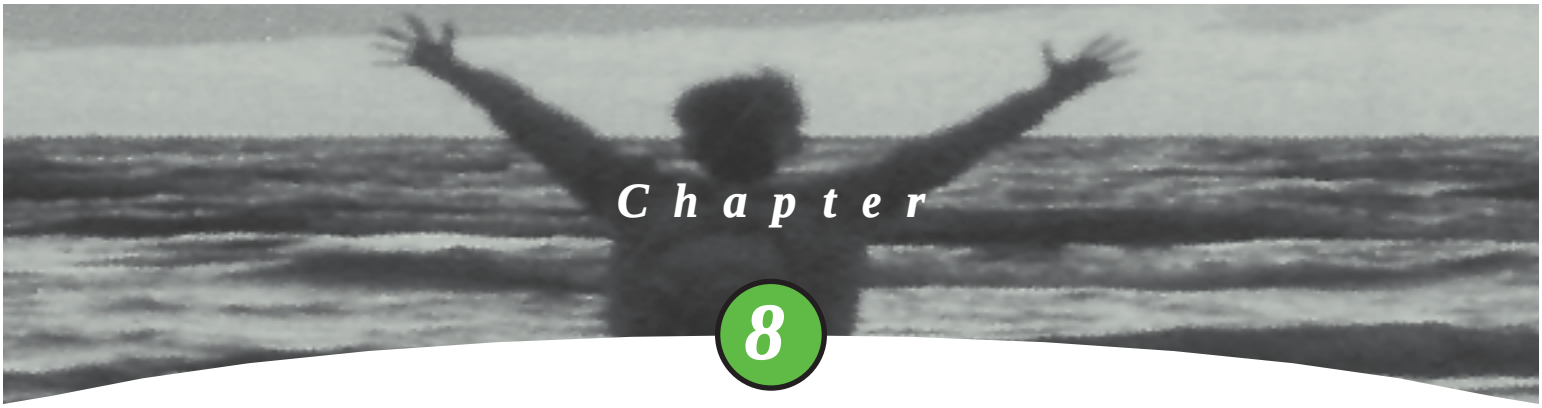

Chapter

8

Genetic and Biological Factors

Overview

The basic biology and the dynamic, organic nature of the human body are fundamental determinants of health. These scientific perspectives focus on the genetic endowment of an individual, the functioning of the various body systems and the processes of development and maturation.

Genetic endowment represents the inherited variations in DNA that form the building blocks of the body. Our genetic background can predispose us to develop inherited disorders or conditions (e.g. Tay Saks disease, autism) and can influence resistance to diseases and promote general healthiness. Once an embryo has been conceived, its genetic endowment cannot be changed.

Biological risk factors can be either innate (e.g. Down syndrome) or acquired (e.g. brain damage from a severe head injury). Innate conditions can be caused by chromosomal abnormalities which are not preventable, while acquired conditions may result from teratogenic influences during pregnancy or biological changes during and after birth. These biological factors may be permanent or may be modified by the environment or by the processes of maturation. For example, once treated with medication, children suffering from attention deficit disorder (ADD) may often be able to function normally and would not be considered as having a disability.

Teratogenic effects are caused by outside agents such as alcohol, medications or other chemical or biological agents that influence the growth and development of the embryo or fetus. Examples of teratogenic effects are the birth defects seen in infants born to mothers who, during pregnancy, were infected with rubella, drank alcohol excessively, or took thalidomide.

The biological processes of body system functioning and of development and maturation can be influenced both positively and negatively by other determinants of health such as personal health practices, the physical and social environments, education, and economic and social status.

These risk factors influence child development in a variety of direct and indirect ways, interacting with environments that also affect health. Many of these biological/genetic risk factors also respond to interventions that can minimize their impact and effects. For example, programs that promote healthy child development or remedial programs that help children get ready for school can minimize the impact of biological risk factors related to cognitive development.

With advances in medical science, opportunities for significant new bio-medical tests and treatments that can identify, prevent and treat conditions are anticipated. Medical breakthroughs that will extend the life span of persons with disabilities combined with the reality of an aging population of people with disabilities will signal changes in two areas: an increased demand for specialized clinical and social services to meet the needs of this population at all stages of life and greater recognition of the rights of persons with disabilities.

Relationship to Healthy Child Development

Broadly defined, biological risk factors are those innate or acquired characteristics of the child that place a child at risk of poor health. These factors can affect healthy child development at several levels: from the simple biological fact of the sex of the child, to genetic variants that are relatively common, such as those associated with attention deficit disorder, to brain damage, which can result from any number of causes, such as severe head injury.

It is impossible to talk of nature and nurture as separate entities with respect to child development. Risk factors are not independent variables operating in a vacuum but may interact synergistically or in an additive fashion (Szatmari et al., 1994). Some environmental risk factors may lead to biological outcomes that put children at risk for ill health. For example, lead in the environment can result in lead poisoning which in turn is a risk factor for low IQ, learning disabilities and attention deficit disorders; unemployment and cultural displacement may lead to alcohol abuse which, for a pregnant woman, may translate later into fetal alcohol syndrome for her child. Fetal alcohol syndrome has been associated with learning problems, poor growth and disruptive behaviours.

Biological/genetic risk factors may steer children towards certain environments (e.g. special schools, delinquent peers, detention centres) that place them at further risk of poor health broadly defined. These causal chains are multifaceted, dynamic and complex. As such, intervening anywhere in the chain may have dramatic effects on several levels of health outcomes.

The interaction of biological/genetic factors within the environment is dynamic — constantly changing over time. Interventions aimed specifically at changing the genetic endowment of a child are difficult to implement and few options are available. More potential exists for preventing teratogenic effects and other health-related outcomes from physiological and biological risk factors. Also, interventions aimed at finding and designing environments that promote optimal development are well-known and can be put in place if appropriate resources are available. Early intervention for children at risk or with developmental delays or autism are well-known examples (Zoritch, Roberts and Oakley, 1998; Rogers, 1998).

Types of Biological and Genetic Risk Factors

The following are some examples of biological and genetic risk factors. The list is not meant to be exhaustive but rather to illustrate the broad range of risk factors in this domain that affect child development.

Genetic and chromosomal syndromes

There are many examples of genetic and chromosomal syndromes including Down syndrome, fragile X syndrome, and tuberous sclerosis. Individually, these disorders may be rare, but there are many single-gene disorders and chromosomal abnormalities that affect the brain. Collectively, these conditions carry a very heavy burden of suffering (Costa, Scriver and Childs, 1985).

Many of these conditions are associated with severe learning disabilities and several syndromes are characterized by specific behaviours that may place a child at risk of further health problems (Dykens, 1996). For example, Lesch-Nyhan syndrome is a genetic disorder characterized by self-mutilation (Nyhan, 1997). This can lead to many other health problems both physically and emotionally, not only for the child, but also for the entire family.

Drug abuse during pregnancy

More and more substances are being identified as potentially having a harmful effect on the developing fetus. These include low doses of alcohol, tobacco and illegal and prescription drugs (Mattson and Riley, 1998; Singer, Garber and Kliegman, 1991; Slotkin, 1998). These drugs can affect physical as well as cognitive development (Singer et al., 1997), however the effects on learning and behaviour may not be evident for many years. Fetal alcohol syndrome is a particular problem among those living in severe low-income circumstances (Abel and Skol, 1987; Sampson et al., 1997).

External influences on brain development

There is now accumulating evidence that stress during pregnancy as well as maternal and early infant nutrition can affect the development of the fetal and infant brain. For example, animal models suggest that stress during pregnancy can affect the intrauterine hormonal environment which may then place the infant at later risk of depression (Schneider et al., 1998; Sandman et al., 1997; Anisman et al., 1998). Animal models also show that a stressful intrauterine environment can affect nerve connections in the brain and the architecture of brain development (Hayashi et al., 1998). The effects of early malnutrition on learning and cognition are well known (Richards et al., 1998; Morgan, 1990).

"Women need more folate, a B vitamin, during pregnancy to support their expanding blood volume and the growth of maternal and fetal tissues, and to decrease the risk to the fetus of neural tube defects (NTDs)" (Health Canada, 1999, p. 28). "NTDs result from the improper development and closure of the neural tube during the third and fourth week of gestation. Pregnancies affected by an NTD may result in a miscarriage or stillbirth, and children born with an NTD may have mild to severe disability or die in early childhood. NTDs include spina bifida, anencephaly and encephalocele" (Health Canada, 1999, p. 28). There is evidence that increasing folate intake during the peri-conceptual period via a daily supplement containing folic acid (a form of folate found in supplements) and a healthy eating pattern can reduce the risk of NTDs (Health Canada, 1999, p. 29).

"It is important that pregnant and nursing women consume adequate amounts of essential fatty acids (EFAs), linoleic acid and alpha-linoleic acid in their daily eating patterns for proper fetal neural and visual development" (Health Canada, 1999, p. 35). The fetus and infant are dependent on the mother to supply sufficient EFAs for their healthy development, especially during periods of rapid growth such as the last trimester of pregnancy and the first months of postnatal life (Health Canada, 1999, p. 35).

Prematurity

Premature births are defined as births occurring before 36 weeks gestation. With significant advances in perinatal care, more premature babies are surviving than ever before (Saigal et al., 1989; Roth et al., 1996; Lorenz et al., 1998). Newborns that weigh less than one kilogram now regularly "graduate" from neonatal intensive care units (Lorenz et al., 1998). Most of these children do very well and have minimal disabilities (Saigal et al., 1990; Lorenz et al., 1998). However, some have very special needs in terms of learning problems, physical disabilities, sensory deficits and attention deficit (Saigal et al., 1991a, 1991b; Szatmari et al., 1990). For this reason, many graduates of neonatal intensive care units require follow up and long-term care.

Sex

It is well known that boys may be at greater risk than girls for the development of several developmental disorders, such as autism (Bryson, Clark and Smith, 1988) and certain types of behavioural conditions as well, such as attention deficit and conduct disorder (Offord, 1987). The mechanism for this gender-based predisposition to these conditions is not well understood as little research has been carried out on the links between sex, other related biological risk factors and the environment. While some work has shown that boys have a greater vulnerability to brain dysfunction than girls (Waugh et al., 1996), more research is needed to fully understand the interplay of biological sex and social roles related to gender.

On the other hand, girls are at much greater risk of developing depression and eating disorders in adolescence, particularly after 13 to 15 years of age (Cicchetti and Toth, 1998). The mechanism for this is probably multifactorial and involves hormonal factors during puberty as well as experiences in socialization and gender roles unique to adolescent girls. More research is needed to understand the complex interplay between biology and gender and healthy child development.

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Acute and chronic medical illnesses

Medical illnesses place children at risk of further health difficulties in terms of emotional and behavioural problems (Cadman et al., 1987; Stein, Westbrook and Silver, 1998). Even diseases such as cystic fibrosis, diabetes and childhood cancers that do not affect the brain are associated with an increased risk of emotional and behavioural problems (Thompson et al., 1998; Kovacs et al., 1997; Dunitz et al., 1991). These problems are often a secondary consequence of the functional limitations and social isolation associated with the illness (Cadman et al., 1986). The illness may also affect the child's ability to attend school and so have an effect on educational outcomes in the long term (Gortmaker et al., 1990).

Acute and chronic conditions of the brain and nervous system

Examples of conditions that affect the developing brain include cerebral palsy, head injuries, neural tube defects, and meningitis. These disorders carry a high risk of secondary problems pertaining to adaptation and everyday living (Rutter, Graham and Yule, 1970; Breslau, 1990). Some of these conditions also affect the person's ability to speak, think, perceive and learn, which, in turn, may affect opportunities for achieving school success and securing long-term employment. Disorders of the central nervous system may also marginalize the child and lead to social stigmatization that further impairs health.

Developmental Disabilities

These disorders have a biological basis with strong genetic causes. Mental retardation and pervasive developmental disorders (PDDs), such as autism and specific learning disabilities, fall into this category. In general, these disorders are characterized by delayed acquisition of certain skills and an uneven pattern of development. Mental retardation refers to a general delay in the acquisition of cognitive skills in a variety of abilities and a lower than expected level of adaptation. The pervasive developmental disorders are characterized by impairments in social interaction, communication and play, and are associated with a very high burden of suffering.

Both mental retardation and PDDs are more common in boys (Bryson, Clark and Smith, 1988), but reading disabilities are found equally among boys and girls (Shaywitz et al., 1992). There is currently no cure for these developmental disorders, although treatments are available that improve functioning (Rogers, 1998; Lovett, Ransby and Barron, 1988).

Attention deficit disorder (ADD) and attention-deficit hyperactivity disorder (ADHD)

These disorders first become apparent in the toddler years and are characterized by overactivity, impulsivity and difficulty in information processing. Both maladies often persist into adolescence or even adulthood (Hechtman, 1991). Although the causes of ADHD and ADD are not known,it is clear that genetic factors, prematurity, and developmental immaturity are significant risk factors (Thapar, 1998; Zametkin and Liotta, 1998; Szatmari, Offord and Boyle, 1989a).

If the parents and school cannot adapt to the child's problems of impulsivity and short attention span, other conditions that affect health and development may occur, including aggression, early school leaving, and perhaps later substance abuse (Mannuzza et al., 1993). These outcomes can further impair health and make it less likely that the child will find a health-promoting environment in which to flourish. Effective treatments for ADHD and ADD include medication and psycho-social intervention (Goldman et al., 1998; Pelham, Wheeler and Chronis, 1998).

Other psychiatric disorders

The causes of anxiety, mood and behaviour disorders in children are clearly multifactorial. Although psycho-social risk factors (e.g. abuse, parental psychiatric illness, severe poverty) may be important for understanding disruptive behaviour disorders, many biological and genetic risk factors come into play (Rutter, 1997; Offord and Fleming, 1996), particularly for the anxiety and mood disorders of childhood and adoloscence. All of the psychiatric disorders of childhood have a strong genetic component, although more research is needed to establish exactly how these genetic factors operate (Rutter et al., 1990; Plomin and Rutter, 1998). Moreover, the developmental disabilities referred to above (mental retardation, PDDs and specific learning disorders) are also significant risk factors for these conditions (Beitchman and Young, 1997).

Emotional and behavioural disorders are associated with a poor long-term outcome (Offord et al., 1987) and high economic cost in terms of treatment and lost productivity at school and in the working world. Many adult psychiatric disorders such as substance abuse, alcoholism, depression and schizophrenia are also caused, in large part, by genetic factors; the onset of these conditions often takes place in childhood or adolescence (Rutter, 1995; Fombonne, 1998).

Conditions and Trends

This section summarizes what is known, in the Canadian context, of the prevalence of conditions or disorders caused at least in part by biological and genetic risk factors. It also presents the foreseeable trends that will have an impact on the health of children with disabilities in the future.

The prevalence of biological- and genetically-based disorders is significant.

The prevalence of serious medical conditions of childhood is relatively stable. For example, in 1992 the rate of leukemia for children between ages 0 and 19 was 4.56 per 100,000 population. Despite slight fluctuations, this rate had remained relatively stable since 1985 when the rate was 4.41 per 100,000 population (Huchcroft et al., 1996, p. 92). It is likely that more effective medical treatments will become available in the future for children with acute and chronic medical disorders. As a result, children with diseases such as cystic fibrosis and cancer will live longer and require more intensive care, even into adulthood.

With the significant advances in perinatal care, more premature babies are surviving in Canada today than 20 years ago (Saigal et al., 1989). In recent years, there has been little variation in the prevalence of prematurity: in 1991, 3.7% of babies born in the Canadian population were born prematurely (Statistics Canada, 1993, pp. 18–19), and in 1995, the percentage had remained relatively unchanged at 4.0% (Statistics Canada, 1997, p. 21). With increased chances of survival, the number of babies with disabilities due to prematurity will rise, as will the proportion of severe cases.

It is estimated that, in industrialized countries, between 1 and 3 children in every 1,000 will be born with fetal alcohol syndrome (FAS); however, the rate for children with fetal alcohol effects (i.e. children with prenatal alcohol exposure but only some FAS characteristics) may be several times higher (Health Canada, 1996, p. 4). In Canada, the rate of FAS for the Aboriginal population may be 10 times higher than that for the non-Aboriginal population (CCSA National Working Group on Policy, 1994).

Each year in Canada, approximately 400 babies are born with neural tube defects (NTDs), which represents about 1 of every 1,000 births (McCourt, 1995). Because many cases of NTD are spontaneously aborted or detected antenatally and therapeutically aborted, it is estimated that there may be at least 800 NTD-affected conceptions each year (McCourt, 1995). Between 90% and 95% of NTDs occur in families with no family history of the condition (Cohen, 1987).

As a group, developmental disabilities are common. For example, the prevalence of autism in Canada is estimated at 0.1% (Bryson, Clark and Smith, 1988), mental retardation at about 3%, and specific learning disabilities at approximately 10% (Beitcham and Young, 1997). Although there is no evidence that actual prevalence is increasing, the number of children receiving these diagnoses is increasing, leading to a greater demand for services.

The prevalence of ADD is estimated at between 5% and 10% and is more common in boys than girls (Szatmari, Offord and Boyle, 1989b). The rate of occurrence does not appear to be affected by factors such as place of residence (urban versus rural) or socioeconomic class.

The psychiatric disorders of childhood are also common, with combined prevalence rates of between 10% and 20% among school-aged children (Offord et al., 1987). Some data indicate that the prevalence of substance abuse, depression, suicide and antisocial behaviour is increasing (Fombonne, 1998). Disorders such as depression and anxiety are more common in adolescence than childhood, but more research is needed to chart the appearance and disappearance of emotional and behaviour symptoms over time.

Advances in biomedical research raise serious issues.

With the recent advances in molecular genetics and the anticipated completion of the Human Genome Project by 2002, the genes for many inherited, developmental and psychiatric disorders of childhood will eventually be identified. These medical breakthroughs will raise controversial issues about family planning, disability insurance, confidentiality and genetic stigmatization. Policies will need to be developed to deal with these important ethical questions based on sound empirical research (Dickson, 1998). Moreover, with the revolution currently underway in molecular biology, it is anticipated that the identification of genetic variants responsible for many conditions that affect child health will lead to important advances in drug treatment and possibly even to gene therapy.

Genetic and Biological Factors and Other Determinants

Employment

As more and more children with genetic, developmental and severe psychiatric disorders mature into adults, there will be a need for an increased number of jobs that benefit people with disabilities: jobs that provide the person with dignity and appropriate remuneration, and are suited to their capabilities so that they can be productive members of society.

Education

Both early diagnosis and intervention are essential to ensuring a positive long-term outcome for at-risk children. Evidence indicates that early intervention with a significant educational component has both short- and long-term benefits for disadvantaged children (Zoritch, Roberts and Oakley, 1998). Early intervention for children with developmental disorders has also been shown to be effective (Rogers, 1998).

The education system has at its disposal remedial programs for children with various forms of learning disabilities (Lovett, Ransby and Barron, 1988) that may improve long-term outcome. Children with physical disabilities due to a variety of conditions can now be fully educated in mainstream and integrated settings. This will lead to improved educational outcomes for these children and to better health in the long term.

Social Environment

Biological and genetic risk factors may also limit the kinds of environments in which some children can participate. For example, some schools and recreational facilities may not be able to accommodate children with disabilities. A child with a biological/genetic risk factor in an inappropriate environment may have her/his health further impaired.

A chronic health problem may also lead to emotional difficulties. By itself, a chronic medical illness is not associated with emotional, behavioural, or learning problems; it can, however, lead to difficulties in everyday living that impair the child's ability to participate fully in the community (Cadman et al., 1986). In addition, the actions and reactions of people in the child's social environment can moderate the impacts of the child's limitations and enhance the degree to which the child can cope within the environment.

Children with biological- or genetic-based disabilities may also be deprived of the opportunity to use their innate resilience and coping skills. For example, the tendency is to move children with aggressive behaviour from less restrictive settings (e.g. those in which they are integrated with other children) to more restrictive settings (e.g. segregated classrooms, home schooling). However, these latter environments may be less appropriate for dealing with challenging behaviour because they may lead to labelling, negative peer influences and

fewer opportunities to use positive coping strategies. Some central nervous system diseases (Lesch-Nyhan syndrome) and developmental disorders (autism) may lead to specific behaviours that are maladaptive in themselves, such as self-mutilation, rituals and obsessions.

Natural and Built Environments

More children with severe physical and developmental disabilities will be living in the community as a result of the closing of institutions and the desire of parents to keep their children with disabilities at home. The increase will have an impact on the demand for appropriate housing in the community and the need for community resources to address this population of clients at the various stages of life.

Personal Health Practices

It is becoming increasingly apparent that preparing for pregnancy increases the chances of a safe and successful pregnancy outcome. A striking example of this is the potential for reducing the risk of neural tube defects with the consumption of a supplement containing folic acid prior to conception.

Health Services and Social Services

The degree and severity of a disability are in part determined by the access to services for the condition, the effectiveness of those services, and the accommodations made by the child's parents, school and community. For example, while children with attention deficit may not be able to be cured, they can be treated effectively with medication so that they may no longer exhibit symptoms. Likewise, for a child with cerebral palsy, access to physiotherapy is crucial as this type of treatment can positively influence the degree and severity of the condition.

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As more children with disabilities are cared for at home, a heavy burden is placed on parents to navigate the system, act as advocates for their children and arrange for special services. Eventually these children will grow into adults, which will result in demands being placed on aging parents and on services for adults with developmental disabilities.

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