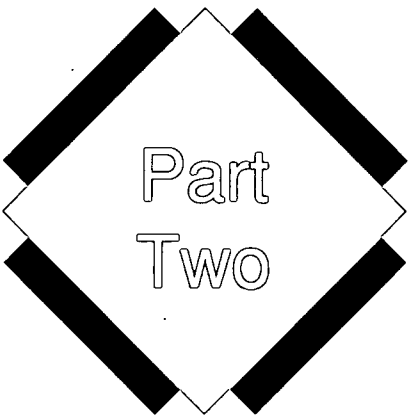

New Reproductive Technologies: Examination of Conditions, Technologies, and Practices

Developing a Comprehensive Picture of Technologies and Practices

Framework of Our Approach

Understanding reproductive technologies involves much more than a grasp of medical conditions, procedures, drugs, and devices. Also important are the decision-making processes that surround use of the technologies; the relationships between people who may wish to use a reproductive technology and health care providers; the new legal and social situations that arise from the use of technologies; the implications of the technologies for the health care system and other social institutions; and what it means for society, for example, to choose assisted conception rather than other ways of addressing involuntary childlessness or to embark on research involving the use of fetal tissue. The Commission therefore needed to develop a comprehensive picture not only of the people involved and the technologies available, but also of the environment and circumstances in which people interact with the technologies. This chapter describes how we went about assembling a comprehensive picture on which to base our assessment of the technologies.

Because the Commission was to examine not only specific conditions and technologies, but also their social, ethical, legal, economic, health, and research implications, we had to have an integrated approach to our work. Some parts of our inquiry were geared to specific health conditions or technologies; others looked at the origins or implications of the technologies. The bulk of our investigations, however, concerned both aspects — learning more about current technologies and understanding

their broader implications — because they are inevitably intertwined. The understanding reached through these investigations, which involved fact finding and analysis, together with an understanding of the context for our work — the social conditions, attitudes, and values that will shape Canada's response to the technologies — was vital to the Commission's ability to make appropriate recommendations. To reach this understanding, we drew together information and data from richly diverse sources and a wide range of activities:

- literature and historical reviews and analysis to understand both how the state of knowledge about conditions and practices covered by our mandate has developed, and what it currently is,
- surveys of patients and practitioners,
- analyses of related Canadian inquiries conducted to date,
- analyses of other countries' decisions and experiences,
- studies of Canadians' views about the technologies generally as well as individual experiences with them,
- field studies and data gathering in Canadian infertility clinics, hospitals, and genetics centres,
- information on pivotal Canadian systems and institutions, such as the health care and legal systems,
- explorations of ethical, legal, psychosocial, and other issues and implications, and
- analyses of economic implications and feasibility studies.

In all, we commissioned an enormous volume of research, totalling approximately 130 studies, and developed a comprehensive body of information and analysis on which to base our recommendations, much of it available for the first time in Canada. This solid base of research findings allowed us to address the issues more knowledgeably and in a way likely to produce practical and useful recommendations based on the reality of the situation, not on speculation. This was a complex but necessary task, involving the melding of our assessment of values and social attitudes with our knowledge about the technologies and their possible implications.

Although the conditions and technologies are related and have similarities, they also differ from one another in significant ways. General statements about them seldom hold true; the impact of each is distinct for different individuals and groups. Although all deal with reproduction in one way or another, each must also be examined and assessed on the basis of its particular characteristics, impact, and implications, and detailed discussion of the Commission's findings is presented in the remaining chapters in this second part of our report. However, recognizing that there are certain aspects about all of them that we needed to bear in mind, we organized our inquiry in each of the principal areas of our mandate

according to a nine-point framework, the elements of which are described below.

Origins and Historical Development

To understand the current situation with regard to new reproductive technologies, it is important to understand how they developed, the driving forces behind them, and the social context within which that development took place. The Commission examined the history and development of specific technologies, such as *in vitro* fertilization (IVF), assisted insemination (AI), and prenatal diagnostic techniques, as well as newer developments, such as research involving human zygotes and the use of fetal tissue. We also reviewed how perceptions of infertility and options for dealing with it — such as adoption or living without children — have evolved in Canadian society. Among the aspects of the technologies we examined were the roles that commercial and industrial interests have played and continue to play in their development and provision.

Current Practices

Until the Commission completed its research, no large-scale picture of the actual practice and results of new reproductive technologies in Canada was available. Yet this picture is essential to an understanding of whether and how the technologies should be used and in shaping public policy responses to them. To assemble the picture, the Commission gathered data and information from many sources, including field surveys of hospitals, clinics, institutions, patients, and practitioners. This original research created a new body of knowledge that provided the basis for our conclusions and recommendations, and remains as one of the Commission's legacies.

Results and Outcomes

Any reproductive activity, care, or treatment has the potential for short- and long-term effects, both physical and psychosocial. Our investigation recognized that results must therefore be considered in the broadest possible perspective. Certainly, the effects on users of the procedures or technologies must be taken into account — for example, the effect on the long-term health of a woman taking fertility drugs. Using an evidence-based approach, evaluations were carried out using meta-analysis, cost/benefit, and other analytic methods to determine which treatments are effective and the nature and extent of potential risks involved. Also important was investigation of the effects on other parties, particularly the children born as a result of technological intervention, as well as on society as a whole and on identifiable groups within it.

Costs and Benefits

A broad perspective on costs and benefits is necessary, so we examined not only how society allocates health care resources and funds medical technologies but also the non-financial costs involved in use of a given procedure or technology, including emotional or psychosocial costs and the impact on the quality of life of users and their families.

New reproductive technologies cannot be separated from economic questions, in part because they involve decisions about resource allocation within the health care system and outside it. The Commission also examined the economic aspects of various programs, treatments, and procedures, as well as ways to measure economic effectiveness as part of an overall approach to technology assessment.

Because society's resources are finite, one consideration in resource allocation is the financial cost of a particular course of action compared with the benefits expected from it. This applies not only to evaluating technologies such as *in vitro* fertilization but also to assessments of prevention programs.

Future Directions

The Commission's mandate directed us to consider the implications of technologies and procedures that may be developed in the future. It is impossible to predict exactly what developments might emerge in the coming years in a rapidly evolving field. It is possible, however, to make some predictions on the basis of current experience and trends, to identify desirable and undesirable directions for research and development, and to consider what social structures or mechanisms should be in place to monitor and manage that development. The issue of future developments is common to all technologies, not just those in medicine. Even if the precise course or nature of technological development cannot be predicted, it is possible for society to be alert to the prospects for change and to equip itself to anticipate and manage change in a manner consistent with social values and priorities.

Implications

As stated earlier, our mandate directed us to examine a broad range of implications, including ethical, social, research, economic, legal, and health. We examined the ethical and other questions raised by the existence of new reproductive technologies through a prism of guiding principles (discussed in Chapter 3) that informs our conclusions and recommendations.

Assessing implications is complex, because the relationship between society and technology is dynamic. Not only are society and technology evolving rapidly, but the sectors of society where change is being felt most

strongly — for example, the role of women and the structure and composition of the family — are precisely those in which the impact of new reproductive technologies may be greatest. The relationship is also interactive; new reproductive technologies have implications for Canadian society, but they in turn are affected by changing social attitudes to reproduction, family, and technology, as well as by the values Canadians hold and the priorities we set as a society. The Commission examined both elements of this interaction; they are described more fully with regard to each aspect of our mandate later in this part of the report.

> There is the potential for greater erosion of the value of human life and the dignity of the human person through the indiscriminate use of NRTs [new reproductive technologies] ... we do not oppose science, we do oppose scientism, which is a philosophical variety of idolatry which posits the justification for the implementation of a technology merely in its availability. We do not believe that because certain technologies are available that they should therefore be utilized. This ignores the social, ethical, and spiritual consequences of technological advance.
>
> *G. Gianello, Christians for Life, Public Hearings Transcripts, Toronto, Ontario, November 20, 1990.*

As our detailed discussion of the technologies makes clear, health implications differ with the condition and technology being considered; the same is true for their legal implications. Several areas of law are affected by new reproductive technologies, ranging from constitutional and human rights law through family law to laws affecting privacy and intellectual property. Issues such as access to new reproductive technologies, for example, are affected by the *Canadian Charter of Rights and Freedoms*.

Alternatives

The Commission asked numerous questions about alternatives to the use of reproductive technologies, including the prevention of infertility and adoption as alternatives to the use of the more technologically oriented techniques of assisted conception. We looked at choices such as living without children and nurturing children other than through parenthood. We tried to discover the extent to which prospective technology users are informed and counselled about the availability of alternatives, and to what degree these are realistic. With respect to adoption, for example, which has been seen traditionally as an alternative for couples who are infertile, we found that it is now not feasible as an option for many people, because far fewer children are available for adoption. In fact, the number of children born through assisted conception currently exceeds the number of infants available and adopted in Canada each year. This has implications for how we look at alternatives such as donor insemination (DI) and *in vitro* fertilization.

In addition, it was important to examine the alternatives available to individuals within the range of technologies and what should determine choices among them. For example, factors such as invasiveness and expense may determine what is acceptable to some people; others may weigh more heavily the implications for family and interpersonal relationships or the ethical and social consequences of their decisions.

> This Commission has a mandate to study and make recommendations which might affect all of Canadian society. It is good to keep in mind that our society nowadays is secular and pluralistic; that is, multi-ethnic and multi-religious, with many groups espousing varying philosophies and lifestyles. It is a democratic society with the principle of freedom of religion and conscience enshrined in the Charter.
>
> Consequently, this Commission should not follow any particular religious point of view, and make its recommendations based on factual knowledge, the best interest of the population, the protection and respect of individual rights and the welfare of people, and the maximum freedom of persons to make responsible choices compatible with the common good.
>
> *H. Morgentaler, private citizen, Public Hearings Transcripts, Toronto, Ontario, November 20, 1990.*

Options Considered

The Commission considered the options available to Canadian society for establishing boundaries around new reproductive technologies and managing the technologies within those limits. This involved making evidence-based assessments of the technologies; taking into account our understanding of Canadian values and attitudes in these areas; considering the nature and structure of the systems within which our recommendations must be implemented; and looking at all these considerations through the ethical prism formed by the guiding principles we adopted.

Recommendations Made

After the range of options to deal with a technology was identified and Commissioners had considered them, we developed recommendations consistent with our guiding principles. Our specific recommendations are set out in the remaining chapters of our report.

As we weighed the evidence before us to reach conclusions and develop recommendations, our ethical principles and the interests of the individuals and groups affected were always borne in mind. In the narrative leading to our recommendations, we describe this process and the reasoning by which we reached our conclusions. Where Commissioners were unable to reach agreement on specific recommendations, an alternative view is presented in an annex.

Organization of the Commission's Work

The Commission organized its work around two major streams of activities: (1) consultations and communications, and (2) research and evaluation. The balance of this section offers a brief description of these activities and how they contributed to the Commission's findings and conclusions.

Consultations and Communications

The Commission used several approaches to solicit and gather opinions and concerns, including public hearings, calls for submissions, toll-free telephone lines, and an extensive publications program (see box). Participants in the public hearings represented Canadian society in all its complexity and diversity. We heard from women's groups, medical organizations, community groups, labour organizations, representatives of Aboriginal peoples and members of racial and ethnic minorities, and the academic and research communities. We also heard from these groups and others speaking from an ethical, religious, or legal perspective. By bringing together people from various disciplines and interests through events such as hearings and panel discussions, the Commission hoped to promote increased interaction and exchange on the issues at the community level.

The strong desire of Canadians for information about the issues and for opportunities to make their views known was evident in the number of people who communicated with the Commission to ask for or to impart information. Some 6 000 people called the Commission's toll-free telephone number. More than 2 000 took part in the hearings and in the lively debate at the public panel discussions the Commission organized. In all, more than 40 000 Canadians were involved in the Commission's work — in these ways and through submissions, surveys, and clinical studies.

To respond to this desire for information and to promote a more lively and informed debate and greater public participation, we used various outlets for information about the Commission, such as community newspapers, cable television broadcasts, and satellite transmission of panel discussions. We tried to ensure that all those with an interest in the issues had access to the information they needed and a way to participate in the Commission's work. In particular, we looked for ways to facilitate involvement by people living in rural or isolated areas and by women with both a job outside the home and family responsibilities, who might otherwise have found it impossible to participate in the Commission's consultations.

Consultations and Communications

Input from Canadians

Public and Private Hearings: more than 550 Canadians took part in and presented briefs to public hearings across the country.

Submissions and Letters of Opinion: 500 written submissions and opinions up to September 1993.

Personal Experiences and Private Sessions: 500 individuals wrote to the Commission about their personal experiences or participated in private sessions held across the country.

Information Meetings: to consult organizations such as public health associations, women's groups, religious organizations, groups representing people with disabilities, the legal and medical professions, the research community, and the pharmaceutical industry.

Search Conference: three-day session involving 32 experts in fields such as health, law, bioethics, and religion, as well as representatives of people with disabilities.

Public Opinion Research: more than 15 000 surveyed; surveys explored awareness, values, and attitudes.

Toll-Free Telephone Lines: to facilitate participation in the Commission's consultations for people who might have found it difficult or inconvenient to participate through hearings or submissions; to provide access to information about the Commission and its work; more than 6 000 calls received.

Informing Canadians

Research Reports Released: Commission released 14 research studies during its mandate.

Newsletter Published: 50 000 copies of semi-annual newsletter, *Update*, detailing our research and other activities, were distributed through mailing list and public events.

Distribution of Information: 250 000 pieces of information distributed during the life of the Commission, such as information kits, brochures on the public participation and research programs, newsletters, speeches; information for use by community newspapers, journals, and opinion and editorial page editors; and information distribution also by cable television and satellite networks.

Media Activities: more than 1 000 media interviews were given and more than 7 000 media articles appeared about the Commission and its work.

At the same time, we worked to enhance public awareness about the issues raised by new reproductive technologies. The chairperson and commissioners participated in speaking engagements and other public forums, and we issued two dozen publications during our mandate, including a newsletter, pamphlets describing our public participation and research programs, and an analysis of our public hearings. In addition, the Commission sought and received permission to publish some of the research and analysis studies before we submitted our final report. (A list of these studies is provided in the Appendices.) These activities helped to raise Canadians' awareness of the nature and importance of new reproductive technologies and to promote public debate about them.

Research and Evaluation

The agenda for the research program was based on the Commission's mandate, on what we heard from Canadians, and on discussions among Commission members regarding the subjects on which information and analysis were needed. Also important were consultations with experts in disciplines ranging from ethics, law, and philosophy to medicine and the other life sciences. The result was a broadly based, multidisciplinary research and evaluation program designed to ensure that our recommendations were informed by solid, timely, and in-depth information. Much of the research funded by the Commission in the numerous disciplines relevant to our mandate will act as a catalyst in these disciplines, inspiring additional work in the coming years and acting as a foundation for that research. The conclusions drawn from our research studies and surveys are set out in the remaining chapters of our report. The studies themselves are available in the 15 volumes of research being published along with our report.

In designing a research program to address the four specific areas of inquiry — the prevalence, risk factors, and prevention of infertility; methods of assisted reproduction; prenatal diagnosis (PND) and genetics; and research involving human zygotes and the use of fetal tissue — we used the framework described at the beginning of this chapter. We also recognized that some ethical, social, and legal issues could be common to more than one area and commissioned analyses to address these. In addition, several other activities helped us to understand the context within which new reproductive technologies are being developed and put into practice:

- The first was an analysis of the experience of other countries in studying the technologies and dealing with the issues they raise. How have other jurisdictions developed their approach to the technologies? What issues did they consider important? What kinds of solutions have been proposed? We analyzed the mandates, findings, and recommendations of more than 60 inquiries held in such countries as the United States, the United Kingdom, France, and Australia. Critiques of the reports helped to improve our understanding of their

scope, strengths, and shortcomings, and their relevance to the work of this Commission. We review our findings later in this chapter.

- The second was to develop an understanding of the current situation in Canadian society, including values and attitudes of Canadians. We analyzed demographic trends relevant to the use of new reproductive technologies, as well as how these trends may be influenced by these technologies. We commissioned public opinion research to ascertain the level of awareness about new reproductive technologies and the issues surrounding them, and to understand the values and attitudes of Canadians in relation to the technologies. The two surveys, conducted in 1990 and 1992, involved a total of 9 167 people. We also analyzed results from two Canada Health Monitor surveys of 5 448 people concerning, among other issues, whether they thought they were infertile, their knowledge about how the human reproductive system works, and their attitudes toward adoption. We summarized our findings in Chapter 2 and refer to them again throughout this part of the report as they relate to specific technologies or practices.
- The third way of coming to understand the relevant context was an analysis of the current situation in Canadian systems and institutions. We commissioned descriptive and analytical papers to help us understand the organizational structures, responsibilities, powers, and resources of the systems within which the Commission's recommendations will have to be implemented: the health care system; the social welfare and education systems; the science and research system; and industry and government structures. The sectoral interests (for example, pharmaceutical) affecting the technologies and their use were examined and analyzed.
- Finally, the Commission examined relevant areas of law, such as
  - (a) occupational health and safety legislation, which has an impact on the risk factors associated with infertility;
  - (b) family law, which is basic to the issues raised by new reproductive technologies;
  - (c) legal trends related to judicial intervention in pregnancy and birth;
  - (d) property law and intellectual property law;
  - (e) aspects of criminal law;
  - (f) physician responsibility;
  - (g) rights of privacy relating to the collection, use, and disclosure of personal information, and obligations of confidentiality relating to personal information kept in records;

(h) Canadian common law and Quebec civil law approaches to reproductive issues; and

(i) Canada's obligations, under international law and international conventions and covenants, in such areas as human rights, the rights of women and children, and the right to the benefits of scientific progress.

In total, the Commission's research and analysis efforts involved more than 300 scholars and academics representing 70 disciplines — including ethics, law, the social sciences, humanities, medicine, genetics, life sciences, philosophy, and theology — at some 21 Canadian universities and 27 hospitals, clinics, and other institutions. In some cases — such as our surveys regarding 1 395 patients at fertility clinics and 22 222 women attending prenatal diagnosis clinics — the Commission's research provided national data for the first time in the research areas. The Commission was also able to call on the expertise of researchers in the United States, the United Kingdom, France, Australia, and other countries.

New Reproductive Technologies Inquiries Elsewhere

One of the lessons emerging from our review of inquiries in other jurisdictions in Canada and abroad is that new reproductive technologies must be examined in the broadest possible light. It would be inappropriate to criticize earlier reports for neglecting some of the broader issues; in many cases, inquiries were not asked to study them, or were not given the time and resources to examine them properly. This Commission's wider mandate and resources enabled us not only to consider the issues from an ethical and social perspective but also to explore their various dimensions in much greater detail through extensive public consultations and wide-ranging research.

Nevertheless, the work already done by other inquiries to grapple with the issues raised by new reproductive technologies remains a significant part of the domestic and international context for Canada's response to them. The fact that so many governments have established inquiries and passed legislation, all in the last 10 years, attests to the seriousness of these issues and to the speed with which they have become a subject of public concern and government activity. In Canada, several public inquiries and working groups have been established, both federal and provincial, to examine particular aspects of the technologies. However, there has been no previous comprehensive Canadian examination of new reproductive technologies and related issues such as research involving human zygotes/embryos and the use of fetal tissue. Moreover, few of the recommendations of these previous reports have been acted upon. Internationally, several countries have passed legislation to deal with some

of the issues surrounding new reproductive technologies, often following public inquiries. No two inquiry reports or pieces of legislation take an identical approach, but certain trends are emerging. Although these trends were not necessarily evident in all inquiries, and the inquiries had different points of departure and brought varying perspectives to the issues, opinion appears to be converging on several broad conclusions apparent in the reports and legislation. Here we identify emerging areas of consensus among them, as well as areas of continuing disagreement and gaps that remain.

Emerging Consensus, Continuing Disagreement, and Unresolved Issues

We can divide the issues into four groups: issues on which there is broad agreement; issues on which there is substantial and persistent disagreement; issues on which opinion seems to be shifting and a new consensus emerging; and issues that have not been addressed at length to date.

Areas of Agreement

Virtually all inquiries and advisory bodies have concluded that

- *in vitro* fertilization and assisted insemination are legitimate medical responses to infertility; internationally, the trend has been to institutionalize this response through some form of national accreditation or licensing and record keeping for assisted conception research and treatment;
- informed consent is a precondition for all medical treatment and must be obtained for all uses of human gametes, zygotes/embryos, or fetal tissue in treatment or research;
- some forms of embryo research are clearly unacceptable (for example, cloning, human-animal hybrids); other forms of research are acceptable within the first 14 days of development *in vitro*, provided they are strictly regulated and approved by an ethics review committee and no attempt is made to establish the zygote *in utero* following research; no such research should ever be done for profit;
- internationally, there is general agreement that the use of donated gametes or zygotes is permissible; and
- the legal status of children conceived through the use of donated gametes or zygotes should be regularized.

In addition, the emerging international consensus is that a time limit should be placed on the storage of human gametes and zygotes/embryos. Decisions about the use or destiny of stored gametes and zygotes/embryos (for example, in the event of death or divorce of the donors) should be made

in advance, either by law or by the donors at the time of donation. There is also agreement that commercial preconception agreements are unacceptable, as are financial inducements for gamete donors. Sex selection for non-medical reasons has also been prohibited in several countries or recommended for prohibition by a public inquiry.

Areas of Disagreement

In contrast with these common conclusions, in other areas differing policies or legislation, or both, have emerged, with no clear convergence in the conclusions reached. Several such issues are worth noting:

- Although most permit some embryo research up to 14 days of development, there is no agreement on the limits to such research. In particular, some allow research only on "excess" zygotes created for purposes of *in vitro* fertilization, while others allow researchers to create zygotes specifically for the purpose of research. There is also disagreement about the purposes for which such research is permissible; all agree that such research should never be done for profit, but some permit it only if it is intended to improve infertility treatments, while others allow research that offers new knowledge that could lead to health care benefits. Where legislation has been passed, the sanctions for inappropriate research vary as well.
- Although there is general agreement that assisted conception procedures are appropriate medical responses to infertility, there are differences of opinion on the criteria that should be used to determine who has access to these procedures. Most of the inquiries to date have recommended restrictions based on both social and medical grounds, and some governments abroad have introduced legislation imposing such restrictions. However, they differ on how these criteria should be defined and who should have the authority to apply them. In some cases, access would be restricted to married couples; in many, access would be open to unmarried heterosexual couples in stable relationships; and in a few, single women would have access. Opinion also differs on whether applicants should be assessed for their suitability as parents and what avenues of appeal should be available to those denied access.
- With the sole exception of the Ontario Law Reform Commission, Canadian inquiries and most jurisdictions abroad have firmly rejected the idea of commercial preconception arrangements. They differ, however, in their approach to discouraging or regulating non-commercial arrangements.
- There is general agreement that assisted insemination by donor (AID) is a legitimate medical treatment, but there is disagreement about whether it should be provided only by medical professionals. Some argue that AID should be deemed the practice of medicine, so that any

non-professional who provides the service would be committing a criminal offence. Others argue that the provision of AID by women's self-help groups should not be prohibited.

Evolving Views

In some areas we can identify clear changes over time in the reasoning and recommendations advanced by public inquiries or advisory bodies. For example,

- Opinion seems to be shifting about whether children born of donated gametes should have access to biological and social information about the donor. The earliest Canadian inquiries strongly defended the principle of donor anonymity; indeed, some recommended that children not be told that they were conceived through the use of donor gametes and that records not be kept regarding the identity of the donor. More recent inquiries in Canada and abroad, however, suggest that children should be told the truth about the circumstances of their conception, accepting that the child has a legitimate interest in learning certain information about his or her biological parents, for both psychological and medical reasons. Hence, the reports insist that proper records about gamete donors be kept and that the child have the right to non-identifying information about the donor. Some reports also support the principle that access to identifying information should be possible as well, at least under certain conditions, such as medical necessity, when access is approved by a court, or (in a few reports) when the donor gives his consent. Countries' policies and laws differ regarding whose consent should be required in order for information to be disclosed and the age at which the child should have this information.
- There is increasing emphasis on the need for standardized and centralized record keeping on the use of assisted conception technologies and for some regulatory apparatus to ensure this. Earlier inquiries rejected the need for centralized record keeping or for a system of licensing. More recent inquiries have argued, however, that proper record keeping is essential for all such procedures. Indeed, some have recommended that some form of national accreditation or licensing be established for assisted conception clinics and that proper record keeping be a condition of acquiring the accreditation. In general, there is greater emphasis on the need for national standards, national registries, and a national agency to monitor new reproductive technologies.

Remaining Gaps

The Commission learned a great deal from the experience of other inquiries, many of which tackled difficult issues with rigour and insight,

even if some lacked the mandate, time, or resources to engage in extensive public consultations or research. Our job was made easier by the excellent work that preceded ours in Canada and internationally, as well as by the resources that permitted us to adopt a broad social and ethical perspective. We also learned from the critics of the inquiries conducted in the past decade. The release of these reports invariably generated considerable debate among groups affected by new reproductive technologies and the general public. As this debate has evolved, and as the public has become more informed, certain gaps or issues not dealt with fully have become apparent in the way past inquiries approached the subject:

- the long-term social implications of reproductive technologies for particular groups in society (including women, children, people with disabilities, and members of racial and ethnic minorities);
- the implications of the diverse values and desires inherent in a multicultural population;
- the social meaning of infertility and the medicalization of reproduction;
- the prevention of infertility and alternatives to the use of technologies to treat infertility;
- technologies other than assisted conception (for example, prenatal diagnosis, research involving the use of fetal tissue);
- economic considerations and the relationship of new reproductive technologies to health care priorities (for example, should the procedures be publicly funded?);
- the role of commercial interests in new reproductive technologies; and
- the effects of globalization on new reproductive technologies.

In our own inquiry, some particular issues emerged that cut across the technologies and practices identified in our mandate; they relate to some of the clearest messages Commissioners heard from Canadians. These issues include access, safety, and effectiveness, the appropriate roles for prevention and acute care in dealing with infertility, the need to ensure informed consent and informed choice with respect to technology use, and the need to protect individual privacy by safeguarding the confidentiality of information gathered in the course of providing services related to reproductive technologies. Along with our review of the conclusions reached by public inquiries and advisory bodies in other jurisdictions, this input from Canadians provided an invaluable part of the context for our deliberations and of our integrated approach to the issues raised by use of the technologies.

Part of our integrated approach involved bringing together our moral reasoning with the values and attitudes of Canadians. There were a few occasions, however, when our moral reasoning led us to conclusions that were not strongly supported by the responses to some specific questions in our surveys of Canadians. This kind of situation usually arose when a

value which Canadians strongly endorsed and said was important to them, such as equality, was not upheld in answer to a question on a specific situation, such as whether single women should have access to DI or whether people who are disabled should have access to IVF.

We gave great thought to this dilemma. We were guided by and took into consideration what Canadians said about both their fundamental values and their attitudes to specific questions, but they were not the only determinant of decision making in these complex areas. Where there was a divergence on specific policy questions, we decided that our moral reasoning should have greater weight if it was in line with fundamental values endorsed by Canadians, because we had spent much time weighing the evidence and thinking through the implications of different policies on such specific questions.

We turn now to the substance of our mandate — the conditions, technologies, and practices we were asked to examine. First, as background for understanding infertility and the technologies designed to overcome it, we provide a brief overview of the biology of human reproduction. Then, in the remaining chapters of the report, we apply our guiding principles, our weighing of the evidence we gathered, and our appreciation of the domestic and international context to reach conclusions and recommendations about the four main areas of our mandate: the prevalence, risk factors, and prevention of infertility; methods of assisted reproduction; prenatal diagnosis and genetics; and research involving human zygotes/embryos and the use of fetal tissue.

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The Biology of Human Reproduction and Early Development

Society's fascination with reproduction is reflected in intense public and media interest in new reproductive technologies. Yet few people are fully aware of the beauty and complexity of the process of human reproduction — the process in which new reproductive technologies can intervene. In this brief chapter we outline the biology — the anatomy and physiology — of human reproduction, from production and joining of egg and sperm to development of the zygote, embryo, and fetus.

Although scientific and medical research have steadily expanded knowledge of human reproduction, particularly in recent decades, much remains unexplained. We are, however, coming to understand with some precision why reproduction is natural and simple for some people and difficult or even unattainable for others. Although human reproduction cannot be understood solely in terms of biology, knowledge of this elaborate process is fundamental to any discussion of the technologies covered by our mandate: it is vital to any consideration of interventions in that process, whether before conception, as with infertility treatments, or after conception, as with prenatal diagnostic techniques. This account is intended to provide only the minimum information non-expert readers need to understand our analysis and recommendations regarding the risk factors for infertility, regarding the role of specific technologies in overcoming it, and regarding embryo research. Also provided are capsule definitions of reproductive conditions or structures that readers may find useful in understanding the discussion of infertility and technological intervention in subsequent chapters. Readers interested in pursuing this subject further can consult the general sources listed at the end of this chapter.

Human reproduction is a series of intricately connected and interactive steps. For reproduction to succeed, the anatomy of the people concerned, as well as their physiological, hormonal, and genetic systems, must all

function normally and at the right time. The production and the delivery of eggs and sperm are vulnerable processes — anatomical, genetic, hormonal, or behavioural problems may interrupt them or prevent them from occurring at all.

Prenatal development is an equally elaborate and delicately balanced process. Both the embryo proper and the surrounding membranes and placenta develop from a single cell. The organs and body systems mature in a precisely regulated way — again, the physiological, hormonal, and genetic systems of the developing fetus and the pregnant woman must function in flawless coordination.

The complexity of reproduction and prenatal development creates risks of error — errors that are sometimes genetic in origin or caused by some agent, but also errors that occur by chance. Errors or dysfunction at any stage may act individually or in combination, with the result that the process does not lead to the birth of a healthy child. In fact, as explained later in this chapter, about half of all fertilized eggs do not develop in such a way as to result in live births.

The process of reproduction begins well before conception. The woman's hormonal system and reproductive organs must produce a mature egg for fertilization and must provide a hospitable environment for development of the resulting embryo. The man's hormonal system and reproductive organs must be functioning properly to produce sperm and permit sexual intercourse at the appropriate time in his partner's menstrual cycle. The steps between the production of egg and sperm and the birth of a child — as well as how the process can be interrupted and how technologies can be used to intervene if it is — are the subject of this chapter, where we set out the essential conditions that must be present and the developments that must occur for fertilization and pregnancy to result in the birth of a healthy child.

Egg Production

A healthy, fertile woman has some 400 000 immature eggs in her ovaries. Those eggs were in place even before the woman was born — originally, there were a million or more, but by puberty more than half have been lost through natural deterioration. From puberty until menopause, the woman's body goes through periodic cycles of physical and chemical change during which an egg matures and is released by the ovary in the process known as

Ovulation: The maturation and release of an egg from the ovary.

Amenorrhea: Absence of ovulation and menstruation in a woman of menstrual age.

Oligomenorrhea: Scanty or irregular menstruation.

ovulation. After ovulation, the free-floating egg must be captured by the slender projections at the opening to the fallopian tube. The fallopian tubes — about 10 centimetres long and the diameter of a pencil — project from the uterus toward the ovaries. Just how the tiny egg crosses the gap between the ovary and the fallopian tube is still a mystery, but once it does, the egg can begin to travel down the tube toward the uterus.

All of these events and changes in the woman's body are stimulated and controlled by a delicately coordinated process of hormone production and feedback involving the pituitary gland, portions of the brain, and the reproductive system. Each event requires specific hormonal and physical conditions to be present before it can occur. In turn, each occurrence triggers further hormonal and physical changes without which the next steps in the process cannot take place.

Given that ovulation consists of several interdependent stages, the reasons for ovulation dysfunction are not always easy to determine. Ovulation may not occur because the hormones that stimulate it are produced in quantities that are too large or too small, or because the ovaries do not respond normally to the hormones produced. In addition, the cells that surrounded the maturing egg inside the ovary may fail to produce the hormones necessary for maturation of the egg to continue after the ovary releases it. These hormonal disorders could have their origins in the brain, in the pituitary or thyroid gland, or in the ovaries themselves; they can result from disease or exposure to harmful substances or conditions — or the cause may simply be unknown.

Other sources of potential problems with egg production are physical in nature. A woman's ovaries may be missing or damaged as a result of disease, premature menopause, or failure to develop properly in the first place. Failure to ovulate, disrupted ovulation, and other ovulation and menstrual disorders can be treated with drugs or hormone therapy, which can compensate for irregularities in a woman's own hormone production and feedback system. Drugs can be used singly, in combination, or in sequence to stimulate ovulation or to compensate for ovaries that do not function as they should. Drugs can also be used in procedures like *in vitro* fertilization to increase the likelihood of successful egg retrieval. In addition, technologies such as ultrasound scanning can be used to investigate the source of infertility if it is suspected that the problem lies in damaged, malformed, or absent ovaries, or damage to or blockage of the fallopian tubes.

Sperm Production

A healthy, fertile man produces 2.4 to 5 millilitres (one-half to one teaspoon) of semen containing between 200 million and 500 million sperm at each ejaculation. Only one sperm needs to join with an egg for

fertilization to occur, but for this to happen, the sperm must be physically and functionally normal, active, and capable of swimming through the woman's reproductive tract, and be produced in sufficient numbers to ensure that at least one survives and reaches the egg. In addition, the man's hormonal system and reproductive organs must be free of anomalies and working correctly to ensure that he is capable of depositing the semen at his partner's cervix (the lower part of the uterus, opening into the vagina). The sperm must make their way through the opening of the cervix, through the uterus, and into the fallopian tube toward the maturing egg. The right hormones must be circulating in the body at the right time and in the correct amounts to promote normal sperm production and sexual function. This involves various brain structures and endocrine glands, as well as the reproductive organs, in finely coordinated feedback. Because it takes about three months for a man's body to manufacture sperm, factors such as illness, temperature changes, or exposure to drugs or chemicals during that period can affect sperm quality. The effects of some exposures are short-lived, but others may damage the sperm production system permanently. The reasons for scarce sperm or lack of sperm motility are usually difficult to determine, with the result that the condition often cannot be treated effectively.

Stages of Development

Zygote: The fertilized egg until two weeks after fertilization, when the embryo proper and the surrounding structures supporting it begin to form.

Embryo: The developing entity from the third to the eighth week after fertilization.

Fetus: The developing entity from the ninth week after fertilization until birth.

Another problem arises if the man cannot deposit the sperm at the woman's cervix because of physical or psychological difficulties with sex drive, erection, or ejaculation; these may occur because of hormone disorders, physical causes such as disease or disability, or the influence of outside factors such as stress or exposure to harmful substances or conditions — or the cause may be unknown.

In addition, a woman's body may prove an inhospitable environment for her partner's sperm. For example, the cervix secretes a thick mucus that prevents bacteria, sperm, or other foreign substances from entering the uterus during all but a brief part of the menstrual cycle. Around the time of ovulation, however, the mucus normally becomes much thinner and more hospitable to sperm, facilitating their movement into the uterus and toward the newly released egg. Abnormalities in the cervical mucus, or physical or other anomalies, may prevent the sperm from getting through the opening of the cervix and moving up into the uterus and fallopian tubes, or the woman's body may even produce antibodies that destroy the sperm as they travel through her reproductive tract; the reasons for this "cervical factor" infertility are not known. Finally, sperm must be deposited

at the right time in the woman's menstrual cycle, when an egg has been released from the ovary and is available for fertilization; these conditions are present for only a short time during each cycle.

Azoospermia: Absence of living sperm in the semen.

Oligospermia: Scarcity of sperm in the semen.

Motility (of sperm): Movement; specifically, movement needed to traverse a woman's reproductive tract toward the egg; determined by observing a sample through a microscope.

Sperm morphology: The form and structure of the sperm; abnormal sperm morphology may affect the ability of the sperm to fertilize an egg.

Most technological intervention for reduced fertility in men has involved the treatment of sperm to improve its capacity to fertilize an egg; no methods have been developed that can deal with male infertility problems such as failure to produce live sperm. Current methods of increasing the fertilizing capacity of sperm require the use of assisted insemination or IVF because a sperm sample has to be treated before being placed in the woman's reproductive tract or being brought into contact with an egg; these methods therefore involve treatment not only of the sperm, but of the woman as well. Drugs and hormone therapy have also been used to treat men who are infertile or subfertile to try to improve the fertilizing capacity of their sperm. In addition, cervical factor infertility is sometimes treated by depositing the sperm higher in the woman's reproductive tract (intrauterine insemination or IUI), thus bypassing any obstacles at the opening of the cervix.

Fertilization

The First 14 Days

If the egg encounters healthy, active sperm in the fallopian tube during the optimal time for fertilization (about 6 to 12 hours after ovulation), and if the chemistry and physiology of the egg and sperm are working normally, chances are the egg will be fertilized. For this to happen, the fallopian tube has to be unobstructed, and its lining has to be working properly to facilitate movement of the egg and sperm toward each other. If fertilization does occur, the lining of the tube must continue to function normally to move the egg to the uterus. If fertilization does not occur, the egg continues through the tube into the uterus and leaves the woman's body.

Fertilization is possible, though increasingly unlikely to occur, up to 36 hours after ovulation. Given the length of time sperm can survive in a woman's body (up to 72 hours) and the time that elapses between ovulation and the end of the egg's journey through the fallopian tube (12 to 24 hours), there is a regular though brief period in each cycle during which

fertilization can occur. Sexual intercourse can be timed to coincide with ovulation — that is, during the woman's fertile period — but fertilization is not guaranteed. A fertile, sexually active couple not using contraception has an average monthly chance of having a pregnancy that leads to live birth of a child of about 20 to 25 percent.

Gamete: The mature male or female reproductive cell — sperm or egg.

Genome: The total genetic material contained in the chromosomes of an individual's cells. The human genome contains about 100 000 genes.

Syngamy: The process through which the 23 chromosomes of an egg cell and the 23 chromosomes of a sperm cell combine so that the new cell has 46 chromosomes.

The subtle processes immediately following the sperm cell's entry into the egg are only partly understood. Penetration of the egg by a single sperm cell triggers a series of changes that include loss of permeability in the egg's outer covering (the zona pellucida), which blocks the entry of other sperm cells. Within the next 9 to 22 hours, the two nuclei (one from the egg and one from the sperm), now called pronuclei, are discernible inside the egg (see Figure 7.1). Also visible adjacent to the egg are two other nuclei — the first and second polar bodies — which are the non-functional remains of the egg's previous cell divisions. Each pronucleus now in the egg contains a discrete package of genetic information (23 chromosomes), one contributed by the woman and one by the man. After 22 to 24 hours, the nuclear membranes have disappeared, and the chromosomes of the sperm and egg have come together — this is referred to as syngamy.

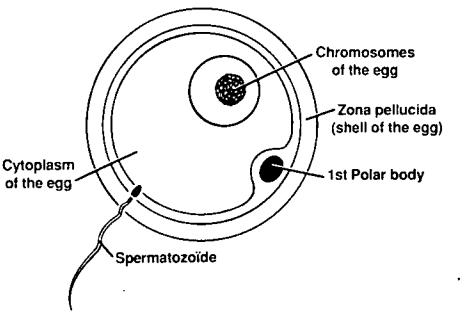
To recapitulate, for fertilization to occur, a woman must have at least one intact and functioning ovary and one functioning fallopian tube; her hormone production and feedback system must stimulate maturation of the egg and the physiological and chemical changes that create a hospitable environment for fertilization and the egg's journey toward the uterus; intercourse must occur at the right time; and the viable egg and sperm must come together, preferably at the end of the fallopian tube nearest the ovary.

Damaged, blocked, or missing fallopian tubes — resulting from congenital anomalies, sexually transmitted and other diseases, or unknown reasons — are a frequent cause of infertility. Without functioning fallopian tubes, an essential factor in helping the egg and sperm come together is missing; there is no place for the egg and sperm to meet and no route for the fertilized egg to travel to the uterus.

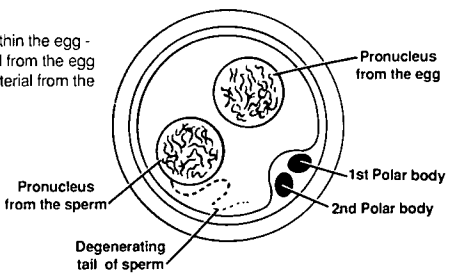
Other reasons for fertilization failure involve anomalies in the physical structure or genetic make-up of the sperm or egg that inhibit their fertilization potential. For example, as the egg continues to mature after leaving the ovary, it must go through chemical and physical changes to make its outer wall ready for the chemical reaction through which sperm

Figure 7.1. Summary of Fertilization

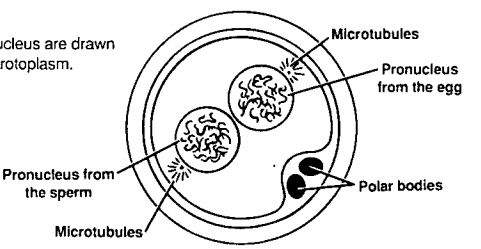
A sperm begins to enter the egg.



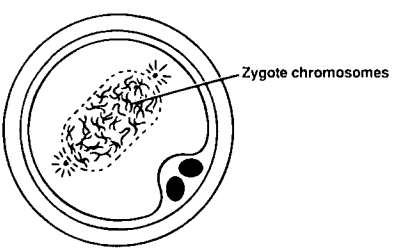
After 9 to 12 hours
Two pronuclei are clearly visible within the egg - one containing the genetic material from the egg and one containing the genetic material from the sperm.



After 10 to 22 hours
The chromosomes in each pronucleus are drawn together by microtubules in the protoplasm.



After 22 to 24 hours
The chromosomes of the sperm and egg combine - referred to as syngamy.
Within 1 to 3 hours, the zygote will undergo the first cleavage division.



and egg are joined in fertilization. If the egg's physiology or chemistry is abnormal, it is less amenable to fertilization. The substances accompanying the egg as it moves into the fallopian tube also have a role in attracting the approaching sperm, although how this works is not fully understood.

Just as eggs mature after ovulation, sperm also continue to mature after ejaculation. If they do not, or if they are physically, genetically, or chemically abnormal, they may not have the capacity to swim up the reproductive tract, respond appropriately to the lining of the fallopian tube and to the substances surrounding the egg, or reach the egg and take part in the process of fertilization.

The period beginning with entry of the sperm and ending with syngamy is being studied actively for insights into why fertilization fails. Sometimes, for example, more than one sperm penetrates the egg, resulting in a fertilized egg with three, not two sets of genetic information. Almost invariably, these eggs do not develop. Study of such eggs may, however, still provide researchers with valuable information about gene activity and early development.

When infertility results from problems with fertilization, technology has been used to intervene in several ways. For example, if the male partner's semen contains inadequate numbers of sperm or too few active sperm, it can be treated and concentrated before being used in assisted insemination or IVF. If the woman's damaged or blocked fallopian tubes cannot be repaired by surgery or other techniques, IVF can be used to circumvent this and bring the egg and sperm together. The woman is given drugs to stimulate ovulation, eggs are removed from her ovaries, and the eggs and sperm are put together in a laboratory dish. About 75 percent of eggs exposed to sperm in this way become fertilized. The resulting zygotes are observed under a microscope, and after one or two days' incubation, those that do not appear to be disintegrating, or that do not have extra nuclei because they have been fertilized by more than one sperm, can be placed in the woman's uterus in the hope that one or more will implant and development will begin.

When infertility results from problems with fertilization, technology has been used to intervene in several ways.

The sperm used for IVF can be treated to improve their ability to fertilize. The techniques include sperm washing (which is used to separate viable sperm from other elements in the semen, thus concentrating viable sperm in a smaller volume of fluid) and sperm swim-up (a technique for isolating and concentrating the most active sperm). Sperm can also be treated with caffeine or other agents to make them more active. Among the newer methods being researched to compensate for sperm with reduced fertilizing capacity are zona drilling, where the outer covering of the egg is ruptured to improve the chances that sperm can penetrate it, and a

technique called intracytoplasmic sperm injection. Further research is needed to show what consequences these treatments might have for the resulting fetus, although adverse consequences for the fetus have not been observed in the pregnancies that have resulted to date.

The Zygote and Its Genome

About 24 hours after the sperm penetrates the egg, the nuclear membranes of the two pronuclei dissolve and the chromosomes come together. This process (syngamy) takes about two hours, and in it the genetic contributions of the male and female gametes are fused into a single entity, the zygote, containing 46 chromosomes (see Figure 7.1).

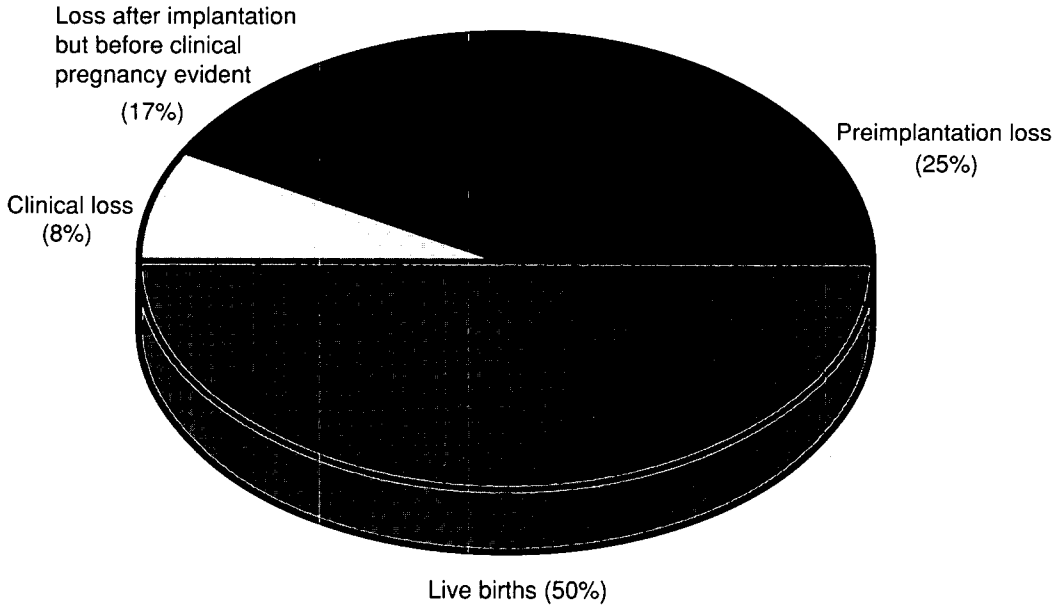
Newly constituted, the zygote is remarkable in its theoretical potential to give rise to a distinct and unique member of the human community. This potential for development is both theoretical and statistical — according to the best available knowledge at this time, about 25 percent of eggs fertilized through sexual intercourse do not implant in the uterus, and about half of fertilized eggs do not result in a live birth (see Figure 7.2).

Although the genetic constitution (the genome) of the zygote is established at syngamy, the genes do not begin to function until the zygote has eight cells. Until then, the zygote is operating under genetically programmed instructions from the egg only. It is usually at the two- to eight-cell stage — about two days after the egg and sperm are first exposed to each other — that a zygote created *in vitro* is transferred to a woman's uterus in the hope it will implant and begin to develop. If all goes well, the information contained in the new genetic entity is replicated in each body cell in the developing embryo and fetus and in each cell of the human being that may result.

Some zygotes have chromosomal or genetic errors that mean they can never develop normally past an early stage. For example, a zygote may have too many or too few chromosomes, or its genetic make-up may not allow for normal development or for functioning of one of the processes essential for life. Other zygotes have a chromosome make-up that means they will develop into tumours (hydatidiform moles). Yet others have three sets of chromosomes, for example, because the egg was fertilized by two sperm. In fact, about 30 percent of human zygotes created *in vitro* have chromosomal abnormalities that mean they cannot survive. It is likely that a substantial proportion of zygotes resulting from intercourse have chromosomal abnormalities as well, given that in about 42 percent of cases, a fertilized egg does not reach the stage of a clinically recognized pregnancy (see Figure 7.2).

The 14-day period before implantation of a fertilized egg in the uterus is an important period of development for purposes of research. Research into fertilization and the early development of zygotes could contribute to our understanding of these processes and thus, for example, help

Figure 7.2. Prenatal Loss in Human Beings*



* as a percentage of all fertilized eggs

Sources: See entries marked with an asterisk in the "General Sources" section at the end of this chapter.

workers in this field to improve the conditions in which zygotes develop following IVF and before transfer to the woman's uterus. A better understanding of how fertilization works could also lead to the development of better forms of contraception for either men or women. An important area of research involves the development of non-destructive viability tests that will enable clinicians to identify fertilized eggs that have a greater chance of implanting in the woman's uterus. Similarly, research is revealing which observable cellular characteristics mean that zygotes are free of chromosomal or other anomalies and are more likely to develop, thus improving the chances that their transfer to the uterus will result in the birth of a healthy child.

Cleavage and the Blastomeres

Within a few hours of syngamy, the zygote begins a process of cell division called cleavage; the cell divides into two, then four, then eight cells, initially at about 18-hour intervals, eventually forming a clump of cells; each cell in the cleaving zygote is called a blastomere (see Figure 7.3). Each successive division reduces the size of individual blastomeres by half, but the overall size of the clump remains nearly constant until implantation — at which time it is approximately the size of the period at the end of this sentence.

In summary, by about three days after fertilization, the zygote has become a tiny mass of cells. A day or so later, having passed down the fallopian tube, the zygote reaches the uterus where, during the next two or three days, it develops a fluid-filled space within it, becoming a hollow ball of cells; it is then referred to as a blastocyst.

Some zygotes inexplicably stop cleaving — only slightly more than half the eggs fertilized *in vitro* reach the blastocyst stage. This failure to develop *in vitro* may be attributable in part to the hormones used to stimulate ovulation or to deficiencies in the culture medium in which the eggs and sperm are brought together, but a substantial proportion of zygotes resulting from intercourse also fail to develop (see Figure 7.2).

Cleavage is an area of active study. As part of the IVF procedure, pre-implantation zygotes are examined under a microscope; those that have stopped cleaving are not transferred to the woman's uterus. Study of their physical and chromosomal characteristics may help to understand what is going wrong.

Implantation and Differentiation

As the zygote moves down the fallopian tube toward the uterus, the corpus luteum — the empty nest of cells in which the egg developed in the

Figure 7.3. Preimplantation Development

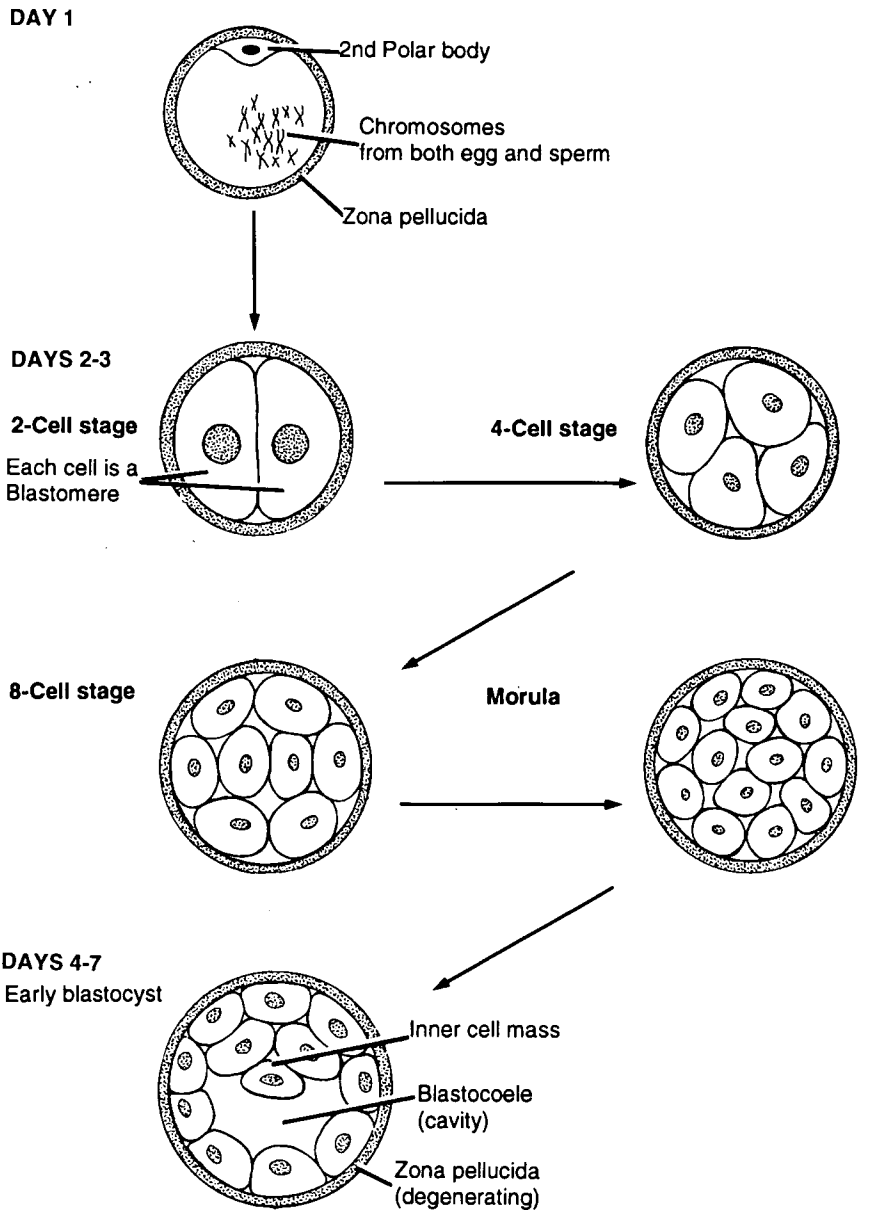
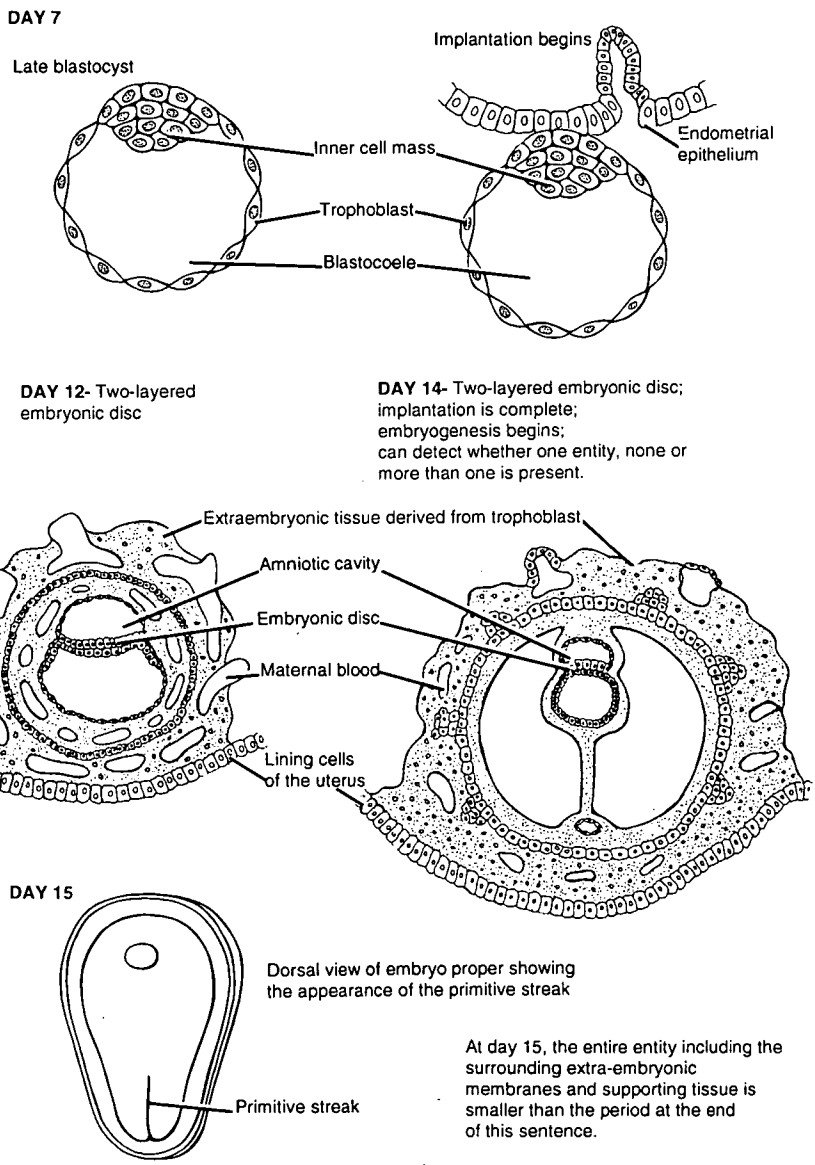


Figure 7.4. Process of Implantation



ovary — sends out a hormone that stimulates changes in the uterus lining, making it ready to receive the fertilized egg.

About the seventh day after fertilization, the outer cells of the blastocyst begin to invade the lining of the uterus (the endometrium), marking the first stage of implantation, a process that may take a week to complete (see Figure 7.4). One area of the blastocyst begins to thicken; it is from this inner cell mass that the identifiable embryo will develop. The cells that make up the blastocyst's outer layer, called trophoblasts, eventually become part of the placenta — the connection between the fetus and the woman's body.

Endometrium: The lining of the uterus, which receives the egg after it has been fertilized in the fallopian tube. In preparation for implantation, the endometrium becomes thicker and engorged with blood vessels.

Luteal phase defect: Failure of the lining of the uterus to develop properly after ovulation; this may prevent a fertilized egg from implanting in the uterus or lead to early loss of the pregnancy. "Luteal" refers to the *corpus luteum*, cells in the ovary in which the egg matures and that produce hormones to stimulate development of the endometrium after the egg is released.

As the blastocyst is implanting in the endometrium, a second fluid-filled space appears, within the inner cell mass. This will become the amniotic cavity that eventually surrounds the developing embryo itself. Now the blastocyst contains two spaces separated by a plate of cells — the embryonic disk. It is from this disk that the embryo itself develops. By about 14 days after fertilization, implantation is complete, and one or two days later the first indicator of a body axis becomes visible. Called the primitive streak, it appears as a heaping up of cells at one end of the embryonic disk. Thus, the embryo proper develops from just a small fraction of the cells that make up the zygote before implantation. Only at this point, 15 or 16 days after fertilization, can *individual* embryonic development be said to have begun, because only with the development of the primitive streak is it possible to tell whether one embryo, multiple embryos (identical twins or triplets), or no embryo at all is developing.

Even where the zygote gives rise to a single post-implantation embryo, in the view of some commentators it is a mistake to say that the zygote is the same individual entity as the post-implantation embryo. Although it is of course genetically identical, the embryo proper is only a very small part of the organic system that develops from a zygote. Part of the zygote develops into the embryo, but more than 99 percent of it develops into the trophoblast and other supporting tissues (the placenta, chorionic villi, amnion, etc.). This is one reason why some people prefer to use the term "pre-embryo" for the zygote before implantation.

Failure of Zygotes to Develop

As mentioned, fertilization of an egg following sexual intercourse does not necessarily mean that pregnancy will result. As we have seen, not all zygotes implant, and of those that do implant a proportion are lost before a pregnancy becomes clinically recognizable. It is estimated that 25 percent are lost without implanting and a further 17 percent are lost after implantation but before a clinically recognized pregnancy; this means that in 42 percent of cases where an egg has been fertilized, no clinically recognized pregnancy results. There is also loss after this stage — at least 8 percent of clinically recognized pregnancies end in spontaneous loss, including about 1 percent that result in stillbirths (Figure 7.2).

Why zygotes fail to develop or implant in the uterus lining is understood only partly. Some losses result from problems in the zygote's functioning, while others could be the result of dysfunction in the hormone signalling and feedback system between the woman's brain, ovary, and uterus lining. Problems with zygote functioning could arise from genetic anomalies in the fertilized egg or damage to it. Dysfunction in the woman's hormone or central nervous system could arise spontaneously or result from exposure to harmful substances or conditions.

Research directed to finding out what inhibits or contributes to successful implantation, and thus how to promote it, is now going on in many parts of the world. If the problem is thought to lie in a hormone deficiency related to the corpus luteum, the woman can take hormones to promote a more favourable environment for implantation and early embryo development. Other research is looking at whether genetic factors could explain why some women are susceptible to pregnancy loss. For example, researchers working with mice have discovered that a defect in the genetic coding for a protein usually present in the uterus lining, resulting in a lack of the protein, may be preventing implantation. A similar mechanism may be at work in some women who have difficulty establishing a pregnancy.

In addition, as part of IVF procedures, zygotes are examined under a microscope to identify which are most likely to implant and develop successfully. Research into this process could help improve the effectiveness of IVF as well as promote successful implantation and embryo development in women who can conceive but have a history of miscarriage early in pregnancy.

Conclusion

Almost nine months of embryo and then fetal development follow the complex processes of ovulation, fertilization, development of the zygote, and implantation. The complexity of this process — as an entire human being develops from the joining of two cells — makes it open to the risk of errors

and dysfunction. In fact, only half of all fertilized eggs survive embryo and fetal development and result in live births. The remainder are lost sometime between fertilization and the end of pregnancy, many of them before implantation and many within the first few weeks after implantation.

As we learn more about the human reproductive process, respect for its beauty and complexity increases. Studying human reproduction brings us into direct contact with the intricacy of our genetic make-up. Human development is the result of continuous interaction among more than 100 000 genes, many environmental factors, and many social and emotional experiences. Studying reproduction and the genetic mechanisms that shape the origins of life contributes to our understanding of the complexity of the human experience.

Even with the technologies and diagnostic capabilities developed since the 1970s, many aspects of human reproduction remain little understood. For example, some cases of infertility cannot be explained, even after investigation using the latest diagnostic tools. Another example is mutations, which can occur, for reasons not fully understood, when cells divide and expected replications of gene sequences do not occur. The examples are many but the point is the same: whatever our current level of knowledge about reproduction, many aspects are still understood imperfectly, incompletely, or not at all, and some may never be.

As this brief description has illustrated, human reproduction is intricate and unpredictable. Given everything that has to go right — at the right place and the right time — for fertilization to occur and then for fertilization to lead to the gestation and birth of a healthy child, the wonder is not that the process often fails but that it succeeds as often as it does. Even when all their systems are functioning normally, the chances that a healthy, fertile couple will conceive during any monthly cycle are only about 20 to 25 percent. For some 7 percent of Canadian couples, however, the chances are much lower. The many factors that can intervene to prevent conception and successful gestation are the subject of the next chapter, in which we examine the prevalence, risk factors, and prevention of infertility.

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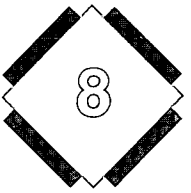


Infertility: Prevalence, Risk Factors, and Prevention — Introduction

The inability to have children is not a trivial matter. The Commission found a great deal of evidence of the value and importance Canadians attach to having children:

- In our survey of values and attitudes, we asked Canadians across the country to rank the importance of various aspects of their lives. They responded that their family and partner were by far the most important — more important than career, religion, ethnic background, or education, for eight out of ten people surveyed. So it is not only people who are infertile who think having a family is important.
- During our public hearings and private sessions, we heard from many individuals and couples who are infertile about how not having children has affected their lives. Participants in our private sessions explained eloquently how they felt without children. One woman said, "You have no future; nobody would know you were here," while another said, "You have lost your place in the chain of life." They talked of how infertility is not a one-time event or condition, something you adjust to and then move beyond. There are constant reminders throughout the life cycle, as the children of friends go to school, graduate from college, marry, and have their own children. So many landmarks and events in our lives together reflect connections to the next generation and a future from which many people who are infertile feel cut off.

Infertility touches the daily lives of many thousands of individual Canadians. Infertility has a strong collective aspect as well, however, and therefore requires a collective response from society. Given its importance to Canadians, the Commission concluded that a responsible and caring

society should seek ways to recognize and support the desire of individuals and couples to have children. One way of doing so is to gain a better understanding of infertility in order to prevent it if possible.

At the same time, we cannot lose sight of the needs of those who are already infertile; this aspect is dealt with in the section on assisted conception (Chapters 18 to 20). Indeed, most attention to date has been given to those who are already infertile. The Commission heard time and again, however, that preventing infertility in the first place would be a more cost-effective and humane approach than using technology to circumvent it later. Consistent with the ethic of care, avoiding harm where possible is also the more ethical approach. Consistent with our guiding principles, prevention could also offer a means of making wiser use of public resources. The knowledge on which to base a greater emphasis on prevention, however, remains imperfect, incomplete, or in some respects absent altogether.

In Chapter 3, we showed how our ethical stance is predicated in part on preventing or avoiding crises where possible, instead of reacting after they occur. Embracing this perspective makes it imperative to reduce the proportion of individuals who become infertile in the first place, rather than relying on reproductive technologies to assist them after they have become infertile. We do not have the knowledge to prevent all infertility, but if policies and programs were in place to reduce exposure to factors known to jeopardize fertility, we could potentially reduce the proportion of people who find themselves unable to conceive, carry a pregnancy to term, or have a healthy child. Throughout the Commission's public hearings, it became evident that Canadians share this view and want more emphasis placed on a preventive approach to infertility.

> We must, in Canada, prevent involuntary infertility in our youth and young adults rather than focusing exclusively on the provision of costly technologies to achieve a pregnancy.
>
> *R. Grover, private citizen, Public Hearings Transcripts, Edmonton, Alberta, September 13, 1990.*

Gaining a full understanding of infertility is challenging, and, as will be seen, the task is far from complete. What we found at the start of our work, however, was a daunting lack of available knowledge and data on the prevalence, incidence, and causes of infertility. No research had ever been conducted to determine the extent of infertility in the Canadian population: most studies that had been conducted focussed on fertility rather than infertility. Although there was some awareness of and some data were available on the role of some factors in causing infertility, there was much less concrete evidence on the role of other factors. Programs to prevent infertility, where they existed, had rarely been evaluated to see what strategies are in fact effective with various groups or categories of people.

> In order to have a clear picture of the issue of reproductive technology, we must collect data on the incidence, prevalence, diagnosis, and treatment of infertility.
>
> *M. Joe, Minister Responsible for the Status of Women, Government of the Yukon, Public Hearings Transcripts, Whitehorse, Yukon, September 11, 1990.*

Given the dearth of information, the Commission had to go back to the beginning, to assemble a knowledge base from which we could analyze the current situation and reach conclusions about the best course of action for individuals and for society. For the first time, then, the Commission developed an estimate of the prevalence of infertility in Canada. For the first time, we assembled a data base of research related to established and emerging risk factors for infertility. For the first time, we linked specific risk factors with strategies for their prevention. And, for the first time, we developed a strategy for incorporating infertility prevention into the wider framework of disease prevention and health promotion programs in Canada.

As we outlined earlier, we took a broad, multidisciplinary approach to our work. Our understanding about infertility was informed by the research we commissioned, as well as the relevant literature. We gathered information from historical, legal, sociological, and economic sources and integrated our findings with research from the biomedical disciplines. Extensive research helped to broaden our understanding of the physiological aspects of infertility. At the same time, the testimony of the many people who spoke to us during the public hearings or in private sessions gave us an appreciation of the profound social and psychological impact of infertility. We were moved by, and are grateful to, the people who spoke to us about their infertility. For many, it was the first time they had spoken of it in public, and we recognize the tremendous courage this took.

Consistent with our commitment to viewing our mandate through the prism of Canadian social values and attitudes, a collective response to infertility requires an understanding of its social context. Because infertility has both individual and societal aspects, it must be responded to at a collective level. This response is conditioned by how widespread the problem is perceived to be; thus, Chapter 9 examines the prevalence of infertility in Canadian society.

The risk factors for infertility are numerous, and we examine the factors that place individuals at risk. One of the most striking aspects of our investigation into the causes of infertility was the lack of definitive knowledge in this area. The immediate physiological cause of infertility, such as an ovulation disorder in the woman or abnormal sperm characteristics in the man, can often be identified. The underlying reason for the disorder is very often difficult, or even impossible, to determine, however, because the factors that may lead to infertility are both complex

and inter-related. The reproductive status of individuals is influenced by many considerations, such as their medical history, their everyday habits or choices — such as diet or use of tobacco, alcohol, or drugs — their age, or exposure to conditions or agents in the workplace or environment. Often these factors occur in combination. When two individuals come together to conceive a child, they bring with them their exposures to these various factors at different times over the course of their lives.

Risk factors are diverse and based on broader and often quite distinct areas of biomedical or sociological research and attendant research disciplines and methodologies. For example, the analysis of the relationship of weight, eating behaviours, and exercise as these concerns relate to fertility comes out of broader considerations about the very complex relationships between exercise, eating disorders, and weight control, an area of considerable research in its own right. Similarly, any examination of either environment- or workplace-related risks to fertility almost certainly moves into the field of toxicological research, an enormous area of biomedical research.

> Because of the scope of the problem, we must invest quickly in the search for new ways of treating and preventing infertility and for new effective means of contraception which are far less harmful to women's health. [Translation]
>
> *L. Marquis, Fédération des femmes du Québec, Public Hearings Transcripts, Montreal, Quebec, November 21, 1990.*

It became clear that what was required was an approach that attempted to take a global perspective on all relevant risk factors. Commissioners concluded that it would not make sense to advance knowledge on any one potential risk factor if this information were not placed in a context, namely, the attempt to understand infertility in a broadly encompassing fashion. Given the extraordinary scale of risk factors as a group requiring research attention, Commissioners were under no illusions about what could be accomplished during the mandate of the Commission. There is simply too much that is not known for this Commission to provide definitive answers about either the incidence or prevalence of specific risk factors or about the relative importance of these risk factors in relation to infertility. Commissioners believed, however, that a strong start could be made in the direction of approaching risk factors in a broadly encompassing fashion through the commissioning of analytic studies and overviews of existing research. In this connection, Commissioners recognized that adopting a deliberately global approach to risk factors potentially affecting fertility would encourage the integration of research now being pursued by various academic and medical disciplines on different risk factors, often in isolation from one another. The following

chapters are the result of that determination to approach the risk factors affecting fertility in a comprehensive and integrated fashion.

Another issue for the Commission was the lack of scientific and medical attention to male infertility. Although researchers have made great strides in recent decades in extending what is known about male reproductive function and infertility, they continue to receive less emphasis than the female reproductive system. Yet a survey of fertility clinics conducted for the Commission showed that in about one-quarter (24 percent) of couples who seek infertility treatment, the male partner has a condition that makes conception difficult or impossible. It is difficult to attach exact figures to the proportion of infertility that is attributable to either the male or the female member of a couple, however, because in a substantial proportion of couples (26 percent) no abnormality is detected, even after thorough evaluation; these couples are "diagnosed" as having unexplained infertility. Nevertheless, the available data suggest that male infertility plays a substantial role in the inability of many couples who are infertile to conceive.

> The investigation of male infertility has lagged tremendously behind the investigation of female [infertility]. My personal viewpoint is that this has been the result of men believing the problem was always their wives.
>
> ... for years and years the wives were sent to the fertility clinics. That attitude has changed in the medical profession ... but I believe this is true in most infertility clinics ... we're not prepared to go on and do invasive investigations on the wife, unless the husband has been adequately investigated.
>
> *R. Reid, Society of Obstetricians and Gynaecologists of Canada and Canadian Fertility and Andrology Society, Public Hearings Transcripts, Montreal, Quebec, November 22, 1990.*

The Commission's objective was to gain an understanding of the range of factors that can make it difficult for people to have children. In general, data about the effects on men were much less available than information about the effects on women, primarily because of the greater emphasis on women's inability to conceive. A historical review conducted by the Commission found that, despite early recognition that some men were sterile, doctors focussed overwhelmingly on female infertility during the period between 1850 and 1950, neglecting the possible role of the man in the couple's inability to conceive.

From the data that were available, we found that there is a relatively clear relationship between infertility and the risk factors of sexually transmitted diseases (STDs), smoking, and aging. The association is less clear between infertility and factors such as most occupational or environmental exposures (although some specific exposures are clearly

documented to be causal), medical interventions, diseases such as endometriosis, or personal factors such as alcohol or drug use, weight, exercise, and stress; however, there is enough evidence to warrant attention. The Commission is also aware that there is still a great deal to be learned about risk factors, so that new risk factors may emerge as our knowledge base broadens.

> Also in prevention there are a number of factors that have to be looked at. There has to be political will, there has to be professional will and there has to be funding, and in order for prevention policies, action plan strategies to be implemented there has to be compliance from the community.
>
> *J. Fontaine, Women's Health Directorate and Women's Directorate, Public Hearings Transcripts, Winnipeg, Manitoba, October 24, 1990.*

As part of our investigation the Commission also examined means of preventing exposure to these risk factors. Current efforts to reduce the prevalence of sexually transmitted diseases and of smoking among Canadians must be reinforced and extended, but programs and policies must also be developed to address the other risk factors we have identified.

The extent to which we are lacking a national infertility prevention policy or strategy in Canada soon became evident from our examination of prevention of specific risk factors. Current policies and programs to address reproductive health are fragmented and disjointed, reflecting decentralized roles and responsibilities of key participants such as provincial and federal governments, educators, and others with expertise and an interest in promoting reproductive health generally and preventing infertility in particular. It is evident that a national approach is needed if real progress is to be made in preventing infertility. In the final section of Chapter 15, therefore, we outline a national response to preventing infertility and highlight priority areas for action. We examine how an initiative at the federal level could be coordinated with existing federal initiatives such as programs to promote healthy lifestyles or to encourage youth not to smoke or use drugs. We show how such an approach would recognize and

> In some areas such as prevention and promotion, Canada's current approach is a dismal failure. We put significant resources into treating infertility but we really make negligible efforts in areas such as sex education campaigns to decrease sexually transmitted diseases which we know heighten the risk of infertility. This is unconscionable in our view. We believe that a national priority must be given to health promotion and prevention programs to address the known causes of infertility.
>
> *A. Baumgart, Canadian Nurses Association, Public Hearings Transcripts, Ottawa, Ontario, September 20, 1990.*

support other programs and address the need for coordination and involvement of federal and provincial governments, health care professionals, educators, and other key partners in prevention. A national response that makes a difference will require the participation of all of these partners.

Our findings with respect to infertility helped to inform our understanding of the possible place of new reproductive technologies in Canadian society. The discussion in this chapter therefore also provides a context for subsequent chapters dealing with specific technologies.

> Nevertheless, more consideration needs to be given to the causes and prevention of infertility. Some of the causes of infertility stem from our social and interpersonal practices. Therefore, preventative programs must emphasize the personal, social and biological causes and consequences of infertility.
>
> *M. Gault, Manitoba Advisory Council on the Status of Women, Public Hearings Transcripts, Winnipeg, Manitoba, October 23, 1990.*

The Social Context of Infertility

Human reproduction is among the most important and complex of human activities, both for individuals and for society as a whole. The process of reproducing ourselves is commonplace, yet it is biologically and socially complex. Any study of infertility has to begin with an understanding of the two aspects of reproduction — biological and sociological. These two aspects have always been intertwined, whether through perceptions and attitudes about parenthood and family, through social practices and taboos, or through public laws concerning, for example, marriage, adoption, homosexual relationships, filiation and legitimacy, abortion and contraception, prostitution, polygamy, and adultery.

As described previously, reproduction is at once a fragile and robust process. All species have a drive to reproduce; it is essential to their survival. Different species have evolved different reproductive strategies. Some species produce many young, increasing the odds of a few surviving to adulthood. Other species have evolved a different approach, with higher rates of loss before birth but relatively more invested after birth to ensure that those who are born do survive. Biologically, human beings fall into the second category; as we have shown, events can occur at many points in the reproductive process that preclude the possibility of a live birth. Thus, although reproduction is indeed "natural," it is increasingly clear that it cannot be taken for granted by individuals or by society. As we heard numerous times in our public hearings and private sessions with Canadians, what is natural and simple for some people can elude and frustrate others. Part of the frustration arises because of the social context

within which reproduction takes place — one in which having children is considered a normal and desirable part of life. Before discussing the prevalence, risk factors, and prevention of infertility, then, we need to situate infertility within this social context, examine how this context affects our definition of infertility and what this means for people who are infertile.

The Social Meaning of a Biological Process

Our discussions with Canadians showed the drive to reproduce is no less complicated than the process itself. Responding to the Commission's national survey on values, for example, 77 percent of Canadians with children said they had felt a need to have children, even though most were unable to articulate just why. Overall, equal numbers of men and women reported a desire to have children, although women were more likely to report a "strong desire." At the time of the survey, 71 percent of respondents between the ages of 18 and 55 had children; 16 percent had no children but would like to have children in the future; and 10 percent had no children and did not intend to have any in the future. Three percent had no children and did not respond.

> We cannot over-emphasize how important we consider it that we dedicate sufficient collective resources to identifying and resolving the root causes of ... [infertility] ... rather than to treating the symptoms. We do know some of the causes that lead to infertility but we need to understand a lot more in order to be able to address them at their roots.
>
> *M. Eichler, Feminist Alliance on New Reproductive Technologies, Public Hearings Transcripts, Toronto, Ontario, November 20, 1990.*

The reproductive drive is likely innate, but in human beings this drive is socially shaped as well. The desire to become a parent is not well understood. How much of the deeply felt urge to bear children is inborn, and how much is created by societal expectations about appropriate roles and behaviours, are fundamental questions. It is obvious that social construction plays an important part in the desire to become a mother or a father. Regardless of its genesis, our survey showed that having children is of great importance to most Canadians. The three most important reasons for having children, according to respondents to our survey, are "It is a necessary part of life," "It's just something I expected to do," and "To help a child grow and learn."

It was also clear from our consultations that parenthood, and hence childlessness, have different implications for women and men. Women

have been seen traditionally as mothers and nurturers of children; womanhood has been viewed in terms of being able to conceive, carry a pregnancy, and deliver a child. Society has expected women to become mothers and has relied on them to raise children. This definition of women's role — which often obscures their other roles and contributions to society — became more entrenched after the Industrial Revolution and the shift to a wage-based economy, where paid work was separated from the home. The home became defined largely as the place of family and the place of the woman, despite the continuing and increasing importance of women in the workforce. By contrast, men have usually been defined in terms of their other roles.

The availability of the first reliable contraception methods played a major role in showing that childbearing is not always inevitable. Today, the greater availability of contraception has enabled women to pursue new options and helped to highlight women's other roles. Even so, most people still consider having children part of the "natural" progression of adult life. Becoming a parent is usually deemed to be synonymous with growing up and acting responsibly. Some religious doctrines also emphasize openness to procreation as a vital part of the marriage commitment between husband and wife.

> Since infertility is defined as the inability to reproduce, it calls into question our very *raison d'être* as a person and as a couple. This phenomenon becomes apparent only when we confront it. Therefore, it should come as no surprise if infertility sparks emotional responses from couples, families, friends, colleagues, the medical profession and society in general. The vast majority of fertile people cannot begin to imagine the pain experienced by infertile couples and what drives them to seek treatment which offers them hope. [Translation]
>
> *Brief to the Commission from l'Association Québécoise pour la Fertilité Inc., November 22, 1990.*

Having children links generations within families and helps to ensure continuation of one's name, values, and genes. The Commission heard from childless couples who spoke eloquently about feeling cut off from the future. The effects of childlessness are felt strongly at all stages of life, not just during the childbearing years.

Given these attitudes toward having children, the inability to have children cannot be dismissed as inconsequential. For many people, the experience of not being able to have children triggers complex and powerful emotions. There is often a loss of self-esteem mixed with feelings of grief, anger, and sometimes guilt about the source of the infertility. Many also experience a sense of isolation from family members and friends. People told us that infertility is not something that is easy to deal with and move on from, because having children is so firmly embedded in the everyday social and family interactions in which most of us take part. As friends and

siblings go through life, milestones in their children's lives — school events, graduations, weddings, the birth of grandchildren — continuously remind those without children of their childlessness. Coming to terms with the inability to have children is not something that can be dealt with once and then left behind.

A psychologist who counsels couples who are infertile explained to the Commission:

> One thing that I've learned through my work is that it is almost impossible to understand what it is like to be infertile, to grasp the profound impact of infertility, unless you personally have been in the position of wanting to conceive a child and have been unable to do so ... I have, since having worked with several hundred infertile couples, learned that loss of control, deteriorating relationships, increases in sick leave, inability to make career changes because of separation from the infertility clinic, lost friendships, depression, and marked deterioration in self-esteem are the hallmarks of the infertility experience. (*P. Gervaize, Reproductive Health Psychologist, Public Hearings Transcripts, Ottawa, Ontario, September 18, 1990.*)

The issue of how to define infertility — whether it should be viewed as a medical condition or as a social condition — continues to provoke considerable debate among Canadians, as it did during our public hearings. This is an important question; how we define infertility has implications for such issues as whether and how the problem can be prevented, whether the cost of medical treatment for infertility should be covered by provincial health insurance, and whether non-technological solutions to help people deal with infertility should be made available.

One view is that infertility has a physiological cause and should therefore be viewed as a medical condition. A representative from the Edmonton-based Fertility Management Services told us: "Infertility is not a disease insofar as it can be caught from somebody else who has it. But if a broken leg can be considered a disease, then infertility is a disease too, because it's something that's not functioning." A professor of medicine from the University of Alberta offered a similar view: "The reproductive system is part of the body. If you define disease as a malfunctioning of any system ... then clearly infertility is a disease."

Defining infertility as a medical problem suggests that medical treatment is the appropriate response. One woman who spoke to us during the public hearings explained: "I have viable ova and my husband has viable sperm. The difficulty is that one of the parts of the system, specifically the fallopian tubes, is not functioning properly. That is a physical disability. It is a medical problem that can be addressed by medical science."

Another way of looking at infertility is as a social condition. Some who see infertility as a social phenomenon argue that the need to have children is determined largely by social attitudes; in this view the painful consequences of childlessness result mainly from social pressures on

couples to have children and from the lack of alternatives for those unable to have their own biological children. If childlessness were more acceptable, they suggest, or if adoption were an accessible alternative, people would find it easier to come to terms with being infertile and would be less likely to see childlessness as a problem.

> I want to suggest that the stress felt by infertile women does not occur in a vacuum. It is societally formed. A married woman who doesn't have a child is pressured to feel less than a woman. But if a single woman wishes to have a child, that's a very different matter. If a lesbian woman wishes to have a child, she may be considered unhealthy for the very wish that would make her married sister appear healthier if she were successful in conceiving. This contradiction illustrates the extent to which these things have much less to do with physiology and much more to do with societal presuppositions.
>
> *Theme Conference on the Impact of New Reproductive Technologies on Women's Reproductive Health and Well-Being, Transcript, Vancouver, British Columbia, July 31, 1990.*

Society does generate pressures to have children: for example, as we have noted, most Canadian couples see having children together as a necessary or highly desirable part of marriage. This attitude is communicated indirectly in many ways, ranging from the casual comments of friends and family to the images conveyed by the mass media and advertising. Our literature review and our survey of Canadians' values and attitudes confirmed that social perceptions — such as the belief that couples who choose not to have children are abnormal or selfish, that "they do not want to give things up" — make it more difficult for people who are infertile who have been trying to conceive for a long time without success to reconcile themselves to remaining childless. Nonetheless, the concern that pressure from spouses, family, and friends is an important factor in their desire for infertility treatment seems, from our survey results, to be unfounded. Indeed, many people who are infertile told us that those close to them do not consider infertility as serious a problem as they do, telling them that life without children is acceptable, when the couple themselves do not feel that way.

Defining infertility as a socially generated problem implies that we should look to social solutions. Those who see infertility this way believe that societal attitudes must change, for example, to be equally accepting of those who cannot have children or choose not to. From this perspective, remaining childless should be considered an equally acceptable and socially approved choice, so that couples feel free to choose that alternative and to decide, for example, not to seek a medical solution for their infertility.

The distinction between the innate need and societal expectations to have children remains unclear, however. Commissioners believe that both the physiological and the sociological dimensions of infertility must be

addressed, because both are important and they are often inter-related. In fact, medical treatment of infertility is used for social reasons quite frequently. For example, in a substantial proportion of cases, a woman is fertile but cannot conceive with her partner because he lacks viable sperm. If she is to be considered infertile, and thus eligible for medical assistance, it must be on the grounds that the couple, not the individual, is infertile. Yet this is in fact a social, not a medical, reason for providing a medical service — she has no fertile male partner; medical services provide sperm for her. It is evident, then, that social and medical considerations are very much intertwined.

In the Commission's view, therefore, it is important to deal with the social consequences as well as the impact on individuals; a caring society recognizes that both medical and social factors are at work and require both medical and social responses. A caring society that empathizes with the desire of people to have children, and recognizes the importance of children in most people's lives, will therefore take steps to prevent infertility where possible. At the same time, for those who face childlessness despite these efforts, a caring society will make other options available, either to help them have children, or to come to terms with childlessness.

The Commission heard from many individuals who have wrestled with these issues in making decisions about the kinds of lives they would lead. Some individuals and couples who are infertile told us of difficult and often deeply frustrating experiences. Others came forward to talk with great serenity about their decision to live without children.

A caring society also acknowledges the collective importance of children. The importance of children to society is emphasized in some concrete ways, such as universal public education. Although society encourages women to have children and it is the expectation that most women will have children, other social supports that would make child-rearing an easier choice — such as adequate and affordable child care — are not always in place. Thus, there is ambivalence about the importance of children and their role in society.

Social change, bringing with it greater acceptance of diverse choices in lifestyle, has made us more aware of how different people are affected by the societal norms surrounding childbearing. The pressures may be felt equally, though in different ways, by people who wish to have children but are infertile, those who choose not to have children, and those whose living arrangements society tends to regard as inappropriate for child-rearing — single people living alone and individuals living with a partner of the same sex.

Despite its social dimensions, understanding the physiological aspects of infertility — that is, the medical conditions that may impair the ability of men and women to have a healthy child — is necessary for two important reasons: to determine the appropriate role of medical treatment in helping people who are infertile to have children, and to identify and develop preventive measures. Understanding the social aspects of

childbearing and infertility provides a context in which to understand how the prevalence of infertility may be defined in order to measure it, the factors that increase the risk of infertility, and how to prevent exposure to these risk factors with the goal of preventing infertility where possible. These issues are dealt with in Chapters 9 to 15.

The Underlying Causes of Infertility

Understanding the underlying causes of infertility is complex, because people's reproductive health is influenced by many factors, including their medical history, everyday habits and choices, their age, and exposure to conditions or agents in the workplace. Some of these factors can have immediate effects, while others may have consequences years later. Some factors may have effects that are compounded or exacerbated by the presence of other factors. Another difficulty is that although the effects of a particular factor may be quite evident in its most severe form, even with well-designed research it is difficult to determine the effects, if any, of mild or moderate exposure. A further complication is the fact that two individuals are involved in conceiving a child, and each may have been exposed to different factors at different times in their lives. Because of all these complexities, it is generally difficult to determine a linear sequence of cause and effect between an individual's exposure to a particular factor and infertility. For that reason, the term "risk factors" for infertility is often more appropriate than "causes of" infertility. It should also be remembered that not all infertility is preventable; for example, some women are born without fallopian tubes or a uterus, and men may also be born with anatomical anomalies that render them infertile.

To gain an understanding of risk factors for infertility, the Commission conducted an extensive investigation of the scientific literature published in Canada and internationally, to investigate the following list of factors:

- sexually transmitted diseases
- smoking
- delaying childbearing
- exposure to harmful agents
  - (a) in the workplace
  - (b) in the environment
- personal and medical factors
  - (a) alcohol and substance use
  - (b) weight, eating disorders, exercise, and stress

(c) medical intervention

- unintended consequences of medical intervention
- sterilization
- contraception

(d) endometriosis.

Our ranking of the risk factors is not definitive, but it indicates where we conclude, after weighing various aspects, that efforts to prevent infertility should be focussed. We believe, for instance, that sexually transmitted diseases and smoking should be highest priority, because of the risks they pose, the number of Canadians in their reproductive years who are exposed to these risk factors, and the feasibility of preventing or controlling exposure to them. At the other end of the list, although endometriosis, if severe, may cause infertility, its cause and how it could be prevented are unknown, and it is therefore not possible to develop strategies to prevent it.

We found there is evidence to show that all these factors may have adverse effects on female fertility given sufficient exposure, and thus they constitute risk factors. Data about the effects on male fertility were much less available than data about the effects on female fertility. This is disturbing in view of the proportion of couples whose fertility problems can be traced to the male partner.

One of the Commission's goals in this area was to assess the relative importance of each risk factor in terms of its contribution to infertility in Canada and the feasibility of preventing and controlling individual exposure to it. Such an assessment is needed to give policy makers a sense of where prevention priorities should lie. This proved impossible to do in a definitive way, however, primarily because information about many of the risk factors was inconclusive, incomplete, or absent entirely. We found little or no information, for example, on the extent of individual exposure to many of the thousands of chemical agents found in workplaces and the environment. In other cases, although we know that severe exposure to a particular risk factor poses a threat to fertility, the evidence is insufficient to determine whether the factor harms fertility in the far more common mild or moderate exposures.

Nevertheless, to give some direction for prevention policy, we considered four aspects of the evidence: the quality of research data and the strength of the evidence about each risk factor; the seriousness of the risks associated with exposure to it; the estimated size of the population exposed; and the feasibility of preventing exposure. The result was a list (see above) showing where we conclude efforts to prevent infertility can best be focussed. We believe prevention efforts should look at sexually transmitted diseases and smoking in the first instance. The impact of age on fertility is less clear than the impact of smoking and STDs, and, in addition, this risk factor is more difficult to address, since delayed

childbearing may not be preventable, for example, in the case of partnerships formed later in life. Nevertheless, research suggests that women who delay childbearing until their later reproductive years face a moderate risk of infertility; this is something of which they should be aware as they make such decisions.

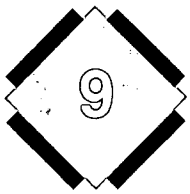
We believe that priority must be given to preventing infertility, rather than focussing only on medical interventions as a way to help individuals after they experience difficulties conceiving. Specifically, prevention efforts must focus on reducing the exposure of individuals to the risk factors we have identified, particularly when the means of accomplishing this are clear. Notwithstanding the complexities of the risk factors for infertility, the inter-relationships among them, and the diverse social, environmental, and occupational contexts within which they arise, this commitment to prevention must be an integral part of society's overall approach to dealing with infertility.

Specifically, prevention efforts must focus on reducing the exposure of individuals to the risk factors we have identified, particularly when the means of accomplishing this are clear.

Strategies to address the risk factors for infertility will also have substantial spin-off benefits for other aspects of health, because factors that affect reproductive health rarely have an effect on the reproductive system alone — they have important effects on other parts of the body as well. For example, reducing the proportion of people who smoke not only could reduce the number of couples who have difficulty conceiving but would also reduce the incidence of heart disease and lung cancer.

Placing greater emphasis on preventing infertility requires that we develop programs and policies to address the different risk factors for infertility that we have identified. This can be done effectively only if other avenues in addition to the health care system are used to address the problem. Educators, health care professionals, policy makers, employers, parents, and many others are key partners in developing strategies and programs to protect the reproductive health of Canadians. Strategies must be diverse and multifaceted, reflecting the complexities of the risk factors they are designed to address and the diversity of the individuals and population groups they are intended to reach.

In Chapters 10 to 14, we describe how exposure to each of the risk factors we have listed can affect the ability to conceive, to carry a pregnancy to term, or to have a healthy child. We also recommend a range of initiatives to prevent individuals from being exposed to factors that may put their fertility at risk.



Prevalence of Infertility

One of the principal tasks facing the Commission was to establish how common infertility is in Canada. Because there has been no Canadian research designed specifically to measure the prevalence of infertility — that is, the proportion of all individuals or couples who are infertile at a specific point in time — we did not know what the rate of infertility is in this country, or whether it has been rising, declining, or remaining stable.

Many Canadians believe that infertility affects a substantial proportion of the population. This perception may result in part from the fact that there is less secrecy surrounding reproduction and fertility than in the past, with people becoming more open about their infertility. A national survey conducted for the Commission found that 43 percent of those surveyed knew someone in their immediate family or among their friends who had experienced an infertility problem. This tells us little about the actual prevalence of infertility, but it does show why Canadians believe the problem is widespread. On the other hand, we also heard the view that infertility has not increased significantly over time. These contrasting views clearly underscore the importance of knowing what proportion of couples in Canada is affected by infertility and whether this is changing.

> Planned Parenthood Alberta wishes to make the following recommendation ... that research be undertaken to determine the actual incidence of infertility in Canadian couples of childbearing age, as well as of the causes of this infertility.
>
> *P. Webb, New Reproductive Committee, Planned Parenthood Alberta, Public Hearings Transcripts, Calgary, Alberta, September 14, 1990.*

This information is an essential basis for Canada's response to infertility. Policy and resource allocation decisions must be premised on the best available information about the prevalence of infertility, as a prerequisite for deciding what emphasis should be placed on understanding and preventing infertility as well as what resources should be devoted to these efforts and how health care resources should be allocated to treat people who are infertile. Thus, our findings on prevalence have an impact on our conclusions and recommendations with respect to infertility treatments in the next chapters.

We took up the challenge of assessing the prevalence of infertility in Canada in two ways. We developed a research approach that involved conducting three national surveys and synthesizing their results to generate a reliable estimate of infertility among Canadian couples. We reasoned that if there was congruence among the findings of the three surveys, it would be evidence that the figures were reliable. In addition to this original research, we conducted a secondary analysis of data from three surveys done for other purposes during the 1980s, comparing estimates of the prevalence of infertility derived from this secondary analysis with our own results.

As a result of our work, we know the prevalence of infertility in Canada for the first time: 8.5 percent of couples — some 300 000 couples — who were married or had been cohabiting for at least one year at the time of our survey, and who had not used contraception during that period, failed to have a pregnancy, while 7 percent of couples — some 250 000 couples — who had been married or cohabiting for at least two years, and who had not used contraception during that period, failed to have a pregnancy.

This information will remain one of the Commission's enduring legacies, not only for what it tells us about the number of people affected by infertility at a given point in time, but also because it provides a baseline against which future researchers can track the prevalence of infertility in the Canadian population. How we arrived at our definition of infertility for the purpose of estimating prevalence, as well as the methodology we used to establish this estimate, are presented in greater detail in later sections of this chapter.

Our estimate is considerably lower than the 15 percent figure commonly reported in the media. However, such media reports are based on a fundamental misinterpretation of the U.S. survey results that were the source of the 15 percent figure. Those surveys did not show that 15 percent of *all* couples are infertile, but that 15 percent of couples *who have not been surgically sterilized* are infertile. This difference is significant, because large numbers of Americans and Canadians choose surgical sterilization as their contraception method. As we discuss in this section, when the U.S. survey results are calculated appropriately — that is, *including* people who have been surgically sterilized — the U.S. infertility rate is close to the Commission's estimate for the infertility rate in Canada.

Commission Research

Until the Commission began its work, data measuring the prevalence of infertility in Canada were extremely limited. Periodic national surveys to gather information on reproductive issues such as infertility, sterilization, and contraceptive use have not been carried out as they have been in the United States. The first and only large-scale national survey devoted exclusively to the reproductive behaviour of women in Canada was the Canadian Fertility Survey, conducted in 1984. Since then, the only sources of data have been two surveys — the Ontario Health Survey (1990) and Canadian General Social Survey (1990) — which have focussed on other topics but included a few pertinent questions. Because these studies were not designed specifically to measure infertility, questions arise about the reliability of estimates based on them.

The Commission considered two ways of estimating the prevalence of infertility in Canada: conducting one large-scale national survey, or piggy-backing onto three smaller independent surveys that were already being conducted for the Commission by Canada Health Monitor and Decima Research. We chose the latter method, for several reasons. It was less expensive and more feasible in the time frame the Commission had available. In addition, if the three surveys gave similar results, we would have strong evidence that both the definition of infertility we had adopted and the results were highly reliable; we would have confirming evidence that the infertility rate generated by aggregating the results of the three studies was a valid estimate. A pivotal aspect of ensuring that the three surveys, taken together, would generate a reliable estimate of the prevalence of infertility was the development of an appropriate definition of infertility for this purpose.

How We Defined and Measured Infertility for the Population Surveys

As we have seen, views vary on how infertility should be defined. It is also evident that somewhat different definitions will be needed for different purposes. For example, the definition of infertility for purposes of conducting a population survey may differ legitimately from the definition used to determine eligibility for an *in vitro* fertilization program. Clearly, deciding who will be counted as infertile influences society's response to infertility: a narrow definition, encompassing fewer people, might mean that infertility is given a lower priority by policy makers, while a wider definition could result in higher priority and more resources being devoted to infertility.

The definition of infertility used to develop population estimates and to track changes in the prevalence of infertility over time must be both

measurable and reproducible. For purposes of estimating the prevalence of infertility we considered three factors: (1) the endpoint to be measured (should we measure failure to conceive, failure to have a recognized pregnancy, failure to carry a pregnancy to term, or failure to give birth to a healthy child); (2) the period of time after which couples would be considered infertile; and (3) the population of interest.

Endpoint

For our population survey on infertility, we adopted the most commonly used endpoint — the absence of pregnancy — because using this standard definition would allow us to compare our findings with those of other studies. Alternative definitions of infertility are certainly useful for purposes other than population surveys; for example, in investigating the impact of various risk factors on the entire reproductive process, we broadened our definition to include failure to carry a pregnancy to term and to give birth to a healthy child. The birth of a healthy child is also a relevant endpoint for other research questions and for Canadians generally, who see the goal of infertility treatment as the birth of a healthy child. Similarly, the inability to conceive is a relevant endpoint in research into the causes of infertility. Such definitions are difficult or impossible to use, however, in estimating the prevalence of infertility in a population. For example, it is difficult to assess the ability to conceive, because miscarriages often take place before a woman knows she is pregnant, and miscarriages very early in pregnancy are usually not even recognized as such. Assessing infertility reliably when it is defined as failure to give birth to a healthy child also presents difficulties, because what constitutes a "healthy" birth is subject to varying interpretations, making it difficult to compare results. Given these factors, we chose as an endpoint whether pregnancy had occurred, as reported by respondents to the surveys.

Time Period

The next issue to be addressed was what time period to use in defining a couple as infertile. Infertility is not the inability to conceive at all (sterility), but rather the reduced ability to conceive over time. Couples in which one or both members have chosen a form of sterilization such as vasectomy or tubal ligation are referred to as voluntarily sterile. Some infertile couples will never conceive over their reproductive lifetimes (we refer to them as involuntarily sterile). Other couples, labelled as infertile, may eventually become pregnant without intervention. In other words, there is no specific point in time at which a couple trying to conceive ceases to be fertile and becomes infertile. To estimate the prevalence of infertility, researchers must therefore choose a time after which a couple who has not had a pregnancy will be considered infertile.

The time frame chosen, though in one sense arbitrary, is important, because it affects the number of individuals and couples included in the definition. The choice of different time frames is based on differing perceptions of how long it should take a couple to conceive. Research suggests that a normally fertile, sexually active couple not using contraception has an average monthly chance of conceiving of 20 to 25 percent (counting only pregnancies that result in live births).[1] This average involves wide variability among couples, because couples differ considerably in their ability to become pregnant. Those who conceive most easily do so during the first few months of trying, so that as time progresses these relatively fertile couples are no longer counted as being among those trying to conceive, while the chances of conceiving for those remaining decline.

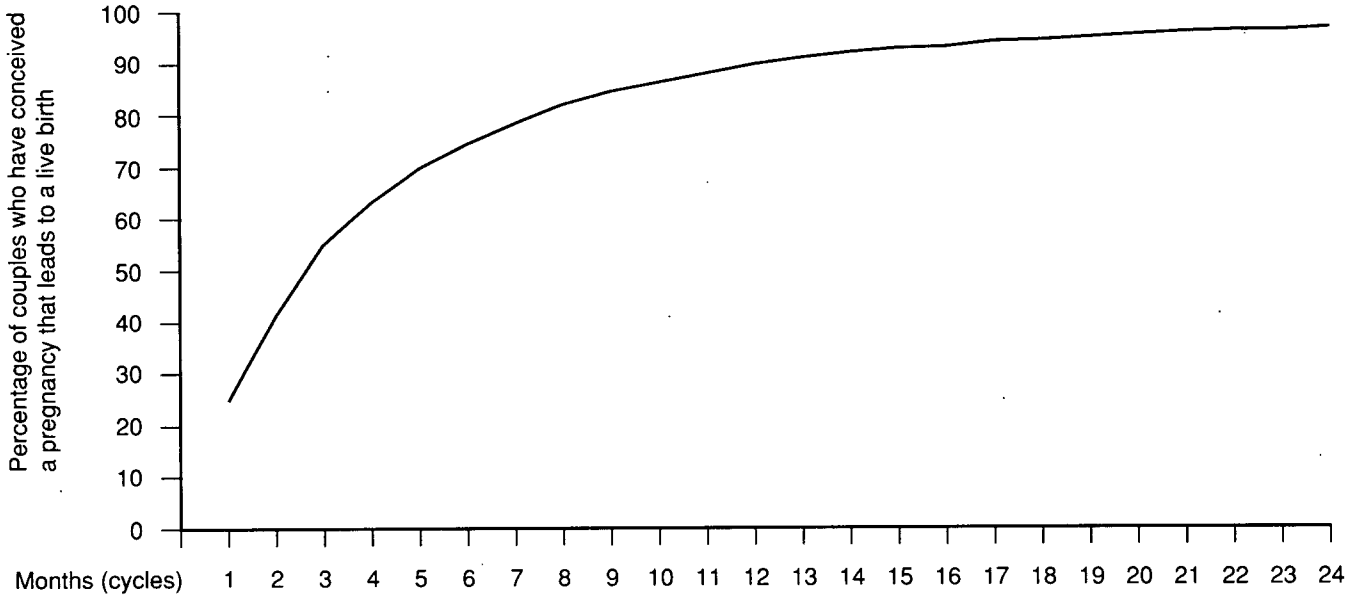
Figure 9.1 shows the cumulative percentage over 24 months who will have begun a pregnancy that leads to live birth, if it is assumed that no couples in the population are sterile.

The time frame used most often by North American researchers assessing the prevalence of infertility — and the one commonly used by the medical profession — is one year because, as we have noted and as Figure 9.1 shows, the majority of couples will have conceived by this time. The one-year definition is not universally accepted, however, because some couples who have not conceived after one year have a pregnancy during the following year. The World Health Organization (WHO) has chosen two years as its time frame for defining infertility, on the basis that the failure to conceive naturally after two years generally indicates that there is a low chance of a couple conceiving without intervention.

Given that a significantly smaller proportion of couples has a pregnancy after two years than during the first two years, we chose to follow the example of the World Health Organization and adopt the two-year definition of infertility. We have also included one-year figures, however, because this is the measure used most often in other studies and allows our findings to be compared with those.

As with choosing endpoints, the appropriate period for defining infertility varies with the purpose. For demographic purposes, such as determining prevalence in the general population, it is important to have one consistent and widely used measure. To decide when to begin medical treatment, however, the period may differ according to the treatment being considered, the age of the participants, and their medical history. A less invasive and intrusive treatment might be started before two years have elapsed, for instance, while physicians might encourage a couple to continue trying to conceive for a longer period before attempting a more invasive treatment such as *in vitro* fertilization. By contrast, older couples in which the woman has fewer reproductive years remaining may be considered infertile and eligible for treatment before two years have elapsed (see Chapter 20).

Figure 9.1. Cumulative Conception Rates Among Fertile Couples*



* For an explanation of how these rates were calculated, see the appendix in Léridon, H., and A. Spira. "Problems in Measuring the Effectiveness of Infertility Therapy." *Fertility and Sterility*, 41(4) (April 1984): 580-86.

Population of Interest

The final element of our definition was the population of interest — in other words, who would be counted. Historically, infertility definitions have focussed on women, in part because pregnancy, the main indicator of fertility, happens in the woman's body. Unfortunately, this focus tends to perpetuate the myth that infertility is the woman's problem, when in fact it may well be the man's problem instead or as well.

We chose to focus on couples, because the reason or reasons why conception has not occurred may lie with either member of the couple or with both. There are also practical reasons for focussing on couples in a survey. Concerns about infertility arise most often in the context of a heterosexual couple who want to have a child. In addition, it can be assumed that couples living together, if they want to become pregnant, have sexual intercourse regularly and do not use contraception.

We narrowed the population of interest further by restricting our definition to couples who had been married or cohabiting* for at least a full year or two full years at the time of the survey. This is because couples *currently* cohabiting may not have been doing so for the one year (or two years) required to meet our definition. Couples cohabiting for less than that period might not have been sexually active for the full year (or two years) in question; therefore, including them in the population to be counted could have had a distorting effect on the number of couples found to be infertile.

We found that about 5 percent of the couples surveyed had not been cohabiting for at least one year. These couples were therefore excluded from our calculation of the one-year estimate of infertility. We also found that an additional 4 percent of those surveyed had not been cohabiting for at least two years; these couples were excluded from our calculation of the two-year estimate of infertility.

Some limitations are inherent in focussing on couples. One is that a significant segment of the population that is of reproductive age is omitted from the estimates. For example, approximately 40 percent of women aged 18 to 44 are not living with a male partner at present and would therefore not have been included in our survey. Methods have been devised in the United States to expand the population of interest to estimate infertility among all women of reproductive age. Researchers in Canada may want to look at these methods when conducting prevalence research in the future. After consulting the researchers in the U.S. survey, the Commission decided not to take this approach. As we will see, however, U.S. infertility estimates do not differ significantly from those reached by the Commission.

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* For simplicity, all further references to cohabiting couples include both married and unmarried couples.

It should be noted that "couple," when used to define infertility, refers to heterosexual couples. We recognize that lesbians and single women might want to use reproductive technologies to pursue parenthood. By excluding them from the definition used for population studies we do not imply they should be excluded from access to services; these issues are dealt with in the next chapter on assisted human conception.

For purposes of estimating the prevalence of infertility in Canada, the Commission adopted two definitions of **infertility**:

The absence of pregnancy in a couple who have been cohabiting *for at least the past year* and who have not used contraception during that period.

The absence of pregnancy in a couple who have been cohabiting *for at least the past two years* and who have not used contraception during that period.

Methodology

Three telephone surveys were conducted across Canada in late 1991 and early 1992, with a total of 1 412 randomly selected women who had been cohabiting with their partner for at least one year.* Despite the focus on couples, the Commission surveys were based on interviews only with women. This is the usual practice in data collection on this topic, as it has been shown that women tend to provide more accurate answers about contraceptive use and pregnancy, both for themselves and for their partners. In each of our three surveys, the method of identifying infertile couples was identical. We asked questions to establish the following:

- Whether the respondent was a woman aged 18 to 44 who is part of a couple that has been cohabiting for at least one year/two years.
- Whether the respondent used contraception in the past year/two years, or if she or her partner had been surgically sterilized.
- Whether the respondent had been pregnant in the past year/two years.

Answers to the first question provided the denominator, which is made up of all couples who have been cohabiting or married for at least one year/two years and in which the woman is between the ages of 18 and 44. The second question was used to identify couples using contraception and those in which one or both members had been sterilized, to distinguish

* See Appendix 1 of this chapter for a brief description. Readers interested in more detailed descriptions of the methodology, data collection, and analysis should refer to the study in our research volume entitled *The Prevalence of Infertility in Canada* accompanying this report: C.S. Dulberg and T. Stephens, "The Prevalence of Infertility in Canada, 1991-1992: Analysis of Three National Surveys."

them from the group that would be considered infertile. The third question (in combination with the second) identified all those couples who had *not* used contraception and were *not* pregnant during the previous year/two years. This established the number of couples to be included in the numerator, that is, the number of infertile couples. The numerator therefore consists of all couples cohabiting for at least one year (two years) who had not been using contraception for that period and who had not become pregnant.

Table 9.1. Classification of Couples Who Had Been Cohabiting for At Least One Year

	Number	Percentage
Contraceptive users	546	38.7
Contraceptively sterile (tubal ligation and/or vasectomy)	592	41.9
Non-contraceptively sterile (e.g., hysterectomy)	45	3.2
Pregnant women	75	5.3
Non-contraceptive users:		
• Fertile (miscarried, had abortion, delivered a child in past year)	34	2.4
• Infertile	120	8.5
Total	1 412	100.0

Source: Calculated using data from Dulberg, C.S., and T. Stephens, "The Prevalence of Infertility in Canada, 1991-1992: Analysis of Three National Surveys," in Research Volumes of the Royal Commission on New Reproductive Technologies, 1993.

Results

The combined results of these three surveys showed that the vast majority (80.6 percent) of couples who had been cohabiting for at least one year either were using contraception or were voluntarily sterile (the female partner had undergone a tubal ligation and/or the male partner had had a vasectomy). In approximately 3 percent of couples, one or both partners were sterile for other reasons; this group included, for example, women who had undergone hysterectomies. These findings highlight the fact that, at any given time, only a small percentage of couples is trying to become pregnant.

Prevalence of Infertility Among Canadian Couples

The combined results of the Commission's three surveys indicated that 8.5 percent of couples in Canada who had been cohabiting for *at least one year* did not become pregnant after one year of not using contraception. This represents approximately 300 000 couples.

About 7 percent of couples who had been cohabiting for *at least two years* were not pregnant after two years of not using contraception. This represents approximately 250 000 couples.

Approximately 5 percent of couples who had been cohabiting for at least one year were pregnant at the time they were surveyed. The remaining 11 percent of couples had been cohabiting for at least a year and had not used contraception during the past year (see Table 9.1). Some of these couples had conceived but were not classified as pregnant because they fell into one of the following groups: (1) they had had a miscarriage; (2) they had delivered a child; or (3) they had had an abortion during the past year. Couples in these categories were considered to be fertile, while the remaining couples were classified as infertile.

We were encouraged to find that the three surveys produced very similar results, suggesting that the one- and two-year estimates of infertility generated by the combined results of these studies are reliable (Table 9.2).

Table 9.2. Prevalence of Infertility Among Canadian Couples: Results of Primary Surveys

Survey	One year of cohabitation (%)	Two years of cohabitation (%)
Canada Health Monitor #6	7.7	6.0
Canada Health Monitor #7	8.6	7.2
Decima Research survey	8.7	7.3
Combined results	8.5	7.0

In our view the two-year estimate of the prevalence of infertility (7 percent) should be adopted because it is a more accurate assessment of the percentage of couples who have difficulty having a pregnancy. The difference between the two estimates suggests that approximately one couple in five that has not had a pregnancy after one year will go on to

become pregnant in the second year.[2] In effect, this means that some couples who are considered infertile according to the one-year definition will simply take longer than a year to conceive.

Based on the two-year estimate of the prevalence of infertility (7 percent), approximately half a million Canadians (250 000 couples) in their reproductive years are currently affected by infertility.* This is not to say that all of these individuals are necessarily infertile; rather, they have difficulty having children with their current partner. The source of the infertility cannot be determined, nor can appropriate policy or programs be developed, solely on the basis of this estimate.

Another way of looking at the data is to consider that if 7 percent of couples have been infertile for two years, 1 couple in 14 has difficulty having children. Given that their chances of conceiving are significantly lower after two years, these couples may seek some form of medical treatment.

Comparison of Canadian and U.S. Infertility Estimates

The results of our three surveys were highly similar to U.S. results when we recalculated our figures using the current approach of the American National Survey of Family Growth.[3] Using this method, the one-year figure was 8 percent in Canada in 1991-92, compared with 7.9 percent in the United States in 1988.

One-Year Estimate of the Prevalence of Infertility — Canadian and U.S. Results Compared

Canada, 1991-92: 8 percent of currently married/cohabiting couples aged 18 to 44.

United States, 1988: 7.9 percent of currently married couples only, aged 15 to 44.

The figure commonly reported in the media — that one couple in six is infertile — is based on a calculation method that was used in the 1982 American National Survey of Family Growth but is no longer used. That method excluded from the denominator all couples in which one or both members had been surgically sterilized. As can be seen in the following box, this is a very substantial proportion; although the same *number* of couples is defined as infertile, they form a larger *percentage* of the whole population of interest.

When we re-analyzed our data using this approach — not counting people who have been surgically sterilized — we found that the prevalence of infertility was 15.4 percent among couples who had been cohabiting for one year and 13.2 percent among couples cohabiting for two years (see

* See Appendix 2 of this chapter.

box). In other words, recalculating our results using the old U.S. methodology showed that our findings were again similar to the U.S. results.

We believe that this approach is inappropriate because it does not estimate the prevalence of infertility in the total population, but only in a segment of the population (that is, those who have not been sterilized). Moreover, figures generated by this approach are too often misinterpreted; they are used to support the claim that 15 percent of *all* couples are infertile, while the percentage in fact applies only to couples who have not been sterilized. This is why the U.S. National Survey of Family Growth is no longer using this method.

Estimating Infertility With and Without the Surgically Sterilized

Surgically sterilized included		1 year	2 years
all couples married or cohabiting one year/two years, not using contraception, and have not had a pregnancy / all couples married or cohabiting for one year/two years	=	8.5%	7.0%
Surgically sterilized excluded		1 year	2 years
all couples married or cohabiting one year/two years, not using contraception, and have not had a pregnancy / all couples married or cohabiting for one year/two years *minus* those couples where one or both members have been surgically sterilized	=	15.4%	13.2%

Prevalence of Infertility by Region, Age Group, and Childbearing Status

We also analyzed the data from our three surveys to see whether they showed any differences in the prevalence of infertility between regions, age groups, or women with different childbearing histories. The data showed no difference in the prevalence of infertility from one part of the country to another. The reliability of this finding is limited, however, by the small sample sizes in each region. The data also showed no statistically significant differences in rates of infertility between couples with younger and older female partners. The reliability of this finding is again limited, because of small sample sizes and because of the greater frequency of contraceptive use and sterilization among older women. This makes it difficult for population-based surveys such as ours to assess the relationship between age and infertility (older women who are infertile are

harder to identify because fewer are trying to conceive). The relationship between age and infertility has been well documented in the scientific literature, however, and is discussed in Chapter 12.

We did find a statistically significant relationship between age and infertility among childless women, with those who were older (ages 30 to 44) almost twice as likely to be infertile as those who were younger (ages 18 to 29). These findings reflect the fact that the older age group is more likely to have "collected" women who are infertile over time — those who have been trying unsuccessfully for several years to conceive. They likely also reflect the fact that women who have delayed childbearing until they reached this age were not trying to conceive before they were 30.

Secondary Research

In addition to our national surveys, we also conducted a secondary analysis of three previous studies conducted in Canada: the Canadian Fertility Survey (1984), the General Social Survey (1990), and the Ontario Health Survey (1990).* The 1984 Canadian Fertility Survey was a large-scale national survey, designed to assess fertility and other reproductive behaviour, that also included a limited number of questions regarding infertility. The Commission conducted a secondary analysis of its findings on contraceptive use and length of couple relationships to try to estimate the prevalence of infertility. By calculating how long couples had not been using contraception, how long they had been in the relationship, and/or how long it had been since their last pregnancy, we were able to develop some projected estimates of the proportion of couples who are infertile.

We further analyzed the 1990 Ontario Health Survey to identify cohabiting women who had not used contraception in the year prior to the survey. The survey included questions about pregnancies over the five years prior to the survey, making it impossible to identify conclusively the number of pregnancies that had occurred in the year prior to the survey. In addition, the way the questions were phrased may have encouraged a non-response from people not using contraception, resulting in an underestimation of infertility.

The 1990 General Social Survey was a large-scale national survey devoted exclusively to assessing fertility and reproductive behaviour. It

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* The following presents only the key findings of the Commission's analysis of these studies. Readers interested in more detailed descriptions of their methodology, data collection, and analysis should refer to the studies in the research volume entitled *The Prevalence of Infertility in Canada* accompanying this report: T.R. Balakrishnan and R. Fernando, "Infertility Among Canadians: An Analysis of Data from the Canadian Fertility Survey (1984) and General Social Survey (1990)"; T.R. Balakrishnan and P. Maxim, "Infertility, Sterilization, and Contraceptive Use in Ontario."

attempted to estimate infertility by asking all respondents whether they or their partner had ever been told that they could not have any, or any more, children. We consider such a question to be inadequate for estimating infertility reliably, as it depends on a medical diagnosis, which not all couples will seek.

Projected estimates of the prevalence of infertility from these three sources were somewhat lower than estimates generated by our primary studies. However, they contain complications that call into question the reliability and validity of infertility estimates derived from them. Thus, although secondary analysis of data from these surveys provided some information, our findings underscore the fact that estimating infertility is too complex a task to be undertaken using methods not designed specifically for the purpose.

Trends in Infertility

U.S. studies show no increase in infertility rates over time. We do not have sufficient data to state whether this is the case in Canada, but the Commission has now established a baseline that will enable future studies to track changes in infertility over time.

The perception that infertility is becoming more common may have arisen in part because of the increased use of effective contraception. The relative success of modern methods of contraception may have contributed to the notion that fertility is completely within our control. As a result, couples who have used contraception for years may be quicker to define themselves as infertile when they decide to have a child but do not conceive as soon as they discontinue contraception. This perception is no doubt heightened by widespread use of a one-year definition of infertility. When this is added to increasing publicity about and availability of technological means to assist conception, the perception of an "infertility epidemic" is understandable.

We know that this perception is incorrect in the United States, where infertility has been tracked through the National Surveys of Family Growth in 1973, 1976, 1982, and 1988: the number of infertile couples there as a percentage of the population of reproductive age has not been increasing.[4] The population of reproductive age has increased because large numbers of baby boomers are now in their childbearing years; the absolute number of infertile couples has therefore increased as well. It is anticipated that the number of infertile couples in the United States will decline in the coming years as the baby boomer population moves out of the reproductive years.

Because Canada's current infertility rate parallels that of the United States so closely, it is not unreasonable to expect that trends in Canada will be closely related to trends in the United States. It would be a mistake to conclude, however, that Canada can continue to rely on U.S. statistics in

this area. For example, as we explain later in this chapter, the incidence of sexually transmitted diseases such as chlamydia observed in Canada among younger women may have negative implications for the fertility of this generation in the future unless treatment and prevention programs are put in place to address the problem. The existence of a publicly supported medical care system in Canada, with easier access to treatment of sexually transmitted diseases, is another factor that may affect the prevalence of infertility — a factor that is not at work in the United States.

Nevertheless, if more individuals are exposed to risk factors associated with infertility, the number of infertile couples may rise in the future. For example, scientists in Denmark recently reviewed 61 studies, published around the world between 1938 and 1991, measuring the semen quality of men who did not have a history of infertility. Their analysis revealed that there has been a 50 percent decline in average sperm counts worldwide over this period, and a threefold increase in the percentage of men who had sperm concentrations in the lowest range.[5] Since male fertility has been shown to be correlated, to some extent, with sperm density, the study suggests that the population of subfertile men has increased. Although changes in the methods used to determine sperm concentrations may have influenced the study results, these methodological changes alone would not explain the large discrepancy in sperm counts between early and later years. The fact that semen quality declined so significantly over a relatively short period of time, as well as the fact that the incidence of testicular cancer increased substantially over the same period, have caused researchers to question whether environmental factors may be affecting male reproductive function.

It is not known, however, what effect the documented decline in sperm counts may have had on infertility trends worldwide. Nor do we know whether sperm counts in Canadian men have declined over the past 50 years or, if they have, what impact this has had on the prevalence of infertility in our country. These findings do, however, point to the importance of understanding the risk factors associated with infertility and the extent of individual exposure to them. They also demonstrate the need for regular data collection on the prevalence of infertility.

Through our own original research and secondary analysis, we have provided a solid base for tracking infertility in Canada from now on. Because estimating infertility is such a complex matter, and because of the pitfalls associated with using surveys and sources not designed for that purpose, any survey that attempts to examine fertility and reproductive behaviour should involve careful design of the necessary questions and the methodology to measure infertility. It is also important that sample sizes be sufficiently large to allow for the data to be analyzed for differences between regions and age groups. Tracking changes in the rates of infertility among specific age groups or risk groups would provide valuable information about the possible impact of such factors as sexually

transmitted diseases and biological aging. The Commission recommends that

> **2. Health Canada conduct surveys of reproductive behaviour every five years, and that these surveys include a measurement of the prevalence of infertility, using a standardized definition, so that infertility can be tracked over time.**

Implications of Prevalence Findings

It is clear that infertility affects the lives of many people in Canada. The human costs implicit in our finding that about 250 000 couples in Canada are experiencing infertility, in that they have failed to become pregnant after two years of unprotected intercourse, contain an important message for policy makers. Given what Canadians told us about the importance of children in their lives, we must take this message seriously. Our findings underscore the importance of allocating resources to reduce the prevalence of infertility and to help people to have the children they want.

Determining whether infertility can be prevented and, if so, how to prevent it requires a thorough understanding of the factors that place individuals at risk of becoming infertile. This information has important implications for the development and targeting of prevention programs. These issues are the subject of the next six chapters.

Appendix 1: The Prevalence of Infertility in Canada — Surveys Conducted for the Commission

Canada Health Monitor #6 (*Price Waterhouse*)

The Canada Health Monitor is an ongoing, semi-annual telephone survey of the Canadian population used to analyze health-related concerns. A total of 2 723 individuals participated in the Canada Health Monitor survey. Demographic information obtained in the survey was used to identify those women who were aged 18 to 44, married or cohabiting for at least one year. Of 2 723 individuals, 281 fit this description and were

willing to be interviewed. Calls were made during the period December 9-14, 1991.

Canada Health Monitor #7 (*Price Waterhouse*)

Infertility-related questions were included in the seventh Canada Health Monitor survey in order to reach a second, independent sample. A total of 2 725 respondents were interviewed from December 1991 through February 1992, resulting in a subsample of 407 women who met the criteria for age and marital status.

Infertility Among Canadians (*Decima Research*)

Relevant data were collected from a third national survey, undertaken for the Commission by Decima Research. Selection of women from a pool of over 5 000 Decima respondents was completed with quotas to achieve a sample proportional to the Canadian population with respect to region and city size. A subsample of 725 women met the criteria for age and marital status. Interviews were conducted from March 1 to March 14, 1992.

Source: The data from Canada Health Monitor and Decima surveys were analyzed by C.S. Dulberg and T. Stephens as described in the research volume entitled *The Prevalence of Infertility in Canada.*

Appendix 2: One-Year and Two-Year Calculations of the Infertility Rate

The number of couples who have been married/cohabiting for *at least one year* who can be considered to be infertile can be calculated as follows:

- The study showed that 8.5 percent of couples married/cohabiting for at least one year did not use contraception and failed to become pregnant.
- In this study, 5 percent of couples in the sample were dropped from the analysis because they were married/cohabiting for less than one year. The actual size of the Canadian population of couples married/cohabiting for at least one year is not directly accessible. Therefore, the size of this population of interest in Canada was estimated, based on the following:

  (a) 1991 Canadian Census Data — 3 781 309 currently married/cohabiting couples (in which female partner is between the ages of 18 and 44).

  (b) Based on sample results, we can estimate that the number of couples married/cohabiting for at least one year is 5 percent

smaller than the number of currently married/cohabiting couples.

(c) Estimate: there are approximately 3 592 244 Canadian couples, in which the female partner is between 18 and 44, who have been married/cohabiting for at least one year.

- The 95 percent confidence interval for the one-year estimate of infertility (8.5 percent) is 7.0 percent to 9.9 percent. This means that there is a 95 percent chance that duplicating the research would generate a one-year estimate of the prevalence of infertility within this range. Therefore, it is estimated that between approximately 250 000 and 360 000* couples, married/cohabiting for at least one year, failed to become pregnant after one year of unprotected intercourse.

The number of couples who have been married/cohabiting for *at least two years* who can be considered to be infertile can be calculated as follows:

- Seven percent of couples married/cohabiting for at least two years did not use contraception and failed to become pregnant.
- In addition to the 5 percent of couples who had not cohabited for the past year, an additional 4.3 percent of couples in the sample were dropped from the analysis (9.3 percent in total) because they were married/cohabiting for less than two years. Again, the actual size of the Canadian population of couples married/cohabiting for at least two years is not directly accessible. Therefore, the size of this population of interest in Canada was estimated, based on the following:

  (a) 1991 Canadian Census Data — 3 781 309 currently married/cohabiting couples (in which female partner is between the ages of 18 and 44).

  (b) Based on sample results, we can estimate that the number of couples married/cohabiting for at least two years is 9.3 percent smaller than the number of currently married/cohabiting couples.

  (c) Estimate: there are approximately 3 429 647 Canadian couples, in which the female partner is between 18 and 44, who have been married/cohabiting for at least two years.

- The 95 percent confidence interval for the two-year estimate of infertility (7.5 percent) is 5.6 percent to 8.4 percent. This means that there is a 95 percent chance that duplicating the research would generate a two-year estimate of the prevalence of infertility within this

* The exact figures were 251 457 and 355 637 respectively.

range. Therefore, it is estimated that between approximately 190 000 and 290 000* couples, married/cohabiting for at least two years, failed to become pregnant after two years of unprotected intercourse.

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1. Hull, M.G.R. "Infertility Treatment: Relative Effectiveness of Conventional and Assisted Conception Methods." *Human Reproduction* 7 (6)(1992): 785-96.

2. Calculated by dividing the difference between 8.5 and 7.0 (which is 1.5) by 8.5. This generates a figure of approximately 18 percent, or one in five.

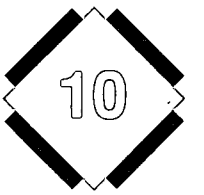
3. It should be noted that the sample group used in the American survey was slightly different from the sample group in our surveys. The National Survey of Family Growth focussed on married couples only, whereas we included both married and cohabiting couples. As well, the National Survey of Family Growth sample included married couples in which the female partner was between the

* The exact figures were 192 060 and 288 090 respectively.

ages of 15 and 44, whereas our study focussed on cohabiting couples where the woman is aged 18 to 44.

4. Mosher, W.D., and W.F. Pratt. *Fecundity and Infertility in the United States, 1965-1988.* Advance Data from Vital and Health Statistics of the National Center for Health Statistics, No. 192 (Hyattsville: U.S. Department of Health and Human Services, 1990). Although the percentage of couples who are infertile appears to have decreased over the past two decades (from 11.2 percent in 1965 to 8.5 percent in 1982), this drop is entirely due to the rise in surgical sterilization. Excluding the surgically sterile, the percentage of couples who are infertile has changed only slightly, from 13.3 to 13.9 percent (United States Congress. Office of Technology Assessment. *Infertility: Medical and Social Choices.* Washington: U.S. Government Printing Office, 1988, p. 51).

5. Carlsen, E., et al. "Evidence for Decreasing Quality of Semen During Past 50 Years." *British Medical Journal* 305 (September 12, 1992): 609-13.



Sexually Transmitted Diseases and Infertility

The future fertility of a proportion of today's generation of young women is at risk from chlamydia and gonorrhoea; many will be unaware of the silent effects of these sexually transmitted diseases until they want to have children and find they cannot. Preventing sexually transmitted diseases must become a greater priority if we are to reduce the future prevalence of infertility in Canada. Strong action and focussed leadership are required to ensure that this happens.

Sexually transmitted diseases are diseases that are transmitted primarily by sexual contact, including oral, genital, and anal contact, although they can also be transmitted by a woman to her child during a vaginal birth. They have long been identified as a national public health problem. Representatives of many groups voiced their concerns to the Commission about the prevalence of STDs, given the clear link between sexually transmitted diseases and infertility. The Commission examined the evidence on the relationship between sexually transmitted diseases and infertility and concluded that STDs are the single most important preventable cause of infertility among women. An estimated 20 percent of all infertility among couples can be traced to damage to the female partner's fallopian tubes that has resulted from pelvic inflammatory disease (PID) caused by a sexually transmitted infection. Moreover, this figure pertains only to difficulties with conception; still more women encounter difficulties with pregnancy and birth — including an increased risk of ectopic pregnancy, spontaneous abortion and stillbirth, premature delivery, and acute or chronic infections in infants born to infected mothers — because of the adverse effects of sexually transmitted diseases.

Significant numbers of Canadians are affected by STDs — one estimate is that perhaps as many as one Canadian in five contracts a sexually transmitted disease during the reproductive years. Young women between the ages of 15 and 19 are particularly at risk; they have the

highest incidence of both gonorrhoea and chlamydia — the diseases identified as having the greatest impact on female fertility — of any group in Canada.[1] We discuss the prevalence of gonorrhoea and chlamydia in greater detail later in this section, but the Commission believes it is important to draw these facts to public attention. Many young women are engaging in unsafe practices, unaware that they may be harming their future fertility. Effective programs to encourage young people to prevent sexually transmitted diseases, by delaying sexual activity, reducing the number of partners, and using barrier methods of contraception, are vital to reducing the overall prevalence of infertility in Canada.

> [Of] major concern is the higher than average rate of sexually transmitted diseases found in the aboriginal population. In the Yukon documented statistical data demonstrates that gonorrhea is prevalent [at] five times the rate of the other population of this territory. Other STDs, notably the aforementioned and *Chlamydia trachomatis*, which can cause or add to the problem of infertility, are of serious concern in this country.
>
> *M. Dion Stout, Indian and Inuit Nurses of Canada, Public Hearings Transcripts, Ottawa, Ontario, September 20, 1990.*

The impact of chlamydia is particularly insidious, because women who contract this infection may lack noticeable symptoms and therefore may not seek medical treatment. Left untreated, or treated incorrectly, these chlamydial infections can progress to pelvic inflammatory disease, which can cause permanent scarring and damage to the fallopian tubes, rendering the woman infertile (if both tubes are completely blocked) or subfertile (if the blockage in one or both tubes is only partial). Some women are unaware that they have contracted chlamydia until tubal damage is diagnosed when they want to have a child and seek medical help for impaired fertility. Because it is a "silent" infection, identifying and treating chlamydia early would require a systematic screening program. This is among the range of options we examine in this section as we consider how to develop a coordinated strategy for preventing infertility linked to sexually transmitted diseases.

The Focus of Our Investigations

The viral or bacterial microbes that cause sexually transmitted diseases affect not only the male and female reproductive tracts but other organs as well. Just under a dozen of the infections that are sexually transmitted can have long-term effects on the reproductive health of women and, to a lesser extent, men (see research volume, *Understanding Infertility:*

Risk Factors Affecting Fertility). We focussed our investigations on chlamydia and gonorrhoea (both of which are caused by bacterial organisms) because of the evidence linking them to infertility in women. Infertility in the context of these diseases is defined as difficulty achieving conception; these diseases had greatest relevance to our mandate, because new reproductive technologies involving assisted conception techniques can be used to overcome their long-term consequences.

We placed secondary emphasis on investigating other STDs, such as human immunodeficiency virus (HIV) infection, syphilis, and mycoplasma infection, which may reduce a woman's ability to give birth to a healthy child but do not appear to have an effect on women or men in terms of the ability to conceive. Assisted conception techniques therefore have less relevance to these diseases, although they have very serious health effects.

> Sexually transmitted infections are endemic in Canada in 1992; however, many are not reported and their consequences not well documented. Perhaps as many as one in five Canadians become infected with one of these pathogens during their sexually active years. More than 30 pathogens are known to be transmitted sexually, about 10 of which are particularly important because they have significant long-term effects on the reproductive health of women and, to a lesser extent, men. Their impacts on reproductive health include acute and chronic pelvic inflammatory disease; difficulties with conception due to tubal factor infertility; pregnancy wastage due to ectopic pregnancy, spontaneous abortion, and stillbirth; premature delivery; and acute or chronic infections in infants born to infected mothers. In addition, sexually transmitted infections can interfere with sexual health due to psychological or physical factors that adversely alter sensory or emotional experiences.
>
> *A. Ronald and R. Peeling, "Sexually Transmitted Infections: Their Manifestations and Links to Infertility and Reproductive Illness," in Research Volumes of the Commission, 1993.*

The Incidence of Sexually Transmitted Diseases

Information about the incidence of sexually transmitted diseases in the population as a whole is limited. Existing data come mainly from reported cases collected by provincial governments and the Laboratory Centre for Disease Control at Health Canada; these data are considered to underestimate rates of STD infection, however, because not all cases are detected or reported. In addition, studies measuring the incidence of sexually transmitted diseases in certain sectors of the population provide an indication of the prevalence of STDs in higher-risk groups. One such study was the Canada Youth and AIDS Study, which found that 5.5 percent

of university and college students had had at least one sexually transmitted disease. The proportion was larger among those who had had numerous partners: infection rates in males and females who had had one partner were 1 percent and 3 percent respectively; by contrast, those with ten or more partners had rates of 11 percent and 24 percent respectively. Certain subgroups within the younger population are also at higher risk. The study found that 9 percent of youth who have dropped out of school have had a sexually transmitted disease. Street youth are at even higher risk: 22 percent reported having had a sexually transmitted disease. Those who have engaged in prostitution and others with numerous sexual partners had substantially higher rates (see Table 10.1).

Table 10.1. History of Previous Sexually Transmitted Disease

	Overall (%)	Males (%)	Females (%)
College/university	5.5		
One partner		1	3
Ten or more partners		11	24
Dropouts	9		
Street youth	22	16	30
Prostitutes	58	45	68
More than 100 partners		— *	70

* Information not available.

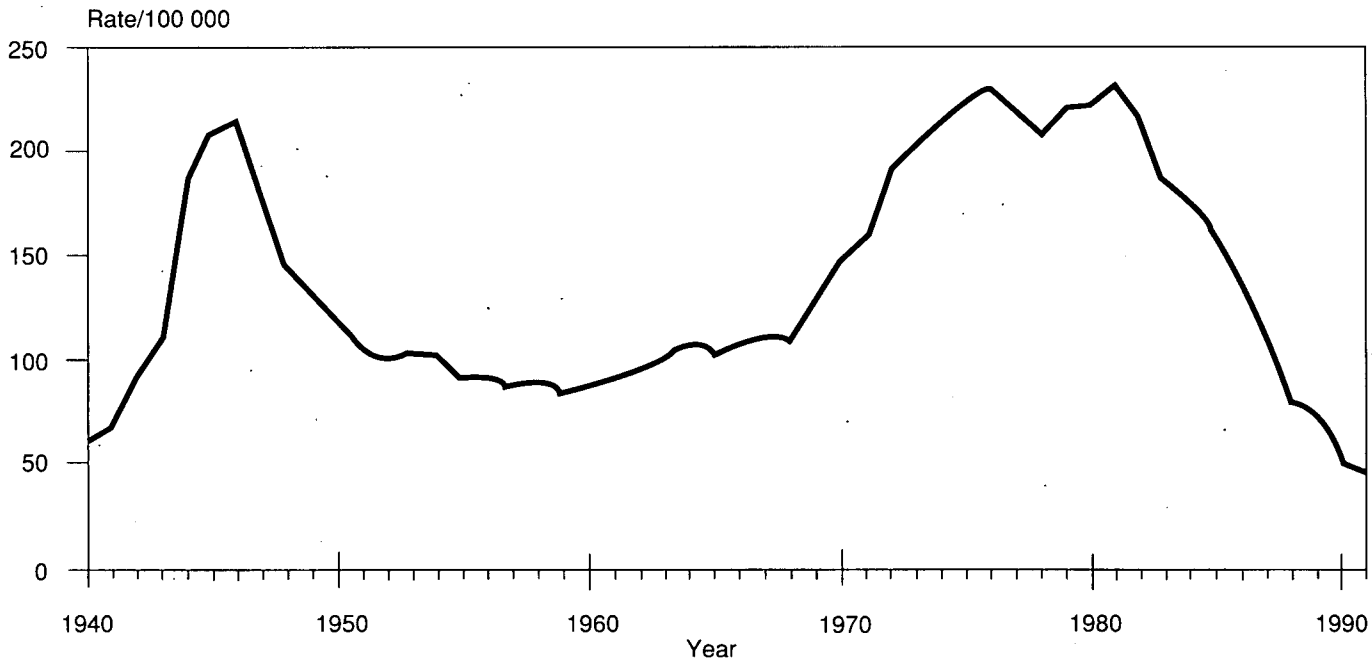
Note: n = 38 000

Source: King, A.J.C., et al. *Canada Youth & AIDS Study.* Kingston: Queen's University, 1989; and Radford, J.L., A.J.C. King, and W.K. Warren. *Street Youth & AIDS.* Kingston: Queen's University, 1989.

Gonorrhoeal Infections

Sexually transmitted diseases have been associated historically with population disruptions resulting from war, famine, and other factors that cause substantial population migration. As shown in Figure 10.1, an examination of the annual incidence of gonorrhoeal infections between 1940 and 1991 shows two periods of dramatic increase. The first was in the late 1940s, following the Second World War. The second period was during the 1970s when Canada, like other industrialized countries, experienced widespread changes in contraceptive practices and sexual behaviour. A large part of this second documented major increase also

Figure 10.1. Gonorrhoea: Annual Incidence per 100 000, Canada, 1940-1991



Source: Health and Welfare Canada. "Sexually Transmitted Disease in Canada 1987." *Canada Diseases Weekly Report* 15(Suppl. S2) (1989), Figure 2. (Updated to 1991 based on data from Division of STD Control, LCDC, Health and Welfare Canada.)

Gonorrhoea

The *Neisseria gonorrhoeae* bacterium can survive for only a short time outside the human body. This means that intimate physical contact with the mucous membranes of an infected individual is necessary to become infected.

Gonorrhoea has an incubation period (the time before symptoms may become apparent) of two to seven days. In women, the most common symptoms of the disease are a burning sensation during urination, increased vaginal discharge, and/or redness or swelling around the vulva. For most women (70 to 80 percent), however, symptoms may be so mild as to go unnoticed. Symptoms of gonorrhoea in men are more apparent; all but 10 percent have visible symptoms, usually a discharge from the urethra.

If untreated, the period of communicability for gonorrhoea may extend for months. This is of particular concern, as asymptomatic individuals may transmit the disease unknowingly for an extended period before the appearance of symptoms or another medical problem causes them to seek treatment. Drug therapy is highly effective and ends an infected person's communicability within hours.

Table 10.2. Rates of Gonorrhoea in Canada by Age and Sex*

Age	Sex	1980	1985	1988	1989	1990	1991
15-19	Male	331.4	277.5	166.4	156.2	119.5	60.1
	Female	539.4	566.0	357.5	337.6	239.1	118.9
20-24	Male	969.8	704.2	345.2	324.1	233.4	115.8
	Female	656.4	546.0	325.7	283.2	194.7	98.1
25-29	Male	711.3	436.3	207.7	196.8	150.5	75.9
	Female	309.6	227.3	132.4	121.0	77.1	38.1

* Rate per 100 000 population in that age group.

Source: *Canada Diseases Weekly Report* 15-50 (December 16, 1989); *Canada Diseases Weekly Report* 17-21 (May 25, 1991); and Health Canada. Division of STD Control/Laboratory Centre for Disease Control (LCDC).

reflects more intensive screening and detection of asymptomatic gonorrhoea (particularly among women) and more complete reporting of gonorrhoea cases.

Gonorrhoea rates among Canadians have declined substantially since the early 1980s, because of the introduction of control programs involving diagnostic services, contact tracing, and effective treatment. It is possible that less risky sexual behaviour among many individuals has also

contributed to the decline. The downward trend shown in Figure 10.1 is very encouraging overall. Nevertheless, as may be expected, teenage girls and men in their early 20s continue to show the highest rates compared to other age groups (see Table 10.2). This finding may reflect more intensive screening as well as sexual activity in this group and the greater vulnerability of the female reproductive system. The incidence of gonorrhoea among young women is of particular concern because of the implications for their future fertility.

Chlamydial Infections

Chlamydia is now the most prevalent STD in Canada. It is three to five times more prevalent than gonorrhoeal infections, depending on the population studied.[2] An estimated 100 000 cases of chlamydial infection occur in Canada each year.[3] The available data are believed to underestimate the prevalence of this disease significantly for several reasons. Reporting requirements for chlamydia vary between provinces; most require that laboratories report all confirmed cases, but this is still not mandatory in some provinces. Even where mandatory reporting exists, testing procedures may not result in accurate results: many laboratories use tests that are not sensitive enough to detect all cases, while some newer tests may actually result in false positives. Moreover, chlamydial infections that are diagnosed clinically (without laboratory confirmation) often are not reported by physicians.

Younger people bear the major burden of chlamydial infections; two-thirds of identified cases are in individuals aged 15 to 24 years. Young women in this age group have the highest rates of chlamydial infections, at about 1.6 percent (see Table 10.3 for reported cases and rates).

Chlamydia

Chlamydial infections are caused by a bacterium called *Chlamydia trachomatis*, which can reproduce only inside cells of its host. The bacterium is an "energy" parasite in that it depends largely on the host cell for energy to fuel its metabolism and growth.

Treatment involves a 7- to 10-day course of antibiotic. If left untreated, chlamydia has been shown to persist for as long as four years.

Rates of chlamydia among sexually active youth are substantially higher than in the general population. A survey of studies published over the last 10 years in Canada shows that the prevalence of chlamydia has ranged from 5 to 7 percent in student health clinics; to 14 percent in family planning clinics; and to more than 25 percent of patients at STD clinics.[4] Most important to remember, however, is the fact that many individuals are asymptomatic and do not come for testing, so their cases are not reported;

50 to 60 percent of women and an estimated 7 percent of men with chlamydial infections are asymptomatic. Because of the reporting problems discussed above, it is not known whether rates are increasing or decreasing. Chlamydial infections became nationally notifiable in 1990; with these data it will be possible to analyze trends.

Table 10.3. Reported Cases and Rates of Chlamydial Infection by Age and Sex, Canada,* 1989-1990

	Male		Female		Total	
Age	**Cases**	**Rate**	**Cases**	**Rate**	**Cases**	**Rate****
0-4	39	4.6	67	8.3	106	6.4
5-9	8	1.0	16	2.0	24	1.5
10-14	24	2.9	550	69.9	574	35.5
15-19	2 008	236.4	12 728	1 578.6	14 736	890.1
20-24	4 732	520.5	13 412	1 525.8	18 144	1 014.7
25-29	2 574	243.8	5 622	532.7	8 196	388.2
30-39	1 579	80.1	3 040	152.0	4 619	116.3
40-59	392	15.1	619	23.6	1 011	19.4
60+	27	1.7	48	2.3	75	2.1
Age not specified	326		1 107		1 433	
Sex and age not specified					1 466	
Total cases	11 709	102.3	37 209	315.6	50 384	216.8

* Excludes British Columbia and the Northwest Territories.

** Per 100 000.

Note: Since not all provinces/territories had 1990 data available, cases and rates were based on the most recent data available (1989 or 1990) for each province/territory, to provide an estimate of chlamydial infection for the period 1989-1990.

Source: Adapted from Health and Welfare Canada. "Chlamydial Infection in Canada." *Canada Diseases Weekly Report* 17-51 (December 21, 1991), Table 2.

Factors That Increase the Risk of Acquiring a STD

Being Female

Women are at higher risk than men of acquiring a sexually transmitted disease for several reasons, the main one being that the female reproductive tract seems to be more vulnerable to organisms transmitted during unprotected sexual intercourse. This is demonstrated by the difference in rates of transmission between the two sexes. A man with a gonorrhoeal infection will infect about half the female partners with whom he has unprotected intercourse, whereas an infected woman will infect about 25 percent of her male partners. Another factor relates to attitudes and inequalities that influence the degree of control women have over their choice of sexual partners and the use of barrier methods of contraception to protect against STDs.

Women's fertility is particularly vulnerable because they are more likely to harbour asymptomatic infections for prolonged periods, during which time internal damage can occur. Without treatment, women are likely to suffer serious long-term consequences such as pelvic inflammatory disease, chronic pelvic pain, ectopic pregnancy, and infertility related to blockage of the fallopian tubes. In contrast, men are less likely to suffer long-term consequences from most sexually transmitted diseases, and their fertility is unlikely to be affected.

Sexual Behaviour

Although sexually transmitted diseases can and do afflict sexually active individuals across all age and socioeconomic groups, research has shown that certain behaviours increase an individual's risk of acquiring a STD. These include younger age at first sexual intercourse (which increases the number of years of sexual activity and the probability of exposure to a greater number of partners), multiple partners, or a relationship with a partner who has a history of multiple partners, and lack of appropriately protective contraception. Barrier methods such as condoms and spermicides have been shown to prevent transmission of organisms, whereas oral contraceptives and intrauterine devices (IUDs), while effective in preventing pregnancy, do not protect against STDs. (Oral contraceptives have been shown to reduce the progress of a sexually transmitted disease into the upper reproductive tract, but they do not prevent women from acquiring the disease in the first place.)

These behavioural factors help to explain why STD rates are highest among young people. The Canada Youth and AIDS Study found that approximately one-quarter of grade 9 students (31 percent of boys/21 percent of girls) and half of all grade 11 students (49 percent of boys/46 percent of girls) have had sexual intercourse at least once. By the time they reach university or college age, three-quarters of Canadian students

will have had sexual intercourse. These results are in line with Canada's Health Promotion Survey (1990), which found that nearly two-thirds (60 percent) of all those aged 15 to 19 have had sexual intercourse.[5] We note, however, that both surveys were based on self-reported data; actual rates of sexual activity may in fact be higher.

> Over the last three, four years, I have had the opportunity to go into many schools to talk about sexually transmitted diseases, to grade school students, junior high and senior high kids, and it is very sad to see how woefully misinformed they are. They just don't know what is going on. And accordingly, they are very much at risk for getting infected and for being candidates for these technologies later.
>
> *S. Genuis, private citizen, Public Hearings Transcripts, Edmonton, Alberta, September 13, 1990.*

The reported level of sexual activity would not necessarily produce high rates of sexually transmitted diseases if young people had a good understanding of what constitutes safe sexual behaviour and if they accepted the necessity of and practised these behaviours. These include, first and foremost, using barrier forms of contraception, as well as delaying sexual intercourse until a later age and minimizing the number of partners. While media coverage and acquired immunodeficiency syndrome (AIDS) education programs in schools have increased young people's awareness of the risk of HIV infection and, to some extent, other sexually transmitted diseases, there are data that suggest such knowledge is not translating into actual behaviour and safer sexual practices. The Canada Youth and AIDS Study found that only one-quarter of female college students who had had one partner use a condom consistently. Other studies have confirmed the low rate of condom use among those who are sexually active; the 1992 Santé Québec study reported that many individuals in the 15 to 29 age group were not using condoms, and the Ontario Health Survey reported that most of those with multiple partners do not use condoms, or they use them infrequently.

What is particularly striking is that less than 10 percent of women with 10 or more partners use a condom. Women who are sexually active with more partners tend to rely exclusively on oral contraceptives, which are very effective in preventing pregnancy but provide no protection against contracting a sexually transmitted disease. In the absence of barrier contraceptives that are as effective as oral contraceptives in preventing pregnancy, it is not surprising that women choose the pill, given that they see pregnancy as the immediate risk and that they may have difficulty persuading a partner to use a condom. The challenge, then, is to convince young women that they need both forms of protection — one for pregnancy protection and a second for STD protection.

Marginalization from Health Care Services

Reduced access to health care services and health education is associated with other risk factors that place sexually active individuals at higher risk of acquiring a sexually transmitted disease — specifically being poor, adolescent, and among those referred to as street youth. STD rates are higher among street youth, among youth who have dropped out of school, and especially among young women engaged in prostitution. Higher STD rates in these groups reflect not only sexual behaviours, but also a decreased likelihood of using health care services, whether because of language or cultural barriers or because of other factors in the design or delivery of services that make them inconvenient, uncomfortable, or "unfriendly" to use. Thus, young people in these groups are less likely to be screened and treated and may unknowingly prolong the lifespan of the disease and transmit the infection to others.

> In spite of the serious, costly consequences of unintended pregnancy and the spread of STDs, many Canadians cannot obtain the most basic health services needed to prevent sexual and reproductive health problems. Access to quality services is especially restricted among individuals in rural and isolated areas, adolescents, single adult women, members of cultural and linguistic minority groups, physically handicapped individuals, and others with distinct health and socioeconomic needs.
>
> *N. Barwin and W. Fisher, "Contraception: An Evaluation of Its Role in Relation to Infertility — Can It Protect?" in Research Volumes of the Commission, 1993.*

Sexually Transmitted Diseases and Infertility in Women

Understanding the link between sexually transmitted diseases and infertility in women requires an appreciation of a sequence of events. Gonorrhoea and chlamydia can lead to pelvic inflammatory disease, which in turn can lead to damaged or blocked fallopian tubes, making pregnancy difficult or impossible to achieve. As well, several STDs are associated with reduced chances of carrying a pregnancy to term and giving birth to a healthy child.

STDs and Pelvic Inflammatory Disease

Pelvic inflammatory disease is an infection of the upper reproductive tract in women that occurs when organisms ascend via the cervix into the uterus and fallopian tubes. This may happen if a sexually transmitted

disease is left untreated, if treatment is delayed, or if an infection is treated incorrectly. PID also can result from other infections — for example, those that can occur after childbirth or surgery. It is estimated that between one-third and one-half of women who become infected with a STD (mostly gonorrhoea and chlamydia) will develop pelvic inflammatory disease and, further, that this group of women accounts for about 80 percent of all cases of pelvic inflammatory disease.[6]

Infections of the cervix, the lining of the uterus, fallopian tubes, and ovaries are included in the overall category of pelvic inflammatory disease. In the most severe cases, infection can spread into the pelvic tissues, where it may infect neighbouring organs, including the bladder, intestines, and liver. Even without treatment, however, most women with PID become symptom-free after an acute illness of 5 to 10 days. Pelvic inflammatory disease resulting from chlamydial infections causes more tubal damage than gonorrhoea because it often causes no symptoms and is therefore less likely to be treated.

In women who develop infection of the fallopian tubes, the disease initially causes acute inflammation; in the long term, it may result in permanent scarring of the fallopian tubes and other areas of the reproductive tract. In cases where scarring damage is severe, both tubes can be blocked completely (this condition is called bilateral tubal obstruction or occlusion), making natural conception impossible. Even if the fallopian tubes are left partially open, with some potential ability to function, the resulting scarring may impair their ability to transport a fertilized egg toward the uterus (see Chapter 20).

Having more than one STD at the same time increases the risk of developing pelvic inflammatory disease. In 30 to 50 percent of women with gonorrhoea, a chlamydial infection has also been detected (see research volume, *Prevention of Infertility*). When acting together, chlamydia and gonorrhoea organisms cause more damage to a woman's reproductive tract than either on its own; when both infections are present, they seem to invade the reproductive tract more rapidly, with more acute and lasting damage to the fallopian tubes. Together they also appear to break down the defences of the reproductive system to allow entry of other organisms that are naturally present in the vagina, and these organisms may cause further damage to the reproductive tract.

Women with symptomatic pelvic inflammatory disease account for less than half the total number of cases, because a woman is often unaware that she has had the disease until she has difficulty conceiving and seeks medical treatment. In one study, over 70 percent of women with blocked fallopian tubes reported no history of a previous episode of pelvic inflammatory disease, despite laboratory tests demonstrating that they have had a previous chlamydial infection.[7]

Determining the prevalence of pelvic inflammatory disease in Canada is difficult, because existing data are based on hospitalization records. These do not capture undetected cases, nor do they include cases treated

without hospitalization. Records collected by Health Canada indicate that in 1988-89 the rate of hospitalization for pelvic inflammatory disease was 205 per 100 000 women[8] (see Table 10.4). As the table shows, pelvic inflammatory disease was on the increase until the early 1980s; since then it has fallen. Women aged 20 to 29 are affected most frequently. Because we know that pelvic inflammatory disease is linked to infertility, the rate of the disease among younger women has serious future implications for their fertility.

Table 10.4. Pelvic Inflammatory Disease, Age-Specific Rates,[1] by Age Group, Canada, Selected Years, 1972-1988/89*

	Age group						
	15-19 years	20-24 years	25-29 years	30-34 years	35-39 years	40-44 years	Total
1972	202.9	328.8	328.8	295.9	242.8	153.8	259.8
1976	245.6	380.3	329.5	292.0	212.2	137.7	276.8
1980/81[2]	281.0	432.0	374.1	295.3	195.3	128.3	301.6
1983/84	275.7	404.7	381.5	279.1	188.5	116.2	289.6
1984/85	286.6	403.3	370.6	285.3	191.5	113.0	289.1
1987/88	255.4	343.3	337.3	263.2	171.9	111.5	254.1
1988/89	243.6	306.1	294.4	274.3	163.6	49.7	205.3

1 Per 100 000 females.

2 Since 1980-81, all hospital morbidity data have been reported by fiscal year.

* Figures based on hospital separations.

Source: Health and Welfare Canada. "Sexually Transmitted Disease in Canada 1987." *Canada Diseases Weekly Report* 15 (Suppl. 2)(1989), Table 15. Updated to 1988/89 based on data from Health Canada.

Pelvic Inflammatory Disease and Tubal Infertility

No data exist that would allow definitive evaluation of the relationship between PID and tubal infertility in Canada. We have attempted, however, to use data from the United States and Sweden, as well as Commission data on the prevalence of infertility in Canada, to infer the proportion of infertility that results from PID, almost all of which is caused by sexually transmitted diseases. Based on our calculations, we estimate that in roughly 20 percent of Canadian couples who are infertile, the woman has tubal infertility resulting from PID. (How we arrived at this figure is explained in the following box.)

Recent research shows that women who do not seek prompt treatment for PID (within two days of symptoms appearing) are at increased risk of

infertility. One study showed that women who waited for three days or longer before seeking treatment for pelvic inflammatory disease caused by gonorrhoea or chlamydia had twice (2.6 times) the risk of impaired fertility as women who received treatment in the first two days.[9] Unfortunately, because many women have no apparent symptoms, particularly with chlamydia-induced PID, they do not seek treatment this quickly.

Estimating the Impact of Pelvic Inflammatory Disease on Tubal Infertility

Although not a rigorous or ideal approach, the following calculation helps to show what the approximate effect of STDs on infertility might be. The calculation is not precise and relies on several assumptions (for example, it does not factor in aspects such as multiple infections); however, it is the best approximation available.

The U.S. National Survey of Family Growth, conducted in 1988, showed that 11 percent of women of reproductive age had reported a previous episode of pelvic inflammatory disease. The 1980 Lund study conducted in Sweden found that 15.2 percent of women had tubal infertility after one PID episode. It has been suggested, therefore, that 1.7 percent (15.2 percent of 11) of all U.S. women of reproductive age were infertile because of an episode of pelvic inflammatory disease.

Commission research showed that 8.5 percent of couples who had been cohabiting for at least one year at the time of the study were infertile. If we assume that the proportion of women who have had PID in Canada is the same as in the United States (1.7 percent), then this condition is the cause of infertility in 20 percent of all couples who are infertile. Twenty percent is considered to underestimate the contribution of PID to infertility because it assumes that all of the American women who reported a previous episode of PID had only one episode. In fact, we know that the risk of tubal infertility is higher with subsequent episodes.

Women with severe episodes of pelvic inflammatory disease have tubal infertility at five times the rate of women who have had mild episodes. Among 900 women studied, the risk of infertility because of blocked fallopian tubes after one episode of pelvic inflammatory disease was found to be 6 percent for mild infections, 13 percent for moderate infections, and 30 percent for severe infections. These rates also seem to hold true for chlamydia-induced PID, despite antibiotic treatment.

Pelvic Inflammatory Disease and Ectopic Pregnancy

Ectopic pregnancy is a life-threatening condition that occurs when a fertilized egg implants and begins development outside the uterus — most often in a fallopian tube. In industrialized countries, about half of all ectopic pregnancies are attributed to previous pelvic inflammatory disease.[10] (Scarring of the fallopian tubes, which can prevent a fertilized egg from travelling normally to the uterus, increases ectopic pregnancy risk.) In fact, an ectopic pregnancy is 7 to 10 times more likely in women

who have had PID than in women who have not. (The rate of ectopic pregnancy is about 1 in 16 for women who have had pelvic inflammatory disease, compared to 1 in 147 for all women.[11])

This increased risk of ectopic pregnancy is important for several reasons: it constitutes a failure of reproduction; it is potentially life-threatening to the woman; and having had an ectopic pregnancy places a woman at further increased risk of tubal infertility in the future (because of damage to the fallopian tube if it ruptures or if the fetus has to be removed surgically). Among women who have had an ectopic pregnancy, an estimated one-third will become infertile, one-third will have a subsequent normal pregnancy, and one-third will have a subsequent ectopic pregnancy or miscarriage.

Disturbingly, the rate of ectopic pregnancies in Canada approximately tripled — from 5.7 to 16 per 1 000 reported pregnancies — between 1971 and 1988. (Reported pregnancies include all pregnancies: live births, stillbirths, abortions, ectopic pregnancies.) These rates also are likely to indicate rates of tubal infertility.[12]

STDs and Adverse Pregnancy and Birth Outcomes

Some sexually transmitted organisms can cause complications during pregnancy that lead to spontaneous abortion, stillbirth, or premature delivery. Sexually transmitted diseases can also be passed from the woman to the fetus during pregnancy and birth. Among the relevant findings are the following:

- Chlamydial infection during pregnancy may be associated with second-trimester spontaneous abortion, stillbirth, neonatal death, prematurity, and low birth weight.
- Gonorrhoea can be transmitted to the fetus through the placenta or birth canal and can cause corneal damage, pharyngitis, meningitis, and arthritis. The routine use of silver nitrate at birth has reduced the risk of eye infection (which can lead to blindness), from 30 percent to 0.5 percent in children born to infected mothers.[13]
- Women infected with syphilis are more likely to have pregnancy complications (for example, spontaneous abortion) and may have pregnancies that result in the birth of an affected child. The risk of prematurity, perinatal death, and congenital syphilis in the newborn is related directly to the stage of the disease in the pregnant woman. Infected children may be born with mental disability, chronic meningitis, blindness, and/or deafness; therefore, pregnant women are always tested for this treatable disease.
- A strain of mycoplasma that may be sexually transmitted (*Mycoplasma hominis*) has been found to be associated with premature delivery. There is some suggestion that the disease may also be associated with spontaneous abortion, stillbirth, and low birth weight.

This brief overview is intended to highlight the range of sexually transmitted diseases that can affect pregnancy and birth outcomes adversely; the effects of many are still not clearly understood, and this list is by no means comprehensive. Readers can refer to the research paper entitled "Sexually Transmitted Infections: Their Manifestations and Links to Infertility and Reproductive Illness" by A.R. Ronald and R.W. Peeling, published in our research volume *Understanding Infertility: Risk Factors Affecting Fertility*, for a more complete review of the subject.

Sexually Transmitted Diseases and Male Fertility

The contribution of sexually transmitted diseases to overall levels of male infertility is thought to be quite small, but our knowledge of the causes of male infertility is limited at present.

Acute infections with chlamydia, gonorrhoea, and other organisms in the prostate gland or genital tract can reduce a man's fertility by temporarily lowering his sperm count. For example, chlamydia can cause epididymitis, an infection of the seminal tubes — the rough equivalent of pelvic inflammatory disease in women. Scarring from epididymitis can obstruct semen flow. However, because it is rare for obstruction of both tubes to occur, it is thought to be very rare for a sexually transmitted infection to be a cause of male sterility.

Preventing Sexually Transmitted Diseases*

Preventing sexually transmitted diseases must become a priority if we are to reduce the prevalence of infertility among Canadian couples in the future. The evidence is clear that chlamydia and gonorrhoea can lead to tubal infertility in women. The incidence of these diseases among young women means that the future fertility of a significant percentage of this generation is at stake. Unfortunately, many will be unaware of the effects of these diseases until they want to have children and find they are unable to do so.

Preventing sexually transmitted diseases must become a priority if we are to reduce the prevalence of infertility among Canadian couples in the future ... Commissioners believe that a country-wide strategy is necessary to combat this public health problem.

* See Annex for dissenting opinion.

Commissioners believe that a country-wide strategy is necessary to combat this public health problem. It would build on existing programs to prevent STDs and involve their coordination at a national level. The plan should be broad-based and multifaceted, involving sexual health education professionals, physicians, public health professionals, and the public.

There is evidence of strong public support for national action on this issue. Canada's Health Promotion Survey 1990 found that 68 percent of men and women believe it is very important for the government to take action regarding sexually transmitted diseases. Reflecting their concern about STDs, 80 percent of young people aged 15 to 19 years believe strong government intervention is required.

> The current approach in Canada focuses on treatment, not prevention. Primary preventive strategies must be developed to reduce unwanted teenage pregnancy and parenthood and the need for abortion, post-abuse psychological treatment, investigation of infertility and resorting to in vitro fertilization or other attempts to restore fertility. The major hurdles to be cleared in achieving this objective appear to be the attitudes of a minority of Canadian society, who do not wish to publicly discuss or teach sexual responsibility, and the failure to utilize the effective approaches to sexuality education already at our disposal.
>
> *Brief to the Commission from the Expert Interdisciplinary Advisory Committee on Sexually Transmitted Diseases in Children and Youth, Health and Welfare Canada, November 26, 1990.*

Quite apart from the personal suffering involved, STDs are a substantial cost to the health care system. One study has estimated that the direct and indirect costs of pelvic inflammatory disease are more than $140 million annually.[14] This figure is in line with findings of a study conducted for the Commission that estimated the costs of chlamydial and gonorrhoeal infections to Canadian society to range from $71 million to $197 million. Thus, preventing STDs will create significant savings for society, even before the cost of infertility treatments for couples unable to conceive because of a STD is considered. Cutting back on STD prevention, then, or failing to provide funding for screening and

> The prevention of pelvic inflammatory disease will significantly reduce the incidence and costs of infertility and the need for expensive new reproductive technologies in Canada ... The need for prevention and its effectiveness in reducing human and health care costs are evident. We now need a commitment to make prevention a reality.
>
> *Brief to the Commission from the Canadian Pelvic Inflammatory Disease Society, April 29, 1992.*

treatment programs, could very well represent a false economy that will cost society more in the long run.

There are two aspects to preventing sexually transmitted diseases. First, we need to prevent people from being exposed to the diseases in the first place. This can be accomplished by ensuring that sexual health education programs exist that equip individuals with the knowledge and skills to enable them to protect their reproductive health. Physicians must also incorporate preventive counselling into their practices. Second, individuals exposed to the diseases require access to early diagnosis and treatment, to minimize the chances of consequent fertility impairment. This requires routine screening of high-risk individuals and effective contact tracing procedures.

Sexual Health Education

As the evidence shows, 60 percent of 15- to 19-year-olds are sexually active, and many are engaging in practices that jeopardize their reproductive health. What knowledge youth do have about safe sexual practices is simply not translating to safe behaviours.

It is clear that we need to re-evaluate the sexual health programs currently being offered to young people to make them effective not only in imparting knowledge, but also in changing behaviours. Several studies have shown that prevention programs that use a variety of vehicles to deliver their messages and that include accessible health services are effective in reducing pregnancy rates among adolescents. Since the skills and knowledge required to prevent pregnancy are also relevant to STD prevention, these studies suggest that sexual health education, when delivered in conjunction with a supportive community environment, could help to reduce the prevalence of STDs.

For example, the Baltimore Pregnancy Prevention Program for Urban Teenagers combined school and clinic counselling to junior and senior high school students. School components included classroom presentations, informal discussion groups, and individual counselling delivered by a team consisting of a social worker, a nurse, and an educator with training in sex education. A clinic located across the street from the high school provided group education, individual counselling, and reproductive health care services. During the program's existence, pregnancy rates declined by 30 percent in program schools but increased by 58 percent in comparison schools without the program. In addition, program recipients were more likely to delay the onset of sexual intercourse.[15]

Another program, conducted in South Carolina, involved the extensive use of a range of sources, including parents, teachers, church representatives, community leaders, and the media, to deliver messages about pregnancy prevention to adolescents. The rate of pregnancy among females aged 14 to 17 years declined over the course of the program, and

the decrease was statistically significant when compared with three other comparable areas without the program.[16]

In Canada, a study conducted for Planned Parenthood showed that teenage pregnancy rates in Ontario declined most dramatically over the period 1976 to 1986 in areas where prevention programs were most accessible and among those young people who were most likely to receive the programs.[17]

These examples demonstrate that sexual health programs that include a variety of components, delivered in a comprehensive way, can have a positive impact on teenage pregnancy rates. We believe that messages about STD prevention should be included in such programs. Specifically, we need to encourage young people to delay the onset of sexual activity, or, if they decide to become sexually active, to minimize the number of sexual partners they have and to use dual forms of contraception to protect themselves against both STDs and pregnancy.

Schools can play a pivotal role in helping to ensure that adolescents receive adequate sexual health education, and we discuss this role later in this section. Schools should not be expected to shoulder all the responsibility, however, for providing sexual health education; parents, church representatives, health professionals, and other community members have important roles as well. In particular, parents who have trusting and supportive relationships with their children are in an ideal position to provide information on sexual health within a context of values and attitudes that emphasize the importance of committed, caring, and respectful relationships. Sexual health educators can recognize that parents are an important resource for positive sexual health education by ensuring they have access to a wide variety of opportunities for learning about sexuality and sexual health issues. The Commission therefore recommends that

Schools can play a pivotal role in helping to ensure that adolescents receive adequate sexual health education ... Schools should not be expected to shoulder all the responsibility, however, for providing sexual health education; parents, church representatives, health professionals, and other community members have important roles as well.

3. Agencies involved in adult education pursue effective methods to equip, support, and encourage parents to assume an active role in providing sexual health education to their children.

Most schools currently offer some sexuality education; however, continuity, comprehensiveness, quality, and content of the instruction vary markedly between individual schools, school districts, and provinces. To address this problem, national guidelines for sexual health education have been developed in response to a recommendation by the Expert Interdisciplinary Advisory Committee on Sexually Transmitted Diseases in Youth and Children and the Federal/Provincial/Territorial Working Group on Adolescent Reproductive Health. The goal was to provide a clear statement of principles of sexual health education to guide and unify those working in this area.

The Guidelines for Sexual Health Education were extensively researched and prepared by a national working group whose membership included a cross section of professionals with expertise in various aspects of sexual health. They set minimum standards against which to assess existing sexuality education programs, develop new ones, and evaluate the overall network of programming and related services available to Canadians.

The Guidelines for Sexual Health Education suggest that sexual health education requires the integrated and collaborative effort of a range of sectors: family, education, medicine, public health, social services, and government. They set sexual health education within a broadly based, community-wide action plan that helps to focus the work of individuals and organizations from these different fields.

The guidelines recognize the diversity of values and perspectives relating to sexual health education and do not suggest that universal agreement is required on all aspects of the content, methodology, and philosophy of sexual health education. Instead, the document outlines common principles that should be used as guideposts in developing and assessing sexual health programs. These principles are accessibility; comprehensiveness; effectiveness and sensitivity of teaching methods and approaches; training and administrative support for educators; planning, evaluating, and updating program objectives; and development of a social environment conducive to sexual health.

The Guidelines for Sexual Health Education are currently being assessed by Health Canada; a release date has not yet been established. In our view, the guidelines are well written, comprehensive, and supported by existing (albeit limited) research. The Commission therefore recommends that

4. Sexual health education programs be based on the national Guidelines for Sexual Health Education.

and that

5. The evaluation, revision, and distribution of these guidelines occur at least once every five years.

These national guidelines should be based increasingly on research that measures the effects of different types of sexual health education programs on the knowledge, attitudes, and behaviours of program recipients. There is little or no Canadian outcome-based research on this subject at present; once designed and implemented, few sexual health education programs are evaluated. This makes it difficult to know which prevention programs are most effective. Accordingly, the Commission recommends that

6. Initial funding for sexual health education programs include funding for an evaluation component to assess if the stated objectives of the program are being met and to guide subsequent program development and modification.

Many schools provide only limited sexuality education in selected grades. Ideally, sexuality education should be offered at all grade levels to reinforce learning and build on the messages conveyed in previous grades in an age-appropriate manner. Individuals should acquire the necessary knowledge and life skills before they choose or feel pressured to become sexually active. The Commission therefore recommends that

7. Provincial/territorial ministries of education mandate the provision of comprehensive sexual health education sequentially from the beginning of elementary school through to the end of high school.

A second problem with existing sexuality education programs is that many provide information without addressing underlying attitudes and behaviours or providing a supportive environment. Research shows clearly that programs focussing solely on knowledge acquisition fail to change risky sexual behaviour. Positive sexual health outcomes are more likely to occur when sexual health education effectively integrates knowledge, motivation, skills-building opportunities, and a supportive environment. Students must not only be given relevant information but also be motivated to change their behaviour and helped to develop the skills to do so successfully. Effective sexual health education depends on a life skills

approach that strengthens self-esteem, personal insight, communication skills, assertiveness, and respect for others. These attitudes and skills, in combination with relevant knowledge, place individuals in a stronger position to avoid unsafe sexual behaviours. For example, increasing the self-esteem and assertiveness of young women would reinforce their ability to refuse to have sexual intercourse or to insist that partners use condoms, just as promoting respect for others would reduce peer pressure to become sexually active or to engage in risky sexual behaviours.

An example of a life skills-based program is the pregnancy prevention program offered by Student Health Services at the University of Western Ontario. The program has three elements: a pregnancy prevention videotape, a pregnancy prevention book, and dormitory-based talks. The program thus combines information with motivation and skills building. Evaluation of the program showed that pregnancy rates at the university dropped as each phase of the program was introduced, and lower pregnancy rates have been sustained throughout the years the program has been in place. The Commission therefore recommends that

8. Effective approaches to sexual health education integrate four key components: acquisition of knowledge; development of motivation and insight; development of behaviour skills; and creation of a supportive environment.

Consistent with the ethic of care, we believe that information about sexual health, pregnancy, and STD prevention should be presented in a context that emphasizes the value of respectful, supportive, and committed relationships. We acknowledge, moreover, that postponing sexual activity until a monogamous and long-term relationship has been established is still more effective than any other method of preventing STDs. We also recognize, however, that even if all sexual health education programs emphasize postponing sexual intercourse, many young people are still going to become sexually active in their middle or later teenage years. Their sexual health is just as important to a caring society as that of young people who choose abstinence or postponement.

Sexual health education programs must balance individual choices and the values and beliefs of the larger society. Programs that promote or give information on only a single approach to sexual health, such as abstinence, offer nothing to protect the sexual health of young people who do become sexually active. Programs should therefore reflect the reality that society is characterized by a range of sexual attitudes and behaviours. Notwithstanding concerns that introducing young people to a variety of options for maintaining sexual health encourages sexual activity or promiscuity, there is no evidence to support this belief. The evidence suggests the contrary, in fact; effective sexual health education can encourage young people to postpone sexual intercourse. Importantly, it also increases the likelihood that those who are sexually active use contraception. The Commission therefore recommends that

9. Sexual health education programs be designed and presented with the recognition that individuals engage in a range of sexual behaviours (including abstinence, delay, sexual activity in the context of a caring and respectful relationship) and that they need accurate information pertinent to all these choices.

A third problem concerns the information being conveyed in sexuality education programs. Too often pregnancy prevention is taught separately from STD prevention; however, the most effective form of contraception to prevent pregnancy (oral contraceptives) does not protect against STDs. Sexuality education programs must emphasize that dual protection is needed — protection against STDs and against pregnancy, condoms in addition to oral contraceptives. Clearly this requires that schools teach prevention of pregnancy and STDs in an inter-related way. The Commission therefore recommends that

10. Sexual health education programs convey the message that young people who are sexually active need to protect themselves in two ways, that is, against both pregnancy and sexually transmitted diseases.

Pharmaceutical companies can also play a role in helping to educate youth (especially young women), through their marketing efforts, about the need for protection against both pregnancy and STDs. This might include, for example, conveying appropriate messages in packages of oral contraceptives (for instance, that condoms should also be used) and providing literature to physicians for distribution to people who are sexually active.

The mass media play a major role in the sexual education of young Canadians; their portrayal of sexual behaviour, for example, is likely to have a strong influence on attitudes. Ideally, the media should convey messages that promote gender equality, encourage the postponement of sexual activity, and promote the need for dual protection for those who are sexually active. But often this is not the case. The Commission therefore recommends that

11. Sexual health education programs be designed to help individuals identify and evaluate the sexual messages conveyed by the media, to understand what these messages mean for individual and societal sexual health.

Research suggests that providing accessible health services in conjunction with sexual health education is more likely to result in safe sex practices, because reluctance to obtain contraceptives from conventional

sources (such as pharmacies) can pose a barrier to their use. For example, an Ontario study found that regions where sexuality education was offered in conjunction with public health family planning services had the greatest reductions in teenage pregnancy rates.[18]

Some school boards have placed condom dispensers in high school washrooms. Others have established health clinics within high schools to provide contraceptive counselling. Providing contraception to young people is controversial; some worry that it will encourage earlier sexual activity. We have shown, however, that the availability of health services does not lead to earlier sexual activity, but rather to safer sexual practices among those who are already or plan to become sexually active. The Commission therefore recommends that

12. School boards consider the benefits of making contraception more accessible to young people who are sexually active, for example, through condom dispensers in high schools and referral to appropriate health services.

The legal situation with respect to access to health services by teenagers varies across the country. In our view, laws related to the age of consent for medical treatment should not preclude teenagers from obtaining contraception on their own behalf.

Many teachers feel poorly equipped to teach sexuality education and to deal with the issues because their training in the area is limited. The Guidelines for Sexual Health Education outline criteria for the training and administrative support of professionals who teach sexual health education. The Commission recommends that

13. Provincial/territorial ministries of education and local school boards ensure that requirements for teachers delivering sexual health education in schools are in accordance with the criteria outlined in the Guidelines for Sexual Health Education.

Sexual health education programs are effective when they are tailored to the needs of specific populations and attuned to the particular realities of those they are trying to reach. Studies such as the Canada Youth and AIDS Study provide valuable data on the knowledge, attitudes, behaviour, and skills of young people; programs based on this type of research are more likely to be effective in changing behaviour. Given that the knowledge obtained through research is essential in enabling the development of effective sexual health education programs, the Commission recommends that

14. National surveys and other research be undertaken at least every five years to document the knowledge, attitudes, and experience of youth and adults regarding sexual health and sexual behaviour. Surveys should be designed to ensure that they also reach segments of the population known to be at high risk of STDs and/or marginalized from mainstream health services and sexual health education programs.

Youth who do not attend school regularly may miss out on sexual health education programs. This is an important omission, as street youth and young prostitutes constitute a subpopulation with very high rates of sexually transmitted diseases. This group therefore accounts for a significant reservoir of sexually transmitted infection, yet one that will be difficult to reduce if group members are marginalized from mainstream sexual health education and services. The Commission therefore recommends that

15. Agencies involved in public health education develop sexual health programs and services designed specifically to target hard-to-reach populations such as street youth and prostitutes.

Health Care Professionals and the Prevention, Diagnosis, and Treatment of STDs

Primary health care workers — for example, family physicians and nurses — are in a unique position to contribute to the prevention of sexually transmitted diseases. First, they see patients regularly, are aware of the health issues facing them, and have the opportunity to engage in one-on-one preventive counselling about how to reduce the risk of exposure to sexually transmitted diseases. Health care workers in specialized settings can counsel individuals who would otherwise be hard to reach, such as street youth and prostitutes. Second, health care professionals have the opportunity to screen patients who are at risk of acquiring a STD, thereby identifying individuals who may be asymptomatic and yet likely to transmit their infection to others. Third, health care professionals have the opportunity to treat sexually transmitted infections and thus reduce the risk of serious consequences to individuals.

There are several impediments, however, to a preventive counselling role for health professionals, in particular the limited time doctors have available for counselling because of pressure to provide treatment. This

reflects the general orientation of the medical care system toward treatment rather than prevention; its structure, training programs, and reimbursement methods focus primarily on treatment. Current efforts to change this orientation are encouraging, with government reports at both the federal and provincial level supporting a greater emphasis on prevention. For example, a recently published federal document, "Enhancing the Provision of Prevention Services by Canadian Physicians," attests to the growing emphasis among both policy makers and health care providers on health promotion and disease prevention.

Training of Health Care Professionals

Surveys conducted in the United States show that physicians generally feel poorly trained and therefore ill-equipped to counsel patients about sexual behaviour. This probably holds true for Canadian physicians as well, with the result that many do not feel comfortable providing preventive STD counselling. Most Canadian medical schools offer only limited instruction to undergraduates and residents on the prevention of sexually transmitted diseases. One survey showed that they provided an average of six hours of classroom instruction and between two and eight hours of clinical experience in the treatment and management of STDs.[19] There are no established Canadian criteria for this type of training, but a U.S. advisory committee has recommended that all medical students and residents receive a minimum of 20 hours of supervised clinical experience in STD management. Most STD instruction in Canadian medical schools clearly falls short of this standard.

Nurses also receive little training in STD prevention. A 1988 survey of university and community college nursing schools conducted by the Canadian Nurses Association showed that nursing students receive an average of six hours of instruction related to sexually transmitted diseases.

Many public health nurses and public health physicians are sensitive, experienced, non-judgemental, and effective in dealing with individuals with sexually transmitted diseases. Other health care professionals need to develop these skills in their dealings with patients. Their training should emphasize that psychological and social issues need to be discussed in a tactful and sensitive way to ensure that patients have the information they need to deal with an infection and prevent a recurrence.

Professional associations should take a leadership role in ensuring that medical students, residents, and nursing students receive STD training. The quality and duration of STD training provided by medical schools for various levels of clinical practice (ranging from family physicians to infectious disease specialists) should be reviewed and standards recommended. Guidelines for the prevention, diagnosis, and treatment of sexually transmitted diseases were released recently by Health Canada and provide standards of care that should be reflected in course content. (The guidelines are discussed below.) Professional colleges should also ensure

that physicians are adequately trained regarding sexually transmitted diseases. The Commission recommends that

16. The Royal College of Physicians and Surgeons of Canada (for obstetricians/gynaecologists and infectious disease specialists), the College of Family Physicians of Canada (for general practitioners), and the Canadian Nurses Association (for nurses) propose standards for the content and duration of STD training provided by medical/nursing schools for various levels of clinical practice. Examining bodies of these organizations should examine candidates regarding the diagnosis, treatment, and management of STDs.

Although improved training in medical and nursing schools will place future professionals in a better position to provide STD counselling, those already practising also need up-to-date knowledge and skills. Many physicians graduated well before the advent of AIDS and penicillin-resistant gonorrhoea, and treatment protocols and knowledge about sexually transmitted diseases are changing rapidly. Continuing medical education is essential to keep those already in the field current and knowledgeable about sexually transmitted diseases. The Commission therefore recommends that

17. Continuing medical education courses be offered by faculties of medicine for obstetricians/gynaecologists and infectious disease specialists and for general practitioners, and by nursing faculties and community colleges for nurses, on the diagnosis, treatment, and counselling of individuals with sexually transmitted diseases.

STD Guidelines for Health Professionals

In November 1992, the Laboratory Centre for Disease Control (Health and Welfare Canada) released the updated *Canadian Guidelines for the Prevention, Diagnosis, Management and Treatment of Sexually Transmitted Diseases in Neonates, Children, Adolescents and Adults.* The guidelines outline how physicians and nurses should diagnose and manage sexually transmitted diseases and incorporate prevention into their practices. For example, the guidelines recommend that a complete sexual health history

be a routine part of practice, providing important information about the extent to which a patient may be at risk for STDs.

The guidelines also recommend that practitioners counsel patients about risky sexual behaviour. This is especially important when a physician prescribes oral contraception for a young woman. Without STD counselling, physicians may inadvertently promote unhealthy sexual behaviour. Strong messages need to be conveyed to young women who are prescribed oral contraceptives about the need for dual protection against pregnancy and sexually transmitted diseases.

Health and Welfare Canada provided 28 000 copies of the guidelines for distribution by the provinces and territories to family physicians and public health workers. Copies will not be distributed to specialists such as obstetricians/gynaecologists, who are presumed to have up-to-date information about the appropriate management and treatment of STDs, although they will be available for purchase. In our view, however, it would be desirable for the guidelines to be provided to all physicians likely to see patients with a STD.

18. The Commission endorses the 1992 *Canadian Guidelines for the Prevention, Diagnosis, Management and Treatment of Sexually Transmitted Diseases in Neonates, Children, Adolescents and Adults* prepared by the Laboratory Centre for Disease Control, Health Canada, and recommends that Health Canada ensure that a free copy of the guidelines is available to all primary care physicians, obstetricians/gynaecologists, urologists, STD clinics, provincial and territorial nurses, community care clinics, nurses in school settings, educators teaching STD management at nursing and medical schools, and nursing and medical students.

We also recommend that

19. The guidelines be updated every five years.

The availability of guidelines does not necessarily mean that all physicians will follow them. A recent study evaluated awareness and use of the 1988 STD guidelines by 153 staff physicians and residents at six hospital family practice teaching units in Toronto. The majority (70 percent) of physicians were unaware of the guidelines. Among those who were aware of the guidelines, 46 percent agreed with them but only 39 percent stated that they followed them routinely.[20] A 1992 study by the Laboratory Centre for Disease Control also found that some physicians are

treating chlamydia and PID inappropriately.[21] These findings highlight the need to ensure that physicians are aware of the new STD guidelines and that they are encouraged to follow the recommended procedures for the diagnosis, prevention, and treatment of STDs. Research is also needed to discover why some recommended preventive practices are not being followed.

A final area of concern with respect to health professionals and the management of STDs is tracing the contacts of people diagnosed with STDs. In our view, it would be desirable if standards for contact tracing were included in future revisions to the 1992 *Canadian Guidelines for the Prevention, Diagnosis, Management and Treatment of Sexually Transmitted Diseases in Neonates, Children, Adolescents and Adults.*

Periodic Health Examination

One way to detect STDs early and offer treatment, so as to reduce the chances of untreated cases leading to infertility, would be through check-ups or periodic health examinations. The Canadian Task Force on the Periodic Health Examination (established in 1976) has developed a scientifically rigorous approach to assessing the efficacy and effectiveness of preventive activities routinely undertaken by clinical practitioners. The task force published its first report in 1979, and several updates have been published since then. The College of Family Physicians of Canada has supported the work of the task force and, in 1983, published a loose-leaf binder containing the preventive care recommendations of the Canadian Task Force on the Periodic Health Examination and, with the help of Health Canada, distributed one to every College member.

The United States Preventive Services Task Force was set up after the Canadian task force but has gone further in its work. In 1989, the U.S. task force published a guide on clinical preventive services that assesses the effectiveness of 169 interventions and provides a series of charts with clinical preventive measures recommended for patients in various age groups. It also developed recommendations for patient education and counselling on preventing transmission of HIV and other STDs.

A summary of proceedings of a joint Canadian and American symposium, "Implementing Preventive Services," held in 1987, called for the creation of an infrastructure to implement the recommendations of the Canadian and U.S. task forces. The Canadian task force does not have adequate funds, however, to update, compile, and distribute its recommendations on effective preventive services. Commissioners were impressed by the task force approach, which involved evaluating evidence and discarding procedures that did not make a difference to health. We believe that it is

an appropriate way of ensuring that health care resources are used effectively. The Commission therefore recommends that

> **20. The federal government provide adequate funds to the Canadian Task Force on the Periodic Health Examination or a similar body to compile, update, and publish its findings in a practical guide for primary health care workers on useful preventive services and that the guide include STD prevention.**

Research Needs

The foundation of all work in the prevention of sexually transmitted diseases is accurate knowledge from well-designed research. This can be obtained only by supporting productive investigators, facilitating continuing research in this field, and providing training for future researchers.

Making the reporting of chlamydia cases mandatory could help to provide a more complete picture of the prevalence of the disease. Pelvic inflammatory disease is not reportable, however, and asymptomatic cases of STDs that are not detected will also continue to be unreported. One way to obtain a more accurate picture of the incidence of chlamydial and gonorrhoeal infections would be to piggyback on an existing approach, such as the National Sentinel Surveillance Program, a Health Canada program that collects demographic and risk factor information from nine health facilities that together serve 10 percent of the Canadian population. Physicians at these facilities could be trained to screen high-risk individuals for STDs, and the data collected would provide a more accurate understanding of the incidence of chlamydial and gonorrhoeal infection in Canada.

Apart from research on AIDS, little targeted funding is available for research in the field of sexual and reproductive health, including sexually transmitted diseases. No government research funding agency earmarks funds for work on infectious diseases other than AIDS, and no funding agency has a specific mandate for research on reproductive health. Given the importance of this research, and given that the objectives of the Medical Research Council (MRC) of Canada include promoting and supporting research that advances the application of scientific research to the prevention, diagnosis, and treatment of disease, the Commission recommends that

21. Federal research funding organizations, such as the Medical Research Council, consider making basic and applied research on sexual and reproductive health, including sexually transmitted diseases, a higher priority.

There is a clear need for evaluation of prevention programs to guide future program development and implementation. To do this, more researchers with epidemiological and evaluation skills will be needed. At present only a handful of researchers is working on the collation of routinely collected data on sexually transmitted diseases, and an equally small number is involved in evaluating STD prevention programs. A concerted effort is therefore required to train researchers and prepare for epidemiological research of the type needed to assess preventive strategies. The Commission recommends that

22. Federal research funding organizations, such as the National Health Research and Development Program and the Medical Research Council, consider targeting funding to the training of epidemiological researchers as part of an overall approach to assigning higher priority to applied research on sexual and reproductive health.

Preventing STD-Related Infertility: A Comprehensive Reproductive Health Strategy

The prevention of sexually transmitted diseases is just one aspect of sexual and reproductive health. The protection and promotion of sexual and reproductive health merit a comprehensive, coordinated response because they affect all Canadians.

As a public policy field, sexual and reproductive health and sexually transmitted diseases lack the degree of integration, coordination, and comprehensiveness needed for effectiveness. There is little internal coordination among government branches with regard to STD prevention, sexuality, and reproductive health. There is also no effective vehicle for maintaining a network of contacts among the various professionals concerned; reproductive and sexual health does not have a broad community network that would facilitate the development of coordinated strategies.

As a result, a piecemeal approach is often taken to addressing the issues, inhibiting advances in STD prevention and reproductive health promotion. Family planning, pregnancy care, and sexual health services,

often isolated from one another, are fragmented within the health care system. Reproductive health care and counselling services designed specifically to meet the needs of women are in short supply or entirely absent.

Furthermore, programs and funding for STD and AIDS prevention are generally kept separate, potentially diluting their effectiveness and requiring greater human and financial resources than would be required for a single concerted effort. Federal AIDS prevention efforts have also failed to capitalize on existing expertise in dealing with STDs.

> Former Prime Minister Pierre Elliott Trudeau stated "government has no role in the bedrooms of its citizens." Although most Canadians would accept the truth of this dictum, it does not exempt federal and provincial governments from assuming a major responsibility for the control and prevention of STDs throughout Canadian society.
>
> *A. Ronald and R. Peeling, "Sexually Transmitted Infections: Their Manifestations and Links to Infertility and Reproductive Illness," in Research Volumes of the Commission, 1993.*

In the view of Commissioners, the most effective way to promote sexual and reproductive health is through integrated and coordinated efforts, with STD prevention pursued within a broader coordinated strategy to address sexual and reproductive health. A national body could be highly effective and efficient in creating, coordinating, and fostering networks and activity in sexual and reproductive health. The Expert Interdisciplinary Advisory Committee on Sexually Transmitted Diseases in Children and Youth, for example, did exemplary work in reproductive health during its mandate (1986-1991). In Chapter 15, we discuss the need for a comprehensive reproductive health strategy and present our recommendations for a body to develop the strategy and oversee its implementation.

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Smoking and Infertility

There is mounting evidence that women who smoke heavily have a reduced ability to become pregnant. This relatively new finding comes in addition to the already well-accepted evidence that smoking during pregnancy is associated with risks for the fetus and eventual child, including higher rates of spontaneous abortions and low birth weight. An association has also been shown between a pregnant woman's exposure to second-hand smoke and the birth of a low birth weight infant.

Twenty-nine percent of Canadian women in their childbearing years (ages 20 to 44) smoke; exposure to tobacco smoke is even more widespread if we take into account women exposed to second-hand smoke in their homes or workplaces. Therefore, the high proportion of women for whom tobacco smoke may play a role in infertility distinguishes smoking as a major risk factor for infertility.

An association between smoking and reduced fertility is biologically plausible, given the hundreds of chemicals in tobacco smoke and what we know about the effects of some of those chemicals on pregnancy. Their effects on fertility in women are not well understood, but animal studies have shown various effects on the hormonal system, testes, ovaries, and uterus that might be expected to reduce reproductive capacity if they occurred in men and women. For example, rats injected with nicotine have been found to undergo hormonal changes and a reduction in ovulation. By-products of cigarette smoke have also been shown to affect ovarian blood flow in laboratory animals.

Analyzing the research data on smoking and infertility in human beings is complex, however, because other factors that can affect fertility must be taken into consideration. For example, smoking is associated with heavier consumption of alcohol and coffee and lower socioeconomic status. It is important but difficult to distinguish the influence of one factor from another. Despite these problems, the existing data, when taken together,

show an association between smoking and a reduced ability to become pregnant. The association is quite clear for women who are heavy smokers; among lighter smokers, the relationship between smoking and the ability to conceive is less clear. In addition, however, the finding that quitting smoking is followed by a return to normal fertility, together with the feasibility of preventing smoking, led the Commission to recommend that smoking prevention should be a high priority for policy makers.

The impact of smoking on male fertility needs to be elucidated; to date, most research has focussed on the impact of smoking on women's reproductive health. An association between heavy smoking and reduced sperm quality and quantity has been shown, however. This area requires further research, but it seems probable that a man who smokes heavily may reduce the ability of his female partner to conceive, if only by exposing her to second-hand smoke.

In the following pages, we examine the impact of smoking on time to conception, pregnancy, birth outcomes, and other relevant factors such as age at menopause. We also discuss what is known about the relationship between smoking and male fertility. Finally, we examine how we can prevent reproductive harm caused by smoking.

Impact of Female Smoking on Fertility

Over the past decade, most studies that have examined the effects of smoking on fertility have found an association between female smoking and a reduced ability to become pregnant.[1] The evidence shows a "dose-response effect," meaning that the more cigarettes a woman smokes, the greater the effect on her fertility (see Table 11.1). As mentioned above, some studies have found that ex-smokers return to normal fertility, which provides further evidence of the relationship between smoking and the ability to conceive.

The exact mechanisms by which cigarette smoking affects female fertility are not clear. Evidence suggests that the presence of nicotine in a woman's bloodstream may affect the ability of the fallopian tubes to transport the egg to the uterus and the ability of the fertilized egg to implant.[2] This also may help explain why women who smoke have been found to be at higher risk of having an ectopic pregnancy.

A multinational study was conducted between 1978 and 1980 by the World Health Organization in 12 centres comparing 1 108 women with confirmed ectopic pregnancies to equal numbers of women with normal pregnancies and to non-pregnant women. For developing countries, the prevalence of smoking was significantly higher among women with ectopic pregnancies (17 percent) than among women with normal pregnancies (7 percent); the relevant figures for developed countries were 47 percent and 37 percent. Even after adjusting for known risk factors (history of PID or

gonorrhoea, IUD use, tubal ligation, and prior ectopic pregnancy), the women with ectopic pregnancies were still found to be twice as likely to be smokers.[3] This provides further evidence of a link between smoking and tubal dysfunction.

Table 11.1. Probability of Achieving Live Birth Among Smokers and Non-Smokers

Cigarettes smoked	Relative fertility rate*
Never smoked	1.00
Ex-smoker	0.99
1-5 cigarettes/day	1.00
6-10 cigarettes/day	0.97
11-15 cigarettes/day	0.93
16-20 cigarettes/day	0.79
More than 20 cigarettes/day	0.78

* The number of months elapsed between stopping contraception and achieving a live birth was compared between groups. Women who had never smoked were used as the reference group, and all other groups were compared to this group.

Source: Howe, G., et al. "Effects of Age, Cigarette Smoking, and Other Factors on Fertility: Findings in a Large Prospective Study." *British Medical Journal* 290 (June 8, 1985): 1697-1700.

The biological effects of smoking on fertility require further research. It is essential to know more, as the subject has clear implications for public policy and programs to prevent infertility, and for individual women's decision making when they plan to have children.

Infertility Treatment Results and Smoking

Does smoking make it less likely that infertility treatment will be successful? Recently, researchers have begun to examine this question. At some infertility clinics a sizable proportion of patients are smokers; for example, in 1990-91, 27 percent of women undergoing *in vitro* fertilization at the McMaster IVF clinic were smokers.[4]

Evidence from a Canadian study[5] and a British study[6] suggests that smoking may have detrimental effects on the chances of a live birth occurring following IVF, but large studies with complete and careful data collection are necessary to define the precise nature and extent of these

effects. Evaluating the effects of smoking on IVF outcomes is complex; in particular, the impact of variables such as socioeconomic status must be taken into account.

In summary, the available data on this question are too limited to be conclusive, but they are enough to suggest that women who smoke are less likely to have a live birth after undergoing *in vitro* fertilization than women who do not smoke. Given the evidence linking smoking to adverse effects on the ability to conceive and on pregnancy outcomes, together with the overwhelming evidence that smoking is detrimental to health in general, there are compelling reasons for women undergoing infertility treatment to quit smoking.

Smoking, Pregnancy, and Birth Outcomes

The evidence that smoking reduces the likelihood of having a healthy, full-term infant (that is, using our broader definition of fertility) has been clearly documented; it is well recognized that smoking during pregnancy poses risks to the woman, the fetus, and the eventual child. These include an increased risk of ectopic pregnancy, abruptio placenta (premature separation of the placenta prior to delivery), placenta previa (placental attachment covering the inner cervix), spontaneous abortion, stillbirth, and infant death during the first month of life. Infants born to smokers are more likely to have low birth weights (on average, weighing between 150 and 300 grams less than children born to non-smokers[7]), resulting from intrauterine growth retardation and/or premature delivery. Cigarette smoking has also been shown to have an adverse effect on breast milk; women who smoke produce significantly less milk per day than non-smokers, and their milk has lower concentrations of fat, which is crucial for a child's growth and development.[8] Children born to women who smoke during pregnancy are also more likely to succumb to sudden infant death syndrome or to suffer from childhood respiratory illnesses.[9]

Clearly, risks associated with smoking during pregnancy have considerable implications for public health. In the United States, it has been estimated that approximately 14.5 percent of low birth weight births and 10 percent of all fetal and infant deaths are attributable to smoking. Children of women who smoke may also have a somewhat greater chance of developing cancer during their childhood and subsequently in their adult years.[10]

Smoking and Age at Menopause

Several researchers have noted a relationship between smoking and the age at which menopause begins. The toxic effects of smoking may cause depletion in the number of eggs in a woman's ovaries, thus hastening the onset of menopause. Research has shown that women who smoke half a package of cigarettes per day have a median age at menopause about one

year younger than that of non-smokers.[11] The average age at menopause of heavier smokers — those who smoke at least a pack a day — is about two years younger than that of non-smokers. These findings indicate clearly that smoking has an effect on the female reproductive system, influencing women's fertility by reducing the number of years during which they are capable of bearing children.

Male Smoking and Infertility

Relatively few studies have been undertaken to measure the relationship between male smoking and infertility as an outcome; most have been concerned with outcomes more easily measured, such as sperm quantity and quality. A review of 12 published studies found that heavier smoking is associated with declines in both the quantity and the quality of sperm.[12] Eleven of the 12 studies found a reduction in sperm density among smokers; the average sperm density of smokers was 22 percent lower than that of non-smokers. Eight of the studies also found a relationship between male smoking and reduced sperm motility, which may affect the sperm's ability to reach the egg. Ten of the studies also evaluated the proportion of normally shaped sperm in smokers compared to non-smokers, but it was not clear whether the proportion of normally shaped sperm was affected.

In summary, most of the studies reviewed found a relationship between male smoking and reduced sperm density and motility. However, the small number of subjects and the fact that most studies used volunteers from infertility clinics may have influenced the results. How changes in sperm quality/quantity resulting from smoking affect the likelihood of conception and pregnancy remains largely unaddressed. Some studies have investigated whether there is a relationship between the man's smoking habits and the results of fertility treatments. The limited data available provide no clear evidence that a man's smoking adversely affects the likelihood his partner will become pregnant. For example, a Canadian study of IVF patients found that although a male partner's smoking was associated with a significant reduction in sperm concentration in samples prepared for insemination, there was no statistically significant effect on pregnancy or birth outcomes following IVF;[13] however, the numbers in the study were small.

Further studies are required to determine whether a relationship exists between smoking and reduced fertility in men. However, evidence does exist showing that a man's smoking during his partner's pregnancy affects the fetus, especially with regard to low birth weight.[14] This information, together with what is known about the adverse effects of cigarette smoking on female fertility, pregnancy, the health of children, and general health, show clearly that men whose partners are trying to conceive should try to

stop smoking or, at the very least, should avoid exposing their partners to second-hand smoke.

Preventing Reproductive Harm

Research linking smoking and infertility adds to what is already known about the serious health risks associated with tobacco consumption. Tobacco use is considered the single most important and preventable risk to the health of Canadians. It has been estimated that 30 000 Canadians die each year from tobacco-related illnesses, making it the number one public health problem. Given that some one-third of Canadians in their childbearing years (aged 20 to 44) are regular smokers, as well as documented effects of smoking on the full range of reproductive outcomes, smoking must be considered to be a major risk factor for infertility. Reducing smoking among Canadians, and in particular among young people who are about to enter or are now in their childbearing years, could help to reduce the number of couples who have difficulty conceiving. It could also reduce the number of miscarriages, the incidence of low birth weight, and the number of children who suffer long-term health and developmental problems as a result of pre- and post-natal exposure to cigarette smoke.

First, continued efforts are needed to reduce and prevent tobacco consumption in the general population. Programs are required to reduce and eliminate tobacco use among Canadians who currently smoke; to help non-smokers to remain smoke-free; and to eliminate involuntary exposure of non-smokers to tobacco smoke. Women who are trying to conceive or who are already pregnant should ideally live and work in smoke-free environments. Second, people who want to have a child, including those seeking medical assistance to do so, must be informed of the effects of smoking on their fertility.

Our recommendations for preventing reproductive harm from smoking focus on two broad areas. First, continued efforts are needed to reduce and prevent tobacco consumption in the general population. Programs are required to reduce and eliminate tobacco use among Canadians who currently smoke; to help non-smokers to remain smoke-free; and to eliminate involuntary exposure of non-smokers to tobacco smoke. Women who are trying to conceive or who are already pregnant should ideally live and work in smoke-free environments. Second, people who want to have a child, including those seeking medical assistance to do so, must be informed of the effects of smoking on their fertility.

Reducing and Preventing Tobacco Consumption

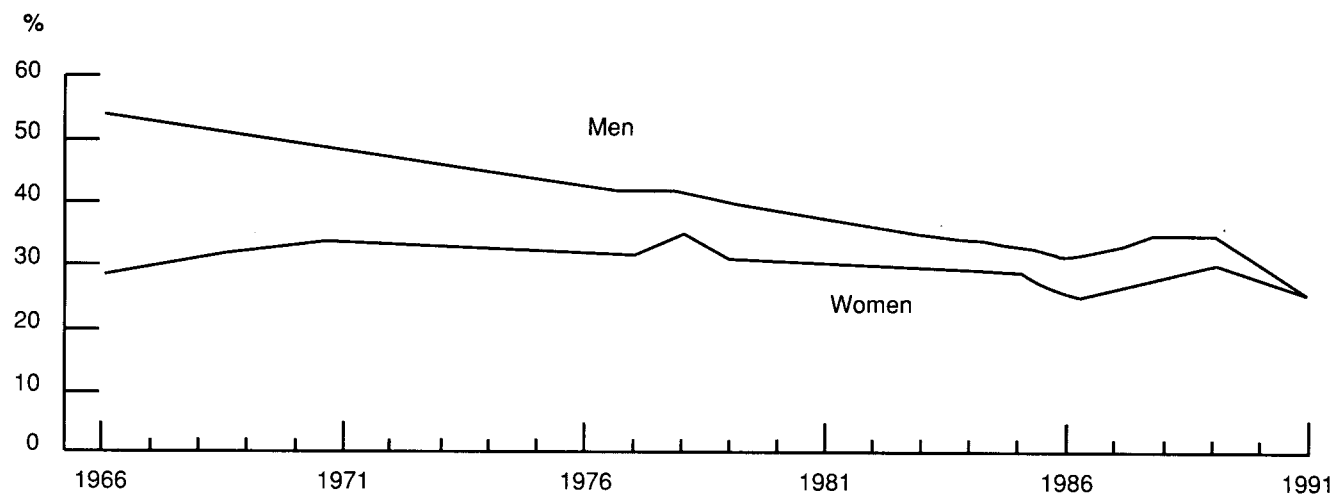
Policies and programs to reduce smoking among Canadians have proved effective. High taxation and strong legislation to restrict cigarette advertising and smoking in public places, in combination with education and smoking cessation programs, have resulted in substantial declines in tobacco use. The decline in the proportion of regular smokers has been equally significant (see Figure 11.1). Canada is seen internationally as being in the forefront in developing strong measures to reduce tobacco consumption.

Efforts to reduce tobacco consumption have been driven by the federal government's adoption of a comprehensive approach to discourage smoking and the work of the Steering Committee of the National Strategy to Reduce Tobacco Use in Canada, whose membership includes federal, provincial, and territorial governments and eight national health organizations. Seven strategic directions were developed: legislation, access to information, availability of services/programs, message promotion, support for citizen action, intersectoral policy coordination, and research/knowledge development. Since these seven activities cannot be pursued by any single government or group on its own, this approach emphasizes the need for many organizations to work together and to coordinate their activities and make the best use of resources.

23. The Commission endorses the work of the Steering Committee of the National Strategy to Reduce Tobacco Use in Canada and encourages governments at all levels, major health organizations, and community groups to continue actively to seek ways to encourage and help those who smoke to quit, to prevent tobacco use among non-smokers, and to protect the health and rights of non-smokers.

Of particular concern is the fact that one-fifth of teenaged girls and boys smoke. Special efforts are required to prevent and eliminate smoking among younger people, because research has shown that the vast majority of smokers become addicted in their teens; the average age at which regular smoking begins is between 12 and 14 years. Teenagers tend to underestimate the addictive powers of smoking; a recent U.S. study showed that 92 percent of teenagers who smoke say they do not plan to be smoking in another year, but only 1.5 percent of them manage to quit.[15] People who reach the age of 20 years as non-smokers are unlikely to become smokers; therefore, if young people can be prevented from smoking in the first place, they are more likely to remain non-smokers throughout their lives.

Figure 11.1. Age-Adjusted Smoking Rates for Population Aged 15 and Over, by Sex, Canada, 1966-1991



Note: Data are for regular smokers and are adjusted for differences in age distribution across time.
Source: General Social Survey 1985 and 1991, Labour Force Survey supplements on smoking habits, and other selected health surveys.

Some provinces plan to introduce legislation to reduce tobacco consumption among young people. For example, in 1992, the Chief Medical Officer of Health in Ontario released a report entitled *Opportunities for Health: A Report on Youth*, which emphasizes that "eliminating smoking by young people is the front line in the war against tobacco use." In addition to educational efforts, the report recommends legislative measures to make tobacco less accessible to young people. In response to the report, the Ontario government is proposing the broadest measures in Canada to discourage smoking, particularly among young people. They include raising the legal age for buying tobacco from 18 to 19 years, imposing fines on retailers who sell tobacco to under-age people, banning tobacco vending machines, outlawing the sale of tobacco in pharmacies, and including stronger health warnings on cigarette packages. Other provinces are also considering raising the legal age for purchasing tobacco.

Provincial efforts to reduce smoking among young people are encouraging; however, the effectiveness of the proposed measures will depend largely on whether and how well they are enforced. A 1992 study found that 93 percent of stores in four major cities in Ontario and Quebec would sell tobacco to minors.[16]

24. The Commission endorses provincial/territorial governments' plans to introduce legislative measures to restrict tobacco use among teenagers and urges them to ensure that these measures are enforced.

Educational programs are also required to persuade young people to avoid or stop smoking. Such programs are not a mandatory part of health curricula in all provinces. In our view, all young people should receive health education that includes smoking prevention throughout elementary and high school grades. Therefore, the Commission recommends that

25. Provincial/territorial ministries of education mandate health education that includes smoking prevention for all young Canadians in elementary and high school grades.

In the 1960s and '70s, school programs tended to focus on the health risks of smoking and did not address the social pressures on teens to smoke. Since many young people see smoking as an avenue to peer acceptance, and many young women believe that smoking will help them control their weight, initiatives that address these underlying attitudes are needed. Approaches that promote the immediate and long-term physical and social benefits of non-smoking appear to be more meaningful to young people than approaches that emphasize the dangers of smoking.

Because smoking, alcohol abuse, and other high-risk behaviours tend to occur in tandem, and the strategies for preventing one high-risk behaviour apply to others, it makes sense to coordinate education about smoking with education about alcohol and drug use and the risks of unsafe sexual behaviours, all in the context of promoting healthy life choices. School efforts to prevent smoking among young people will have the greatest impact if they are coordinated with programs in the community. The Commission recommends that

26. Provincial/territorial ministries of education and health ensure that health curricula and school programs, in conjunction with community programs, focus on the benefits of a smoke-free life as a means of preventing and reducing smoking among young people.

Health education can cause a short-term decline in smoking among young people, but changes in the long term are more difficult to sustain in a culture that still promotes tobacco use through such avenues as the sponsorship by tobacco companies of automobile racing, sports events, and concerts. Governments have already taken such steps as banning magazine, television, and radio advertising of cigarettes and tightening restrictions on tobacco purchases by minors. Commissioners strongly support such actions to reduce smoking among Canadians and believe that every additional step should be taken to discourage young people from smoking.

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Reducing and Preventing Smoking Among Couples Who Plan to Become Pregnant

As the evidence before the Commission shows, couples who want to become pregnant or who seek infertility treatment should be aware of the possible effects of smoking on their ability to conceive and have a healthy pregnancy. Smoking cessation is difficult for most people, however. Health care professionals should recognize this and when counselling them about the need to stop smoking should make their recommendations in a non-judgemental and supportive way. The effort to reduce and prevent smoking among couples who plan to become pregnant will need to be supported and

carried out by several categories of individuals. The Commission recommends that

27. Public education efforts endorsed by the Steering Committee of the National Strategy to Reduce Tobacco Use in Canada include informing women of the evidence regarding the effect of cigarette smoking on ability to conceive, in addition to the adverse effects on their pregnancy and the health of the fetus.

and that

28. Public education efforts include messages that encourage men to stop smoking to maximize the chances that their female partner will be able to conceive and have a healthy pregnancy and birth.

29. Physicians and other health professionals (such as public health nurses) encourage women who smoke and who plan to become pregnant to quit smoking, and provide them with the support to do so.

and that

30. Prenatal classes (supported by provincial/ territorial ministries of health or municipal governments) include information and support with regard to the importance of smoking cessation.

In infertility diagnosis and treatment, it is important that physicians (both general practitioners and those who evaluate couples at infertility clinics) carefully investigate whether factors such as smoking may be contributing to a couple's difficulty conceiving. Both partners should always be asked whether they smoke, and men and women should be counselled about the importance of changing habits or practices that may

jeopardize their ability to conceive and have a healthy pregnancy and birth. The Commission recommends that

> **31. Physicians determine whether either partner in a couple having difficulty conceiving is a smoker and recommend smoking cessation as the first approach before beginning fertility treatment for either partner.**

Given how common smoking is among people of reproductive age, it is important that research be undertaken in the future to clarify the relationship between smoking and fertility in women and men. Greater focus is needed on this ubiquitous and preventable risk factor. We believe that agencies such as the National Health Research and Development Program, the Medical Research Council, and provincial health research funding agencies should take this into account in their planning and funding decisions.

Preventing Smoking-Related Infertility

We have recommended a vigorous approach on several fronts, involving many groups and individuals, to prevent the onset of smoking among young people, to accelerate cessation among current smokers, and to reduce the exposure of non-smokers to tobacco smoke. By reducing the prevalence of smoking in the general population, these efforts could ultimately reduce the proportion of couples who are infertile in the future.

In addition to these broad strategies to reduce tobacco consumption among the general population, we have made specific recommendations about informing couples who wish to conceive about the adverse effects of smoking on their fertility. Public education is one route to increasing this awareness. Physicians and other health professionals who have regular contact with people in their reproductive years also have an essential role; they can provide counselling that includes information about the effects of smoking on the ability to conceive, to sustain a healthy pregnancy, and to promote the birth of a healthy child, as well as support to help people quit smoking and to make that decision a permanent one.

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Age and Infertility

As women grow older, their fertility declines. This decline is inherent in human biology and the aging of the reproductive system; it is also related to cumulative exposure to risk factors such as those discussed in the chapters in this section. In addition, research has shown that women who have children in their later reproductive years (particularly after age 40) face an increased risk of adverse pregnancy and birth outcomes.

From a biological perspective, the ideal time for a woman to have children is when she is in her 20s. From a social perspective, however, for many women having children at this time is either not practical or not desirable. For some, obtaining an education and establishing a career occupy a portion of this time; others do not establish a long-term relationship until they are in their late 20s or 30s. For many women, the inadequacy of social supports makes it impossible for them to have their children earlier without paying a substantial penalty. And for some women a combination of all these factors is involved. Delaying childbearing for a few years may have positive consequences — those who begin parenting in their late 20s to early 30s are likely to have acquired more life skills, greater maturity, and financial stability, all of which may benefit their children.

Although many couples who delay childbearing may be better off as a result, and indeed society may benefit as well, some who delay may have to pay the unanticipated price of infertility. Women who try to conceive in their mid-30s or later are likely to be less fertile than they were in their 20s, and therefore they may have to wait longer before becoming pregnant. Once they have made a decision to have children, many couples who have postponed having children and have used contraception for many years are surprised when they do not conceive immediately, or at all, after discontinuing it. It is therefore important that couples make a decision about the best time to have children with full information about the impact of aging on a woman's fertility.

In this section, we examine the social context of childbearing, demographic trends in childbearing, and the potential implications for infertility of delaying childbearing. We go on to make recommendations for public education efforts to increase awareness of the impact of aging on fertility, as well as for programs and policies that would enable couples to have children earlier in their reproductive lives if they wish to and thus avoid some of the risks of infertility associated with aging.

The Social Context of Age and Infertility

The fact that women bear and are the primary caregivers of children remains the most profound factor defining women's role and society's expectations of them. But in the Canada of the 1990s, bearing and caring for children are far from being women's only roles. Most women today combine paid work with raising children and managing a household; indeed, one of the most significant shifts in society in the last three decades or so has been the influx of women into the labour force.

Over the past two decades, the number of women in Canada's paid labour force has almost doubled, and more and more women, representing a wider age range, are participating in paid work. Recent figures show that women account for 45 percent of all workers in Canada. Most of these women are combining paid work and raising children. In 1976, 31 percent of women with children under the age of six were in the paid labour force. By 1991, 57 percent of such women were working outside the home. When women with children aged 6 to 15 are included, the figure jumps to almost 70 percent.

Similar changes are evident in women's education. The percentage of women aged 15 years and over who obtained at least some post-secondary education rose from 25 percent in 1981 to 40 percent in 1991; women are also now earning more than half the bachelor and professional degrees awarded by Canadian universities.

Despite significant changes in women's lives in recent decades, and despite giving lip service to the importance of child-rearing, society has yet to accommodate these realities of women's lives; in particular, governments have taken few steps regarding adequate child care programs to accommodate women's dual roles as mothers and participants in the paid labour force, despite strengthening social consensus about the need to do so. Compared to several European countries, including France, the Netherlands, and the Scandinavian countries, Canada's lack of adequate policies on prenatal care, parental leave, child care, and workplace policies that accommodate family responsibilities is particularly evident. The shortage of social supports for those who bear and raise children has implications for the age at which women decide to have children.

Other factors related to family formation also have implications for the age at which women begin to have children. These include a trend toward marrying at a later age; a decline in the total number of marriages; and rising rates of divorce and remarriage.

A major consequence of these changes is that more women are delaying childbearing to pursue higher education, to achieve economic stability, and to establish a long-term relationship before having children.

Despite significant changes in women's lives in recent decades, and despite giving lip service to the importance of child-rearing, society has yet to accommodate these realities of women's lives; in particular, governments have taken few steps regarding adequate child care programs to accommodate women's dual roles as mothers and participants in the paid labour force, despite strengthening social consensus about the need to do so.

Although there has not been much Canadian research examining who is delaying childbearing, it is generally believed that women in this group are more likely to be career-oriented, live in urban centres, and have higher household incomes than those who bear children at an earlier age. This does not necessarily mean, however, that only upper-income couples are waiting longer to have children — as we will see in the next section, the overall shift is too marked to be attributable only to this segment of the population. Moreover, many of the social and financial factors that are influencing couples to delay childbearing apply to all socioeconomic groups. During the 1980s, for example, economic conditions and the uncertainty they generated, together with unchanged family incomes relative to rising living costs, likely influenced many couples to postpone having children.

Later marriages and changes in family structure are also affecting childbearing patterns; although not as strong an indicator as in the past, marriage is still a good predictor of childbearing in Canada. The average age of women at the time of their first marriage rose from 22.6 years in 1971 to 26 years in 1990. In many cases, couples who are marrying later are also having children later. Increasingly there are more blended families, single-parent families, and people who have never married, and these changes in family forms have implications for the timing of childbearing. For example, if a couple divorces before having children, childbearing may be delayed while they establish new relationships and start a family with a new partner.

Changes in women's education and occupations have also influenced childbearing patterns. In the past, women generally finished their education or were employed before marriage, then took several years off or left the workforce altogether to raise their children. In the 1990s, paid work is not a temporary activity before raising children; many women return to the workforce for financial reasons soon after having a child — their income

is required to help support the family — and/or because they wish to pursue their careers.

Finally, access to effective contraception, sterilization, and abortion has given women greater control over their fertility than in the past. In the 1990s, women have a choice about whether to delay childbearing so they can achieve their financial, educational, career, or other goals.

Demographic Trends in Childbearing

The past two decades have seen a shift in the age at which women are having children (Figure 12.1). In that period many women in their 20s have postponed having children; this is evident in the downward trend in the birth rate among the 20- to 24-year-old age group, the stable birth rates among women in their mid- to late 20s, and the increased rates in women aged 30 to 34. The birth rate in the group aged 30 to 34 years has risen from 68 per 1 000 in 1981 to 86 per 1 000 in 1990.[1] Added to this is the fact that the "bulge" of baby boomers — those baby boomers born between 1953 and 1963 — are now in their 30s; these two things together have meant a substantial increase in the number of births to women aged 30 to 34 — 35 671 more in 1990 than in 1981.

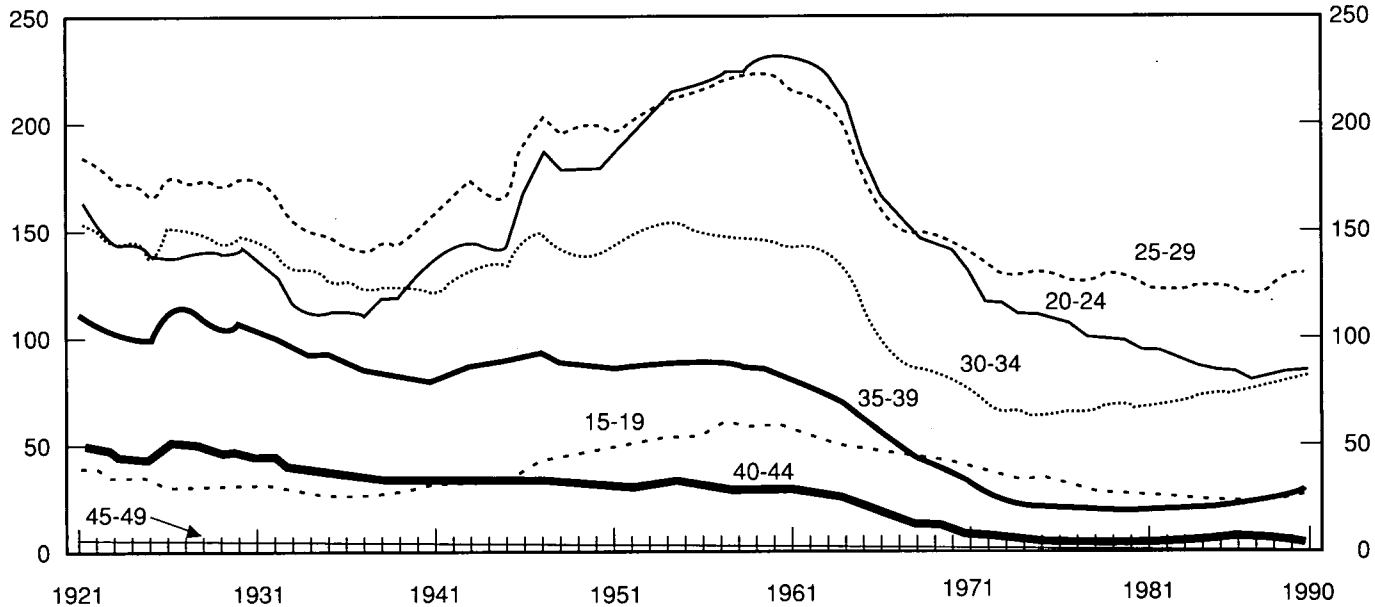
The birth rate for women aged 35 to 39 has also risen — from 19 births per 1 000 women in 1981 to 28 in 1990; similarly, the number of births increased substantially, with 15 743 more in 1990 than in 1981. We can expect that the number of women bearing children in their 30s will remain high until the last baby boomers (those born in the early '60s) have moved beyond their prime childbearing years and entered their 40s — and this will occur in the early 2000s.

As a result of these trends, women over the age of 30 now account for a greater proportion of births than was the case a decade ago, while women in their early 20s account for a smaller proportion of births (see Figure 12.2).

Women having children in their 30s or even 40s is not a new phenomenon. During the baby boom, women in all age groups were more likely to be having children than in the early 1990s. In 1961, the birth rate for women aged 30 to 44 was more than twice what it was in 1990, reflecting the high fertility rate for all ages at that time. Strikingly, the 1961 rate for women aged 40 to 44 was more than seven times as high as the 1990 rate of 4.0.

These high birth rates during the 1950s and '60s were influenced not only by economic conditions but also by the fact that safe and reliable contraception was not as available as it is now. The average age at marriage and the birth of the first child was younger than it is today; most women were in their early 20s when they had their first child, and many continued childbearing into their 30s or even early 40s. This is a key difference between that period and the 1990s — many women are now

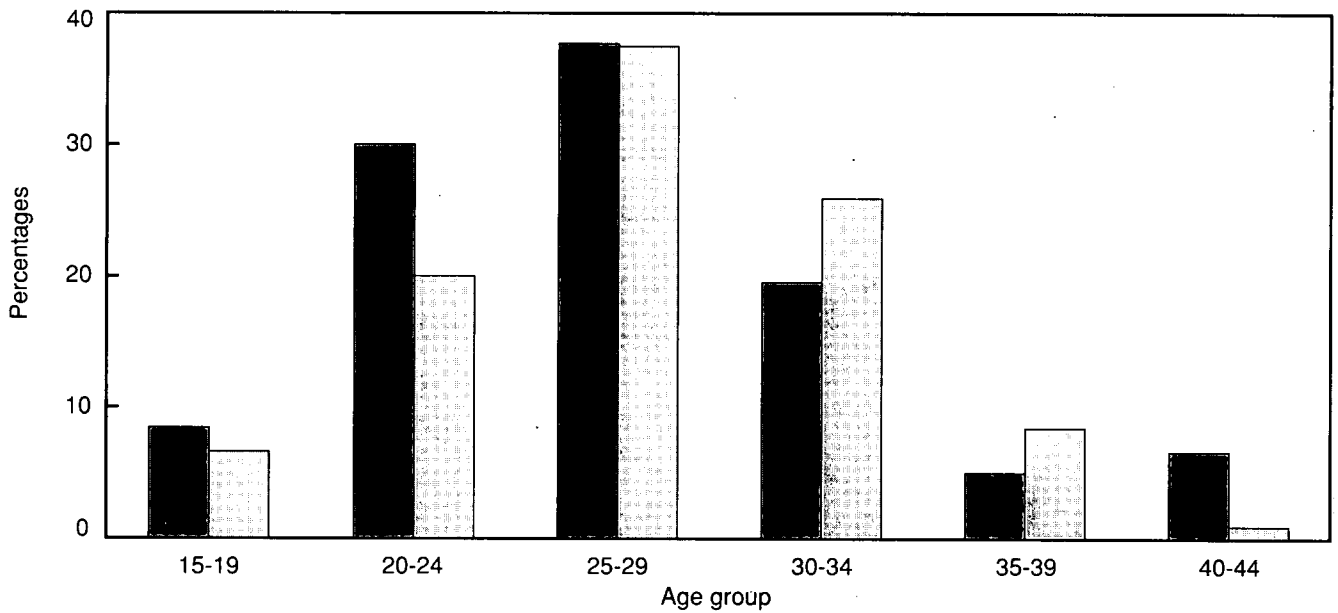
Figure 12.1. Age-Specific Fertility Rates,[1] Canada,[2] 1921-1990



Notes: 1 Number of live births per 1 000 women of same age group
2 Excluding Newfoundland

Source: Statistics Canada. Canadian Centre for Health Information. *Selected Birth and Fertility Statistics, Canada, 1921-1990.*

Figure 12.2. Percentage Distribution of Live Births by Age of Mother, 1981 and 1991*



* Figures do not include Newfoundland

Source: Data adapted from Statistics Canada. Canadian Centre for Health Information. *Selected Birth and Fertility Statistics, Canada, 1921-1990.* Updated to 1991 using Statistics Canada, Vital Statistics Births 1991 Data.

beginning their families in their early or even late 30s, whereas in the past, children born to women of that age were usually not their first.

As Figure 12.1 clearly shows, in the last half of the 1960s and into the '70s, the birth rate for all women, including older women, declined dramatically. The average family size declined as more effective contraceptive methods, better sterilization procedures, and legalized abortion became available, giving women greater control over the timing and number of their children. It is only in the past decade that birth rates have started to rise again in some age groups, particularly for women over the age of 30. This pattern of delayed childbearing is also evident in the United States and Europe. As we will see in the next section, this has implications for women's fertility and thus for society.

The Impact of Age on Female Fertility

Two kinds of factors contribute to reduced fertility as women age: (1) biological aging, that is, changes in the organs and tissues of the reproductive system and in the hormonal messages that govern its functioning; and (2) the cumulative effects of fertility risk factors that women may be exposed to over time.

With regard to the first, our understanding of the innate biological factors affecting reproduction is still limited. The maturation and release of eggs, embryo implantation, and the ability to carry a pregnancy to term are all known to be affected by aging, but the mechanisms and pathways by which this occurs have not been elucidated. Our survey of infertility clinics in Canada found that older women were more likely than younger women to have unexplained infertility, suggesting that there may be changes in women's reproductive systems as they age that are difficult to pinpoint.

> An increasing number of Canadian couples marry and start having children later in life ... The major question that this trend raises is whether couples — and women in particular — are compromising their ability to procreate by postponing childbearing. It is obvious that people expect to live well past their ability to reproduce. But what does the scientific literature say about the ending of ability to reproduce?
>
> *J. Jantz-Lee, "The Physiological Effects of Aging on Fertility Decline: A Literature Review," in Research Volumes of the Commission, 1993.*

The likelihood that fertilization of an egg will lead to pregnancy declines as a woman ages. For example, a recent study on *in vitro* fertilization in older women showed that the likelihood of pregnancy is greater when the eggs of younger women are used.[2] Moreover, a proportion of women stop ovulating before menopause;

one study showed that 10 percent of women have ceased to ovulate by the time they reach age 40.[3]

Apart from the effects of aging on the reproductive system, with the passage of time the various risk factors discussed in this and other chapters in this Part can also affect women's reproductive health. Cumulative exposure to these factors over time increases the risk of infertility, with implications for the fertility of older women. Moreover, the length of time between a woman's first sexual encounter and the onset of childbearing used to be quite short. This is no longer true; the period of time between first sexual activity and childbearing is now often a decade or more. As a result, the period for potential exposure to sexually transmitted diseases, and the consequent risk of pelvic inflammatory disease leading to tubal infertility, are greatly increased.

Separating the effects of biological aging on reproduction from the effects of other factors is difficult because they occur concurrently; the longer a woman lives, the greater her chances of being exposed to hazards and the older her reproductive system. The later the age at which a woman tries to conceive, the greater the chances that her fertility will have been reduced, either by aging or by the combined effects of biological aging and exposure to specific hazards on fertility over time.

Studies examining the effects of aging on female fertility have focussed on various aspects of reproduction, including the ability to conceive, to carry a viable fetus to term, and to give birth to a child without congenital anomalies. In addition, the effectiveness of various infertility treatments in older and younger women has been compared; such comparisons also help to shed some light on the relationship between age and fertility.

Conception

Although there are differing views on the specific ages and rates at which fertility declines, it is generally agreed that fertility declines as women age, beginning in their mid-20s through to the mid-30s, then more sharply in the mid- to late 30s. In the research, fertility is measured in terms of time to conception; in general, women in their mid- to late 30s take longer to conceive than women in their 20s.

Demographic studies of historical populations (using birth and marriage records) have been used to evaluate the length of time to conception and rates of sterility for different age groups of women. Such studies are useful because contraception and voluntary sterilization were not used to control fertility in these populations. However, these studies also have significant limitations; they do not take into account such factors as rates of miscarriage, marriage duration (with the possibility of reduced coital activity over time), the possible contribution of the male partner's age to infertility, medical histories, and reproductive impairment as a result of previous births, so exactly how applicable the results are to modern populations is not clear.

Despite such limitations, data from historical populations that did not practise contraception ("natural" populations) do provide a useful picture of the natural decline in female fertility that could be expected to occur in the absence of factors such as contraception. Figure 12.3 presents the fertility rates from seven populations — five natural populations, and the U.S. population in 1955 and in 1981. The data demonstrate that although the fertility rates vary significantly between the same age groups and time periods, the rate of fertility decline is similar among different natural populations.

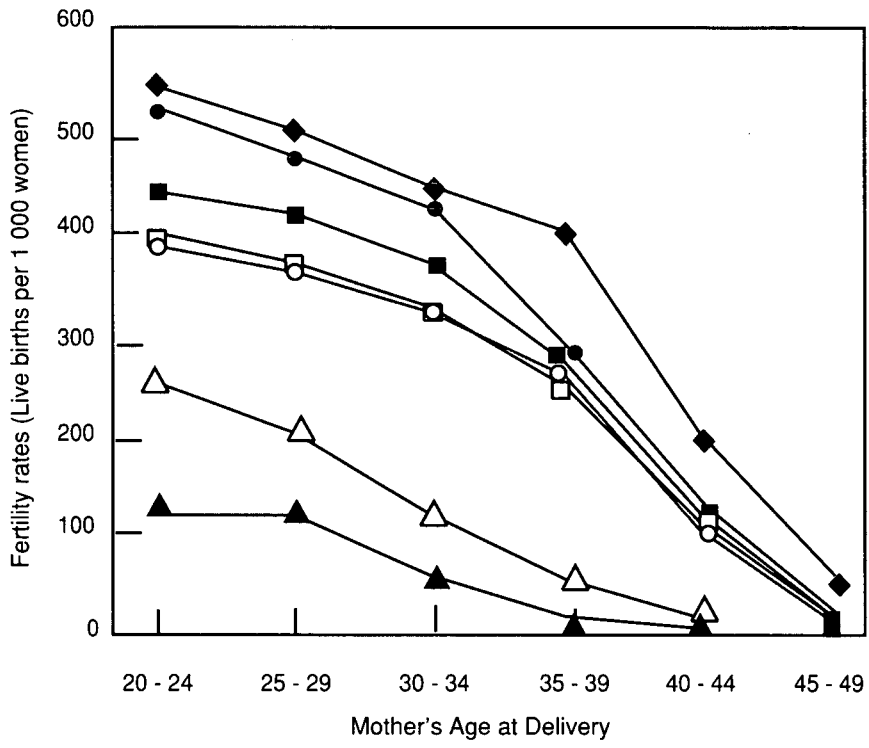
The data from natural populations can also be used to give information on relative fertility rates; these are calculated by comparing the highest pregnancy rate observed within the population with the pregnancy rates observed in other age groups. Figure 12.4 demonstrates that fertility rates remain relatively stable until women are in their early 30s, beyond which the rate starts to decline. After the age of 40 years, the decline is more dramatic. For example, comparisons of fertility rates using data on women aged 20 to 24 years old as the baseline reveal a drop of 4 to 8 percent in the 25- to 29-year-old group, 15 to 19 percent in the 30- to 34-year-old group, 26 to 46 percent in the 35- to 39-year-old group, and as much as a 95 percent decline in the fertility rate of the 40- to 44-year-old group.

Data from natural populations (studies of 16 English parishes) also show that sterility rates rise with the woman's age.[4]

Another approach to assessing the effect of age on fertility is to study donor insemination of women whose husbands are azoospermic (not producing any sperm). These studies offer a way to overcome some of the major weaknesses of demographic studies, because the effects of coital frequency, the man's age, and the health of participants can be removed as influencing factors. The studies assume that the women are representative of the population, that they are healthy, and that the only obstacle to achieving pregnancy is lack of sperm.

One of the most widely cited of these studies, conducted in the early 1980s in France, reported on the results of donor insemination in 2 193 women who had not previously had a child. The probability of success after 12 insemination cycles using frozen sperm was 74 percent for women under 31 years of age, 61 percent for women aged 31 to 35, and 54 percent for women over 35 years of age.[5] This is not the only such study. A review of the four other studies available found that in the two largest studies[6,7] pregnancy rates (if compared to women aged 21 to 25 as the baseline) were similar for those aged 26 to 30, were stable or declined slightly among those who were 31 to 35 years old, and declined more precipitously after the age of 35. The remaining two studies[8,9] had very small sample sizes in the age group over 36, so the data were not as informative.

Figure 12.3. Fertility Rates in Natural Populations

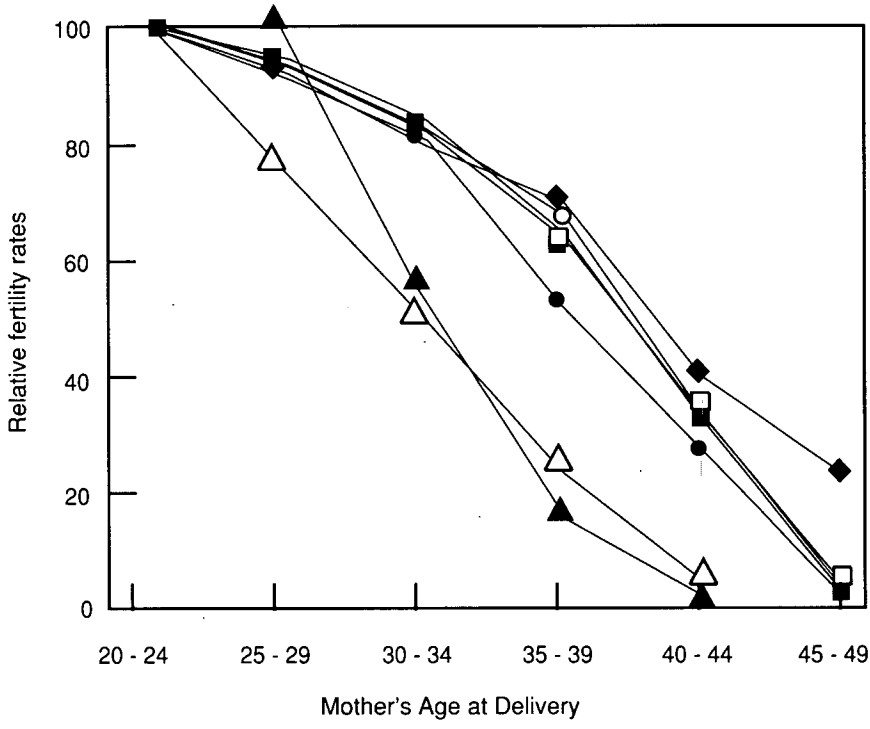


◆ Hutterites (USA 20th Century)
● Burgeoisie Geneva 17th Century
○ Burgeoisie Geneva 16th Century
■ French Village 17th Century
□ Iranian Village 20th Century
△ USA (1955)
▲ USA (1981)

Source: Maroulis, G.B. "Effect of Aging on Fertility and Pregnancy," *Seminars in Reproductive Endocrinology* 9(3) (August 1991), p.168. Reprinted with permission from Thieme Medical Publishers, Inc.

A Canadian study of 2 106 couples registered at 12 infertility clinics also showed the impact of the woman's age on the likelihood of achieving a pregnancy, finding that the woman's age is an important predictor of pregnancy success among infertile couples. If a woman was infertile for three years or more, each additional year in her age reduced the probability of pregnancy by 9 percent.[10]

Figure 12.4. Relative Fertility Rates in Natural Populations



Source: Maroulis, G.B. "Effect of Aging on Fertility and Pregnancy," *Seminars in Reproductive Endocrinology* 9(3) (August 1991), p. 168. Reprinted with permission from Thieme Medical Publishers, Inc.

The effectiveness of infertility treatments such as *in vitro* fertilization and gamete intrafallopian transfer (GIFT) has also been shown to be affected by the woman's age. After 40, pregnancy rates for GIFT decline greatly. As well, pregnancy after reversal of tubal ligation occurs less often in women over the age of 40 years (45 percent) compared to younger women (60 percent).

In essence, although there is controversy about the exact age at which women's fertility declines significantly, in general, then, a woman will take longer to conceive if she is in her mid- to late 30s than if she is in her 20s. Factors other than aging are also important, however, and can affect fertility. For example, an older woman who has been monogamous and had a healthy reproductive history is less likely to be infertile than a younger woman who has been exposed to such reproductive hazards as sexually transmitted diseases.

Pregnancy and Birth Outcomes

Another way of evaluating the effects of aging on female fertility is to examine pregnancy and birth outcomes, since the goal of couples is to have healthy children. Over the past 40 years many studies have evaluated the influence of aging on the risk of adverse outcomes such as spontaneous abortion (miscarriage), low birth weight, and death of the infant or of the woman who gave birth. Taken together, these studies suggest that older women who are pregnant have an increased risk of experiencing one or more of these adverse outcomes. However, the absolute level of risk remains low.

Studies show an increase in the spontaneous abortion rate among older women, but exact figures are difficult to provide because of the need to separate the effects of aging from other factors such as smoking habits and childbearing and medical history. The results of several large studies (five in the United States, one in Canada, one in Ireland, and one in Hungary) show that compared to women in their 20s, the rates of spontaneous abortion are about 50 percent higher in women in their 30s and two to four times higher for those over 40 years of age.[11] These figures may be somewhat inflated, however, because the older group is more likely to include a greater proportion of women who have miscarried a previous pregnancy and are attempting to become pregnant again than is the younger group; these women would be more likely to have a loss again, resulting in a bias toward higher rates among older women.

Similarly, the rate of stillbirth increases with age. Compared to those in their 20s, the rate doubles for women in their mid- to upper 30s and shows a three- to fourfold difference for women in their early 40s. Rates of stillbirth among different age groups vary dramatically between studies, however.

Older women also have an increased risk of having a low birth weight or premature infant or a very large infant (over 4 000 grams). This is attributed to higher rates of hypertension and pre-eclampsia (associated with pre-term infants and infants that are small for their gestational age) and diabetes (associated with large infants) among older pregnant women. Caesarian section is also more common in women over 30 years of age, especially those over 35.

In addition, studies have shown that rates of death resulting from pregnancy or birth complications rise with age. For example, U.K. data for 1985 to 1987 found that the mortality rate was 5.3 per 100 000 pregnancies in women aged 20 to 24, compared to 53.9 per 100 000 pregnancies in women aged 40 or over.[12] This still translates to a low absolute risk (one-twentieth of 1 percent), however, even for women over the age of 40. Also, recent studies have found that mortality does not increase with age if women receive excellent obstetrical care.

Finally, women who have children in their late 30s or early 40s also face a well-documented increased risk of having a child with a significant chromosomal disorder, such as Down syndrome (see Table 12.1).

Table 12.1. Estimated Risk of Giving Birth to a Child with a Significant Chromosomal Disorder, by Maternal Age

Maternal age	Any significant chromosomal disorder	Down syndrome
30 years	1 in 380	1 in 900
35 years	1 in 180	1 in 310
40 years	1 in 60	1 in 90
45 years	1 in 20	1 in 25

Source: Adapted from Hook, E.B. "Rates of Chromosome Abnormalities at Different Maternal Ages." *Obstetrics and Gynecology* 58 (3) (September 1981): 282-85.

Taken together, these findings suggest that women over the age of 30 face a greater chance of experiencing a range of pregnancy and birth complications, although the absolute level of risk for most of these remains low until the woman reaches her late 30s. For women over the age of 40, the potential risks during pregnancy and birth increase substantially. Nevertheless, good obstetrical care means that the absolute risk remains small.

The Impact of Age on Male Fertility

Men do not have a biological end to their reproductive years and can continue to father children until late in life. Research into the impact of aging on male reproductive ability is limited, but such evidence as does exist suggests that there is a much less direct relationship between increasing age and declining fertility in men than in women.

To evaluate the effects of a man's age on conception rates, studies have been conducted using demographic data from polygamous societies where contraception is not used and where the norm is for a man to marry women of different ages. These studies have not shown a decrease in fertility attributable to the man's age.[13]

Other demographic studies have suggested that there may be a link between age and male fertility, although it is much less significant than for women. One study found that male fertility declined slowly and was still at 73 percent of the base rate of the early 20s when the men were 50 to 54 years old.[14]

Dominantly inherited genetic disorders are seen more frequently in the children of older fathers and are thought to be the result of new mutations occurring during the production of sperm (see Chapter 26). The nature of the sperm production process is such that there is a much higher chance of error in the copying of genetic material as cells divide and genetic material is replicated in the resulting sperm. For example, sperm produced by a man aged 28 will have undergone about 15 times more cell divisions than an egg ovulated by a woman of the same age. This is because sperm are produced continuously during adulthood, whereas all the eggs a woman will ever produce are present in her body even before she is born; each egg that matures during her childbearing years is ovulated and thus completes cell division only once. The incidence of mutation resulting from failure to copy a gene correctly at cell division is therefore much more likely to be related to the male partner's age than to the woman's, because the more times genetic material is copied, the greater the chance of an error occurring.

Down syndrome, on the other hand, does not result from gene mutation but from lack of proper chromosomal separation during cell division. The contribution of the male partner's age to the risk of having a child with this chromosomal anomaly is minor. By contrast, the egg may have been in "suspended" cell division — for up to 40 years or so — waiting to be ovulated; as mentioned above, the relationship between the woman's age and the risk of Down syndrome is very strong.

Implications

Current childbearing patterns have implications for the prevalence of infertility and the call for new reproductive technology services in the future. Women who wait to have children until they are in their mid-30s or older have a greater chance of having difficulty conceiving and complications during pregnancy; they also have a somewhat reduced chance of having a healthy child than women who have children in their 20s. These risks increase with the woman's age; a woman who tries to

conceive at the age of 40 is more likely to experience difficulty than a woman who is 35.

Apart from the rise in the number and proportion of women who are having children in their late 30s or 40s, it is not known if infertility *rates* among older women are changing over time. The proportion of women aged 40 to 44 who have ever been married and who are childless declined slightly, from 10 percent in 1961 to 7 percent in 1981, then rose again to 11 percent by 1991. The data do not allow for an analysis of the proportion who are voluntarily childless; thus, we cannot determine whether infertility rates are stable, rising, or declining among older women. Future studies to track infertility rates over time will therefore need to be based on sample sizes large enough to allow for analysis of the incidence of infertility by age group.

> Professional and family life can be reconciled thanks to a host of measures such as paid parental leave, a universal network of daycares, and working conditions that are equal and respect the quality of life. As we know, more and more young women and couples are forced to give up the idea of, or postpone for some time, having a first or second child because of difficult living or working conditions. These young adults must enjoy better conditions in order to make the decision to have children. [Translation]
>
> *Brief to the Commission from Confédération des syndicats nationaux, November 22, 1990.*

Delaying childbearing to later ages in reproductive life could affect the demand for infertility treatment. However, couples in their mid- to late 30s or early 40s who find that they have a fertility problem will have less time to conceive or seek treatment than if they had attempted to become pregnant when they were in their 20s or early 30s.

In summary, healthy women who have not had a medical condition that could impair their fertility (such as pelvic inflammatory disease or endometriosis) have a reasonable chance of conceiving when they are in their late 30s and early 40s, although biological constraints mean conception is likely to take longer. Women's biology dictates a natural span of childbearing years; delaying childbearing reduces the amount of time available for a couple to conceive naturally. In addition, with increasing age, the risk of pregnancy and birth complications, while still low in absolute terms, will be greater than for women in their 20s.

Preventing Age-Related Infertility

People who want to have children should be aware of the normal decline in fertility as they age and consider this in their decisions about when to have children. Such decisions have to take many factors into

consideration, but a knowledge of the biological realities of postponing childbearing should be part of the information couples have available when making this choice.

One approach is to provide the information in school biology and family life programs. Pregnancy-related public health programs, gynaecologists, and family physicians should also inform women of the impact of aging on their fertility. The curricula of nursing and medical schools should cover the subject in the context of maintaining and promoting reproductive health. Educating these professionals, who are an important source of health-related information for many Canadians, about this would help to make the information more widely available for couples who are deciding about whether and when to have children. Women (and men) can maximize their chances of having a healthy pregnancy if they consider factors that could affect their fertility (such as their age and whether they smoke) well before they actually try to conceive. Some physicians have begun to advocate getting pregnancy off to a healthy start by encouraging women to eat a balanced diet, not to smoke, and not to exercise excessively, even before they try to conceive.

Steps must also be taken to address the obstacles that contribute to the decision to delay childbearing. Interrupting a career to bear children is costly to women in terms of wages and status. Women who leave the workforce to have children tend to leave at a crucial time in their careers — between the ages of 25 and 35. When they do, they often pay an enormous lifetime price in terms of promotion, seniority, and skills acquisition. A study conducted for the federal departments of Justice and Status of Women found that a 25-year-old woman who leaves the workforce for two years to raise children will take 18 years to close the wage gap with a fellow worker who never left the workplace, at an estimated earnings loss of more than $30 000. The opportunity costs of having children — lost career opportunities, lost income during pregnancy and child care leave — together with the cost associated with raising children (which has been estimated conservatively at more than $150 000 to raise a child to the age of 18) and the shortage of high-quality, low-cost child care constitute major financial and social barriers that lead many women to delay the birth of their first child.

> Given the importance of children in our individual and collective lives, as well as what we know about the effects of age on fertility, having children earlier in their reproductive lives should be a realistic option for Canadian women, and one that is supported by social policies.

Policies to protect women who leave the labour force temporarily to bear and raise children are generally inadequate. This is especially true in non-unionized workplaces, settings in which a disproportionate number of women are employed. The lack of adequate leave provisions means that

women must frequently sacrifice career opportunities, job security, pension vesting, and other work-related benefits when they leave the workforce to have children.

Moreover, few employers have programs or policies that provide assistance for employees trying to balance work and family responsibilities. Since the majority of women who work outside the home still assume most of the responsibility for child care and home management, reconciling childbearing with other responsibilities is much more difficult for women than for men.

The current imbalance in work and family responsibilities can be mitigated in part through work-related policies and programs that help both women and men balance their job and family requirements. Employers can be encouraged to support initiatives that recognize the needs of working parents. These initiatives do not necessarily involve high costs; they include approaches such as flexible work arrangements, job sharing, work at home, permanent part-time employment (with seniority rights, promotion opportunities, and pro-rated benefits), seasonal leave, information and referral to child care services, and paid leave for family responsibilities such as caring for an ill child. Work-related policies and programs must be designed not only to reduce the stress of family responsibilities on women, but also to encourage men to share those responsibilities.

Family-oriented work policies can also benefit employers. Employees who are relieved of the stresses associated with juggling work schedules and child care arrangements are generally able to work more productively and take less time off. Employers are becoming aware of the need to adopt policies that respond to family needs; some Canadian businesses have already introduced innovative workplace measures. However, despite increased interest and activity in such policies, relatively few employers have taken concrete actions to deal with work/family conflicts that may contribute to couples' decisions to postpone childbearing. In "Workplace Benefits and Flexibility," the authors of the Canadian National Child Care Study noted that despite employer awareness of work/family issues, many have been reluctant to implement policies that support workers in their dual roles.[15]

Employer initiatives are one route to flexibility for employees to handle work and family demands. Another option is to seek workplace changes through collective bargaining. Progress on this front, too, has been slow. The potential for change through collective bargaining is limited by the fact that only one-third of Canada's workforce is unionized and the fact that women tend to be under-represented in unionized workplaces and occupations.

The Women's Bureau of the federal Department of Labour has conducted research on the range of employers' policies and programs

available for women and for dual-earner families in Canada. We support this activity. The Commission recommends that

> **32. The federal Department of Human Resources and Labour inform employers about and encourage them to adopt work-related policies and programs that help employees balance work and family responsibilities.**

and that

> **33. Federal, provincial, and territorial departments with responsibilities for labour-related issues review their legislation, policies, and programs to ensure that these provide adequate time for paid parental leave and that they protect employment opportunities, seniority, and work-related benefits for women who leave the workforce temporarily to have children.**

The lack of community supports, particularly child care services, may also be contributing to couples' decisions to postpone childbearing. In 1984, the federal government appointed a Task Force on Child Care to explore the issue of quality child care and adequate parental leave. This was followed in 1986 by a Special House of Commons Committee on Child Care. Both inquiries supported measures to address the problem — the demand for high-quality, affordable child care clearly outweighs the supply.

The special committee recommended that the federal government introduce a Family and Child Care Act that would complement the Canada Assistance Plan and provide federal funds to licensed child care centres and family day care homes. We support the intent of this proposal. The Commission recommends that

> **34. Health Canada, in conjunction with its provincial and territorial counterparts, introduce a comprehensive strategy for child care that addresses the need for licensed and affordable child care services.**

Child care may be the most pressing need for two-earner or single-parent families, but there is also a need to support women (or men) who choose to stay at home with their young children. Many Canadians recognize the need for public resources to be allocated in a way that supports people's choices about family formation and childbearing — suggesting, for example, that the value of child care provided by a parent who chooses to remain at home should be recognized through such

measures as tax benefits for the income-earning member of the couple. Exploring the potential cost and other social implications of this proposal is beyond the mandate of this Commission. In our view, however, a caring society has a responsibility to consider the diverse needs of all its members and to support measures that offer families a degree of flexibility and choice in matters such as childbearing and child-rearing. Given the importance of children in our individual and collective lives, as well as what we know about the effects of age on fertility, having children earlier in their reproductive lives should be a realistic option for Canadian women, and one that is supported by social policies.

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Exposure to Harmful Agents in the Workplace and the Environment and Infertility

Research over the past few decades has demonstrated the dangers to the health of humans if they are exposed in sufficient dosage to various agents commonly encountered in the workplace and in the environment. When the Commission set out to investigate the impact of exposures in the workplace and environment on reproductive health, however, and in particular their effects on fertility, we found very little information. The actual contribution of most workplace and environmental agents to male and female infertility, or to reproductive problems such as miscarriage and congenital anomalies, is largely unknown: most have not been well researched.

Although the whole field of workplace and environmental hazards is characterized by a lack of information, data on the effects of workplace agents on male fertility are particularly scarce. Earlier, studies focussed almost exclusively on women's exposures, particularly during pregnancy, and on pregnancy losses or congenital anomalies. There are differing views on what underlies this emphasis. Some researchers attribute the research bias to society's traditional association of reproduction with women. Another view is that research on reproductive hazards has been used to justify discriminatory labour practices and policies that keep women out of the more highly paid jobs held mostly by men. Advocates of this view point to the fact that there has been less research about the effects of workplace hazards in female-dominated occupations. Whatever the reasons, the male contribution to infertility is only now beginning to be recognized and the effects of workplace and environmental hazards on it investigated.

The lack of both general and specific information meant that the Commission had to take a different approach to these risk factors than to others for which the evidence of an association with infertility is clearer. After examining what is known about the dangers that environmental and

workplace hazards pose for various aspects of health, as well as the limited information that does exist on reproductive hazards, we concluded that this field will likely grow in importance as more information becomes available.

The Commission identified this area as a priority for further research and for expanded prevention efforts. Both must be planned and carried out within the broader context of occupational health and safety and environmental protection, and such efforts need to be harmonized across provinces and territories; a coordinated country-wide response at this early stage could help to avert future harm to the fertility of Canadian women and men. In addition, we believe that Canada should take a leading role in encouraging a major collaborative international effort to improve the state of knowledge about the effects of harmful agents in the workplace and the environment on human reproductive health.

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Why So Little Is Known

There are several reasons why this field is characterized by so much uncertainty. The first is simply the magnitude of the problem. An estimated 67 000 chemicals and substances exist in the workplace, and we are all exposed to minute quantities of many of these chemicals in the environment. In 1983, the U.S. National Research Council identified 65 725 substances to which human beings are exposed, including 3 350 pesticides and 48 523 commercial chemicals. Testing every one of these substances to determine their impact on reproductive health would be virtually impossible, requiring vast human and financial resources.

Isolating the effect of specific agents is very difficult; multiple exposures are common in the workplace, and everyone is exposed to many chemicals in the environment, making it difficult to establish the effects of any one chemical on health or to find a comparison group of unexposed individuals. Moreover, the task involves evaluating not only the effects of individual substances but also their potential impact in combination with other chemicals with which they are likely to be found in the environment. For example, two chemical substances that have been found individually to have no adverse effect on human health may have a combined impact that is altogether different because their molecular structures could combine to form a harmful new compound.

The impact of other factors that may influence health must also be taken into account. For example, individuals exposed to chemicals in the workplace may also be exposed to physical factors such as cold or noise. Biological factors such as a worker's general health and social factors such as whether the person smokes or uses alcohol can also have a direct or indirect impact on reproductive health. Exposure to these other factors makes it difficult to isolate and assess the health effects of specific substances found in the workplace or the environment.

Another reason we lack information about the reproductive effects of workplace and environmental agents is that most studies have focussed on the acute or short-term effects of exposure to a substance or agent without assessing longer-term chronic effects such as reproductive impairment. Because acute effects are the easiest to assess, this is still the most commonly available information about most substances. Most of the studies that do address effects on the reproductive system equate "reproductive health impact" with "negative birth outcome" in the form of pregnancy loss or the birth of a child with congenital anomalies. Relatively few studies examine the effects of environmental or workplace hazards on reproductive health at earlier stages — such as irregular menstrual cycles or reduced production of sperm, delayed conception, or failure to conceive.

> Several factors have contributed to the general lack of information on reproductive health effects [of exposures in the workplace and environment]. Traditionally, toxicological evaluations of chemicals seldom considered the effects on reproductive health. In some instances, pregnancy, miscarriage, and congenital birth defects were studied, but rarely did toxicological studies examine the effects of harmful agents on gametes, hormones, or, more generally, couple infertility ... This is also partly a reflection on our level of understanding of human reproduction.
>
> There are many other reasons why information is lacking. For example, suitable methods to measure various reproductive outcomes and their associated health hazards have not been adequately developed. This has made it difficult to identify cause-effect relationships between suspected risk factors and adverse reproductive health outcomes. In some cases, this problem is compounded by a lag period of years or decades between the time of first exposure and the time the problem eventually arises. Further complications arise in the difficult, if not impossible, task of trying to sort out the effects of other influences on reproductive health, such as lifestyle or heredity.
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> *P. Abeytunga and M. Tennassee, "Occupational and Environmental Exposure Data: Information Sources and Linkage Potential to Adverse Reproductive Outcomes Data in Canada," in Research Volumes of the Commission, 1993.*

One way of evaluating the probable health effects of substances is by conducting laboratory tests on animals. These studies are valuable, but they have significant limitations that make it difficult to extrapolate their results to human beings. For example, the actual doses to which human beings are exposed in the course of everyday living are much lower than those usually used in animal experiments. Moreover, differences in the way species metabolize a substance may mean that what is harmful for one species is harmless for another. A third limitation of animal studies is that they tend to focus on the last stages of reproductive harm and do not deal adequately with damage to reproductive functioning that may occur earlier in the reproductive process.

In short, the existence of a large number of substances and the difficulty of testing them all rigorously mean that there are many potentially harmful materials in the workplace and environment whose health effects are largely unknown. In fact, no information on human health effects is available for the majority of chemicals now in commercial use in Canada and elsewhere. Even when data on a given substance exist, researchers may draw different conclusions about whether the substance represents a "suspected" or "proven" hazard to human health, or whether at "normal" levels of exposure it represents a health hazard at all. This is a complex field strewn with pitfalls; researchers must often overcome major hurdles and withstand criticism related to methodology, and research results are often subject to attack and reinterpretation by people with vested interests depending on whether the findings are "positive" or "negative."

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This brief review of the complexities facing researchers illustrates the difficulty of determining the reproductive health effects of substances and agents found in the workplace and environment. Since the data are so limited, the contribution of occupational and environmental exposures to existing levels of infertility in Canada is simply not known. Moreover, even for some substances or agents for which there are good quality data to show reproductive health effects in sufficient dosage (such as lead and nitrous oxide), information on the number of individuals who are exposed and the levels at which they are exposed is not available. Such major gaps in knowledge make it difficult to determine what preventive strategies are needed. Further, we do not know whether or what preventive strategies are needed with respect to many other exposures. Until we know more, we are not in a position to make good use of prevention or control strategies. This is no reason for lack of action, however.

There is an urgent need to mount a comprehensive research program, with funding and a long-term training strategy to develop new researchers,

to address our lack of understanding about occupational and environmental reproductive health effects. Canada is not the only country trying to deal with these issues in the face of major gaps in knowledge; this is an international problem with implications for the health of the human race. We believe that Canada should take the initiative in promoting a worldwide cooperative effort to assemble and analyze existing data, conduct new research, and draw conclusions about potential occupational and environmental hazards that face all of us.

We believe that Canada should take the initiative in promoting a worldwide cooperative effort to assemble and analyze existing data, conduct new research, and draw conclusions about potential occupational and environmental hazards that face all of us.

Discussion here is divided into two sections, one dealing with workplace hazards and the second with environmental hazards. In each section we discuss the agents or substances that are known or suspected to be hazardous to reproductive health, together with strategies for preventing reproductive harm. In the final part of the chapter, we outline our recommendations for a major international cooperative research effort aimed at improving our understanding of this complex area.

Exposure to Harmful Agents in the Workplace

Agents that may harm reproductive health are known to exist in a wide variety of workplaces across Canada (see research volume, *Prevention of Infertility*) and the United States. The U.S. government has estimated that a potential 14 million workers are exposed each year to known or suspected reproductive hazards on the job — and this figure likely underestimates the situation because it is based on nine selected substances or conditions.[1] If the same level of exposures were occurring in Canada, an estimated 1.5 million workers would be exposed to potentially harmful agents in

> The lack of adequate research, the lack of thorough knowledge is often used as an argument against action. We don't think that inadequate knowledge or uncertainty should be a bar to preventive action. There is much that can be done even given incomplete levels of knowledge about reproductive hazards. That's the emphasis that we put because we approach this from the standpoint not of scientists but of representatives of the people that are affected.
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> *J. Rose, Canadian Union of Public Employees, Public Hearings Transcripts, Toronto, Ontario, November 20, 1990.*

workplaces. Many Canadian workers employed in a diverse range of occupations are apprehensive about the possible effects of workplace factors on their fertility and their ability to have healthy children. The Canadian Union of Public Employees expressed its concerns to the Commission:

> Our members are speaking out because they *know* they are exposed to hazards at work. They read the newspaper stories ... [They] suspect they are exposed regularly to hazards that may cause infertility or adverse reproductive outcomes directly or indirectly. Unfortunately, since little is known about reproductive hazards at work, it is very frustrating looking for "proof" ... when workers suspect their reproductive health, or their children's health, is linked to their work. (*Brief to the Commission from the Canadian Union of Public Employees, November 20, 1990.*)

It is essential to acknowledge in this discussion that no work environment can ever be absolutely safe. There is always an element of risk to health or safety involved in work — whether it stems from the job itself, the circumstances under which it is performed, or the environment in which it is carried out. Reducing the risks to a very low level in many workplaces carries costs, but there are also costs (health, environmental, and financial) associated with failing to reduce the risks. Determining an acceptable level of risk involves consideration of both the costs and the benefits involved. This is a complex process, because not all costs of attaining very low exposure levels accrue to employers, nor do all the benefits accrue to employees. There may be costs to workers of setting exposure levels too low — for example if another process is substituted that is not believed to cause harm but does, or if the company becomes less competitive and unemployment results. No workplace can be made completely safe, but specific strategies can nevertheless minimize risks to the reproductive health of workers. The first step, however, is to establish what known or potential reproductive health hazards exist. As we have shown, this is a difficult and complex task.

> Employers have been more energetic in excluding workers at risk from the work site than they have been in reducing the hazards. Workers at risk has meant women of childbearing age, not just pregnant women. Industrial hazards that threaten reproductive capacity and foetal development and cause birth defects are not confined to the work place. Members of the community are also exposed.
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> *C. Micklewright, British Columbia Federation of Labour, Public Hearings Transcripts, Vancouver, British Columbia, November 27, 1990.*

Current Knowledge

Reproductive hazards can be broadly defined as agents that cause reproductive impairment in adults or developmental impairment or death in the embryo/fetus or resulting children. Exposure to reproductive hazards may result in a range of adverse effects. These include delayed or prevented conception as a result of irregular menstrual cycles, sperm abnormalities, or reduced interest in sexual activity. Other potential effects include spontaneous abortion, pregnancy complications, prematurity, and damage to the developing embryo or fetus. Factors that may harm reproductive health generally fall into one of five categories — chemical, physical, biological, psychosocial, and ergonomic.

> Canadian employers are charged with the legal responsibility to protect the health and safety of their employees. They cannot do this effectively without adequate information on the possible hazards and how they can be prevented. We urge the Commission to recommend a massive education program about workplace reproductive hazards aimed at employers, workers, students, health professionals and the general public. At best, such information will lead to corrective measures. At worst, it will allow workers to make informed choices if they are exposed to known reproductive hazards on the job.
>
> *Brief to the Commission from the Public Service Alliance of Canada, Addendum II, "Workplace Reproductive Hazards," August 1991.*

Chemical Agents

Chemical substances can invade the body through inhalation, ingestion, or absorption through the skin. In women, a variety of chemical substances can cause menstrual disorders, affect the maturation and release of eggs, leading to infertility or sterility, prevent the implantation of the fertilized egg in the uterus, or interfere with the normal growth and development of the embryo and fetus. In men, chemical substances may reduce sperm count or affect sperm quality (for example, causing a greater number of misshapen sperm or reduced motility, making it less likely that sperm can reach and fertilize an egg).

Exposure to chemicals is not unique to workers in industrial worksites. Chemical hazards are also present in health care facilities (anaesthetic gases, solvents, medications), in offices (chemicals used in photocopy machines and other office equipment), in schools (cleaning solutions, laboratory supplies), in parks and other outdoor areas (pesticides, fertilizers), and many other work environments. In addition, as the discussion on environmental conditions later in this chapter shows, women who work in the home, and indeed all family members, can be exposed to toxic chemicals.

Among the chemicals or classes of chemicals known or suspected to cause reproductive impairment in men and/or women are the following: heavy metals; agricultural chemicals such as pesticides; polyhalogenated biphenyls; organic solvents; anaesthetic agents; epichlorohydrin; ethylene dibromide (EDB); ethylene oxide (EtO); formaldehyde; vinyl halides; and some hormones. Metals that have been shown to cause adverse reproductive effects in human beings and animals in sufficient doses include lead, mercury, cadmium, arsenic, lithium, antimony, boron, and manganese. Other metals that may occur in some workplaces, such as chromium, copper, nickel, and selenium, cause reproductive harm in animals, but their effects in human beings have not been examined.

In fact, relatively few chemicals — whether they are found in the workplace or in the home environment — have been investigated for their effects on reproductive function; the limited research has focussed for the most part on general health effects. One chemical that has been investigated for its effect on female fertility is nitrous oxide, a gas administered with oxygen as a sedative for dental patients. In the 1970s, nitrous oxide came under suspicion as a reproductive toxin, but the studies that demonstrated this association were criticized for methodological weaknesses. A recent U.S. study, however, has provided good evidence that dental assistants exposed to high levels of nitrous oxide are less likely to conceive each month than those who are exposed to low levels of the gas.

Apart from isolated studies of this type, however, no information exists about the general human health effects of 70 percent of substances in the industrial environment, and even less is known about the effects of these substances on male and female reproduction. The National Institute for Occupational Safety and Health in the United States has records on more than 79 000 chemicals, but data on their reproductive effects are available for less than one-fifth of these chemicals. The quality and accuracy of most of the data have not been evaluated, which means that few conclusions can be drawn about whether they represent reproductive hazards.

Physical Agents

Contact with physical agents probably represents the most common form of exposure for most workers. Whether these agents have effects and, if so, what they are, are even less well understood than for chemical agents. The physical agent about which most is known is ionizing radiation (X-rays), which can impair reproductive function in human beings exposed at sufficient dosages; workers at risk of exposure include dental office workers, hospital employees, and scientists. Sufficient exposure to noise, temperature extremes, and vibration may also affect reproductive cycles, but it is not known what proportion of assembly line and construction workers, for example, are exposed to levels sufficient to have an effect or indeed what those levels are. Although there is concern about the potentially negative general health effects of non-ionizing radiation and

magnetic field exposure from electrical appliances and video display terminals (VDTs), there are no conclusive studies that show harmful reproductive effects.

Many studies have been carried out to evaluate any association between working with video display terminals and adverse effects on pregnancy. In most of these studies, no significant associations were found. However, the results of a recent study undertaken in Finland are worth noting. The purpose of the study was to investigate whether work with VDTs and exposure to low-frequency magnetic fields were related to spontaneous abortion. No relationship was found when VDT users were compared to non-VDT users. However, the study also measured the strength of the electromagnetic fields (EMFs) emitted by VDTs and found that the small subgroup of workers using VDTs that emit high levels of extremely low frequency magnetic fields were more likely to have spontaneous abortions than workers using VDTs that emitted low levels of these fields. The possible risk appears to apply to only a small proportion of users, then, namely those whose terminals emit high levels of low-frequency electromagnetic fields. It is difficult to determine the significance of these results in view of the fact that other electrical devices, including many found in the home, also emit this kind of electromagnetic field; some would estimate that women face greater risks of exposure in a well-equipped kitchen than in front of a VDT. It is clear that more research is required on the effects of low-frequency electromagnetic fields on pregnancy.

Biological Agents

Women and men who work in health care or scientific occupations with direct patient contact, laboratory exposure to infectious materials, or production of biological materials may be at risk of exposure to biological agents that can impair reproductive function. Some workers in non-health care occupations involving contact with animals or animal products, refuse collection, earth moving, and work or travel in areas where certain infectious diseases are present may also be at risk. Workers in some occupations (for example, teachers and nurses) have a greater chance of being exposed to diseases such as rubella, cytomegalovirus, and hepatitis B, which can cause intrauterine infections, produce teratogenic effects in offspring, infect the fetus, or cause spontaneous abortion. However, steps can be taken to prevent individual exposure to these diseases. Rubella immunization is offered to people, such as teachers of young children, who may be exposed in their work. Those who are at risk of hepatitis B through exposure to blood and body fluids can also be immunized to prevent infection. Cytomegalovirus can occur in individuals who work with young children, but several studies have indicated that women with such jobs are no more likely to have infants with problems than women not exposed; this

is partly because their pre-pregnancy exposure may have already rendered them immune.

Psychosocial Factors

Psychosocial stress has been proposed as contributing to infertility in men and women for many years. Research has demonstrated clearly that stress can affect reproductive behaviour and function in animals. Psychosocial factors that can cause stress are found in every workplace; they include the number of hours worked, complexity of the task, the degree of supervision, and organizational structure. Their effects are very difficult to measure, however, because of the great range of individual behavioural responses to given conditions — what is stressful for one person may not be for another. Not only is occupational stress difficult to quantify, but the level of stress in people's personal lives also affects their perception of stress at work.

Studies on the influence of occupational stressors have tended to focus on male workers, examining health aspects such as the incidence of stomach ulcers, hypertension, and alcoholism but not reproductive effects. Only recently have studies included women and examined conditions such as job satisfaction, workload, and worker job control as stressors. Increasing attention is also being given to stress in women who put in a double workday — paid work outside the home combined with child-rearing and household management responsibilities.

In men, psychological stress can lower testosterone levels and has been associated with reduced sperm count. In women, stress can affect hormonal function, leading to temporary interruption of menstruation. Work-related psychological stress may also interfere with the sexual relationship between couples. A variety of sexual problems have been linked to psychological stress, including impotence and ejaculation difficulties in men, vaginismus in women, and reduced frequency of intercourse.

Job-Related Factors

"Ergonomics" refers to the study of the relationship between workers and their working environment, including such factors as the body position, types of movement required to perform a job, and forces exerted on various parts of the body when performing a job. Although the information base in this area is growing, there are relatively few studies of the effects of ergonomic factors on reproductive health. Heavy lifting and working in a confined position are known to pose potential risks to pregnant women, while shift work may interfere with women's menstrual cycles. For example, studies of female flight attendants have shown a high incidence of menstrual disorders (for example, cycles longer or shorter than normal),

with jet lag and disrupted circadian rhythms as possible contributing factors.[2]

Preventing Reproductive Harm

The ability to have healthy children is fundamentally important to individuals and to society. Preventing reproductive harm must therefore be a fundamental part of society's approach to caring for its members. It is impossible, however, to separate reproductive health from overall health; workers' reproductive health cannot be protected in the absence of protection for their general health. This is not to say that if policy makers ensure that occupational health and safety regulations protect the overall health of workers, their reproductive health will necessarily be protected. In some situations, it may be necessary to develop special measures for particular reproductive hazards.

The ability to have healthy children is fundamentally important to individuals and to society. Preventing reproductive harm must therefore be a fundamental part of society's approach to caring for its members.

There is currently no coherent or consolidated public policy response to regulate occupational exposures that may affect reproductive health in any jurisdiction in Canada (see research volume, *Legal and Ethical Issues in New Reproductive Technologies: Pregnancy and Parenthood*). Rather, five discrete legal regimes involving occupational health and safety, labour and employment law, workers' compensation, human rights legislation, and tort law (civil actions in respect of a wrongful act or injury for which a designated party is deemed responsible) are in place at the federal and provincial levels to deal with workplace exposures. Of these legal regimes, occupational health and safety legislation is the major instrument through which provincial governments regulate exposures that may affect health in the workplace. These regulatory mechanisms were not designed originally to deal with exposures that may affect reproduction. They have been adapted on an ad hoc basis to address various aspects of the problem in response to scientific and medical findings as these become available and as specific cases arise.

Given the number of agents present in workplaces, as well as the fact that reproductive dysfunction can occur in various ways that are difficult to measure, it is unlikely that policy makers will ever have complete information regarding the extent of reproductive impairment attributable to workplace conditions. This situation presents distinct difficulties in designing appropriate policies and targeted prevention strategies. Nonetheless, several preventive actions can help protect workers from exposure to potentially harmful substances, agents, and conditions.

The first approach involves eliminating from the workplace materials that have been identified as hazardous. For example, the use of certain

substances identified as hazardous, such as the pesticide dichlorodiphenyltrichloroethane (DDT), is prohibited under environmental laws. This approach is limited, however, because very few substances have been identified with certainty as being hazardous. It is evident that banning chemicals one by one after proof of toxicity will not be an effective or rational approach.

Although it would take decades to conduct scientific inquiries on the health effects of thousands of discrete substances, structural analysis can advance our knowledge base by considering information on classes of chemicals. One of the methods currently used to identify adverse health effects is a process called "structure-activity relationship" analysis. Structure-activity relationship analysis compares the molecular structure and properties of a chemical with unknown effects to the molecular structure and properties of structurally similar chemicals with known toxic effects. If we know that agents within certain classes of substances are hazardous to human health, then it is likely that any chemical within that family is potentially dangerous to reproductive health. Although this approach has limitations, the use of this information could constitute a second approach for preventive action — namely, to ban particular families of chemicals.

A third approach is to introduce controls requiring specific steps in the design of manufacturing processes or workplaces to reduce worker exposure to known or suspected hazards. This strategy attempts to minimize or eliminate the risk at source and is enforceable because design controls are visible — it is clear when they have not been implemented.

A fourth approach is to develop limits stipulating the maximum permissible level of exposure to substances identified as harmful at certain concentrations. For example, radiology and laboratory technicians exposed to radiation in their work are monitored to gauge their individual exposure, and maximum allowable levels of exposure have been established, including for pregnant women. However, this approach requires sufficient knowledge to establish what constitutes

> In our opinion, many infertility problems can be linked to conditions in the workplace. It is a fact that women are active labour force participants and that during their reproductive years, the vast majority of them are in the labour force and exposed on a daily basis to conditions and to an environment that can affect their reproductive capacity.
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> Since our union also represents men, we wish to point out that certain conditions or elements in the workplace can affect the reproductive capacity of men as well. [Translation]
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> *M. Simard, Confédération des syndicats nationaux, Public Hearings Transcripts, Montreal, Quebec, November 22, 1990.*

an acceptable level of exposure for most individuals, and, as we have shown, in many cases this information does not exist.

Each of these approaches has something to contribute; none is ideal or complete by itself. These approaches are not mutually exclusive — all are needed. The federal government has recognized the need to remedy the lack of adequate risk assessments. As we discuss later in this chapter, regulation of all new substances is expected to become more stringent as a result of the *Canadian Environmental Protection Act* (CEPA), which will create a national system for screening new substances introduced after January 1, 1987. This is discussed in the next section.

Although such an initiative has merit, we are concerned that the new provisions in the *Canadian Environmental Protection Act* may ignore the specific potential of workplace substances and processes to impair the reproductive health of women and men and the health of their children. Without adequate protection, there is potential for harm for all: workers and children could suffer the emotional and financial costs of reproductive harm; employers could also be affected, through either the workers' compensation system or tort liability; society could also have to bear the costs of medical and support services to help those affected. In line with our ethic of care and our goal of avoiding harm, we make recommendations later in this chapter with respect to these issues.

Design Controls, Exposure Standards, and Regulatory Measures

As alluded to above, design controls are one option after a determination that a hazardous substance, agent, condition, and/or process will be permitted in the workplace. Unlike exposure limits or performance regulations, which specify a measurable result that must be achieved while giving employers discretion about how to accomplish this, design controls specify the control measures that employers must adopt. These can include, for example, the isolation of hazardous agents, the physical enclosure of noisy equipment, or the use of specified measures such as ventilation equipment.

Design control regulations are easier to enforce than exposure limits because non-compliance can be detected visually. If these regulations remove the risk at source (for example, with ventilation equipment), they likely offer a higher level of protection than that achieved by setting exposure limits. This is particularly so since concerns have been expressed about the extent to which existing Canadian exposure standards actually represent "safe" levels for workers in general and for workers who may be particularly vulnerable to harm (such as pregnant women). In 1988, an estimated 2.2 million of the 12.6 million workers in Canada worked in jurisdictions where the exposure limits of the American Conference of Governmental Industrial Hygienists (ACGIH) have been incorporated into statutory provisions. The remaining 10.4 million workers worked in jurisdictions that either adopted ACGIH exposure limits initially and then

began modifying them (for example, Saskatchewan, Manitoba, Alberta) or never legally adopted the standards and have been working to develop their own standard-setting procedure (for example, Ontario, Quebec). Of the made-in-Canada standards, only those for lead, radiation, and mercury take into account reproductive effects.

Where standards acknowledge the potential for reproductive harm, a two-tiered approach, establishing different exposure levels for men and for women of childbearing age, has generally been adopted. When health and safety officials have regulated substances deemed to be hazardous, they have done so to protect the fetus. Protection has been achieved by setting lower exposure levels for women who are pregnant or of childbearing age rather than for all workers. This approach raises equality concerns.

Protection has been achieved by setting lower exposure levels for women who are pregnant or of childbearing age rather than for all workers. This approach raises equality concerns.

A recent U.S. court case with regard to lead is instructive about several aspects of the issues surrounding exposure to reproductive hazards in the workplace. At the Johnson Controls Inc. battery-making plant, the employer's policy barred all women, except those whose infertility or sterility was medically documented, from jobs involving actual or potential lead exposure exceeding the Occupational Safety and Health Administration standard. The issue was thus whether an employer could discriminate against women because of their ability to become pregnant. A lower court held that the employer could do so, but a 1991 U.S. Supreme Court decision reversed the lower court ruling. The Court held that an employer could not defend exclusionary policies directed at fertile women on the grounds that they are warranted as a form of fetal protection; it decided that such a policy violated the *Civil Rights Act* by discriminating against women on the basis of their sex, because it required only female employees to produce proof that they were not capable of reproducing, despite evidence of the debilitating effect of lead exposure on the male reproductive system.

The Court ruled further that the employer could not defend its policy on the basis of a "bona fide occupational qualification"; it was unable to establish that a woman's reproductive potential prevented her from performing the duties of her job. Further, the employer's professed concerns about the welfare of the next generation did not offer a defence, because those concerns could not be considered part of the "essence" of the business. According to the Court, it is the woman's right, and not her employer's, to balance her interest in employment against her concern for the well-being of future children.

Where exposure levels for reproductive hazards are lower for women of childbearing age, then, the employer may have an incentive not to hire

women. For example, the employer could face potentially higher monitoring costs, or the employer might wish to avoid disrupting work arrangements by removing a female employee from a hazardous environment. Critics have also pointed out that focussing on the fetus reinforces the notion that it has interests distinct from those of the woman, as well as the perception that the state and employer should be able to intervene in the pregnant woman's conduct to protect the fetus. This approach diverts attention from the central issue — that exposure to a substance at a level that affects the fetus is probably harming the health and fertility of men and women as well. An approach that establishes different exposure limits for men and women ignores men's role in reproduction and the mounting evidence that the man's exposure to hazards in the workplace may result in reduced fertility and congenital anomalies in his children. The Commission therefore recommends that

35. Control of workplace hazards not be sought through discriminatory personnel policies, and that reduction of hazards be sought through the use of engineering and workplace design controls wherever feasible.

Health and safety standards are effective only to the extent that they are respected. Because enforcement resources are extremely scarce in all jurisdictions, the probability of a workplace being inspected in any given year is low. The current approach to enforcement is one of persuasion; more stringent measures such as the power to issue compliance orders or stop-work orders or initiate prosecutions for violations are rarely used, yet they can be much more effective than persuasion. Stop-work orders put an immediate end to potentially dangerous situations because it is usually less expensive for employers to comply with the requested change than to shut down production. At present very few regulations are in place to control exposure to reproductive hazards in the workplace. However, we believe that stop-work orders and prosecution should be used more often by governments as a means to improve compliance with existing health and safety regulations.

The workers' compensation system can also play a role in encouraging compliance by creating financial incentives for employers to protect employees' health. Workers' compensation is funded through employer contributions; some workers' compensation boards have developed funding schemes that encourage employers to maintain safe working environments and penalize those who violate health and safety regulations. In some jurisdictions, these boards have the legal authority to impose penalties on employers whose claims costs are significantly higher than average among employers in similar industries. An approach that places greater emphasis on prevention would involve imposing penalties on the basis of observed hazards, before harm has occurred. At present, however, penalties are

imposed only when conditions are detected that are unusually hazardous or that involve a serious violation of health and safety laws, and penalties may not be assessed until the employer has been cited for repeated non-compliance.

In our view, appropriately designed financial incentives administered through workers' compensation boards can play an important preventive role in protecting workers' health. An approach based on using penalty assessments related to observation means employers are less likely to adopt discriminatory employment practices encouraged by other types of approaches. For instance, penalty assessments based on claims cost experience may deter an employer from employing fertile women. Such discriminatory employment practices are, of course, against the law, but violations are difficult to detect. Implementing the other observation-based approach, however, will require that adequate resources be devoted to enforcement.

36. The Commission endorses the approach of workers' compensation boards that have established their employer contribution rates using penalty assessments based on observed hazards or health and safety audits. This approach should be adapted to include specific provisions for reproductive hazards.

The workers' compensation system in each jurisdiction provides compensation for work-induced injuries or diseases, regardless of fault on the part of the worker or employer. To assess the merit of compensation claims, most boards have developed guidelines on what qualifies for compensation, identifying a list of diseases and conditions and a series of criteria, and often identifying the workplace processes in which exposure to a particular substance may have occurred. If the exposure and duration of exposure criteria specified in the guidelines are met, it is assumed that the disease or condition was work-induced, and the worker is therefore entitled to compensation. Claims that do not meet the criteria must be considered on their individual merits.

To date, no guidelines have been issued with respect to reproductive impairment. In theory, the principal reproductive impairments and injuries that might result in a claim for compensation include sexual dysfunction, such as impotence in men; infertility; sterility; miscarriage; medically recommended abortion because of a workplace exposure that could have harmed the fetus; stillbirth; and birth of a child with physical disabilities or intellectual impairment or who is at increased risk of cancer or other health problems. However, good evidence about which exposures are harmful is lacking at present; there are literally thousands of low-level exposures for which there is no reliable information concerning

reproductive effects. This lack of knowledge makes it difficult not only to set policy but also for workers' compensation boards to adjudicate claims.

We recognize that the use of guidelines is controversial. In our view, however, guidelines that are developed carefully and implemented appropriately can improve the ability of workers' compensation boards to make decisions with respect to disease claims in general and reproductive impairment more specifically. We believe that workers' compensation boards should review data on the reproductive effects of workplace exposures and, where knowledge exists, consider using the information to develop guidelines regarding compensation for reproductive harm.

> That which is dangerous to a pregnant woman can also be dangerous to women and men prior to conception (affecting the ovaries and sperm). The [Confédération des syndicats nationaux] believes that eliminating the danger at the source and enforcing specific reproductive safeguards is the only way to guarantee that jobs are accessible to everyone and that our places of work are healthy. We would like to broach the problem of fertility and the workplace from this angle. [Translation]
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> *Brief to the Commission from Confédération des syndicats nationaux, November 22, 1990.*

Information for Workers

In addition to regulatory and control measures, exposure to suspected workplace hazards can be reduced through education of workers. Occupational health and safety legislation in each jurisdiction sets out workers' rights in three key areas: the right to know about hazardous workplace agents, the right to participate in workplace health and safety decisions, and the right to refuse unsafe work.

The Workplace Hazardous Materials Information System (WHMIS), which became part of federal and provincial health and safety laws in 1988, is the legal mechanism that regulates workers' right to know about workplace hazards. WHMIS applies only to hazardous substances, not to hazardous physical agents such as radiation, heat, and noise, and requires that hazardous products be labelled and that they be accompanied by a material safety data sheet. Employers are also required to train workers in the safe use of controlled products and to instruct them on the significance of the information provided on labels and material safety data sheets. If a product is controlled because it is a reproductive hazard, then exposed workers must receive instructions on its safe use.

The federally funded Canadian Centre for Occupational Health and Safety (CCOHS) has also been an important source of information for workers and employers. It operates an international data bank and makes information on hazards, including potential reproductive hazards, available to employers and workers.

Different standards exist in different provinces regarding occupational health and safety. Companies with operations in more than one province must often function, therefore, under a variety of standards. Labour unions with employees in more than one jurisdiction face the same problem. It is important the federal government, in partnership with provincial governments, initiate a process that would allow for the standardizing and harmonizing of standards within Canada. This would eliminate the current expensive duplication of effort that occurs when each province reviews data and develops legislation or regulations to deal with various workplace agents. The Commission therefore recommends that

37. The federal government initiate and promote federal/provincial/territorial consultation and information sharing and, in cooperation with other governments, attempt to establish uniform standards in occupational health and safety across the country, in particular in relation to reproductive hazards.

Worker Participation

The principal way for workers to participate in decisions regarding workplace health and safety standards and policies is through health and safety committees made up of employer and employee representatives. In some provinces, these committees are mandatory for all workplaces over a certain size; in other jurisdictions, committees are established at the employer's discretion. Where they exist, these committees identify situations thought to be hazardous, conduct investigations, and make recommendations to the employer about health and safety issues. In all provinces except Quebec, health and safety committees lack decision-making power. In Quebec, the committees have designated powers, including the right to choose the physician in charge of health services, approve health programs developed by the physician, make decisions about worker training and information, and select personal protective devices.

In no province, however, is there a mechanism for resolving disagreements between workers and employers. This gap should be remedied, because employers and employees may not always have the same view on health and safety issues, and, in most situations, the balance of power lies with the employer. This is a concern, particularly in the case of workers in non-unionized workplaces (mostly women), because if harms occur, they are suffered first by workers. The Commission therefore recommends that

38. Provinces/territories consider how their occupational health and safety legislation could be amended to provide more equal participation by employers and workers, with a view to reducing reproductive workplace hazards. This could include

(a) vesting health and safety committees with the same decision-making powers guaranteed by Quebec's occupational health and safety legislation;

(b) requiring that employers obtain the approval of the workplace health and safety committee for significant workplace changes; and

(c) identifying and appointing external resource persons with health and safety expertise for non-union or small unionized workplaces to provide information on health and safety.

Refusal of Unsafe Work

Although health and safety statutes vary by province, most give workers the right to refuse work when they have reason to believe that the equipment they are using, the physical condition of the workplace, or a breach of the act or regulations is likely to endanger them or another worker. Employers are prohibited from retaliating against workers who exercise their right to refuse unsafe work. In most provinces, the statutes do not give workers the right to be paid during all or part of the work refusal; Quebec and Ontario are the two exceptions. Workers in most provinces therefore face the difficult choice between performing unsafe work and not working and losing pay. The right to refuse unsafe work is exercised overwhelmingly by unionized employees. Non-unionized workers, who are disproportionately women, enjoy less employment security. Because they have fewer resources to support disputes with employers, they are much less likely to exercise their statutory rights (see research volume, *Legal and Ethical Issues in New Reproductive Technologies: Pregnancy and Parenthood*).

Quebec is the only jurisdiction whose health and safety laws currently provide for protective reassignment or compensation. Protective reassignment allows workers to remove themselves from situations considered to be unsafe and to be reassigned or compensated if alternative work is not available. The decision about whether the work is in fact unsafe is made by the Quebec Occupational Health and Safety Commission after a complaint is submitted by the worker's doctor and investigated by the local community health department.

In June 1993, amendments to the *Canada Labour Code* were proclaimed giving a pregnant employee or employee nursing a child the right to request reassignment or job modification should she perceive that continuing any of her job functions might pose a risk to her health or that of her fetus or child. Under the revisions, the employee can submit a request for reassignment or modification accompanied by a medical certificate indicating the expected duration of the potential risk and the activities or conditions to avoid in order to eliminate the risk. In consultation with the employee, the employer then makes a decision to modify the job or reassign the employee if it is "reasonably practicable." Should the employee's job be modified or she be reassigned, she continues to receive the same benefits and wages. If the employer decides that reassignment or job modification is not feasible, or if the employee cannot perform any work, she has the right to maternity-related leave without salary. The employee receives the amount available through unemployment insurance rather than full compensation through the workers' compensation system, as she would in Quebec.

Workers who have suffered some form of occupational injury are covered by workers' compensation and so are not usually permitted to launch tort actions against the employer. It is possible, however, for the spouse or child of a worker to be exposed to reproductive harm as a result of the worker's exposure. For example, workers may bring home toxic substances on their clothes or, through their own exposure, may transmit substances to a developing fetus. Spouses and children are ineligible to claim for workers' compensation, but they can sue the employer. They may also have a cause of action against manufacturers of the substance or product alleged to have caused the harm. In the Commission's view, however, tort liability is not a suitable instrument for encouraging employers to adopt measures to protect pregnant workers.

In our view, the best way to reduce reproductive harm in the workplace is by developing a knowledge base that provides a solid foundation for definitive preventive action.

In our view, the best way to reduce reproductive harm in the workplace is by developing a knowledge base that provides a solid foundation for definitive preventive action. The fundamental problem is the lack of information on reproductive health in general and on the specific occupational factors that might cause reproductive harm. This information can be generated through research that seeks to produce new data, through analysis and linkage of existing data bases, and through expansion of the scope of existing occupational health and safety research to include reproductive health. At the end of this chapter, we outline recommendations for a research plan that involves these elements.

The Environment and Reproductive Health

Some of the discoveries and conveniences we take for granted in our daily lives (modern transportation, central heating, materials such as plastics) have come at a price. Many industrial products and processes and their resulting wastes have damaged the environment. There are also questions about the effects on human health of many substances used in consumer products and industrial processes that subsequently find their way into the environment.

Contaminants known to be harmful to human beings when they occur in sufficient concentration are generally found in the environment in concentrations lower than those considered to pose a health risk. Although environmental exposure to most harmful substances is low for most people, this is no reason to be complacent about the possible dangers. There is growing concern and some evidence linking exposure to agents in the environment to various diseases, including cancers, respiratory illnesses, neurological problems, and skin disorders.

We are particularly concerned about the classes of substances in the environment that are mutagens and teratogens. "Mutagens" are contaminants that may alter genetic material. "Teratogens" are substances or exposures that may affect the developing embryo or fetus and cause congenital anomalies. Our concern arises because many substances that could be mutagens or teratogens are used for industrial purposes and as a result occur in the environment. We do not have good information, however, about whether many of these substances have health effects, and we have much less information on their reproductive health effects, if any. A major challenge is to show causation of harm when studying environmental agents, since levels of exposure to hazards in the environment are lower than in the workplace, and it is difficult to find "control" populations that have not been exposed. Nevertheless, this issue is of critical importance to our future as a species. Data such as those showing a decline in sperm quality worldwide over the last 50 years sound a warning that must be taken seriously.[3]

Current Knowledge

Exposure

Human beings are exposed daily to both natural and artificial substances that could be harmful if they occurred in sufficiently high concentration. These substances are found in the home, in schools and workplaces, and in the outdoor environment — we come into contact with these materials through the air, water, and soil, as well as the food we eat. Low concentrations of contaminants are transported by air from various

sources in the form of gas, fibres, dust, or other bits of matter. Human beings are also exposed to chemical substances in water; for example, more than 300 chemical compounds have been detected in the Great Lakes, and many of these are present in minute quantities in the drinking water of cities located on the lakes. In high concentrations, some of these are known to be carcinogens (cancer-causing agents), mutagens, or teratogens in animals.

Contaminants and chemicals can also enter the body through food and drink. They can be ingested directly or indirectly through the food chain. In the latter case, microscopic amounts of contaminants are absorbed by plants and concentrated there. They then become more concentrated in the organs of small fish and animals that eat the plants. Concentration levels rise as each organism stores the substance before it can be broken down and expelled by the body. This is referred to as "bioaccumulation." Through bioaccumulation, concentrations of substances can reach toxic levels by the time the chemicals are ingested by animals and human beings higher in the food chain. For example, DDT, a pesticide that bioaccumulates, has reached sufficient concentrations in certain geographic areas to have had a severe impact on birds' reproductive systems.

Polychlorinated biphenyls (PCBs) are substances that bioaccumulate; they are insulating oils used until the 1970s, when they were banned. Trace amounts of PCBs are still found everywhere in the environment. Studies have identified a relationship between the amount of local fish eaten by inhabitants of the Great Lakes Basin and levels of PCBs in their blood. One study found that the exposure of pregnant women to PCBs was associated with lower birth weight and smaller head size,[4] although another study did not confirm these findings.[5] Whether or not the long-term development and growth of children exposed to PCBs *in utero* are affected is not known; research findings have been contradictory in this area.

Human beings also absorb some chemicals and other substances through the skin. Although the actual amounts entering the body in this way may be small, absorption contributes to the total load — that is, to the total amount taken in through breathing, ingestion, and absorption. It is difficult to monitor how much of a particular substance has been ingested after exposure to toxic substances in soil and dust, however, and this problem has not been studied in depth.

Substances with Harmful Effects on Human Reproduction

The following discussion on substances found in the environment that in sufficient concentration may have a harmful effect on reproductive health is by no means exhaustive. There is a voluminous literature on suspected harmful agents, although in many cases we lack data on human beings and can only extrapolate from animal studies.[6] Because of the vast nature of the subject, our discussion is intended to be illustrative. It

focusses on three factors — metals, pesticides and other chemicals, and radiation — that have been linked clearly to reproductive harm when individuals are exposed to sufficient doses.

Metals can be released into the air through industrial activities, the use of consumer products, and the burning of fossil fuels. Three metals stand out as seriously toxic to the reproductive process: lead, mercury, and cadmium. In 1982 alone, the use of these metals in the United States included 1.3 million pounds of lead, 3.4 million pounds of mercury, and 8.2 million pounds of cadmium. Pesticides, other chemicals, and ionizing radiation have also been associated with serious reproductive harm when they occur in sufficient concentrations. At least 50 chemicals currently in widespread use in U.S. industry have been shown to impair reproductive function in animals. These chemicals include the heavy metals mentioned, glycol ethers, organohalide pesticides, and organic solvents. If these substances occurred in the environment above recommended levels, it would be of grave concern.

Lead: Because lead is prevalent in the environment, it can contaminate food through direct deposit on crops or absorption by plants. Food is the greatest source of exposure to lead for most people. Chronic exposure may produce generalized but serious symptoms, including anaemia, impairment of nervous system function, fatigue, headaches, and kidney problems. Lead and its compounds have been shown to cause adverse effects in both the male and female reproductive systems. Studies have shown increased rates of spontaneous abortion in the wives of workers exposed to lead. The effects of lead exposure on female reproduction include menstrual disorders, infertility, spontaneous abortion, stillbirths, and neonatal deaths. Moreover, lead is now recognized to cause toxic effects on the health of workers at levels of exposure that only recently were thought to be safe. These effects have been shown to occur in workers at levels of exposure to airborne lead that are below the permissible exposure limit of 50 micrograms per decilitre set by the U.S. Occupational Safety and Health Administration. The current action level in Canada — that is, the level at which some action is necessary if lead is in the blood — is 25 micrograms per decilitre. This level is being reviewed by the Federal/Provincial Advisory Committee on Environmental and Occupational Health.

Children and developing fetuses experience much more serious health effects than the general population from given levels of exposure to lead because they absorb 50 percent of the lead they ingest, while adults absorb only 10 percent. Recent research has found that exposure to relatively low levels of lead before birth or during infancy and early childhood may impair intellectual development or hearing, cause behavioural problems, and result in smaller body size.

Mercury: Human beings are exposed to mercury largely through the food chain (primarily through fish), although workers in certain industries may

inhale air containing mercury vapour. In the United States, an estimated 40 000 workers are exposed to this form of mercury in manufacturing and mining. At high concentrations, mercury vapour can cause lung irritation and destruction of lung tissue and may eventually cause central nervous system disorders. Certain organs, particularly the liver and kidneys, accumulate mercury more than other organs. The metal also accumulates (although more slowly) in the brain.

Exposure to mercury is known to affect fertility. Research shows that mercury affects sperm production and reduces fertility in male animals. Men who have been accidentally exposed to mercury have been found to have altered libido. Women with occupational exposure to mercury have been observed to have menstrual disturbances. In sufficient concentration mercury affects a developing fetus so that physical growth is retarded and the nervous system is impaired, resulting in motor coordination difficulties or cerebral palsy. The impact of low doses of methyl mercury (organic mercury) in particular may be subtle, including reduced intellectual development and problems with coordination and behaviour.

The risk of damage to the central nervous system in fetuses and children (whose brains are still developing) is especially high for Aboriginal Canadians living in areas affected by mercury used in industrial processes. This is because they may eat large amounts of fish or animals exposed to high concentrations of contaminants such as mercury. During the 1970s, Health and Welfare Canada set up programs to monitor their exposure to mercury by conducting blood and hair tests. High-risk levels were found in 2.5 percent of residents from 43 Aboriginal communities.[7]

Research has been conducted in Canada into prenatal exposure to mercury. Between 1971 and 1978, scientists analyzed a total of 520 blood samples from pregnant women and 739 blood samples from infant umbilical cords. All levels in the women were below 100 parts per billion, the maximum level at which no adverse effects are expected. Infant levels were higher, however, and included four results over 100 parts per billion. No abnormalities were detected in these infants, although the researchers did not rule out the possibility of longer-term development effects.

The federal, provincial, and territorial governments set guidelines for the consumption of fish that are more likely to be contaminated with mercury, and identify where these species are located. They recommend that pregnant women in areas of concern not consume large quantities of fish.

Cadmium: Cadmium is a relatively rare element that occurs naturally in the earth's crust. It is used primarily in electroplating metals or alloys to protect them from corrosion. Industrial and municipal wastes are the major sources of cadmium pollution. Heavily industrialized areas — especially those with nickel or copper smelters — have the highest concentrations of cadmium. Once in the body, cadmium accumulates and is concentrated in the kidneys and liver. Cadmium can cross the placental

barrier between the pregnant woman and the developing fetus. Animal studies have found that high levels of cadmium cause congenital anomalies, changes in the testes, and reduced fertility.

Pesticides and Other Chemicals: Chlorine-containing insecticides belong to a family of chemicals known as organochlorines; the pesticide DDT is in this group. At high levels of exposure, pesticides can cause serious harm to human health. For example, dibromochloropropane (DBCP) has been shown to cause testicular atrophy and male sterility. The pesticides DDT and EDB are believed to cause adverse reproductive outcomes in male animals. Because of their chemical structure, pesticides do not break down easily, and they remain in the environment for a long time. As a result, they accumulate in the food chain and may result in toxic concentrations in higher animals and human beings. Organochlorines have been found to interrupt normal breeding cycles and cause congenital anomalies in sea birds and laboratory animals. Because organochlorines bioaccumulate in the food chain, they may have a significant impact on other species, but this effect has not been explored.

Laboratory tests on animals have raised concerns about the impact of two particular families of related chemicals: dioxins and furans. Animals exposed to more than a certain level of the most toxic dioxins and furans experience adverse health effects such as impaired liver function, cancer, and impaired reproduction, including congenital anomalies. The federal government has implemented a wide range of controls to minimize human exposure to dioxins, furans, and PCBs.

Chemicals known as PAHs (polycyclic aromatic hydrocarbons) at high levels can cause cancer in human beings. They have also been implicated in genetic change and problems in development.

Radiation: Radiation from both natural and human-made sources is present everywhere in the environment. "Background radiation" is emitted from natural sources, such as the sun's rays and various elements in the earth, and is impossible to avoid. Other exposures to radiation arise from technologies such as X-rays for medical diagnostic purposes, television sets, and video display terminals. There are three major types of radiation: ionizing radiation, non-ionizing radiation, and electromagnetic fields.

Ionizing radiation is high-energy radiation. It is commonly used in X-rays, in baggage check-in equipment at airports, and as tracers in nuclear medicine. Ionizing radiation can be dangerous to human beings in that it can dislodge electrons from molecules in the body, thereby creating ions that, in turn, can damage cells. High doses of radiation harm the body's mechanisms for defending against infection and may also affect the central nervous system. High doses of ionizing radiation are known to be carcinogenic, mutagenic, and teratogenic.

Non-ionizing radiation refers to low-energy radiation. It is emitted from a variety of sources, including the sun's rays, sun lamps, and

microwave ovens. Non-ionizing radiation does not have the capacity to dislodge electrons and damage cells in the same way as ionizing radiation. Nonetheless, at sufficient doses it can penetrate and produce heat in human tissue and cause subsequent damage. Chronic direct exposure to sunlight, for example, harms skin and eyes.

Electrical power creates electric and magnetic fields. Electric fields result from the strength of the electric charge, while magnetic fields result from the motion of the charge. Together, these fields are referred to as electromagnetic fields. Virtually all electrical appliances emit EMFs. EMFs have been found to produce various physiological effects such as changes in the functioning of individual nerve cells as well as the nervous system as a whole. These findings have raised questions about the possible impact of EMFs on reproductive health. Exposures to EMFs may occur at work as we have mentioned with VDTs. They may also occur near power transmission lines, electric blankets, and many other devices. Reports available to date on adverse effects are quite speculative, and present indications from the scientific literature are that low-frequency fields hundreds of times stronger than those usually observed near VDTs, for example, do not produce harmful effects.[8]

Current Legislative Framework

The identification and regulation of environmental hazards fall within the purview of the *Canadian Environmental Protection Act*, which took effect in 1988. CEPA gives the federal government broad powers to define national standards for any given toxic substance in the environment. The act is intended to control toxic substances at all stages of production, including development, manufacture, transportation, distribution, use, storage, and disposal.

CEPA is administered jointly by Environment Canada and Health Canada. The regulations under the act are designed to control toxic substances in the following categories: existing, new, priority, and toxic. "Existing" chemicals are defined by the Domestic Substances List. The list, consisting of about 20 000 substances, serves as an inventory of existing substances.

"New" chemicals or substances are those that do not appear on the current Domestic Substances List. No new substance can be introduced commercially unless it is first assessed for safety. Companies wishing to introduce a substance not on the Domestic Substances List must notify the federal government under the New Substances Notification Regulations and provide enough data for its assessment. If, after assessment, a substance is suspected as harmful, the federal government has several options under the new law: to prohibit manufacture or import, to permit manufacture or import subject to specified conditions, or to request additional information.

"Priority" substances are chemicals that must be assessed before February 1994. A priority list has been developed that identifies 44

substances with the potential to harm the environment or endanger human health. Information on toxicity is obtained from animal testing as well as from studies of disease patterns in populations correlated with levels of exposure.

If a substance is defined as "toxic" under the priority review process, it is moved from the Priority Substances List to the toxic category and becomes subject to controls. These usually take the form of regulations, although guidelines or codes of practice may be used. The government may ban the substance, improve the safety requirements for its use, or limit how much of the substance can lawfully be discharged into the environment. Regulations have already been implemented for substances defined as toxic, and other regulations dealing with the remaining substances will be implemented on a continuing basis.

In addition to federal law, provinces and territories have their own environmental controls. The Ontario Ministry of the Environment, for example, recently released a list of hazardous substances that are candidates for possible ban or phase-out in that province.[9] The list includes contaminants that are present in or discharged into the Ontario environment. They are considered to be hazardous on the basis of their persistence, bioaccumulation, and toxicity. Most of these are carcinogens as well as mutagens and teratogens. A list of candidate substances for ban or phase-out helps identify chemicals that pose the greatest hazard based on their potential to cause damage to the environment or to human health. Where a ban or phase-out is not technically feasible, the province will seek to reduce the use or release of the substance.

Proposed Action on Environmental Exposures

The presence of a regulatory framework at both the federal and the provincial/territorial level provides a basis upon which to take action to protect reproductive health. We believe that two types of action are required. First, steps must be taken to improve our knowledge base. Research is required to identify the impact of designated substances and particular families of chemicals on reproductive health. Studies must consider a broad range of reproductive effects, not only pregnancy losses and congenital anomalies.

> We believe that specific consideration of the impact of environmental exposures on reproductive health should be incorporated in the regulations promulgated under the *Canadian Environmental Protection Act*, as well as in the general thinking and approach of federal and provincial/territorial departments of the environment and departments of health.

Second, action must be taken to ensure that concerns about reproductive health assume a higher profile in all aspects of environmental action. We believe that specific

consideration of the impact of environmental exposures on reproductive health should be incorporated in the regulations promulgated under the *Canadian Environmental Protection Act*, as well as in the general thinking and approach of federal and provincial/territorial departments of the environment and departments of health. The Commission therefore recommends that

> **39. Reproductive health experts be asked to examine existing and proposed regulations under the *Canadian Environmental Protection Act* and make appropriate recommendations to ensure that they take into account reproductive health risks.**

and that

> **40. Environment Canada and Health Canada specifically include consideration of the issue of reproductive health in all actions undertaken to protect the environment.**

A Comprehensive Research Strategy

A major conclusion of this Commission, after reviewing the existing data on the effect of exposures in the workplace and the environment on reproductive health, is the vital need for more knowledge in this area. Until we have better information about what agents and substances, at what levels of exposure, pose risks to human fertility, and about who is affected, it will be difficult to develop rational or effective preventive strategies.

Canada is not alone in facing this problem. Indeed, the scope of the issue is too enormous for any single country to take on all the necessary research and analysis. We therefore propose an international cooperative effort to address the problem. There would be significant economies of scale and other benefits in joining forces with occupational and environmental health authorities in other countries to establish the range of tasks to be completed and the priorities for action and then to divide up the responsibilities according to where the necessary expertise and resources are located or can be assigned. This approach could apply to assessing existing data, conducting new research, and developing and evaluating preventive measures, with all countries participating in the effort benefiting from the results.

If this cooperative international approach were adopted, there would be no need, for example, for Canada to review the evidence on each agent

or chemical independently; it would be more effective and efficient for groups of experts from different countries collectively to appraise the existing data on various substances. Several data bases that collect literature on occupational and environmental hazards already exist — they include TOXLINE and MEDLINE. What is missing, however, is any critical appraisal of the quality of the studies listed in these data bases or any overall conclusions about substances that should be considered general and/or reproductive health hazards. For example, the U.S. National Institute for Occupational Safety and Health has 79 000 chemicals in its *Registry of Toxic Effects of Chemical Substances*, as well as data on the reproductive effects of almost 20 percent (more than 15 000) of these, but the accuracy, quality, and reliability of these data have not been assessed.

Commissioners believe that Canada should take the lead in initiating a comprehensive international effort to critically assess the existing data and studies worldwide and identify the chemical, biological, and physical agents that have been associated with reproductive disorders in animals or human beings. Such an effort could be important to the future of our species.

Commissioners believe that Canada should take the lead in initiating a comprehensive international effort to critically assess the existing data and studies worldwide and identify the chemical, biological, and physical agents that have been associated with reproductive disorders in animals or human beings. Such an effort could be important to the future of our species. This research analysis should be conducted to identify substances or agents for which data are (1) sufficient to classify them as reproductive hazards for human beings; (2) inadequate to classify them as reproductive hazards for human beings; or (3) sufficient to indicate that the substance or agent is not a hazard to reproductive health. This important initiative cannot take place without the leadership and commitment of the federal government. The Commission therefore recommends that

41. The federal government organize and provide funding to a working group of Canadian experts in the field of reproductive health and workplace and environmental exposures, to work with the World Health Organization to initiate a cooperative international effort to critically assess the existing data on occupational and environmental substances that may represent risks to reproductive health.

Where there is sufficient evidence to suggest that a substance or agent does pose a risk to reproductive health, programs must be put in place to monitor the number and locations of individuals exposed and the extent of their exposure. Occupations or industry groups that are shown to be at

risk of exposure to a known reproductive hazard should then be targeted for preventive programs. Research should also be undertaken to determine current exposure levels to these hazards among various occupational groups, and, where problems are identified, prevention programs should be put in place to protect the reproductive health of exposed individuals. Accordingly, the Commission recommends that

42. The federal government, in conjunction with provincial/territorial governments, develop programs to monitor the exposure of workers in various occupations to known reproductive hazards, with the aim of developing appropriate control and prevention measures.

Where the evidence is insufficient to categorize the reproductive health risk associated with a substance or agent, additional research will be required. However, given the vast number of substances that will fall within this category, priorities will have to be established. Assessment by an international working group, such as we have recommended, would be the most effective way to address this issue. Consensus on the potential reproductive hazards that should be priorities for further research would help to focus international research efforts in the most important areas of concern. Canada could play an important role by accepting responsibility for conducting the necessary research on some of the priority substances identified through this process. The Commission therefore recommends that

43. The federal government and its research funding bodies support research studies on the impact of designated substances and families of chemicals that are suspected of causing adverse reproductive health effects.

A range of research approaches could be taken to evaluate substances identified as potential reproductive hazards. One approach, discussed throughout this report, is to make better use of data that have already been collected. For instance, existing computerized data bases containing information about workplace exposures, and about health outcomes or medical treatment, could be linked and compared to detect evidence of reproductive impairment, pregnancy complications, congenital anomalies, and so on. Record linkage studies using existing data bases could be done at relatively low cost, since the most expensive part — the data collection — has already been done. Studies have already been carried out that demonstrate the feasibility of this approach for specific purposes. Ensuring this approach is successful on a wide scale will require the cooperation of unions, employers, and governments and their willingness to allow such linkage studies, provided appropriate confidentiality guidelines are in place.

Consensus on the potential reproductive hazards that should be priorities for further research would help to focus international research efforts in the most important areas of concern.

For data bases to be useful in record linkage studies, they need to contain specific items of information. For example, if researchers wanted to look for an association between people's occupations and the risk of specific reproductive outcomes (for example, low birth weight, congenital anomalies, spontaneous abortion), a data base would have to be available that provided reliable information on men's and women's occupations that could be linked to records, for example, on children with congenital anomalies. Efforts are therefore needed to promote the development of provincial health and vital statistics data collection systems that incorporate these types of information, and, also important, that have standard identifying information across provinces and data bases. As we have discussed elsewhere, Canada needs a system of administrative data collection that is structured in such a way as to allow record linkage. Only then will it be possible to do the necessary analysis of outcomes and consequences (whether after work exposures to particular hazards or suspected hazards or after treatment for infertility) that allow public policy to be based on reliable evidence. Statistics Canada has already done a good deal of work to identify what is needed in the area of health information statistics. For example, the 1991 report of the National Task Force on Health Information addressed this issue in detail. The Commission endorses its work and recommendations.

To be successful, research programs to identify and assess reproductive hazards must be undertaken by researchers who are knowledgeable about complex epidemiological issues. New methodologies that address the complexities of human reproduction will also need to be developed. No effort to evaluate the huge array of data about reproductive health hazards or to conduct new research on suspected hazards can happen overnight — the process will take decades and will require that new researchers be trained in this complex area. Research bodies such as the Medical Research Council of Canada, as well as Health Canada, could play an important role in this respect, for example, with regard to funding training positions and career scientists. The Commission recommends that

44. Research funding bodies, such as the Medical Research Council of Canada and Health Canada (National Health Research and Development Program), consider how to increase the pool of trained researchers qualified to conduct research in the area of occupational and environmental reproductive health effects.

Thus, progress in developing knowledge and prevention strategies regarding risks to reproductive health arising from workplace and environmental exposures will require the involvement and commitment of a significant number of key partners both domestically and internationally. The Commission looks to the federal government in particular to demonstrate leadership and commitment, given its responsibilities with respect to international cooperation, its spending power to influence research and training priorities, and its capacity to promote interprovincial collaboration and harmonization. The Infertility Prevention Sub-Committee of the National Reproductive Technologies Commission could further explore needs in this area and define more precisely what steps need to be taken by the federal government. Its establishment will provide a stimulus to put in place federal initiatives in this field; it will also create a source of continuing public policy advice and public education in this important area.

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