How Should Federal Policy Reflect Recent Research in the Area of Intrauterine Exposure to Environmental Hazards?

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Present policy neither evaluates nor adequately protects the fetus from the effects of intrauterine exposure to environmental hazards. Some examples are intrauterine lead and methylmercury exposure and intrauterine PCB exposures. A sound policy based on a few basic principles can be developed to protect the fetus from harm from intrauterine exposures. — Environ Health Perspect 103(Suppl 6):143–145 (1995)

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Introduction

While intrauterine exposure to environmental hazards has many similarities to postuterine exposure, it is important in formulating policy to keep in mind some obvious but important differences between these two exposure periods. The most obvious yet most important fact is that intrauterine exposure can only occur through exposure of the mother. The implications of this are many and complex. Clearly, the mother’s environment and behavior are important determinants of the exposure of the fetus. The mother’s environment encompasses both recent and present exposure to toxicants and other environmental hazards. A clear and difficult example of this is fetal exposure to lead. While it is clear that fetal blood lead measured by cord blood lead determinations approximates maternal blood lead (1), it is not clear to what extent maternal blood lead during pregnancy reflects current exposure versus mobilization of lead from bone stores as a function of pregnancy. Protection of the fetus from this exposure may require prevention of both current and prior exposure. Since very low levels of maternal lead are necessary to prevent fetal injury, it may well be that prevention of fetal exposure to lead may require lifetime maintenance of very low levels of lead in the mother. This would require aggressive prevention of childhood exposure as well as markedly stricter regulation of occupational exposure of adults. An active research agenda in the area of fetal lead exposure is presently supported by the National Institute of Environmental Health Sciences (NIEHS) and includes studies in adult pregnant humans and nonhuman primates. The question to be asked in this context is: Should policy await complete research in this area, or should action be taken immediately to monitor parental and fetal exposure?

The example of methylmercury exposure and its effect on the fetus presented in this issue present further policy dilemmas in this area (2). Since a primary source of methylmercury exposure of parents and thus the fetus is parental eating of contaminated fish, particularly large predatory fish, policy should be directed toward limiting ingestion of such contaminated fish by adults, particularly women of childbearing age. However, such policy confronts several difficult limitations. First, the primary source of mercury may not be controllable. In fact, such environmental mercury is not a product of human activity and therefore is extraordinarily difficult to control. Certainly every effort should be made to control industrial and refuse contamination; such efforts can decrease environmental mercury contamination but will not remove naturally occurring mercury sources. Second, monitoring contamination of fish requires an aggressive and extensive program, as there may be very large differences in contamination of fish over very small geographic areas. For instance, one freshwater lake may have fish with high levels of methylmercury, while another in the same state or county may have fish with much lower levels of contamination. Similarly, marketplace monitoring will have little effect on consumption of contaminated fish that come to the table without passing through the marketplace. Finally, though laws, regulations, or warning notifications may decrease consumption of contaminated fish by sport fishermen, such actions have little effect on persons who consume fish caught for subsistence.

In fact, subsistence fishing, with the risk of methylmercury, PCB, and other exposures, represents a major issue related to environmental justice. It is particularly those of low socioeconomic status and ethnic minorities who are most likely by custom or socioeconomic status to rely on potentially contaminated fish for subsistence.

An additional problem requiring consideration in our desire to protect the fetus from environmental hazards is the needs and rights of the mother. Some of the neurotoxic effects on the fetus related to maternal environmental exposures may be considered entirely related to the behavior of the mother. Some examples of these exposures include maternal use of tobacco products, drug use, and ethanol ingestion. These types of behavior may be considered voluntary, though many mothers may be addicted to an extent that they cannot control their behavior. How should federal policy attempt to prevent such behavior? This issue is beyond the scope of this workshop but presents an important concern for policy on both the federal and local government levels.

A more direct concern for this conference is the issue of parental workplace exposure. In those workplace situations where the fetus is equally or more susceptible to
the exposure than the adult, protection requires actions aimed at protecting the fetus that may appear excessive for protection of the adult worker. Again, good examples of this are lead, mercury, and some chemicals. In such a context, there are only two possible interventions. First, women could be excluded from such hazardous workplaces. Obviously, such a policy has important implications regarding the rights of those excluded from the workplace. Alternatively, the workplace can be made sufficiently safe to protect the fetus, even though this level of protection may be more than is necessary to protect adult workers. While this form of policy clearly is the more protective of the rights and prerogatives of the adult worker, it is far more difficult and expensive to achieve.

Prevention of exposures that are not primarily a function of behavior such as occupation, substance abuse, and ethnic custom presents a somewhat different challenge. In such cases it may not be necessary to limit choice of occupation, alter ethnic customs, or alter addictive behaviors. However, the challenge of policy may still be formidable. Limitation of parental exposure to airborne lead has been accomplished largely by eliminating lead from gasoline. However, further reduction of parental exposure, which is largely a function of residual lead-based paints and contaminated soils and dusts, is a far more difficult and costly process. Similarly, limitation of exposure to farm and industrial chemicals often has been an extraordinarily difficult policy task. As our population and resultant use of chemicals increase, control of exposure to such agents becomes increasingly difficult. It is unfortunate that such chemical exposures disproportionately affect persons of low socioeconomic status and ethnic minorities. This greater effect on relatively disenfranchised populations often has led to inadequate attention by policymakers to the plight of these adversely affected populations.

**Recommendations**

In light of these considerations, several specific recommendations can be made to guide policy decisions. These recommendations seem to me to be reasonable standards by which to judge the regulatory process.

**Policy Should Follow the Science**

It is clear that some risks, specifically carcinogenic and water contamination, are overvalued by the public and some policymakers. On the other hand, neurodevelopmental risks such as exposure to lead, methylmercury, and PCBs are underestimated by the public and in public policy. Only when these toxicants are found in water, or are thought to be carcinogens, do they stimulate high-level public concern. While the political process requires public support to develop and implement policy, we as scientists must improve the level of public understanding of the actual risks to children from these toxicants and the relative impacts of various health endpoints and routes of exposure on our children. It seems incongruous that there is enormous public concern over 20 parts per billion of lead in first draw water of some homes (especially when many occupants of these homes rarely drink water or offer it to their children), while contamination of dusts and soils to thousands of parts per million by lead-based paint contamination often arouses little or no public support for lead-based paint abatement efforts. While it is certainly appropriate to reduce lead in water to the lowest level possible, it is even more desirable to reduce direct and indirect exposure to lead-based paints. Education of the public and legislators in the science is necessary to enact appropriate public policy.

**While Policy Clearly Should Be Based on Science, the Science Should Not Serve as a Barrier to Timely Policy**

Often the public interest requires action in the absence of complete science. In particular, actions often can be adequately justified using animal models in the absence of complete human data. Dead or damaged animals often should be sufficient to justify action to protect humans, particularly the fetus and young infant. It is not necessary for sound public policy to require dead or severely damaged infants prior to acting to protect the fetus from environmental hazards. Also, human neurobehavioral data may allow action in the absence of complete mechanistic understanding. For example, the intrauterine effects of lead are probably real based on behavioral studies in the first years after birth, but our understanding of the mechanism(s) for this effect is limited. This limited understanding should not deter efforts to decrease intrauterine lead exposure. Nor should incomplete data on methylmercury effects or mechanisms delay action to decrease intrauterine exposure to this toxicant.

**Policy Should Be Goal-directed and Reasonably Consistent**

**All Government Policy Should Specifically Identify the Fetus and Newborn as Potentially Vulnerable and Susceptible Hosts.** Regulatory policies should evaluate toxicants specifically for their risks to the fetus and newborn. In light of the vulnerability of the developing nervous system of the fetus, specific concern for neurodevelopmental outcomes should be an intrinsic part of the evaluation and regulatory processes. As the productivity of our population is largely determined by its neurodevelopmental capability, neurodevelopmental risk should be the most important of the outcomes evaluated in this process. It should always be remembered that the two primary tasks of infancy and childhood are growth and development and that development is the more susceptible of these tasks to injury from environmental hazards. Intrauterine environmental injuries can and do affect both of these tasks. Government policy should specifically and explicitly protect the most susceptible segments of the population, who are the fetus and the infant.

**Government Policy Should Recognize that the Fetus and Newborn Differ Biologically from Adults.** It is not possible with any degree of assurance to extrapolate from adults to children. It is true that some environmental hazards affect the fetus less than adults, and some affect the fetus more. Similarly, some toxicants are concentrated by the fetus, while others do not reach the fetus at all due to placental protection. For example, as noted previously in this session, lead seems to equilibrate with maternal lead, while methylmercury seems to concentrate in the fetus above maternal levels. In addition, the processes of development of the nervous system of the fetus, as outlined by Dr. Tilson at this workshop, are quite different from maintenance of the mature nervous system of the adult. Therefore, effects on this fetal development must differ both qualitatively and quantitatively from effects on the mature nervous system. We must demand that these effects be specifically assessed and addressed in the regulatory process to protect our children.

**Decisions Must Be Made That Protect the Fetus and the Newborn.** However, these policies may be directed specifically to the fetus (such as limiting lead exposure only for women of childbearing age and...
pregnant women) or to the population as a whole sufficient to protect the fetus and newborn (e.g., limiting lead exposure of all men and women equally to protect the fetus, even though this protection may be excessive for the general population). The policy that seems most protective of the fetus without infringing on the rights of adult women is to decrease the exposure of the total population sufficiently to protect the fetus. Though this may be quite difficult, particularly in the workplace, it seems the most desirable approach on social and ethical bases.

Policy Should Ensure the Safety of the Population

Testing, evaluation, registration, and control of environmental hazards, particularly environmental toxicants, should reflect specific concern for the fetus and the newborn. Specifically, it is reasonable and appropriate to require testing based on neurodevelopmental effects upon the fetus. In addition, regulation of these hazards should reflect our best understanding at the time of the risk to the fetus from such environmental exposures. While it may be true that subsequent research may show that we have been overly cautious, it is preferable to err on the side of safety to the fetus rather than to recognize after many years that we have allowed unnecessary injury to occur.

Policies Should Reflect Parental Differences That May Differentially Affect the Fetus

In particular, differences in habitation, occupation, location, and ethnicity have major impacts on exposure of the fetus to toxic substances. Also, diet and health of the mother dependent or independent of the above factors have major impacts on fetal exposure to toxicants. All our citizens should be allowed to live in environmentally safe environments. Policy should not allow the influence of more affluent and influential segments of the public coupled with a "not in my back yard" attitude to subject less affluent segments of our population to hazards considered unacceptable to the rest. Also, all occupations should be provided a level of environmental safety sufficient to protect the fetus. It is not acceptable for some occupations to be intrinsically hazardous and thus to subject the worker and the fetus to unnecessary risk. It is not appropriate, either, to require that some populations accept major cultural alterations to protect themselves and their children from environmental hazards.

Federal Research Agenda Should Work to Fill Gaps in Our Knowledge

Of major interest are the changes that occur in maternal biokinetics during pregnancy and determinants of placental transport and fetal accumulation of toxicants. The example of the metals lead and mercury illustrates this area of concern and need for increased information. While it appears likely that methylmercury accumulates in the fetus preferentially, the determinants of this accumulation are not clear, nor are potential methods to prevent such accumulation; likewise with lead accumulation in the fetus. Many mothers today have large stores of lead in stable pools, particularly bone. There are virtually no data, however, as to the extent to which this lead is mobilized and transported to the fetus. Also, there is little evidence as to the timing of such transport, though it would seem likely that it would occur preferentially during the latter period of gestation when mineralization of the fetus is most active. Little is known of the kinetics of absorption and distribution of lead in the pregnant woman related to current exposure. Improvements in such information could be quite useful in efforts to protect the fetus from intrauterine lead neurotoxicity.

In addition to biokinetics, evidence is lacking relating to the specific effects that toxicants have on development of the nervous system in utero. Specific information regarding toxic effects on morphogenesis, synaptogenesis, and biochemical development of the fetal nervous system could be invaluable in assessing and preventing the neurodevelopmental damage occurring with intrauterine exposure to toxicants.

There is a need for improved methods to detect and measure intrauterine developmental toxicity. Methods that do not require developmental measurement or cross-species extrapolation would markedly improve our ability to assess and regulate intrauterine exposure to developmental toxicants. Such methods presently seem far in the future but could be predicted as a realistic outcome of basic research into the precise mechanisms of toxicant injury to the developing nervous system.

Finally, federal research could do much to provide a framework in behavioral research that might allow alteration of behavior that results in injury to the fetus. Obviously, such research and interventions must be conducted in a culturally sensitive fashion to allow improved outcomes for the fetus without being destructive of the rights of parents.

Conclusions

It appears clear from this workshop that our ability to protect the fetus from neurodevelopmental environmental injury is presently very limited. Limitations exist in all areas. We are limited in our understanding and limited regarding a consensus on the basic principals of fetal protection. We are limited by a lack of understanding and resolve on the part of policymakers regarding extension of suitable and adequate protection to the fetus. Despite these limitations, we owe it to our unborn children, and to all children, to provide an environment that will allow full realization of their intrinsic potential. We must not lose sight of this duty as we proceed in the scientific and regulatory arenas.

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