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Editors

Defining Prevention Science

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Prevention Science: A Global Issue

There are few countries or populations which are not affected by the consequences of behavioural risk (Ezzati et al., 2002). Obesity, for example, was once considered primarily a problem of high-income countries, but its consequences are now linked to more deaths worldwide than a lack of food (WHO, 2004). Despite young people traditionally being perceived as more healthy than older members of the population, a large proportion of premature adult deaths (up to 70%) are associated with behaviours initiated in adolescence (Resnick, Catalano, Sawyer, Viner, & Patton, 2012), and young people’s involvement in preventable risks such as drug and alcohol use or engagement in unsafe sex are now important contributors to the global burden of disease (Gore et al., 2011). The consequences of these behaviours in both adults and young people are also expensive. Although it is difficult to estimate the costs placed on health and social services as a result of preventable disease, good population health is considered a prerequisite of current economic growth strategies (e.g. Health 2020 in Europe). This global priority is also echoed in the World Health Organisation’s Action Plan for Global Strategy for the Prevention and Control of Noncommunicable Diseases (2008–2013) (WHO, 2008), which outlines activities to prevent and control the four main non-communicable diseases; cardiovascular disease, diabetes, cancers and chronic respiratory diseases. To help achieve this, the Action Plan recommends developing and promoting prevention interventions that are designed to reduce shared risk factors (tobacco use, unhealthy diets, physical inactivity and harmful use of alcohol) (WHO, 2008). Underpinning this priority is the recognition that success is dependent upon international collaboration and shared learning; indeed the current economic climate means that sharing knowledge and resources is the only viable forward for many countries. However, even operating within an international framework, the challenge for the prevention field is to develop and disseminate evidence-based policies that not only ensure equality of access to interventions but are also sensitive to local moderators (Resnick et al., 2012).

Great advances have been made in recent years, in diverse fields ranging from molecular biology to behavioural epidemiology, that have allowed for the identification of important psychobiological, developmental and environmental mediators of
risk behaviour (Catalano et al., 2012). Many of these are common across cultures, but equally, many are not (e.g. Beyers, Toumbourou, Catalano, Arthur, & Hawkins, 2004). Indeed, the influence of socioeconomic status and social inequalities on health and well-being, for example, can differ even within small geographies (Marmot Review, 2010). This means that global prevention success depends not only upon robust theory and demonstration of programme efficacy but also upon consideration of the implementation, transferability and adaptation of programmes across diverse delivery systems and policy objectives (Brotherhood & Sumnall, 2011). Interventions that have demonstrated effectiveness in their country of development (most commonly the USA) are not easily translated, and notable examples exist of beneficial programme effects that are not sustained when transferred internationally (Fraser et al., 2011; Malti, Ribeaud, & Eisner, 2011), especially when assessed by independent research teams (Eisner, 2009). This not only suggests a need for theory-driven adaptation processes (Ferrer-Wreder, Sundell, & Mansoory, 2012) but also highlights the importance of independent international replication of intervention effects.

Similarly, moving away from intervention theory towards implementation, we must also consider the diverse range of sociocultural environments into which prevention is likely to be delivered (Li, Mattes, McMurray, Hertzmanm, & Stanley, 2009). Interventions, particularly those targeted towards young people may be most effective when delivered in accordance with (or are at least sensitive to) prevailing social trends and attitudes (Room, 2012). However, because of their diversity, these may often be in opposition to both international policies and conventions (e.g. UN Single Convention on Narcotic Drugs), and the priorities of health and social care professionals (e.g. prevention of cannabis use). These differences can be seen reflected in international epidemiological data on preventable behaviours (e.g. Hibbell et al., 2012), public preferences towards regulation of risk (Gallup Organisation, 2011), political, social and cultural norms on acceptability of risky (Nutt, 2009), and cross-national differences in policy regulating access to risky behaviours (e.g. Joosen & Raw, 2006). For example, there is a sixfold difference in per capita consumption of pure alcohol between the lowest and highest consuming countries (WHO, 2011), and global differences in alcohol policy manifest in an array of marketing regulations (e.g. sports sponsorship bans), interventionist pricing policies (e.g. minimum alcohol unit pricing), cultural norms (e.g. legal alcohol purchase age), and the acceptability of industry lobbying (such as industry self-regulation and “responsibility deals”) (Babor et al., 2003). Subsequently, what might be considered an acceptable prevention strategy in one country (e.g. “dry” University campuses) may be rejected by another. Similarly, prevention success as defined in one country (e.g. alcohol abstention as the goal of prevention) might not be acceptable in another (e.g. where an alcohol harm reduction approach is preferred).

It is into such complex mixes of behavioural moderators that we try to introduce prevention work, and so it is unsurprising that our findings are often not transferable. As prevention researchers we can have faith in the robustness of our theories, and can modify our interventions in relation to specific and consistent population characteristics. However, we often assume populations welcome intervention, but recipients of prevention are dynamic social actors who face multiple competing and increasingly
global influences on their behaviour (Labonte, Mohindra, & Schrecker, 2011). The introduction of tobacco control policy, for example, has been a relative public health success in the developed world, but it has also shown us that as one market is restricted, others are exploited (Otañez, Mamudu, & Glantz, 2009). Most prevention researchers are unable to influence such macro determinants of health and well-being, but as challenged by the World Health Organisation, it is through international collaboration that we might begin to address the major global health and social challenges we face. This is of course easier to write than enact, and successful action will need the cooperation of many stakeholders, from the general public to international organisations. By taking a global perspective on prevention, particularly through our activities in international fora, we might more readily achieve this. This first volume in the Advances in Prevention Science Book Series is also to be welcomed as it will help to create a solid foundation for international prevention science activities. It provides a universal prevention lexicon, and outlines evidence-based theories and methods that will support a unified approach to preventing and managing engagement in unhealthy and risky behaviours across the lifespan.

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Prevention Science is a relatively new field, with some of the first papers outlining the conceptual framework, methods and research priorities having been published in the early 1990s (e.g., Coie et al., 1993; Kellam & Van Horn, 1997). These early descriptions highlighted the breadth of prevention science, which draws from multiple disciplines and encompasses a broad range of research including studies of epidemiology, studies designed to identify risk and protective factors of a problem or disorder and the development of interventions for preventing or ameliorating high-risk behaviours, disease, disorder or injury. In addition, prevention science also includes research on the translation and dissemination of effective preventive interventions into practice; studies to understand the science of bringing efficacious and effective interventions to scale in order to have public health impact.

Significant progress in prevention has been made over the last 30 years. Epidemiological and etiological research has identified numerous biological, psychological, social and environmental risk and protective factors that influence behaviour and positive well-being as well as disorders and illness. This research has contributed to the development of programs and policies that have demonstrated efficacy to prevent behavioural and health problems and promote well-being by targeting these empirically identified risk and protective factors, representing great potential for enhancing public health and well-being. When carefully implemented, such interventions can prevent a wide range of health problems, promote positive development and achieve economic benefits (CDC, 2007; National Prevention Strategy, 2011). Considerable evaluation data indicate that these types of interventions have had significant and far-reaching effects in reducing unhealthy eating; physical inactivity; alcohol, tobacco and other drug abuse; teen pregnancy; school failure; delinquent behaviour; violence; and other mental, emotional, behavioural and physical health problems. Furthermore, these interventions have shown a cost-beneficial economic impact on education, criminal justice, social and health services (O’Connell, Boat, & Warner, 2009).

Based on these data and on recognition of this potential, a number of current federal initiatives have been put in place to support scale-up of evidence-based programs (e.g., home-visitation, teen pregnancy, social innovation fund). Several of these efforts include a tiered approach to funding, with greater funding available for
those programs that meet the highest level of evidentiary standards (i.e., typically randomized controlled trials), making additional resources available for evaluating programs with some supportive evidence of effects, and encouraging agencies to innovate and test ideas with strong potential that are supported by preliminary research findings. These initiatives have been met with tremendous enthusiasm, both because of the potential to positively impact our nations’ health and decrease risk for a range of social problems, and also because of the ability to advance knowledge regarding what works and how evidence-based preventive interventions can be effectively implemented and evaluated at scale.

Despite the impressive progress made, considerably more work is needed to advance both the science and practice of prevention. Research is needed to test new approaches, identify mediating mechanisms of intervention effects, understand factors associated with poor implementation fidelity and how to surmount them, determine whether adaptation is necessary to make prevention programs suitable to different populations as well as how to adapt evidence-based prevention programs without undermining their effectiveness. Research is needed to test the optimal combination of prevention programs together to create effective comprehensive prevention strategies and extend current prevention findings to multiple problem behaviours.

This volume is important in aiding in these efforts, as it is one of the first to provide a comprehensive set of chapters devoted to theory, research design and analytic techniques specific to prevention science. Mainly, the editors are intentional in their effort to bring a global perspective to the field, including chapters written by an international set of experts. Increasing collaboration will allow for greater flow of information across geographical boundaries and provides opportunities to apply principles and programs in multiple contexts—to better understand questions of how, for whom and under what circumstances.

In June, 2010 President Obama signed an Executive Order creating the National Prevention, Health Promotion, and Public Health Council. Charged with creating a National Prevention Strategy, the formation of the Council and the focus on an integrated national strategy provided an unprecedented opportunity to shift the United States from a focus on sickness and disease to one based on wellness and prevention (National Prevention Strategy, 2011). The goals of the Council are ambitious and largely based in research that has been conducted in prevention science. By continuing to advance the science of prevention, there is tremendous potential for improving not only this but also all nations’ health by reducing the incidence of morbidity, mortality and the associated social costs of problems and disorders such as drug addiction and alcoholism, HIV/AIDS, mental illness, cancer, cardiovascular disease, obesity and violence. This volume provides a solid foundation to aid in these goals.

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Preface

To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science.

Albert Einstein

The maturity of an evolving science is marked by the development of its own theories, ethics, methodologies and lexicon. Prevention research has progressed over the past three decades towards becoming the basis for a new science, prevention science, defined as: a science that tests theory-based hypotheses towards enhancing or refining the process that makes individuals’ engagement in healthy and non-risky behaviours more likely (Biglan et al., 2011).

The establishment of the American Society for Prevention Research (SPR) in 1991 and the European Society for Prevention Research (EU-SPR) in 2010 has increased the recognition that the prevention of mental, emotional and behavioural problems shares similar approaches, requires similar research designs and warrants its own terminology, skills and competencies. In response, in 2011, SPR published Standards of Knowledge for the Science of Prevention (http://www.preventionresearch.org/Society%20for%20Prevention%20Research%20Standards%20of%20Knowledge.pdf) that laid out the foundation for this new field, drawing from epidemiology, psychology, medicine, sociology, social work, education, economics, public health, biostatistics, geography, anthropology, policy analysis, criminology, neuroscience and genetics. The work lays out three domains, Epidemiology, Intervention Development, and Research Methodology (to include design and statistical applications) and the prevention-related competencies of each.

Taking the Standards of Knowledge document as a point of departure, the focus of this book lies in documenting the state of the art in prevention knowledge while at the same time emphasizing the importance of developmental benchmarks and competencies as a basis for understanding vulnerability, socialisation and decision making. In addition, the book integrates implementation and prevention science, and, presents cutting-edge concepts related to alternative research designs for evaluations of prevention interventions and the integration of cost assessment into prevention program evaluations.
As with any other science, we believe that Prevention Science should not be confined by geographic or cultural boundaries. To start the international dialogue, we therefore wanted to include authors from outside the United States and were pleased by the enthusiastic response of our European colleagues, many of whom are members of the EU-SPR. We wish to acknowledge with great appreciation the contributors to this first book on prevention science. Their names and affiliations are listed below. We want to thank them for sharing our vision and especially for their patience with the process of creating the book and their tolerance in addressing our comments and edits.

We also wish to thank Wendy Caron of JBS International, Inc. for her assistance in the formatting and editing of the chapters. Her attention to details in the text and references is much appreciated.

We particularly wish to thank Gail Bassin and Jerri Shaw, the CEO and President of JBS International, Inc., for allowing us the time to work on this book. Without their enthusiastic support, the book most likely would have not come to fruition.

Finally, we would like to thank our Springer editor, Khristine Queja. She has patiently worked with us over the past 3 years to develop not only this first book but three others in the series, Preventing Substance Use, Prevention Science in School Settings, and, Preventing Crime and Violence.

The final chapter in this book by Dr. Fabrizio Faggiano and his colleagues Fabrizia Giannotta and Elias Allara provide recommendations for the next advancements in prevention science. This chapter sets out an agenda and a challenge for prevention scientists both those who conduct the research and also those who deliver the prevention interventions. We all want to assure the delivery of evidence-based prevention programming to improve and enhance the lives of ourselves and future generations.

We view this book not as the final word on prevention science but as a starting point that will encourage discourse, discussion and refinement. In line with the quote by Albert Einstein, we hope that this book can help to initiate the creative process of defining and refining Prevention Science.

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Chapter 1
Prevention Science: An Epidemiological Approach

David Cordova, Yannine Estrada, Shandey Malcolm, Shi Huang, C. Hendricks Brown, Hilda Pantin, and Guillermo Prado

Introduction

This chapter provides an overview of prevention science and the role of epidemiology in the field of prevention science. Specifically, we discuss several major ways in which prevention science is informed by epidemiology. First, we describe how epidemiology is useful in identifying target populations and vulnerable periods as well as discuss the distribution of disease, etiological risk and protective factors, and human development across the lifespan. Second, we highlight the ways in which epidemiology is used to develop frameworks, including an ecological and developmental framework to prevention, and how these frameworks are useful for understanding and comparing targeted populations for specific times of risk. Third, we describe experimental epidemiology and widely used analytic and methodological approaches for testing the efficacy and effectiveness of interventions. Fourth, we describe the role of epidemiology in implementation strategies. Finally, we discuss the need to work toward feedback loops whereby prevention science findings are used to inform epidemiology and vice versa. Although the fields of prevention science and epidemiology share a common goal and interest in health promotion and disease prevention, to some extent, both disciplines often operate in isolation with a minimal feedback loop process. These feedback loops may be essential in advancing both fields. To highlight these concepts, we use several disease and health-risk behaviors, including HIV/AIDS, obesity, and alcohol and drug use.

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Introduction to Prevention Science and Epidemiology

Prevention science is concerned with, among other things, identifying antecedents that impact health and health behavior, as well as the development of models to ameliorate undesired health outcomes and promote health behavior. A relatively new field, prevention science is interdisciplinary and combines life-course development, community epidemiology, and preventive intervention perspectives. Epidemiology in particular plays an important role in prevention science. Below, we describe the role of epidemiology in the field of prevention science.

Traditionally, epidemiology has been defined as the study of the distribution and determinants of health; its aim is to prevent and reduce, survey, and control health disorders (Susser & Stein, 2009). As the cornerstone method of public health research, epidemiology plays a key role in prevention science. Of particular importance to the field of epidemiology is describing the natural history or career of the outcome of interest. The natural history can be defined as the progression of the outcome of interest from the time of exposure to cessation/desistance (Gordis, 2009). From this perspective, central to epidemiology is to identify those factors that contribute to the onset, progression/escalation, and cessation/desistance of the behavior or problem of interest. Using substance use as an example, epidemiology is interested in identifying factors contributing to the onset of substance use, risk and protective factors, whom to target and at what developmental stage, and the methods and design that may be most optimal for highlighting the natural history of substance use. For example, epidemiologic studies show us that early onset of substance use among adolescents, an important period of development, is associated with a greater likelihood of later abuse and dependence (Behrendt, Wittchen, Höfler, Lieb, & Beesdo, 2009; Grant & Dawson, 1998), as well as identify those correlates and risk factors that may contribute to the escalation or progression from use to abuse and dependence (Swendsen et al., 2012).

Epidemiological concepts, including the distribution of disease, determinants of health, and the role of host-environment-agent in understanding disease and etiology, are important in advancing the field of prevention science. These concepts are described below.

The distribution of disease refers to the frequency, pattern, and history of a particular condition, disorder, or disease among groups or populations. Identifying the distribution of disease is helpful in determining segments of the population that are most affected by a disease, condition, or disorder and plays an important role in informing the development of preventive interventions for specific subpopulations, including racial/ethnic minorities, developmental age groups, and/or those who live in certain geographic regions. For example, epidemiologic research indicates that, when compared with their non-Hispanic White and African American counterparts, Hispanic youth report the highest lifetime, annual, and 30-day prevalence rates of both licit and illicit substance use, excluding amphetamines (Johnston, O’Malley, Bachman, & Schulenberg, 2013). These epidemiologic research findings indicate that specific populations may require specialized prevention services, including the
development of Hispanic-specific preventive interventions (Prado et al., 2007, 2012). The distribution of disease, however, does not operate in isolation and is influenced by genetic, environmental, and social determinants of health that also involve risk and protective factors (Susser & Stein, 2009).

The determinants of health can be defined as those risk and protective factors that may have an impact on the distribution of disease and occurrence of a condition or an event (Torrence, 1997). Models of causation, including the host-environment-agent, are useful for better understanding the role of risk and protective factors associated with physical and psychological health disorders.

The host-environment-agent model is used to describe the intersection of the host (e.g., an individual), the environment (e.g., vehicle), and agent (e.g., driver distraction) that interact with one another in the development of a condition such as motor vehicle injuries. The host is the individual and his/her inherent characteristics (e.g., genetic, psychological), which may be a precursor for the development of a particular health or psychological condition. Across different prevention fields, the role of agent can vary and refers to the organism or direct cause of the condition. Using motor vehicle injuries and driver distraction as an example, the agent could include the use of mobile communication devices. The environment includes all external factors that may contribute to the development of a condition and interacts with an individual’s susceptibility. For example, accessibility of mobile communication devices, cultural norms and practices, and legislation on the use of mobile communication devices while driving are environmental factors that may impact a driver’s use of mobile communication devices and consequently motor vehicle injuries and through which risk and protective factors can be targeted by preventive interventions. In fact, prevention science findings have highlighted the significant consequences and public health concern of using mobile communication devices while driving and motor vehicle injuries (Ibrahim, Anderson, Burris, & Wagenaar, 2011). For example, findings from the 2008 Fatality Analysis Reporting System (National Highway Traffic Safety Administration, 2009) indicate that approximately 16% of all reported fatal crashes are attributable to driver distraction, including the use of mobile communication devices. Although it is still unclear how restricting the use of mobile communication devices while driving impacts motor vehicle injuries, these data have led to the implementation of preventive legislation (i.e., environment) on the use of communication mobile devices (i.e., agent) while driving (i.e., individual, host) in 39 states and the District of Colombia (Ibrahim et al., 2011). Thus, the host-environment-agent model has helped guide the field of prevention science and the development and evaluation of motor vehicle injury legislation prevention models to target risk and protective factors within the host, environment, and agent domains (Ibrahim et al., 2011). Therefore, etiological frameworks, including the host-environment-agent model, facilitate advances in the field of prevention science by providing a conceptual framework for better understanding problems, diseases, and disorders; selecting settings and stages of life that may be particularly conducive to intervention; and guiding the choice of what constructs to measure.

To summarize, epidemiology aims to contribute to the prevention of health disorders and health-risk behaviors by providing models through which the natural
history of disease, along with the potential risk and protective factors associated with it, can be described and defined (Torrence, 1997). As shown in Fig. 1.1, the roles of the distribution of disease, determinants of health, and the host-environment-agent are key first steps in understanding disease and etiology, as well as informing the development of prevention programs. In the next section, we describe the role of etiological models in the development of preventive interventions.

**Etiology**

A relatively new perspective has emerged shifting focus to the developmental vulnerability of individuals in context. This paradigm shift allows us to better understand the etiology of the outcome of interest, as well as who will and who
will not engage in certain risky and unhealthy behaviors (Sloboda et al., 2012). Specifically, the etiology of health-risk behaviors, such as adolescent drug abuse, may best be understood through a risk and protective factor model, informed by a developmental framework, that examines the intersection of genetic, psychological, and environmental factors (Prado et al., 2009; Sloboda et al., 2012). As early as the mid-1960s, researchers began to identify a host of risk and protective factors associated with behavioral health problems (Berrueta-Clement, Schweinhart, Barnett, & Weikart, 1987). Identified risk and protective factors include individual-level (e.g., genetic, psychological), proximal environmental (e.g., family, school, peers, and work), and distal environmental factors such as community and social/economic conditions (Kellam & Langevin, 2003). Furthermore, researchers state that risk and protective factors do not operate in isolation and should be studied as an integrated developmental process that also includes genetic factors (Schwartz, Pantin, Coatsworth, & Szapocznik, 2007). Risk and protective factor models have great utility to the field of prevention science, particularly as it relates to identifying different points of intervention that prevention programs may target.

**Genetics**

Research has highlighted the ways in which genetic markers play an instrumental role in the predisposition to engage in, for example, alcohol and drug use. In fact, studies examining heritability estimates suggest that genetics account for as much as 40–70 % of the risk and susceptibility in the development of alcohol or drug abuse and dependence (Heath et al., 1997). Thus, prevention science may play an important role in ameliorating health-risk behaviors, including alcohol or drug abuse and dependence, particularly through a better understanding of the process of genetic markers. For example, it is hypothesized that adolescents with one or two copies of the short variant 5HTTLPR genetic marker may be more susceptible to engaging in health-risk behaviors, relative to adolescents with two copies of the long variant 5HTTLPR genetic marker. Prevention scientists have demonstrated that participating in a preventive intervention may mitigate the risk of the 5HTTLPR genetic marker, thereby ameliorating the genetic predisposition for engaging in health-risk behaviors (Brody, Beach, Philibert, Chen, & Murry, 2009; Brody, Chen, Beach, Philibert, & Kogan, 2009). Therefore, disease and problem behaviors are best understood in the context of the interplay between genetics and environment. For example, gene × environment approaches have played a significant role in advancing the field of prevention science, including working toward a better understanding of genetic susceptibility and cigarette smoking in people with Crohn’s disease (Helbig et al., 2012) and gene × lifestyle and gene × drug interactions and obesity (Franks & Poveda, 2011). Advances in technology, methodology, and statistics will further our understanding of the role of gene × environment in prevention science, as well as advance rodent models to human models to
identify the disease or problem behavior’s susceptibility pathways (Blackburn & Jerry, 2011). The gene × environment model, therefore, is very promising with respect to advancing the etiology literature, which in turn has the potential to maximize the efficacy and effectiveness of prevention programs (Howe, Beach, & Brody, 2010).

Psychological Factors

In addition to genetic factors, psychological or intrapersonal factors are important in understanding health-risk behaviors. Psychological or intrapersonal factors refer to those cognitive, emotional, and attitudinal processes that vary across individuals and can serve as risk or protection for health and behavior (Hemphill et al., 2011; Tonin, Burrow-Sanchez, Harrison, & Kircher, 2008). For example, adolescents who report positive attitudes toward alcohol or drug use may be more vulnerable or susceptible to engaging in alcohol or drug use compared with youth who report more negative attitudes toward alcohol or drug use (Cordova et al., 2011; Hemphill et al., 2011; Tonin et al., 2008). To this end, prevention science may play an important role in ameliorating negative psychological or intrapersonal factors. For example, cognitive and attitudinal processes are pathways through which prevention programs have demonstrated efficacy in preventing/reducing alcohol and drug use among adolescents (Hops et al., 2011).

Environmental/Ecological Factors

Environmental/ecological factors also play a role in the development of health conditions. Environmental/ecological factors are those social, cultural, and contextual processes, including family, peer, community, and legislation, that both influence and are influenced by the individual (Bronfenbrenner, 1979, 1989; Catalano & Hawkins, 1996; Szapocznik & Coatsworth, 1999). A substantial amount of research has demonstrated the ways in which environmental/ecological factors influence risk or protection for health and mental health (Catalano & Hawkins, 1996; Cleveland, Feinberg, & Greenberg, 2010; Griffin & Botvin, 2010). For example, studies suggest that communities characterized by higher levels of social capital and neighborhood collective efficacy may have protective effects on depression among certain Hispanic subgroups (Vega, Ang, Rodriguez, & Finch, 2011). Thus, the environmental/ecological context is important in better understanding risk and protection for health and mental health. Prevention programs that target environmental/ecological processes at multiple contextual levels may be particularly helpful in decreasing health-risk behaviors and promoting health (Hawkins et al., 2012). In fact, Hawkins and colleagues (2012) have shown that, when compared with youth in control communities, youth in Communities That Care, a community-based prevention
program, demonstrate a decrease in community-wide levels of health-risk behaviors, including substance use over time.

**Etiology Across the Lifespan**

The role of genetics, psychological, and environmental/ecological factors on health and health-risk behaviors should be informed through a developmental and life-course lens (Kellam et al., 1991; Sloboda et al., 2012). For example, we know that individuals might be at increased risk for alcohol and drug use in certain developmental periods across the human development life cycle. In fact, research has shown that adolescence and early adulthood in particular are developmental stages in which drug abuse might be more pronounced and likely to occur, compared with middle adulthood (Botvin, Griffin, Paul, & Macaulay, 2003; Dishion, Kavanagh, Schneiger, Nelson, & Kaufman, 2002; Hawkins, Catalano, & Miller, 1992). Therefore, adopting a developmental and life-course perspective to inform prevention science might be important in interrupting the sequelae of negative health and psychological outcomes during critical periods across the lifespan (Braveman & Barclay, 2009).

**Developmental Epidemiology**

Informed by both a developmental and life-course perspective, developmental epidemiology identifies specific proximal individual or environmental factors at an early stage of life to then target preventive interventions at these factors (Kellam & Langevin, 2003). Interventions are then evaluated to determine whether and the extent to which targeting the identified risk factors has positively impacted more distal factors across both time and development. Critical periods are an important concept in developmental epidemiology and are essential to describing the individual’s life course (Braveman & Barclay, 2009). A critical period refers to “a window of time during the life course when a given exposure has a critical or even permanent influence on later health” (Braveman & Barclay, 2009, p. S164). Therefore, a critical period refers to those critical benchmarks, including age, gender, and cultural relevance and expectations that might interact during certain times of transitions across the life course (Chambers, Taylor, & Potenze, 2003; Kuh, Ben-Shlomo, Lynch, Hallqvist, & Power, 2003). Here, we use the Good Behavior Game (Kellam et al., 2008) prevention program as an example. A developmentally informed and universal classroom behavior management prevention model, the Good Behavior Game (Kellam et al., 2008) targets first and second grade children and has demonstrated long-term positive effects, particularly during critical periods (e.g., late adolescents and emerging adulthood), on several health outcome indicators, including substance use and delinquency. The choice of its use on entry into
elementary school was based on prospective, longitudinal studies that identified aggressive/disruptive behavior in first grade as a strong antecedent for adolescent drug and alcohol use and abuse/dependence in young adulthood (Kellam et al., 2008). Thus, the development of prevention programs such as the Good Behavior Game (Kellam et al., 2008), which aim to combat problem behaviors early and during a developmental stage that has been identified as a critical period for subsequent drug use, is an example of how developmental epidemiology may be used in informing prevention services.

Life Course/Social Field Theory

Building on developmental epidemiology, life course/social field theory posits that individuals are embedded in social fields or contexts that require social task demands. These social task demands have criteria for success or failure and vary based on developmental stages of life as well as critical transition periods across each developmental stage of life (Kellam & Van Horm, 1997). For example, learning how to drive responsibly is one social task demand that many experience during late adolescence and early adulthood in the United States. The life course/social field framework provides prevention scientists with a platform to integrate various disciplines (Kellam & Van Horm, 1997).

Genetic, psychological, environmental/ecological, developmental, and life-course factors provide a risk and protective framework for understanding complex human behaviors and the ways in which these factors both influence and are influenced by one another over time (Kaufman et al., 2007; Sloboda et al., 2012). Furthermore, descriptive epidemiology constitutes a key first step to understanding the disease or problem behavior and provides prevention scientists with the necessary tools to identify both the frequency and the distribution of risk and protective factors in populations as well as to assess the extent of a disease or problem behavior (Gordis, 2009). Analytical epidemiology then uses this information to examine, for example, these risk and protective factors to better understand the etiology of the outcome of interest. Next, we describe the role of etiological frameworks in guiding the development of preventive interventions.

The Role of Etiological Models in Prevention Science

Several etiological models have been developed to highlight the role of genetic, psychological, environmental, and developmental factors on risk behaviors, including Bronfenbrenner’s (1979, 1989) ecological systems theory. From this perspective, risk behaviors are a function of both the individual and the environment. Ecological systems theory (Bronfenbrenner, 1979, 1989) conceptualizes development as taking place within contexts, namely, the microsystem, mesosystem,
Exosystem, and macrosystem. The microsystem consists of risk and protective factors proximal to the individual. For example, risk factors for childhood obesity in the microsystem include the type of nutrition provided in the home. The mesosystem refers to the relationship and processes between two microsystems. Factors in the mesosystem, for example, may include parental involvement that supports healthier meal options or choices in a child’s school context. The exosystem are those systems in which an individual does not directly participate but that can have an impact on the individual. For example, parental work conditions (e.g., long work hours) might prevent parents from providing a healthy dinner at home, which in turn may lead to children having to prepare processed foods and thereby have an effect on the child’s eating habits. Lastly, the macrosystem encompasses those variables present in the broader social and cultural systems such as a policy requiring more transparent nutritional food labeling for consumers. Etiological models, including the ecological systems theory (Bronfenbrenner), have helped advance the field of prevention science and develop next generation etiological models.

Building on Bronfenbrenner’s work, several next generation ecological frameworks have been developed to conceptualize the role of environmental/ecological factors on the etiology of risk and protection and advance the field of prevention science, including the ecodevelopmental theory (Szapocznik & Coatsworth, 1999). Ecodevelopmental theory (Szapocznik & Coatsworth, 1999), for example, is helpful in conceptualizing integrated developmental risk and protective processes operating in the lives of individuals (Pantin et al., 2003; Prado et al., 2010; Szapocznik & Coatsworth, 1999). Ecodevelopmental theory (Szapocznik & Coatsworth, 1999) affirms that social domains in which the individual is embedded both influence and are influenced by the individual in a developmental context and occurs on various levels, including those microsystems, mesosystems, exosystems, and macrosystems described above. From this viewpoint, health behaviors are influenced by a multiplicity of factors, some of which are proximal to the individual, whereas others are distal.

The development of theoretical models, such as ecodevelopmental theory (Pantin et al., 2003; Prado et al., 2010; Szapocznik & Coatsworth, 1999), serve a vital role to the field of prevention science and epidemiology. Theoretical models help prevention scientists understand etiology, aid in predicting health-risk behaviors among the populations we work with, and help ascertain the pathways through which prevention programs work (Brown et al., 2008, 2009). Conversely, the fields of prevention science and epidemiology also play an important role in developing and testing theoretical models, at both the population level and the more targeted high-risk groups.

Prevention science and epidemiology inform what population-based strategies (i.e., universal), as compared with high-risk targeted strategies (i.e., indicated), are theoretically able to accomplish (Brown & Faraone, 2004). We take, for example, the prevention of drug abuse in adolescents. LifeSkills Training, a universal school-based prevention program found to be effective in preventing/reducing drug use, was designed for all ethnic and racial students within a particular school setting.
(Griffin, Botvin, Nichols, & Doyle, 2003). This drug use prevention strategy has the potential to reach a large segment of students, and therefore it is a population-based or universal strategy (Brown & Faraone, 2004). In comparison, identifying drug abuse risk factors can also lead to the development of interventions that target a specific segment of the population that shares a particular risk factor (Brown & Faraone, 2004). For example, Familias Unidas (Pantin et al., 2009; Prado et al., 2007; Prado & Pantin, 2011), a Hispanic-specific, family-based preventive intervention that targets identified risk factors that may be more pronounced in Hispanic families (e.g., cultural differences and parent–adolescent communication), has been found to be efficacious in preventing/reducing drug use among Hispanic adolescents. Thus, prevention science can be seen as an epidemiologic experiment because it aims to determine whether and the extent to which prevention programs and population-based or high-risk strategies target identified etiological and theoretical predictors, as well as identify which processes account for the differences caused by the intervention.

As shown in Fig. 1.1, epidemiology and theoretical models inform the field of prevention science and the development of preventive interventions. Prevention programs in turn can be used to test these models and help advance and adapt theoretical frameworks as a result of new evidence and knowledge gained. In the next section, we describe some of the epidemiologic methods and study designs used to evaluate prevention programs.

The Use of Epidemiologic Methods and Study Design in Evaluating Preventive Interventions

Advanced longitudinal epidemiologic methods and study designs have provided prevention scientists with the necessary tools to efficiently and more effectively evaluate preventive interventions and determine to what extent the effects are sustained over time (Hayes, 2006). These tools facilitate moving a program of research from efficacy to scale and promote the use of prevention research findings in the advancement of epidemiologic models (Kellam et al., 2011). Longitudinal methods and research designs examine change over time by following individuals beyond the period when they are actively participating in prevention or early intervention efforts and thereby provide valuable insight into the sustainability of prevention programs. Change and trajectory of outcomes over time can now be conducted because of advancements in epidemiologic data collection methods and advanced statistical methods that allow for the testing of more complex etiological and theoretical models (McArdle, 2009). Thus, advanced longitudinal methodologies inform the effects of preventive interventions, both short and long term, promote the advancement of epidemiologic and prevention models, and work toward best practices. Before a prevention program has been found to be an evidence-based or best practice model of prevention, however, the program must
first undergo rigorous scientific testing and go through a research process that includes basic science, efficacy, effectiveness, implementation, and taking interventions to scale (Brown et al., 2008, 2009; Van Spall, Toren, Kiss, & Fowler, 2007). Basic science and epidemiology are used to develop etiological and theoretical models, which in turn can be used to examine the efficacy of a prevention program. The efficacy of a prevention program is determined by whether and the extent to which it works under ideal conditions. If and when a program is found to be efficacious, then effectiveness trials, which examine the effects of prevention programs in real-world settings, can take place. Once established as an effective model, prevention programs can work toward implementation and scale to ensure widespread adoption. It should not be surprising that epidemiological and prevention science methods are integrated throughout this process. For example, theoretical models may be adapted, or prevention programs tailored, based on the results of outcome and process data, which help optimize efficacious or effective models. Additionally, evaluation is particularly important throughout the research process. Several epidemiological research methods are used to evaluate the effects of prevention programs, including time to event, growth curve, multilevel modeling, mixture modeling, and mediation modeling. Below, we discuss some of these widely used methods in evaluating prevention interventions.

Of importance to the field of prevention science is the evaluation of prevention programs, and prevention trials methodology has developed as a particularly important type of experimental epidemiology (Brown et al., 2008). This is accomplished through the testing of etiological and intervention models that help guide prevention services, as well as identifying those pathways through which preventive interventions work. This is important not only to gain a better understanding of intervention processes but also to confirm that the intervention is in fact targeting the hypothesized etiological factors and is casually related to the outcomes of interest. Therefore, prevention science is concerned with, among many other things, answering the question: \textit{How do preventive interventions work, for whom, and under what cultural, social, and institutional conditions} (Brown et al., 2008; Kellam et al., 2011; Tein, Sandler, MacKinnon, & Wolchik, 2004)?

Given that the primary goal of epidemiology is to describe the natural history of the outcome of interest, advanced statistical methods, including time-to-event, growth-curve, and multilevel models, are especially important for measurement of change over time and thereby more accurately describe the natural history process. For example, time-to-event analysis provides prevention scientists with the tools to capture, to some extent, the natural history of an outcome of interest, including the onset of the behavior of interest, progression/escalation, and the cessation/desistance of that behavior. Multilevel modeling, for example, is used to describe how individuals change over time as well as the extent to which the changes may vary across individuals (Singer & Willett, 2003). In growth-curve modeling, we can examine individual trajectories, individual differences in these trajectories, predictors of individual differences, and their effects on development over time. Furthermore, growth-curve modeling can describe important group statistics to better understand developmental processes at the group level (Duncan,
Duncan, & Strycher, 2006). For example, prevention scientists interested in examining whether and the extent to which a prevention program is efficacious in preventing an outcome of interest, relative to a control condition, may find the growth-curve modeling approach useful. Here, we can describe trajectories of individuals both within and across conditions. Additionally, mixture modeling, including latent class growth analysis (LCGA) and growth mixture modeling (GMM), allows prevention scientists to capture classes or subpopulations that are unknown (Muthen & Muthen, 1998–2010). For example, mixture modeling may be helpful in identifying those classes or subpopulations that benefit most from participating in a drug abuse prevention program.

Some research has been conducted to highlight for whom preventive interventions work and for whom they do not work. For example, Hispanic adolescent preventive interventions may be more efficacious among US-born youth, relative to foreign-born youth, on some behavioral and mental health outcomes (i.e., moderator; Cordova et al., 2011; Martinez & Eddy, 2005). Additionally, research has demonstrated the ways in which the effects of preventive interventions vary by gender (i.e., moderator; Kulis, Marsiglia, Ayers, Calderón-Tena, & Nuño-Gutiérrez, 2011; Kulis, Yabiku, Marsiglia, Nieri, & Crossman, 2007). Furthermore, research has been conducted to identify how prevention programs work. For example, we now know that family functioning is one pathway through which family-based, drug abuse preventive interventions are efficacious (i.e., mediator; Pantin et al., 2009; Prado et al., 2007; Sandler, Schoenfelder, Wolchik, & MacKinnon, 2011). Although some research has focused on answering for whom and how preventive interventions work, little research has been done to identify research processes associated with the cultural, social, and institutional conditions that may have an effect on prevention programs (Kellam et al., 2011; Sandler et al., 2011). Working toward a better understanding of these research processes might have great utility in identifying potential factors that contribute to prevention intervention outcomes. This knowledge may elucidate optimally efficacious and effective preventive interventions, which in turn could aid in adapting or extending etiological and theoretical models (Kellam et al., 2011). One widely used model for better understanding research processes and testing theoretical frameworks in the field of prevention science is the mediation model.

The mediation model examines whether and the extent to which a third variable has an effect on the relation between two other variables (Brug, Oenema, & Ferreira, 2005). Theoretical frameworks are especially important in the selection of mediating processes and predictors because they, by definition, are informed by a large body of scientific research and can provide strong evidence for the etiology (e.g., risk and protective factors) of a disease. In addition to facilitating the selection of mediation processes, theoretical frameworks present a systematic way of understanding causal determinants of disease and how these factors may operate to reduce disease, which may be helpful in advancing the fields of epidemiology and prevention science. Once a viable mediation process has been identified, a hypothesis can then be generated that will guide the research protocol, including the pathways (e.g., family functioning) to target and how change processes occur.
Thus, a mediation analysis can test a theory in intervention; to the extent that changes in a hypothesized mediator predict distal outcomes, the theoretical model is confirmed (MacKinnon & Luecken, 2008).

In addition to the importance of statistical methods in evaluating preventive interventions, equally important is the study design. Below, we describe several study designs that are helpful in evaluating prevention programs.

The randomized controlled trial (RCT) can be particularly helpful in moving forward the prevention science field because RCTs, in theory, generate equivalent condition groups that in turn allow prevention scientists to say with greater certainty that prevention effects are attributable to the intervention itself (Jadad et al., 1996; Olsen, Christensen, Murray, & Ekbom, 2010; Silverman, 2009). Although RCTs are the optimal strategy in the field of prevention science, they may not be feasible in the evaluation of all preventive interventions (Silverman, 2009). For example, there may be circumstances in which participants cannot plausibly and ethically be randomized to an experimental or control condition; consider faith-based interventions among persons who may not practice organized religion (Rubin, 1974, 2005). Therefore, several preventive intervention evaluation alternatives exist that may be more appropriate for examining the effects of prevention programs, including observational, rolled-out, quasi-experimental, and randomized encouragement designs.

Observational methods may be particularly helpful for better understanding disease in instances where randomization of participants is impossible or unethical or in the outbreak of a rare disease. Observational methods, including the cohort design, allow prevention scientists to follow a segment of the population that may not have the disease or disorder of interest and observe this sample as a natural ecological experiment. That is, through longitudinal and correlation analyses and life histories, the cohort design allows prevention scientists to examine risk and protective factors associated with that particular disease or disorder in a natural setting (Hemingway & Marmot, 1999; Stroup et al., 2000). A limitation to observational studies, however, is that they introduce several types of biases, including selection bias when the choice of control groups may differ systematically from intervention groups (Benson & Hartz, 2000; Hemingway & Marmot, 1999).

Another alternative to the traditional RCT design is the rolled-out or dynamic wait list design (Brown, Wyman, Guo, & Peña, 2006; Brown et al., 2009). In this design, an intervention that has already been selected for wide-scale implementation is evaluated. For instance, a government mandate may require that all schools within a specific district deliver a sex education program. The sex education program may have limited empirical support, but an opportunity exists to evaluate the program as it is “rolled-out” into the school district. In the rolled-out methodology, all of the study units (individuals or clusters) receive the intervention but are randomly assigned to a time interval in which to receive the intervention. More specifically, all of the study units begin in the control condition and, as participants receive the preventive intervention services, participants are switched to the experimental condition. This process occurs until all of the study units eventually receive the intervention. Finally, the effects of the experimental condition on the outcomes...
are examined and compared with the control condition. This process occurs until the last interval, when all study units have received the intervention and comparisons can no longer be made. There are several benefits to this type of design. For instance, the rolled-out method is advantageous in circumstances where ethical concerns or public health mandates do not support the exposure of an intervention to only a subset of individuals. The rolled-out method is also advantageous for practical reasons, for instance, when financial resources limit the ability to deliver the intervention simultaneously to all study participants (Brown et al., 2006, 2009).

Nonrandom or quasi-experimental trials are also alternatives to RCTs. Several types of quasi-experimental designs exist. For example, in time-series quasi-designs, a single group of study participants is assessed both before and after the prevention intervention activities. A significant favorable outcome between pre- and post-intervention, to the extent that it is not due to chance, suggests an efficacious/effective intervention (Grimshaw, Campbell, Eccles, & Steen, 2000).

Randomized encouragements are epidemiologic designs in which participants are randomized not to a preventive intervention but rather to an opportunity or encouragement to take part in an intervention (Vinokur, Price, & Schul, 1995). In a smoking cessation prevention program, for example, participants may be randomly assigned either to receive an invitation or not to receive an invitation. In this methodology, it is assumed that the impact of the assignment is mediated entirely through the receipt of the treatment. This process aims to remove the necessity to fully adhere to the prevention protocol, as is the case in RCTs. Finally, in nonrandom quantitative assignment designs, participants are not randomized but rather assigned to treatment based on a quantitative measure such as financial need (Finkelstein, Levin, & Robbins, 1996a, 1996b).

Additionally, epidemiological study designs include case control studies, cohort-age-period designs, twin studies, and cross designs. Case control studies, for example, have great utility in situations where the disease of interest is rare, observing a sample or “control series” of the population. This sample is then used in place of the complete assessment of disease frequencies, including the proportion, rate, and odds (Rothman, Greenland, & Rash, 2008).

**Applying Prevention Research Findings to Epidemiology: Informing the Advances of Epidemiologic Models**

We have described the ways in which epidemiological data have great utility guiding and informing the development and evaluation of preventive interventions. For example, epidemiological data show that HIV risk behaviors are a complex phenomena occurring at multiple levels (DiClemente et al., 2004; Prado, Pantin, Schwartz, Lupei, & Szapocznik, 2006), which in turn has called for the development and evaluation of HIV preventive interventions at multiple levels, including family (Villarruel, Jemmott, Jemmott, & Eakin, 2006), peer (Guarino, Deren, Mino,
Sung-Yeon, & Shedlin, 2010; Raja, McKirnan, & Glick, 2007), school (Nkansah-Amankra, Diedhiou, Agbanu, Harrod, & Dhawan, 2011), and community (Harper, Bangi, Sanchez, Doll, & Pedraza, 2009) to help curb the tide of HIV infection. Although the use of epidemiologic findings to inform the development and evaluation of preventive interventions has been widely practiced, little has been done with respect to using prevention findings to inform epidemiology (Sloboda et al., 2012). That is, the use of scientific knowledge produced from the implementation and evaluation of prevention programs to inform epidemiology has been minimal. Working toward epidemiologic models that are informed by prevention findings might prove useful in advancing the fields of epidemiology and prevention science, particularly with respect to public health. Therefore, the contribution of prevention science for epidemiology is then to better specify when to measure, what to measure, whom to measure, what to target, and more specifically to assess the viability of the dominant perspective on the etiology of the natural history of the outcome.

To highlight one way that prevention findings can inform epidemiology, we refer back to the mediation model and use the Familias Unidas (Pantin et al., 2009; Prado et al., 2007; Prado & Pantin, 2011) preventive program as an example. As previously mentioned, family functioning is the pathway through which Familias Unidas has an effect on both drug use and unprotected sex in multiple efficacy studies (Pantin et al., 2009; Prado et al., 2007; Prado & Pantin, 2011). The question still remains, however: Will family functioning remain the significant pathway through which Familias Unidas operates if the program moves to implementation? For example, it may very well be that other factors such as community processes, including community partnerships and networks, may be the pathway through which the Familias Unidas program has an effect on the outcomes. This in turn can be used to inform epidemiologic models. To that end, Kellam and colleagues (2011) have proposed several strategies that may be helpful to the process of prevention findings informing epidemiologic models and the field of prevention science, including community partnerships and networks (Kellam et al., 2011).

Community partnerships are essential to the research process and for the development of the next generation of prevention research. For example, preventive interventions are effective only to the extent that they are accepted and implemented with fidelity by the community. Thus, building and sustaining community partnerships for prevention efforts are strategies through which prevention science findings may inform epidemiologic models, which in turn may advance the field of prevention science (Kellam et al., 2011). For example, community partnerships can inform prevention scientists whether and the extent to which the prevention program’s aims and goals are shared with that of the communities’ aims and goals (Kellam et al., 2011). This information can then be used to tailor prevention services and epidemiological models and work toward optimally efficacious and effective programs.

Prevention research findings may also help advance epidemiologic models, particularly when moving a prevention program from efficacy to effectiveness to
implementation (Kellam et al., 2011). To do so, networks should be established that consist of researchers, policy makers, and practitioners with a shared goal of working toward translational research (i.e., efficacy to effectiveness to implementation). To this end, networks can foster the sharing of diverse research experiences, including identified theoretical models, measures, and relevant assessment for a particular population and context (Kellam et al., 2011).

A prevention model that has been shown to be effective, particularly as it relates to implementation strategies, is the RE-AIM framework (Glasgow, McKay, Piette, & Reynolds, 2001; Glasgow, Vogt, & Boles, 1999). The RE-AIM framework (Glasgow et al., 1999, 2001) is a translational research model—moving efficacious programs to real-world settings—and is concerned with factors and processes related to long-term effectiveness impact. The RE-AIM framework is guided by five steps: reach, efficacy, adoption, implementation, and maintenance (Glasgow et al., 1999, 2001). Reach refers to engagement, active participation, and retention in prevention services, which are affected by contextual barriers to participation, including transportation, work schedule, and child care. Efficacy is concerned with the effects of a prevention program on the outcome variables when it is implemented with fidelity and in a controlled setting. Adoption can be described as the process by which a best practice program is delivered at the system level and the proportion of organizations that are willing to adopt a particular best practice model. Implementation operates at the real-world level and is concerned with the consistency of delivery and translation of a best practice model. Finally, maintenance is concerned with the long-term effects of prevention programs on behavior and how the best practice is institutionalized and put into practice (Glasgow et al., 1999, 2001). The Nurse Family Partnership (Olds, 2008; Olds, Henderson, & Kitzman, 1994; Olds, Henderson, Kitzman, & Cole, 1995) prevention program is an example of a translational program of research that has implemented the RE-AIM framework and has been rigorously tested over the past 20 years (Donelan-McCall, Eckenrode, & Olds, 2009). Nurse Family Partnership (Olds, 2008; Olds et al., 1994, 1995), a home-visiting prevention intervention, is efficacious in preventing/reducing child maltreatment, including child abuse and neglect, emergency room visits, and mothers’ substance use during gestation. First evaluated in 1977 in an RCT, Nurse Family Partnership has spanned a program of research from reach to efficacy to adoption to implementation to maintenance (Donelan-McCall et al., 2009). In fact, the Nurse Family Partnership now houses a national service office that assists communities with replication and ensuring fidelity in the implementation of the Nurse Family Partnership program. Here, the Nurse Family Partnership provides a model to the field of prevention science on how prevention findings can be used to inform epidemiology as it moves along the research continuum from basic science to implementation.

Qualitative methodologies may play an important role in informing the feedback loop between prevention science and epidemiology. Although the use of qualitative methods in the fields of prevention science and epidemiology has been minimal, prevention scientists have developed an increased awareness with respect to the use of qualitative methods, particularly to understanding processes at the
implementation stage (Bucher Della Torre, Akré, & Suris, 2010; Pontin, Peters, Lobban, Rogers, & Morriss, 2009; Voogdt-Pruis, Beusmans, Gorgels, & van Ree, 2011). To this end, qualitative methods have great utility in elucidating processes that facilitate or hinder adoption of effective programs, including feasibility and acceptability of prevention strategies among individuals and communities (Parra-Cardona, Cordova, Holtrop, Villarruel, & Wieling, 2008; Parra Cardona et al., 2009), contextual challenges experienced by underserved populations that could serve as barriers to participation (Cervantes & Cordova, 2011; Cordova & Cervantes, 2010), and adaptations to ensure adoption of prevention services in communities (Dodson et al., 2009). Thus, qualitative methodology, when used as a tool to gather prevention findings and process data, has the potential to serve as a feedback loop and inform epidemiology.

To summarize, the field of prevention science could benefit from using prevention findings in the advancement of epidemiologic models. Doing so may prove helpful in transporting a prevention program from bench to practice. As shown in Fig. 1.1, the prevention research cycle should include a feedback loop consisting of multiple steps, including the identification of a problem and large-scale implementation.

Epidemiology and Prevention Science: Working Toward a Mutually Informed Process

In summary, epidemiology plays a significant role in the field of prevention science. Central to epidemiology is the description of the natural history or career of the outcome of interest and consequently focuses on factors that contribute to the onset, progression/escalation, and cessation/desistance of the outcome of interest. Epidemiology provides a framework for prevention scientists to identify the outcome of interest and develop etiologic models and preventive interventions, methods, and study designs to test preventive interventions. Such efforts are aimed at promoting health and well-being in individuals, families, and communities alike. Although a substantial amount of research has demonstrated the ways in which epidemiological findings are useful to the field of prevention science, little has been done with regard to prevention findings informing epidemiologic models. Working toward a mutually informed process will advance the fields of epidemiology and prevention science. A mutually informed process, whereby both epidemiology and prevention science inform each other, may aid in the development of optimally efficacious and effective preventive interventions that promote health and prevent/reduce health-risk behaviors.

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References


Part I

Individual Physical, Cognitive, and Emotional Vulnerability Across the Life Course: Benchmarks and Developmental Challenges
Chapter 2
Benchmarks, Developmental Challenges, and Risks During the Prenatal and Infancy Period

Hellgard Rauh and Karl E. Bergmann

Introduction

The 1989 UN Convention on the Rights of the Child has not yet been signed and put into action by all nations. Nevertheless, the 2000 UN Millennium Declaration and the UN Millennium Goals for 2015 indicate that these initiatives appear to have stimulated a wealth of investigations and research, within nations and among nations, that aim at improving the lives of children, particularly those of very young children (Britto, Yoshikawa, & Boller, 2011; U.N. 1989, 2000, 2010). The foremost goals of the UN initiatives, with regard to young children, are reducing child mortality, improving maternal health, combating highly infectious diseases (such as HIV/AIDS and malaria), eradicating extreme poverty and hunger, achieving universal primary education, and promoting gender equality and empowerment of women particularly by addressing birth rate and children’s development. The other major environmental and sociopolitical aims are ensuring environmental sustainability and a global partnership for development.

A Historical Sketch of Prevention in Early Childhood

Preventive public health care became linked to basic human rights already during the 1848 revolutions in Europe (Stöckel, 2007). These revolutions were stimulated by the democratic concepts of the French Revolution of 1789 and instigated by the consequences of rapid industrialization and urbanization with ensuing health problems in cities and disintegration of rural areas.
In 1870, one in four children in Germany and other industrializing countries did not survive their fifth birthday. Poverty, uncontrolled growth of compact urban areas, long workdays of both parents in factories and the ensuing neglect of the children, and unhygienic conditions contributed to this situation. The last decades of the nineteenth century saw the introduction of preventive measures, some of which continue today.

The first measures of prevention were taken at different system levels. At the local level, they ranged from systematic city planning with parks in residential areas, improved public transportation, municipal sewage systems, indoor plumbing, and community gardens for urban families. Socially committed factory owners improved workplaces and dwellings for their workers. Medical science flourished, and medical care improved, especially with the work of Nobel Prize winners such as Robert Koch and Ignaz Semmelweis. Bacteria of specific diseases were discovered, and vaccinations became possible in the following decades. Puerperal fever, which had led to the death of many women during childbirth especially in research-oriented hospitals, was drastically decreased by strict hygienic barriers between hospital care and pathology units. Prevention was also introduced at a behavioral or lifestyle level. The first books on infant care by Alfred Grotjahn appeared in 1912 (Stöckel, 2007). Auguste Victoria, the socially committed last German empress, founded the first prevention research clinic in Berlin in 1909 (Bergmann, Bergmann, Richter, Finke, & Dudenhauen, 2009) that was primarily devoted to improving and popularizing prenatal and infant care, especially breastfeeding and prevention of chronic illness. One of these preventive measures, originally introduced to combat tuberculosis and rickets, is still part of a typical German lifestyle: the family Sunday walk in the parks and forests.

These preventive measures at national and local levels were largely effective. The childhood mortality rate decreased to fewer than 100 per 1,000 children in 1930, in spite of war, hunger, and a disastrous economic recession; this rate is similar to many countries in Africa today. Currently, the infant mortality rate is below 0.6 % in the United States, below 0.45 % in the European Union, and below 0.25 % in Japan (CIA, 2012). Child and infant mortality rates continue to be major indicators for a country’s health situation in underdeveloped and developing countries. Prevention measures in developing countries are generally similar to those in developed countries 100 years ago. UNICEF initiatives and support reduced the child and infant mortality rate worldwide from 1990 to 2006 by 24 % not only through improvements in hygiene (especially safe drinking water), vaccination against infectious illnesses, provision of additional vitamin A, and insecticidetreated mosquito nets but also by supporting breastfeeding efforts and providing community health services (UNICEF, 2012).

The prevention of childhood death continues to be an important goal at all levels: parents, communities, nations, and international organizations. The idea of prevention has, however, changed as the apparent needs and problems of children have changed given the greater diversity in family compositions, the improvements in health care and mental health care, and the advancement of child development research. Whereas prevention originally addressed protecting a young child from
physical dangers or from specific illnesses and diseases, prevention efforts in the 1960s and 1970s focused on preventing or compensating for social and psychological risks of the young child and recognizing early risk indicators of unfavorable outcomes in later childhood and adolescence (e.g., school dropout, juvenile delinquency and risky behavior, mental health problems). Preventive interventions combined physical/medical support with compensatory education, as in the Head Start programs in the United States, or focused on education and stimulation for all young children, as in the Sesame Street television series that was copied and adapted in many countries. While the TV series was available to anyone who was interested, education-oriented prevention was usually restricted to children with specific risks (e.g., children who were born prematurely, are disabled, or are from socially disadvantaged families). Numerous programs were developed and implemented. Well-controlled experimental studies as well as follow-up studies were conducted at research institutions, especially in the United States and Canada. Quasi-experimental longitudinal studies followed risk and comparison infants into later childhood and adolescence. Advancements in medical research and health provision, as well as the expansion of research and academic training in behavioral and social sciences and improvements in international scientific cooperation and exchange, stimulated large-scale studies also in other developed and industrialized countries (e.g., Europe, Australia, and Japan). In recent decades, globalization has accelerated in part due to rapidly changing communication technologies. Research cooperation with developing countries is growing. With support of the World Health Organization (WHO), international classification systems, such as the International Classification of Diseases, have been adopted worldwide. Supported by UNICEF, indices for a country’s overall quality of life are being developed, such as the Human Development Index (which comprises gross domestic product, education, and life expectancy), to better compare countries, especially developing countries, and to measure improvements or declines (Bornstein et al., 2012). Improvements and declines may have many causes. Major changes in the living conditions of even the youngest children may offer opportunities but may also pose challenges and new risks, in developing as well as in developed countries. Research-based preventive interventions, even when they have proved to be effective, have to be adapted to these “historical” changes, and transfer of expertise to developing countries has to account for sociocultural and even physical differences.

Issues Related to Risks in Infancy and Early Childhood

After thousands of years of very similar upbringing and care for children in the infancy period, the infant ecology has changed dramatically in the past century and even more rapidly in the last few decades. 

*Intentional birth control* (i.e., the prevention of an unwanted child) has eventually become pharmaceutically and medically accessible and legally accepted in most, except some of the poorest, countries since the 1960s. Birth control has led to
fewer children being born to increasingly older and better educated mothers. Unfertile couples and single women can now have their own biological children through in vitro fertilization, donor sperm, donor egg, and surrogate pregnancy. Although hotly discussed because of the ethical implications, methods of preimplantation genetic diagnostics, embryo selection, and genetic modification will be accessible in the near future.

Close surveillance of fetal gestation increases the number of pregnancies ending in live births, as well as the numbers of premature and multiple births. Adaptive changes in medical and psychological perinatal care have dramatically improved the survival chances of premature newborns and reduced major neurological, sensorimotor, and respiratory birth defects. Because of these advances, more fragile neonates and infants with overt or discreet health restrictions survive and have a good chance to live well into adulthood.

Family structures and family values, even within a culture or nation, have become extremely varied, and for many children they are unstable and unpredictable. Many children grow up in single-parent households or in nontraditional patchwork families (McCall, van IJzendoorn, Juffer, Groark, & Groza, 2011). The responsibility for a child can be split between the parents resulting in total setting changes for the infants on a daily or weekly basis, as sometimes in the case of separated parents. In modern urban settings, social and psychological care for the infant has become a complex and demanding task even in traditional families. Many infants may spend hours outside the home and with different caregivers several times per week or even per day. The number of directly accessible people for a young child is often highly restricted, and the contact periods are highly structured and only minimally controllable by the infant. New parents often have limited experience with young children and/or are skeptical about parenting styles of previous generations. They are left with being uncertain about parenting and are coping with parenting helplessness.

Child neglect, child maltreatment, and even child abuse have become public concerns involving children even at very young ages. Primary prevention focuses on introducing new parents to sensitive and secure parenting or on addressing factors that prevent parents from realizing the needs and reactions of their infant (e.g., stress, maternal depression).

Fewer and intentionally conceived children are more precious for their parents and receive more parental investment (Belsky, Steinberg, & Draper, 1991). Overprotection and overstimulation can become harmful for the developing child. Some parents feel pressure to start education as early as possible to prepare their children for the demands of a future world. Some children may even suffer under the load of parental expectations. Parents may cognitively overstimulate their babies with an overabundance of toys and introduce even toddlers to using media and electronic communication (e.g., Skype). It is still unknown how new electronic possibilities will influence or change the mental, communicative, and emotional development of preschool children.

Early institutional care is apparently inevitable not only for orphans but also for children of physically, mentally, socially, or emotionally dysfunctional parents.
when there is no supportive network of relatives. In most developed countries, childcare institutions have become safe and child-oriented places, but they cannot replace the atmosphere of family upbringing. Therefore, foster care and adoption are generally preferred. In the 1970s, adoption and foster parenthood was advocated as being nearly equivalent to biological parenthood. Recent research is less optimistic, especially in the case of international adoption (Grotevant, 2011). Timing of adoption is important. Attachment research has demonstrated the sustaining importance of a first intensive socio-emotional bond between an infant and a primary caregiver. Even in the case of adoption or foster care shortly after birth, the infant’s psychobiological system has already been shaped during pregnancy, as recent epigenetic research has shown (Meaney, 2010), for example, with regard to stress reactivity. Epigenetic research findings should be considered in surrogate situations, especially when the surrogate mother lives in poverty.

The following sections present overviews on recent scientific insights into typical development in the prenatal and perinatal periods, infancy, and toddlerhood, along with period-specific risks and vulnerabilities and prevention issues. For the postneonatal periods, and with reference to Bronfenbrenner’s ecological model (Bronfenbrenner & Crouter, 1983), vulnerabilities are discussed relative to proximal and distal risks in age-specific environments and settings (i.e., for quality of parenting, quantity and quality of extra-parental care and education, institutional care, and poverty as an overarching impact).

Development, Risks, and Prevention in the Prenatal Period

Advanced methodology in biological, medical, and psychological research has contributed to increased knowledge of regular and deviant prenatal development and positive and detrimental influences during this period.

Throughout the 40 weeks of gestation, from fertilization until birth, the fetal organism develops not only by unfolding a genetic program. Fetal development is constantly stimulated, channeled, and controlled by processes from within the fetal organism, by the biological environment provided by the womb, by maternal metabolism and activity, and even by external influences. These influences interact and change with fetal organic and functional development. At birth, the child is just one of the possible developmental variants given the initial genetic endowment. Most influences of the interacting prenatal milieu systems have a stimulating, channeling, and shaping effect and can be considered continuous adaptations of the fetal organism to its present situation. From an evolutionary perspective, some of the epigenetic effects could be interpreted as preadaptation to an external world as translated to the fetus by the maternal organism (Bornstein, 1989a; Fox, Levitt, & Nelson, 2010). Recent epigenetic research (Azar, 2011; Meaney, 2010; Zhang & Meaney, 2010) has revealed some of the microbiological mechanisms that produce and change the specifically adapted gene expression and gene transcription, especially during cell specialization. These processes involve triggering or silencing
certain regions of the genome (by methylation) in a manner that is specific for each cell type. Some cell structures are more prone to epigenetic alterations than others (Zhang & Meaney, 2010, p. 447). Cells involved in metabolic functioning and nerve cells appear to be among those that are sensitive to epigenetic reprogramming. These biological microprocesses explain the rather enduring effects of some early influences, although epigenetic reprogramming does not seem to be totally limited to the prenatal period.

For a long period, the embryo and fetus were considered largely protected from external influences except for exposure to alcohol, radiation, and specific maternal infections that had been proved to seriously disturb prenatal organic development especially in the first trimester. Epigenetic understanding will differentiate scientific knowledge of period-specific effects of non-noxious as well as noxious, or damaging, influences (teratogens).

In the first 3 months (first trimester) when most of the organic structures are being built, teratogens may cause a severe developmental deviation or even growth cessation of a specific inner organ or limb, as was sadly demonstrated in people prenatally exposed to thalidomide. In the second trimester, most of the brain architecture is being differentiated and functionally specialized (Fox et al., 2010). The hormonal milieu, for instance, as produced by the male infant and the mother, stimulates sexual differentiation of the organs but also of brain regions (Berenbaum & Snyder, 1995; Dörner 1989). Additional hormones introduced into the fetal–maternal system externally (e.g., by medication, polluted water, pesticides) can alter the developing neural sexual centers (Dörner et al., 2001). In the last trimester, the fetal system becomes more interconnected (e.g., between the sense organs and the brain), more differentiated, and partly adapted to smooth functioning by reduction of superfluous nerve cells and synapses. Infant gross and fine motor activity contributes to this process, and most senses are being tuned to the expected external world. The fetus becomes accustomed to basic melodic and rhythmic features of the mother, to acoustic-endocrine associations of acoustic emotional information, to different kinds of touch, and even to culture-specific tastes (Fox et al., 2010). Major detrimental conditions in this period can trigger premature birth. If born premature, the infant is now usually viable though still immature and highly vulnerable. More subtle stresses for the fetus in this period may affect the neuro-psycho-physiological functioning of the infant and may become apparent only as age-inappropriate imbalance of the physiological and/or the attentional systems of the newborn and the young infant.

The concepts of sensitive and critical periods have been frequently applied to obviously time-bound vulnerabilities or susceptibilities in prenatal, perinatal, and postnatal development (Bornstein, 1989a; Fox et al., 2010). These concepts could give the illusion that there is a special time of vulnerability or heightened susceptibility either for a range of functions or for specific types of outcomes. Research has, however, shown that the processes are much more varied, complex, and specific and that these concepts cannot, at present, serve for more than a rough and superficial orientation.
Several research activities have studied specific influences on fetal development that are potentially measureable and amenable to preventive actions. Some prominent examples are prenatal exposure to external toxicants, maternal drug use, and maternal stress.

Air, water, and soil, as well as commercial products, are replete with chemicals from factories, traffic, fertilizers, pesticides, sewage, and food additives not only in industrialized countries but also, and sometimes even more severely, in the developing countries. Free market practices usually allow the introduction of new chemicals without proof of their nontoxic effects on young organisms. Because of the unavoidable mixture of potential toxicants, it is difficult to prove the impact of a specific toxicant on the fetus and on the growing child. Koger, Schettler, and Weiss (2005) summarized and interpreted the existing empirical evidence. According to Koger and colleagues, toxicants interfere with brain development in critical periods, thereby affecting sensory, motor, and cognitive development. But they can also increase the propensity for aggression and violence in adolescence and adulthood. The former East Germany was late in prohibiting the use of DDT, giving room for a quasi-experimental design between cohorts from the former East Germany and West Germany. The study found that there was a significant difference in estrogen-sensitive female cancers in East Germany (Dörner, 1989).

In many countries, individuals are considered responsible for their own drug use. A partial exception is tobacco exposure that cannot be avoided even by strict nonsmokers. This might have been the reason why nations have been effective in prohibiting smoking in public places. Pregnant women are strongly advised to avoid smoking.

Deciding on the use or restriction of assumed necessary medication during pregnancy is much more difficult (e.g., in the case of maternal epilepsy). Even when controlling for maternal education and age, epileptic attacks during pregnancy, maternal postnatal infirmity, prenatal exposure to specific antiepileptic drugs, and combinations of drugs appeared to have a lasting detrimental effect on intelligence and information processing in offspring (Koch et al., 1999; Titze et al., 2008). This effect is acerbated when postnatal drug exposure is followed by, and combined with, social risks such as low-quality parental care and stimulation. A major challenge to the pharmaceutical industry is, therefore, to test for and acknowledge long-term behavioral consequences of prescribed drugs.

Alcohol is the most common substance used. Its teratogenic effect in the embryonic stage of prenatal development is well documented. The effects range from physical/facial signs and reduced brain volume and brain differentiation with ensuing severe mental retardation to impaired information processing and imbalanced emotional regulation. Elliot and colleagues (2008) reviewed epidemiological studies of prenatal alcohol exposure and fetal alcohol spectrum disorders (FASD) and experimental studies of primary and secondary prevention. They found that the most effective primary prevention of FASD was alcohol prohibition. There was no evidence that warning labels on alcohol containers or mass education campaigns reduce alcohol consumption in pregnant women. Individualized interventions were generally more effective in women who consumed low levels of alcohol at study
entry. High-risk women were less able to change their drinking behavior. The authors complained about the sometimes infrequent, and usually not coordinated, use of assessment instruments, the evaluation criteria or measures, and the study designs. They regretted the lack of evidence-based recommendations for effective prevention.

While toxicants, drugs, and alcohol can be considered objectively definable external influences, maternal stress is a subjective reaction to previous and current experiences. When the first studies of stress effects during pregnancy appeared, some women became even more anxious about the possible impact on their child, and others used potential stress effects as an argument for abortion. The effects of different kinds of stress have since been studied more carefully. These effects are generally not comparable with those of external influences, but they can add to the effects of external factors. Schetter (2011) reviewed the available studies. In a population with low socioeconomic status, maternal depressive symptoms and general distress predicted, with other potential influences controlled, growth retardation and low birth weight of the infant.

More acute forms of stress (e.g., death of a family member, earthquake, terrorist attack), chronic stress (e.g., general strain, household strain, homelessness), poverty, and neighborhood violence predicted more frequent premature birth. Good and effective partner relationship were positive, protective influences, but social support had varying effects depending on ethnicity, race, cultural values, and type of support. Severe chronic stress in late pregnancy was often associated with heightened infant irritability and emotional and attention-regulation problems in childhood (Schetter, 2011).

Population studies of those in the higher socioeconomic strata differentiate degrees of tolerable, or even mild, stress experiences. In a study by DiPietro and colleagues (2010), pregnant women were followed prospectively from 24 weeks gestation until the first weeks after birth. In this population, tolerable to mild stress appeared to have a slight accelerating effect on some infants, especially boys, with regard to motor maturity and neural conduction as a measure of information processing. They were also less irritable as neonates. In a previous study, infants born under similar conditions even had higher developmental test scores at age 2. Although severe and multiple stress can retard development or even terminate the gestational period by premature birth, some light or positive stress may benefit the infant’s neural development in the perinatal period.

In the prenatal period, the fetus is not isolated from influences on its organism. These influences normally stimulate and channel the next developmental steps. They interact in a probabilistic way (Meaney, 2010; Rutter, 2000) and in a systemic manner (Sameroff, 2010) to build and form a unique individual, partially pre-adapted via the effects of maternal lifestyle and health status. Single environmental toxicants or noxious influences can usually be tolerated or compensated for by the developing fetus when they impinge in low dose and when there are no additional biological or social adversities, such as maternal drug use or abuse, poor nutrition, poor prenatal care, low maternal education, and poverty (Koger et al., 2005; Rutter, 2000).
When, however, several risks cumulate during gestation over longer periods, an extreme effect on the fetus could be the termination of growth and stillbirth; in less severe circumstances, the effect could be premature birth and low birth weight after intrauterine growth retardation. It is usually the fetus, not the maternal organism, that induces premature birth. The kind and intensity of external influence, the number and variety of additional previous and contemporaneous stressors, the actual developmental status of the fetus, and the specific individual vulnerabilities combine to determine the kind and extent of the effect at the microlevel. The effect will usually be viable, alternative developmental paths with either more or fewer degrees of freedom. The outcomes will usually not be defects but rather variants. In some extreme cases, these variants are not viable and lead to spontaneous abortion.

In other cases, as with trisomy 21, the superfluous genetic information of the extra chromosome disturbs the prenatal fine-tuning of the developmental course, resulting in usually viable neonates but with individually very diverse combinations of extra problems (i.e., prenatal organic deviations). It seems that the extra load of genetic information leads to reduced epigenetic resilience (Rauh, 2006).

Prevention during pregnancy usually means primary prevention from the perspective of the child, primary prevention for some women, and secondary prevention for high-risk women. Positive social awareness of pregnancy may be an important factor in introducing preventive interventions when necessary. Pregnancy has become “chic” in Western countries, and young women overtly show their status instead of hiding it in large clothing as was the style in previous times. In many countries, women have regular, free gynecological checkups, take preparatory classes, and/or visit a midwife long before the birth. The expectant father is involved, and pregnancy-specific partner problems are discussed. Special help is offered, or even mandatory, if abortion is being considered, in situations of high stress, or in early diagnosis of a severely handicapped fetus. Some countries offer professional advice and support. All this has contributed to a low incidence of neonatal death rate in these countries. Abortion rate, especially for psychosocial reasons, should be considered a benchmark for a society’s responsibility for its children. However, even in countries with a well-developed health and social system, the most-needy people fall through the net because they seem to be unable or unwilling to use the options available.

Risks and Prevention in the Perinatal Period

Maternal deaths during or shortly after delivery have become extremely rare in countries with high standards of prenatal, medical, and social care, even with increased maternal age at delivery. They are still an important issue in some developing countries. In more affluent countries, the mother–newborn dyad and optimizing early physical and socio-emotional care have come into focus.

The human infant is born immature neurologically and physically, even compared with other primates. Brain development extends well into the second year of
life and is not completed until adolescence. The human newborn’s poor motor abilities have long camouflaged its differentiated competencies. Therefore, until recently, the neonate had been considered a brainstem-controlled, immature biological system. Psychological and biological research has since completely altered this image, and accordingly neonatal care.

The *newborn infant* is now considered a human being with typically human, albeit still immature, attributes such as perceptions, feelings, psychological needs, interests, basic knowledge, and social orientation. His or her biopsychosocial behavior is organized in labile systems (physiological, motor, tonus, arousal states, attention) (Als, 1986; Prechtl & Beintema, 1968); he or she shows active efforts of self-regulation, orientation, and interaction (Brazelton, 1973) and has astonishing acoustical and visual perceptual competencies, especially for social stimuli (Bremner & Fogel, 2001; Bremner & Slater, 2004; Fanz, 1961, Schaffer, 1989). *Competent Infant* (Stone, Smith, & Murphy, 1973) has become a catchword for infancy researchers and practitioners. Although being open to, and dependent on, socio-emotional interactions early on (Bowlby, 1958), the infant forms a strong emotional and person-specific tie to the primary caregiver not before the second half of the first year.

In most industrialized countries, it has become standard that the laboring woman can choose among several *delivery modes*, the child’s father can participate in birth, the healthy newborn stays with the mother or parents immediately after birth before the general diagnostic procedures are applied, the infant’s crib is right next to the mother during most of the day, and lactating and breastfeeding are strongly encouraged. Psychological needs of the baby and parents are respected, or even celebrated. Mutual familiarization of mother and father in the first hour after birth (Klaus & Kennell, 1976/1982) and extensively in the neonatal period appears to facilitate a strong emotional tie, or bond, of the parents to their child and promote sensitive parenting.

**Newborn Infants at Risk**

As one outcome of improved medical prenatal care, more newborns are considered at risk, or even at high risk, today than in previous decades.

The number of children who are born prematurely and/or with very low birth weight is increasing. This increase is due to older maternal ages at birth, close monitoring of potentially risky pregnancies, and an increasing number of multiple births following artificial facilitation of pregnancies. Maternal chronic diseases (e.g., epilepsy, AIDS, diabetes, kidney problems) or detrimental lifestyles (e.g., drug or alcohol use, poor nutrition) may also result in newborns at risk being underweight or overweight, sick, or addicted.

*Neonatal care of at-risk infants* has been successful over the past 50 years and a model for early intervention and prevention. Even extremely premature babies with little more than half the full-term gestational age of 40 weeks now have a fair
chance not only to survive but also to have fewer and less severe physical or neurological sequelae than ever before. Technological advances (e.g., incubators, mechanical respiratory support, refined intubations), pharmaceutical innovations (e.g., surfactants for accelerating lung maturation), and surgical refinements contributed to increased premature and neonatal survival, albeit at sometimes high costs of lasting physical and/or neurological functional damages (e.g., lungs, brains, or eyesight). Psychologically based sensitive observations led to suggesting psycho-physiologically better adapted neonatal environments and care (Als, Duffy, McAnulty, & Badian, 1989; Hess, 2005; Schott, Broghammer, & Poets, 2011). Incubator noise was reduced, alarm beeps were replaced by other means to inform caregivers, a night–day rhythm was introduced, and painful procedures were replaced by less invasive methods; infants are being dressed and placed into nest-like cushions. With very fragile infants, stimulation has been reduced, including stroking the infant in situations of high arousal. Soft stimulation (auditory, visual, tactile), at least partly controllable by the infant (e.g., water beds), is being used with more stable infants. Mothers and fathers are not only allowed to see their child regularly but often included in their infant’s care. “Kangarooing” (i.e., skin-to-skin relaxed contact of mother or father, a method first developed in poverty areas in Colombia) of very premature infants was first ridiculed in the high-tech neonatal intensive care units but has been accepted even in university intensive care wards as an effective way to improve the infant’s breathing and temperature stability (Cattaneo et al., 1998). If positively accepted by parents, kangarooing can help them learn the subtle behavioral signals of their infant and fine-tune their psycho-physical communication with the fragile baby. Parents report higher confidence in infant care and appear to develop more sensitivity in the interaction with their baby (Chwo et al., 2002; WHO, 2003).

The attitude change of parents and professionals toward the newborn and premature baby (i.e., realizing the individual even in the neonate) has not only improved and refined neonatal and intensive care but also reduced some of the highly intrusive, and often painful, mechanical supports and monitoring, alleviated the initially strict regulations of care and visiting, and emphasized the parent–infant interaction as important for any newborn, but especially for infants at risk. Pediatric practice and developmental psychological research had participated in these changes.

Perinatal Risks and Long-Term Outcomes

With improved neonatal care, even very premature and sick newborns can survive. As a consequence, the number of people with physical handicaps, chronic illnesses, and physical vulnerability who will reach adulthood has risen significantly (Bergmann et al., 2009). Biological prenatal and perinatal risks continue to be major threats to an infant’s physical, emotional, and social development. Premature birth, low birth weight, and early central nervous system injuries are still the main
risk factors for cognitive, motor, and language development; functional deficiencies; and compromised school achievement. Even when these children are functioning well in familiar and less complex situations, they can activate only reduced resources for complex problems (Evrard et al., 2011) and are more prone to psychosocial problems, psychopathology, and maladaptation.

An overview of longitudinal data confirmed several assumptions. (1) An increased incidence of functional problems in later life for children with prenatal risks can only be predicted at the statistical group level, not at the individual child level. Risk is a probabilistic concept based on group statistics (Farran & McKinney, 1986; Rutter, 2000). This is bad news if limited prevention resources are to be allocated to the neediest individuals. It is, however, good news against any early “negative selection,” and it is also good news for parents hoping for good outcomes. (2) The same risk condition can have quite diverse outcomes emerging at different times in the life course. (3) A single risk factor—even a severe one—can often be compensated for or overcome. For all risk groups, this is most probable for children who experience a positive socio-emotional climate and interaction in their families in the early years. Low-quality parenting can aggravate the consequences of even minor risks. (4) Biological risks, such as premature birth and perinatal and postnatal illnesses, appear to affect motor, cognitive, and language development primarily in the first few years of life, whereas social risks (psychopathology of parent, inadequate parenting, inappropriate or lack of stimulation) become increasingly effective in the later years of development (Bornstein, 1989b; Carta et al., 2001; Laucht, Esser, & Schmidt, 2002; O’Connor & Rutter, 1996; Rauh, 1989, 2005). Exposure to chronic risk situations increases the probability of adverse outcome, often even in a curvilinear fashion. A combination of both biological and social risks tends to have an overadditive effect—that is, infants born at biological risks are even more susceptible to psychosocial and social risks and children in highly stressful environments are more prone to encountering biological and social risks (cascading effect; Koger et al., 2005).

In research and in practice, risk indices combining biological and social risks focus on perinatal risks. Prechtl (1980) suggested instead an “optimality index” assessing how close to completely healthy a newborn is. This concept and a mixture of risks and optimality seem to have entered indices for older children, as in the Child and Youth Well-Being Index (Foundation of Child Development, 2010).

Risks, Vulnerabilities, and Prevention in Infancy and Toddlerhood

Typical Development Benchmarks

In the first 2 months, the human infant is considered by many researchers to be primarily an extrauterine fetus adapting to the new physical and physiological
conditions, stabilizing the basic behavioral systems, practicing the senses, and differentiating the brain structures. A major “milestone” with great impact on the parents is the social smiling at about 6 weeks after expected birth date. The infant becomes increasingly active in social and emotional interaction, intensively studying familiar human faces. Rochat and Striano (1999) characterize the changes between 2 and 3 months as “revolution” or “social birth.” Already within the first few months, infants differentiate between physical and social stimuli and soon tend to react differentially: they smile and babble to even a “still” face of a living human to reactivate it but rarely to a puppet (still-face paradigm), even one that had been moving previously. They habituate to repeated stimuli and prefer a familiar person to a strange person and familiar language, ethnic features, smells, and tastes.

In the second half of the first year, infants not only become motorically more independent and explorative (sitting, locomotor activity, grasping) but seem to develop an intuitive understanding of major physical principles (behavior of objects of different sizes and masses, weight, gravity, physical causality, object permanence, local relations) as well as of human intentional, or unintentional, actions. At around 8 months (“second social revolution” according to Tomasello, 1999), they start to enjoy games that involve taking turns, and signal by social referencing to their partner that they associate actions and action results with the actor. They can now not only differentiate between emotional expressions of their adult caregiver but also use his/her encouraging or warning facial expressions as information for their own actions. At approximately their first birthday, they start to actively orient the caregiver to objects or events of their interest, share their own emotional experience with their caregiver, request information or evaluation, or even playfully tease their caregiver. During the second half of the first year, the infant gets tuned to those patterns of stimuli and events that are meaningful and characteristic for his/her culture, and he/she sometimes becomes insensitive to those physical differences that do not carry cultural meaning (e.g., specific language sounds, forms, color shades).

At 18 months, the infant has grown into a competent toddler, coping well in a here-and-now world at a sensorimotor level. He/she has developed a basic sense of psychophysical self as differentiated from others; can move about and act in a still limited physical world of objects, plants, and animals; can refer his/her actions and success or failure to the self as actor; and can actively participate, interact, and communicate (nonverbally) in a concrete social world of real and familiar people. He/she can infer at least some psychical experiences of others and differentiate them from his/her own experiences (distinguish between own feelings and wishes and those of others, between what the other person can see or has just experienced and what he/she sees and knows).

During the second year of life, new cognitive competence emerges and revolutionizes the toddler’s worldview: the ability to represent. The child eventually acquires the ability to represent the objective world in gestures, words, drawings, and somewhat abstract mental representations, as well as the social world in symbolic play, imitation, and role-play, initially using concrete actions then increasingly mental representations. By 18 months, the child discovers the self as
a counterpart, visibly reflected in a mirror and internally represented as a mental object. Via language, even subjective feelings can become reified, controllable, and amenable to cultural influences. These representational worlds seem to be unlimited and may sometimes overwhelm the young child. Logical structuring helps the child to eventually tame the representations of the physical world, starting with prelogical abilities of classification and seriation and turning to concrete and formal operations in school children and adolescents (Piaget, 1952). The represented social worlds will eventually be structured by social and moral rules and values. Toward the end of the second year, children are usually eager to participate in their social setting. They imitate adults and other children, learn social scripts and social rules, and communicate orally. They become susceptible to cultural socialization and even eager to become socialized and participate in enculturation (Pauen & Rauh, 2008).

**Attachment, the Infant–Parent Relationship**

Infant development is closely linked to parenting. All infants need an attachment relationship to grow. Attachment develops over the first year of life from a general openness to social stimuli and interactions to a clear distinction between familiar and unfamiliar people. With the infant’s advances in locomotion and with cognitive structuring of the social and physical world, the attachment figure becomes the emotional center for the infant. The intensity of attachment peaks at the end of the first year and continues into the second and third years of life; it protects the child from getting lost and from threats and dangers. Attachment also serves as a secure base for exploration in the physical and social world. The child develops a system of strategies and emotional experiences to cope with novelties and threats. At the representational level, the system of attachment relationships and coping strategies eventually forms an internal working model for social relations in general and the self in these relations (Bowlby, 1969; see Stevenson-Hinde & Verschueren, 2002). Parent–child relationships continue throughout life, and individuals’ socio-emotional relationships with friends, partners, and later their own children have general similarities and can even be traced back to those first relationships.

Three major strategies characterize infants’ primary attachments (Ainsworth, Blehar, Waters, & Wall, 1978; Crittenden, 2008): A securely attached infant will explore his/her surroundings freely in the presence of an “attachment figure,” will freely express positive and negative feelings, and will turn to and seek security, comfort, and support from the attachment partner when feeling frightened, unsafe, and endangered. Infants with an insecure–avoidant attachment relationship also have strong emotional attachments, but they balance, or even curb, their need for closeness and comfort on the basis of the caregiver’s reaction to the infant’s negative emotions. Infants with an insecure–ambivalent attachment relationship intensify their emotional expression of distress to compel their attachment partner’s total attention.
All three strategies are basically effective to get, and keep, the caregiver close. A secure strategy is prevalent in most societies and is most typical in affluent and stable families with well-educated mothers. The frequency of insecure strategies varies with cultural history and values and with the infant’s early parenting experiences (Crittenden & Claussen, 2000).

A key factor for individual differences in attachment strategies, or attachment quality, in the second year of life is maternal sensitivity, especially in the first months of a child’s life. Sensitivity to a young infant means prompt and reliable reaction to the infant’s distress for establishing emotional security and to the infant’s expressions as a basis for communication and for learning regularities; empathic interpretation of, and reaction to, the infant’s needs; and emotional warmth in distress as well as in joyful situations. The ingredients of sensitivity may change in later infancy and toddlerhood: promptness becomes less important and emotional tenor and teacher qualities become more important. The concept of sensitivity is closely related to the concept of intuitive parenting (Papousek & Papousek, 1987) and to the concept of scaffolding (Vygotsky, 1978). Maternal sensitivity has proved to be predictive not only for attachment quality. Sensitive parenting appears to be the major protective factor for infants born at early biological risks and for irritable babies. Maternal sensitivity and quality of first attachment were predictive of social competence in preschool and school. Social relations, friendships, and even later romantic relationships seem to build on those early experiences, although direct predictions over long periods of life are moderated by many additional factors (Englund, Kuo, Puig, & Collings, 2011; Grossmann, 1988). Some transgenerational studies (Hautamäki, Hautamäki, Neuvonen, & Maliniemi-Piispanen, 2010) suggest that the parent’s own socio-emotional security status translates into parental sensitivity with his/her infant and into infant attachment quality.

Even in the first few years of life, young children present a wide range of individual differences, not only in attachment strategies but also in rate of physical, cognitive, language, and social development; gender; temperament; and stress reactivity. Within the normative ranges, rate of development is not yet stable in early childhood, and prediction into school years, adolescence, or even adulthood is limited (Brim & Kagan, 1980; Kagan, Kearsley, & Zelazo, 1980). Nevertheless, rate of cognitive development and level of achievement at a particular age are frequent measures of intervention efficiency. Gender and temperamental differences, including stress reactivity, are considered major mediators and moderators of stressful experiences and coping efforts.

The Risk of Dysfunctional Early Parenting

The concepts of attachment and sensitive care have entered the fields of infant developmental psychopathology and infant psychiatry. Extreme experiences of the
infant in his/her early social relationships (e.g., with an unresponsive caregiver, an emotionally unavailable mother, or an unpredictable caregiver) may induce the child to develop nonnormative strategies to address immediate paramount needs for self-protection and attachment, but these strategies may eventually result in pathological attachment strategies (Crittenden, 2008). The infant stress system appears to be extremely sensitive to significant caregiving perturbations early in life resulting in heightened anxious behaviors and in cognitive biases to reinforce anxiety. Pathological strategies usually originate as situationally functional in the early caregiver context, but they limit the child’s potential for emotional, social, communicative, and often cognitive development (Goodman, Quas, & Ogle, 2010). Frightening parental behavior, high insecurity in the primary setting, and genetic disposition can be the causes of deviant attachment relationships that predict a host of behavioral problems in childhood and even adolescence (Van IJzendoorn, Schuengel, & Bakermans-Kranenburg, 1999).

**Genetic disposition** and temperament can act as moderators of differential susceptibility. Infants with a highly negative temperament, usually indicative of future behavior problems, were less self-regulated when they were in unresponsive relationships, but more self-regulated than control children when in responsive relationships (Kim & Kochanska, 2012). Recent epigenetic research with rat puppies (Meaney, 2010) suggests not only that prenatal maternal stress experiences epigenetically program stress vulnerability of the fetus but that sensitive early care (licking in the case of rat mothers) may have a preventive/protective effect on stress vulnerability in the pup.

In extreme cases of dysfunctional parenting, the child has to be secured by communal authorities. Programs to promote effective parenting aim at preventing such drastic measures (Sandler, Schoenfelder, Wolchik, & MacKinnon, 2011). In home visiting programs, specially trained nurses guide first-time mothers from low-income homes in how to care for the infant physically and psychosocially. These programs have been established in many countries and usually report positive effects on the infant (developmental indices) and the mother (self-reliance) (Astuto & LaRue, 2009). A well-controlled study of a weekly early intervention for infants at age 6 months and a later intervention at 24–28 months found significant effects on maternal warmth and nurturance after the early intervention and more contingent maternal cognitive responsiveness and language input with the second intervention (Landry, Smith, Swank, & Gutten-tag, 2008). The toddlers were more cooperative, communicative, and engaged in mother–child interaction and book-reading when their mother had received the intervention during toddlerhood. Response to the intervention of very low-birth-weight infants was similar to those of term infants. The study shows that relatively short, but targeted, interventions at focal developmental times can be quite effective. There are, however, only few methodically sound studies in this field, and the kinds of interventions vary greatly as do the targeted families. Little or no information exists on families that do not volunteer in programs or that resent any intrusion for personal or political reasons.