure and Effect, or acting through effect modification.

In order to achieve the aim expressed by Morris et al., of seeing 'how public health policies and action on the physical environment might be more optimally pursued', such evidence on causality from longitudinal studies is required. However, Morris et al’s modified model is an important step forward in conceptual and strategic thinking in this important public and environmental health arena.

References

The authors flag up the potential of environmental impact assessments. The mes-sages which come across from this modified approach are usually clear but sometimes the arguments become unclear, whereas in other areas some statements were over-simplistic. Whilst generalizations are often necessary when trying to look at strategy, it is important to ensure that over-simplifying does not result in kicking out some of the babies with the bathwater.

As a tool, I think the modified model does have potential for trying to sort out the effects of environment on health, but equally in that context, needs to be linked in with other external drivers which need to be considered in a multi-modal

COMMENTARY 3

Getting strategic about environment and health

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The model proposed by Morris et al. is an interesting approach building on the DPSEEA model which is now beginning to be used reasonably widely by a number of groups.1 The authors flag up the limitations of the DPSEEA model and have suggested that it could be expanded in a more contextual way in order to try and take on board sociological factors. In a way this is what is done with Health Impact Assessment, conducted as part of environmental impact assessments. The mes-

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setting, such as sustainable development. The model has the potential, however, to lend itself to testing and is applicable internationally, both in the developed and the developing world. This document provides an interesting forum for discussion but there are two important generic areas worth considering further.

The first is the author’s limitation of the ‘contextual bubble’ to the exposure and effect areas along with their respective transitions. In reality, every one of the areas in the original DPSEEA model has its own context and while it is absolutely right and proper that actions should be targeted not just at the particular DPSEEA areas but to the transition phases, it is likely, nay absolute, that each of these areas and their respective transitions and associated adjacent areas will have their own set of contexts. Sometimes these will substantially overlap across the whole flow chart but in other cases there will be key issues which are specific to one area. Understanding that this is so may then help in quantification, as one of the aims of any such approach needs to be to reduce uncertainty in attempting to get at least a broad quantification of each component factor, so that, even if the key factor identified is not quantified in an absolute form, at least one knows where it stands in priority terms: crucial in terms of deciding action and therefore strategy.

The second issue lies in the limited attention paid to exposure. There is a wealth of information on exposure to environmental hazards and how important behavioural aspects are in terms of defining, quantifying and understanding that exposure. There are many levels of limitation on how we assess exposure and while in some contexts, particularly the occupational context, exposure assessment is really quite strong, in many others, particularly in the broader environmental situation, attempts at exposure estimation are rather poor. This becomes particularly obvious when considering gene–environment interactions, so critical nowadays in trying to determine susceptibility factors, where genetic details can be ascertained with very high certainty but such certainty is almost rendered worthless in the gene–environment situation where exposure assessment is inadequate. This is probably the most important issue in understanding the interactions between environment and health and to my mind is one of the weak points in the DPSEEA model as it stands in its simplistic forms. The authors’ new version does not really address this particular issue.

I do believe that the modified DPSEEA Model is the beginning of an approach which could usefully be built into a method to try and deal with these complex issues although needs to act as a forum for discussion before formal trialling. The authors do suggest in the first instance that groups should work together in their own specific area using the DPSEEA Model but in the first instance a workshop to modify the model further would be appropriate.

The issue of the effects of environment on health, both beneficial and adverse, is complex and some attempt to model these complexities is welcome. But while exposure assessment, whether direct or through biomarkers, is only variably possible, often poorly performed and imperfectly understood there will be limitations to this approach unless this crucial issue is addressed—unless the model itself can be used to help develop understanding of exposures as a step towards the assessment of health impact, the authors original aim?

Reference