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SB 30?

Foreword

Kenneth P. Moritsugu and Ting-Kai Li

Pediatrics 2008;121;S231-S232
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American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

Foreword

RADM (Retired) Kenneth P. Moritsugu, MD, MPH[a], Ting-Kai Li, MD[b]

[a]Former Acting Surgeon General of the United States; [b]Director, National Institute on Alcohol Abuse and Alcoholism

The consumption of alcohol by underage youth in America constitutes a public health problem with serious social and economic costs and often tragic personal consequences. Alcohol is the most widely used substance of abuse among America's youth. Over 4 million of our young people ages 12–17 (18%) report drinking monthly with more than half engaging in high-risk drinking patterns. Approximately 50% of young people have had a full drink by the 8th grade. By high school graduation, this number rises to approximately 75%. The amount of alcohol consumed also increases dramatically between the ages of 12 and 20, as measured by binge drinking (typically consuming 5 or more drinks per occasion) and the frequency of binge drinking.

The number of young people who drink and the way in which they drink, creates problems both for themselves and for others. The physical consequences of underage alcohol use range from medical problems to death by alcohol poisoning; alcohol also plays a significant role in risky sexual behavior, physical and sexual assaults, and various types of injuries, including suicide. Underage drinking can also contribute to academic failure and altered vocational and career trajectories, thereby diminishing our most essential national resource, human capital. Secondhand effects of underage drinking impinge on others, drinkers and nondrinkers alike, in many ways, most significantly in the form of car crashes from drunk driving.

Perhaps most alarming is the recent finding that underage alcohol use is not just associated with a temporary surge in risky behavior, and its immediate consequences. The prevalence and extent of binge drinking among young people makes them more vulnerable to development of full-blown alcohol dependence as well (that is, alcohol dependence of the kind that is diagnosable according to standards described in the Diagnostic and Statistical Manual of the American Psychiatric Association). The earlier the onset of drinking, the higher the risk of developing future dependence. In fact, data from the National Epidemiologic Survey on Alcohol and Related Conditions, a nationally representative survey of over 40 000 participants conducted in 2001–2002, showed that the *highest prevalence* of alcohol dependence in the US population occurs in *youth ages 18–20.*

As we learn more from research about the acute and later consequences of drinking during this early period of vulnerability, it has become clear that underage drinking must be addressed, not as an isolated phenomenon, but as an issue fully embedded in the context of child and adolescent development. From birth, every individual experiences dynamic biological changes in the body and brain as well as changes in the environments in which they grow up (e.g., family, school, and neighborhood, among others). And, as these more obvious changes occur, so do changes in peer groups.

The complex interaction of biology with changing environmental factors leads to behavior that may either move individuals toward or away from underage drinking. For example, certain temperamental characteristics that can be identified in very early childhood are associated with greater risk for early alcohol use. This risk can be compounded by a dysfunctional home environment. In addition, long before individuals begin drinking, childhood experiences may influence the formation of expectancies about the effects of alcohol that are also related to future adolescent alcohol use.

In early adolescence, we also need to consider the multiple effects of puberty, including hormonal changes, overt physical changes, differential maturation of specific regions of the brain, and a shift in reward sensitivity which may contribute to increased risk-taking and sensation-seeking. Combined with greater access to alcohol and less supervision, these shifts can increase the risk for alcohol initiation. Other important changes include increasing responsibility at home, at school and elsewhere, coupled with an increasing personal need for independence. Indeed, by later adolescence most youth are driving and many work outside the home. All these developmental changes, perhaps most importantly peer influences, intersect with alcohol use in complex ways.

This supplement provides important information for understanding and addressing underage drinking in the context of overall development. The information in this group of articles forms some of the scientific foundation of both the National Institute on Alcohol Abuse and

Alcoholism's Underage Drinking Research Initiative, as well as the recently released *Surgeon General's Call to Action To Prevent and Reduce Underage Drinking*. Because a Surgeon General's Call to Action is intended to be a concise document that focuses the Nation's attention on an important public health issue, the articles in this supplement can be viewed as a means of beginning to access the more extensive scientific literature on which the *Call to Action To Prevent and Reduce Underage Drinking* is based. We hope you will find the information in this supplement useful as you work with your patients to foster healthy child and adolescent development. You may also find the recently released Surgeon General's Guide to Action series (www.surgeongeneral.gov/topics/underagedrinking/) helpful in these discussions.

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FORWARD

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SB30?

Underage Drinking: A Developmental Framework

Ann S. Masten, Vivian B. Faden, Robert A. Zucker and Linda P. Spear

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American Academy of Pediatrics
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SUPPLEMENT ARTICLE

Underage Drinking: A Developmental Framework

Ann S. Masten, PhD[a], Vivian B. Faden, PhD[b], Robert A. Zucker, PhD[c,d], Linda P. Spear, PhD[e]

[a]Institute of Child Development, University of Minnesota, Minneapolis, Minnesota; [b]Division of Epidemiology and Prevention Research, National Institute on Alcohol Abuse and Alcoholism, Bethesda, Maryland; [c]Department of Psychiatry and [d]Addiction Research Center, University of Michigan, Ann Arbor, Michigan; [e]Department of Psychology, Binghamton University, State University of New York, Binghamton, New York

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ABSTRACT

A developmental framework for understanding and addressing the problem of underage alcohol consumption is presented. The first section presents the rationale for a developmental approach, including striking age-related data on patterns of onset, prevalence, and course of alcohol use and disorders in young people. The second section examines the fundamental meaning of a developmental approach to conceptualizing underage drinking. The third section delineates contemporary principles of developmental psychopathology as a guide to future research and intervention efforts. Strategic, sensitive, and effective efforts to address the problem of underage drinking will require a developmentally informed approach to research, prevention, and treatment.

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Key Words
development, drinking, alcohol

Abbreviation
AUD—alcohol use disorder

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Address correspondence to Ann S. Masten, PhD, Institute of Child Development, University of Minnesota, 51 East River Rd, Minneapolis, MN 55455. E-mail: amasten@umn.edu

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DEVELOPMENTAL APPROACHES TO understanding and addressing the problem of underage drinking are essential, not only because this problem occurs in a developing organism but also because accumulating evidence strongly implicates the role of development in promising theories and interventions concerning this problem. It is increasingly clear that the emergence and progression of drinking behavior are influenced by development, that underage drinking has developmental consequences, that alcohol use disorders (AUDs) are developmental in nature, and that efforts to prevent or to reduce underage drinking behavior must be developmentally informed to be strategic, sensitive, and effective. Our goals in this article are to summarize the case for a developmental perspective on underage drinking and to outline a developmental framework for underage drinking, to guide future theory, research, and practice. This framework emerged from the collaborative work of an advisory group assembled by the National Institute on Alcohol Abuse and Alcoholism in 2004 as part of the Underage Drinking Research Initiative.

The framework is presented in 3 sections. In the first section, we highlight the rationale for a developmental approach, including examples of data that the advisory group members found compelling as a rationale for developmental perspectives. In the second section, we discuss general developmental principles that guided our thinking, with examples of their application to drinking behavior. In the third section, we articulate principles of contemporary developmental psychopathology as applied to the problem of underage drinking.

RATIONALE FOR A DEVELOPMENTAL APPROACH TO UNDERAGE DRINKING

Focus

When the evidence on drinking behavior is examined through a developmental lens, the rationale for a developmental approach to understanding and preventing this problem comes into focus. In this section, we highlight conclusions based on the most salient data supporting a developmental approach.

There Are Striking Age-Related Patterns of Alcohol Use, Problems, Abuse, and Dependence

Alcohol use typically begins in the second decade of life, often in early adolescence. Although some young people begin drinking in elementary school, the first use of alcohol (defined as drinking a whole drink) typically occurs in early adolescence (at ~13–14 years of age).[1] Data from multiple, nationally representative surveys indicate that rates of alcohol use and binge alcohol use increase sharply between ages 12 and 21. As shown in Fig 1, for example, data from the 2005 National Survey on Drug Use and Health indicated that the proportion of people who have drunk ≥1 whole drink increases steeply during adolescence and then plateaus at ~21 years of age.[2] Furthermore, data from the same study showed that all levels of past-month drinking, from use to binge drinking to heavy drinking, increase with increasing age during adolescence (Fig 2). Similarly, the number of reported binge-drinking days in the past 30 days shows important age-related patterns. As shown in Fig 3, this study also indicated that the number of binge-drinking days increases sharply during adolescence, more so for boys than for girls, and then decreases dramatically for both genders during the third decade of life and continues to decrease thereafter.

Drinking patterns also vary dramatically according to age. As shown in Fig 4, the National Survey on Drug Use and

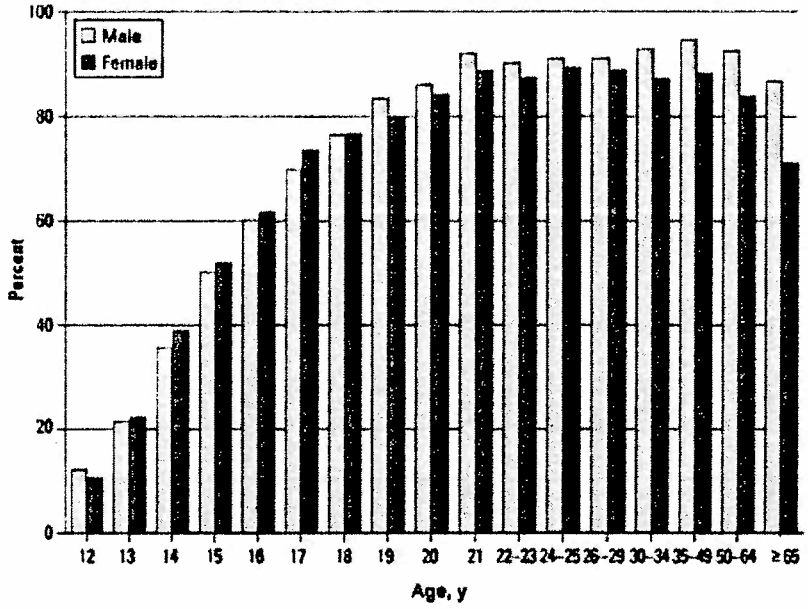

FIGURE 1
Proportion of individuals of a given age in the US who have ever drunk alcohol (a whole drink). Data source: Substance Abuse and Mental Health Services 2005 National Survey on Drug Use and Health.[2]

Health data indicated that, whereas adolescents drink less often than young adults and older adults, they drink more per occasion. When youths between 12 and 20 years of age drink, they drink an average of ~5 drinks, an amount in the binge-drinking range. (Binge drinking typically is defined as consuming ≥5 drinks per occasion for men and ≥4 drinks per occasion for women.) The data shown in Fig 4 are consistent with those from multiple other studies, showing how common binge drinking is among adolescents. Moreover, some of the contexts that attract adolescents specifically, including organized parties, college, and military service, are associated with high rates of drinking behavior.[3,4]

Underage drinking accounts for substantial proportions of all alcohol consumed in the United States and of estimated consumer expenditures for alcohol. The estimated short-term cash value to the alcohol industry of underage drinking was $22.5 billion in 2001.[5]

Alcohol dependence (defined according to the criteria of the American Psychiatric Association, which are summarized in Table 1) typically emerges during late adolescence or early adulthood, as shown in Fig 5.[6] The

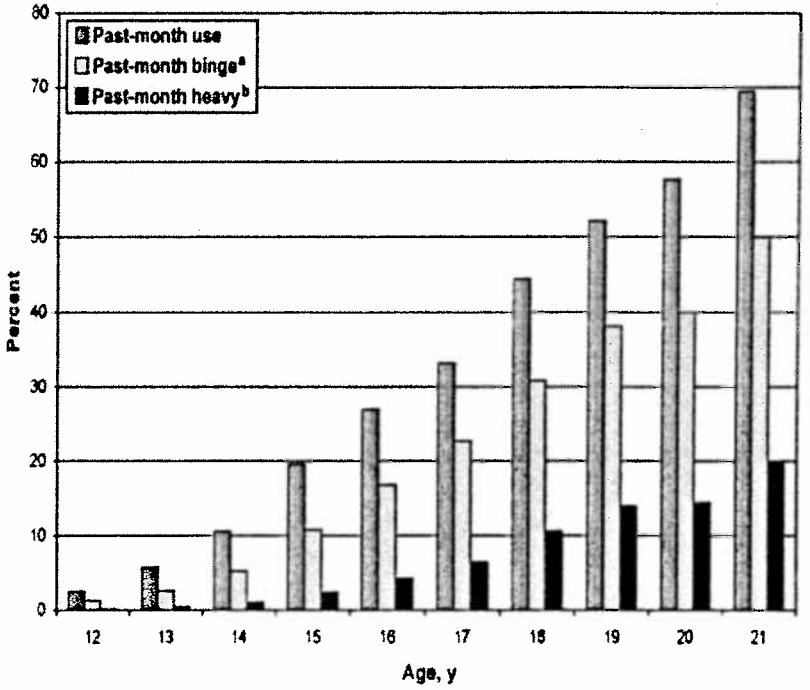

FIGURE 2
Past-30-day alcohol use (any, binge, or heavy) according to age. [a]Binge drinking was defined as ≥5 drinks per occasion; [b]heavy drinking was defined as ≥5 drinks per occasion on ≥5 of the past 30 days. Data source: Substance Abuse and Mental Health Services Administration data from the 2005 National Survey on Drug Use and Health.[2]

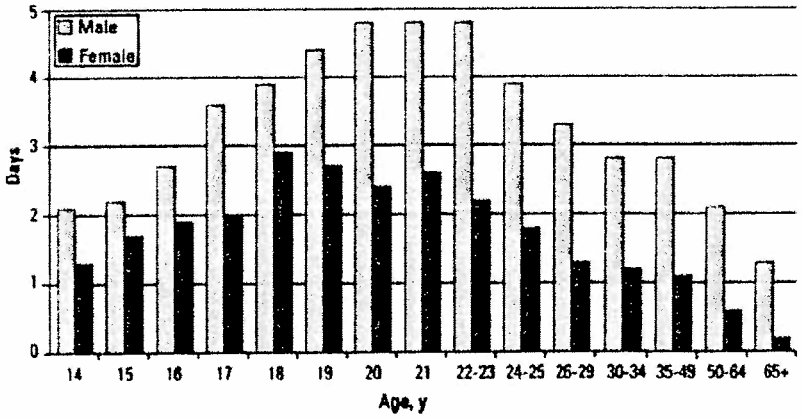

FIGURE 3
Number of days in the past 30 days in which drinkers consumed ≥5 drinks, according to age and gender. Data source: Substance Abuse and Mental Health Services Administration data from the 2005 National Survey on Drug Use and Health.[7]

past-year prevalence of alcohol dependence is highest between the ages of 18 and 20 years, peaking before youths even reach the legal drinking age of 21 years in the United States. Prevalence remains quite high among 21- to 24-year-old individuals and declines thereafter. In addition, as shown in Fig 6, children and youths who begin alcohol use before the age of 14 years are much more likely to develop alcohol dependence at some point in their lives than are those who begin drinking after the age of 21 years.[7]

Multiple, nationally representative surveys indicate that alcohol is the drug of choice among US adolescents of all ages. As can be seen in Fig 7, data from the Monitoring the Future survey indicated that more youths drink alcohol than smoke cigarettes or use marijuana; this is true among eighth-, 10th-, and 12th-grade youths.[8] These figures are even more dramatic among male students; for example, 50.7% of 12th-grade male students had consumed alcohol in the past month.

Alcohol is implicated in large proportions of deaths related to accidents, homicides, and suicides among young people. For example, each year ~1900 persons <21 years of age die in motor vehicle crashes that involve underage drinking (and ~500 additional persons >21 years of age also die in those crashes).[9] Alcohol is also involved in ~1600 homicides and ~300 suicides among persons <21 years of age.[10–13] Finally, ~1600 persons <21 years of age die as a result of alcohol-related, unintentional injuries (not related to motor vehicle crashes).[11,13]

Acute, Intermediate, and Longer-Term Effects of Alcohol Vary According to Age and Development

Evidence is accumulating in animal research and a limited number of human studies that immediate, short-term, and long-term effects of alcohol on individuals can vary as a function of age or developmental status. For example, prenatal exposure to alcohol, which can result in fetal alcohol spectrum disorders, has profoundly different consequences for development than does later exposure, in humans[14–16] and in animals.[17] In rhesus monkeys, the timing of prenatal exposure has differential effects on fetal development.[18] Animal research suggests strongly that adolescent animals, compared with adults, are less sensitive to the aversive effects of acute alcohol intoxication (eg, sedation, hangover, and ataxia) but are more sensitive to alcohol's effects on social facilitation and disruption of spatial memory.[19,20] Additional animal research has indicated that alcohol consumption before and during adolescence can produce long-lasting effects, including increases in alcohol consumption in adulthood.[21]

Research on stress and alcohol in nonhuman primates provides additional evidence of developmental differences in the role of alcohol. For example, studies have shown that adolescent monkeys double their alco-

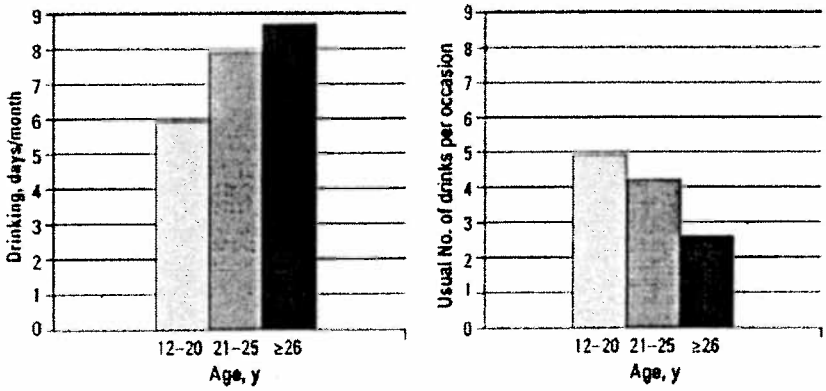

FIGURE 4
Number of drinking days per month and usual number of drinks per occasion for youths (12–20 years of age), young adults (21–25 years of age), and adults (≥26 years of age). Data source: Substance Abuse and Mental Health Services Administration data from the 2005 National Survey on Drug Use and Health.[7]

TABLE 1 Diagnostic Criteria for Alcohol Dependence, Adapted from the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*[112]

Maladaptive pattern of drinking, leading to clinically significant impairment or distress, as manifested by ≥3 of the following occurring at any time in the same 12-mo period:
Need for markedly increased amounts of alcohol to achieve intoxication or desired effect, or markedly diminished effect with continued use of same amount of alcohol
Characteristic withdrawal syndrome for alcohol, or drinking (or using a closely related substance) to relieve or to avoid withdrawal symptoms
Drinking in larger amounts or over longer period than intended
Persistent desire or ≥1 unsuccessful efforts to cut down or to control drinking
Important social, occupational, or recreational activities given up or reduced because of drinking
Great deal of time spent in activities necessary to obtain, to use, or to recover from effects of drinking
Continued drinking despite knowledge of having persistent or recurrent physical or psychological problem that is likely caused or exacerbated by drinking
No duration criterion specified separately but several dependence criteria must occur repeatedly, as specified by duration qualifiers associated with criteria (eg, "persistent" or "continued")

hol intake under stress (peer raised versus mother raised) and also that excessive alcohol consumption is related to changes in levels of stress hormones and serotonin.[22]

Research on the long-term consequences of chronic alcohol exposure in animals also suggests differential sensitivity in adolescence.[23] In 1 study, rats experienced chronic, intermittent, alcohol exposure during either adolescence or early adulthood.[24] After a 20-day recovery period, there were no differences in spatial learning. When the animals were challenged with a low dose of alcohol, however, learning was significantly more impaired in the animals exposed to alcohol in adolescence than in those exposed as adults. In a study using a high-dose, 4-day, binge alcohol-exposure paradigm applied to adolescent or adult rats, some brain damage was found in both age groups but only the animals that had been exposed to alcohol during adolescence manifested damage in the frontal cortical olfactory regions and the anterior portions of the piriform and perirhinal cortices.[25] This finding suggests that, at least with a model of extreme, binge-type, alcohol exposure, certain brain regions may be more susceptible to alcohol-induced damage during adolescence.

Development Itself May Be Altered by Alcohol Exposure

Data on the effects of exposure to alcohol during fetal development and also during adolescence indicate that alcohol can alter development itself. Fetal alcohol exposure clearly contributes to physical anomalies in humans[14] and animals.[17] Animal research has shown that repeated alcohol exposure during adolescence induces inflammatory cell death,[26] as well as morphologic and neurochemical changes in the brain that may persist into adulthood,[27,28] although studies have yet to explore whether adults would be less vulnerable to these effects than adolescents. Research with human adolescents indicates that severe AUD is associated with reduced hippocampal volume,[29,30] although these results should not be interpreted as necessarily being causal.

Drinking also may alter the development of social and academic competence. Underage drinking is associated strongly with academic and social problems, potentially undermining success in domains of competence that are crucial for successful adult development.[31,32] The associations of underage drinking behaviors with problems in social competence or school achievement likely arise from complex (and bidirectional) influences over the course of development, which are not yet fully elucidated. Nonetheless, there is growing evidence that drinking contributes to problems in key domains of behavior among children and adolescents, such as peer relationships and school performance, which have consequences for future opportunities and success in terms of work, adult relationships, health, and well-being.

Alcohol Use and AUDs Have Predictability From Childhood

A substantial body of evidence implicates a set of risk factors that consistently precede and predict early use and/or dependence.[31–34] These factors include the follow-

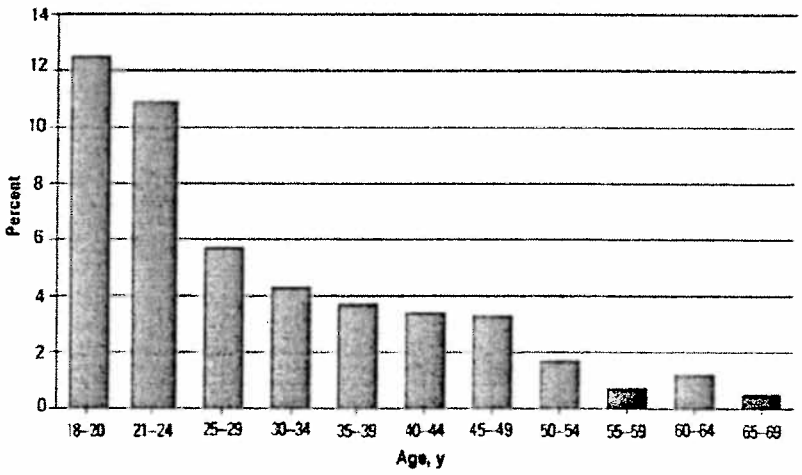

FIGURE 5
Prevalence of past-year alcohol dependence (based on *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*, criteria) in the United States. Data source: 2001/2002 National Epidemiologic Survey on Alcohol and Related Conditions.[6]

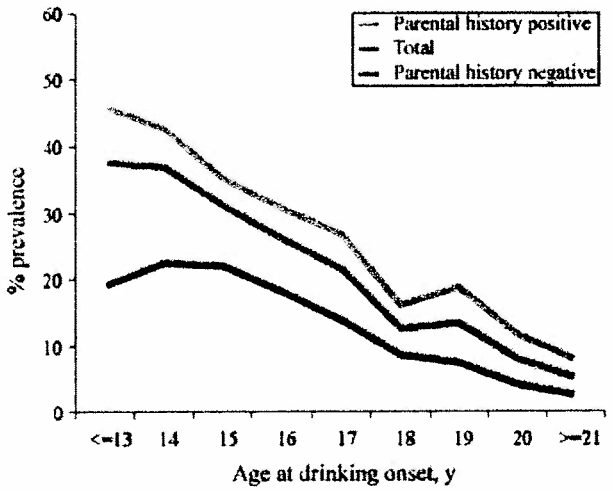

FIGURE 6
Association of age of initiation of alcohol use and lifetime dependence (meeting *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*, criteria for dependence at some point in one's life). Data source: 2001–2002 National Epidemiologic Survey on Alcohol and Related Conditions.[7]

ing: family history of alcohol abuse, parents with antisocial behavior, mothers with depression, poor parenting (eg, maltreatment, neglect, or poor monitoring), prenatal exposure to alcohol and clear fetal alcohol syndrome, child maltreatment, child antisocial behavior, child smoking or substance abuse, self-regulation problems that also predict antisocial and risk-taking behavior (eg, attention problems, effortful control problems, or impulsivity), cognitive learning difficulties in children, and various internalizing symptoms in children.

There seem to be some common pathways that lead toward AUDs.[32,35] For example, considerable evidence suggests a pathway associated with early signs of problems regulating attention and emotion, impulsivity and aggression, early cognitive problems, academic and social problems after school entry, later deviant peer affiliations, and a course of escalating antisocial behavior. In the delinquency/antisocial literature, this pathway is described in terms of early starters or life-course persisters.[36,37] This pathway leads to multiple problem outcomes by adolescence and is associated with many of the risk factors listed above.

Most of the risk (or protective) factors for alcohol use and AUDs are nonspecific, in that they also forecast many problems other than alcohol problems, including conduct problems, learning problems, school dropout, risk-taking behaviors, early sexual activity, pregnancy, antisocial personality disorder, and mood disorder.[32,34,38–41] Moreover, many of these factors are in place early in development, before school begins, including the following: temperament differences related to behavioral and emotional control or dysregulation observable very early in development; problems with self-awareness, self-monitoring, attention, and effortful control; a history of adversity in multiple forms (family history of antisocial behavior, experiences of abuse or trauma, or other negative life experiences); and individual differences in cognition related to response inhibition, forethought, and planning. These major domains of functioning show developmental variations and broad individual differences from early in development, predict many kinds of problems, and thus are nonspecific for alcohol involvement, although they clearly are risk factors for its emergence and progression to problem use.[32]

Risk and Protective Factors Associated With Higher or Lower Use/Dependence Have Age-Related Patterns

Data on expectancies about the effects of alcohol, intent to use alcohol, and access to alcohol all show age-related shifts. Expectancies about the effects of alcohol shift from predominantly negative to positive during later middle childhood and early adolescence.[42,43] These shifts may be linked to the transition from childhood or elementary school to adolescence or secondary school. Hipwell et al,[44] for example, found that positive expectancies increased and negative expectancies decreased during the age period of 8 to 10 years in the Pittsburgh Girls Study. Findings from Dunn and Goldman[42,43] also indicated that this shift occurs earlier than the transition to secondary schooling. Similarly, intent to use alcohol increases with age during elementary school,[45] and access to alcohol tends to increase over the course of childhood and adolescence.[8]

Other data also hint at key shifts in risk factors or perspectives regarding alcohol that are related to age or development. Smoking (a risk factor) typically begins in early adolescence.[46] Peer popularity in elementary school generally is associated with low risk for alcohol

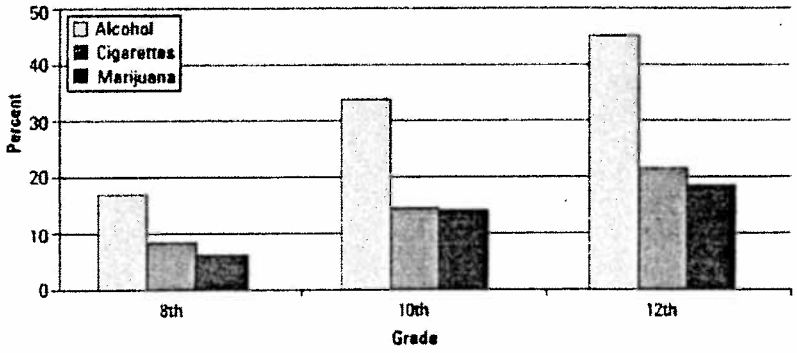

FIGURE 7
Past-month adolescent alcohol, cigarette, and marijuana use according to grade. Data source: Monitoring the Future, 2006 National Survey.[8]

use,[32] but popular high school students may have higher risk.[47] Exposure to alcohol at parties increases in adolescence, which may account for some of the increasing risk of use among popular youths, who are more likely to be invited to parties. Underage drinking is viewed as a rite of passage by many US parents and also by many adolescents.[48,49] Clearly, however, this rite of passage is associated with adolescence and not early childhood, and cultural expectations about this rite of passage reflect an age-related shift in adult expectations or tacit approval of drinking.

Another shift seems to occur with transitions into college. The risk for binge drinking increases sharply among college students, and the first few months of college may be a period of particularly heightened risk for hazardous drinking.[50] Some college students follow very different trajectories, however, with level or decreasing risk during this period.[51,52]

Contextual risk or protective factors embedded in peer and family relationships also show prominent age-related changes.[53] Deviant peer association and delinquent behaviors among deviant peers, both of which are key risk factors for alcohol use, increase in early adolescence, particularly among youths with a cluster of risk factors for antisocial and risky behavior.[36] Parental and other adult monitoring (which can be protective) often decreases during adolescence, as unmonitored time increases.

BASIC FEATURES OF A DEVELOPMENTAL APPROACH

Focus

These age-patterned data on alcohol, including data on incidence, prevalence, use, progression, binging, dependence, expectancies, timing, and consequences, collectively constitute a compelling case for a developmental approach to the problem of underage drinking. Data on onset, offset, use, dependence, developmental consequences, individual and contextual risk and protective factors, and alcohol effects all show striking patterns related to age and developmental changes. In this section, we delineate the core elements of a developmental approach, with particular application to underage drinking. Given our assertion that a developmental perspective is essential for understanding and addressing underage drinking, it is important to consider what it means to have a developmental approach.

What Is Developmental Change?

Developmental science is the study of change over the life course of living organisms, focused on patterns of orderly change as organisms begin to form, mature, and decline. People develop and change throughout life but particularly during childhood and adolescence, when individuals undergo periods of rapid change in many aspects of form, function, and status, including growth, coordination, strength, and movement skills; brain size, organization, connectivity, and function; cognitive, emotional, and social capabilities; motivation and self-directed behavior; physical, financial, and emotional independence from parents; reproductive maturity; and education and knowledge.

People also routinely experience many changes of context in childhood and adolescence, some of which are designed to foster learning and maturation into societal roles (eg, school changes), some of which are precipitated by children for their own enjoyment or interest (eg, friends and activities), and some of which befall people (eg, stressful life experiences). There are dramatic changes in the contexts in which young people spend their time and engage their minds and bodies during these years.[53]

Many behavior problems and disorders emerge in the first 2 decades of life, during these years of dramatic change,[53–59] including alcohol-related problems and AUDs. It is highly likely that the causes and consequences of alcohol use and AUDs are related to these changes in individuals, their contexts, and their interactions. Consequently, it is also likely that intervening effectively to prevent, to delay, or to treat underage drinking must take these changes into account.

Time is required for change to occur, but not all changes are developmental. For example, imagine that a person loses an arm suddenly in a car accident. The change from having 2 arms to having 1 arm, although dramatic, is not in itself a developmental change. However, many developmental changes could have contributed to the car accident, and the consequences of the accident could have far-reaching effects on future development. Moreover, the kind of change through which an embryo develops arms originally is fundamentally developmental, as is the growth of the arms during childhood and adolescence.

Development is related to age, but it is not the same thing as just growing older. This is most clear during periods of rapid development, such as early adolescence, when the timing and pace of development vary widely for individuals.[20,53] Development is slow in some children and faster in others, and it occurs earlier in some children than others. Therefore, a group of adolescents who are all the same age may vary widely in development, because of differences in the timing of pubertal processes. These differences are readily apparent at ballet recitals and in gym classes grouped according to age in early adolescence. Some 12-year-old girls look very grown up, whereas others still look like little girls.

Maturing early can cause problems or advantages, depending on the context. Early-maturing girls who become involved in dating older boys who are drinking at parties may experience trouble. Early-maturing athletes in sports where strength or height is an advantage may benefit in their sport from early maturation. If teammates encourage drinking, however, then the advantages of success on a team may be undermined by the hazards posed by early drinking.

There are normative (typical) patterns of development that are characteristic of a species and often the gender group of the organism. In normal development, human infants learn to walk and to talk during the first few years of life and reach sexually mature form during the second decade of life, as a result of pubertal pro-

cesses. Girls typically enter and complete the growth spurt of puberty earlier than boys do. On average, boys grow to be taller than girls, although they reach peak growth velocity later, and they also end up considerably stronger than girls.

In the case of behaviors (such as alcohol use) that are legally proscribed among children but accepted among adults in many societies, it is important to distinguish between normative patterns of use and acceptable patterns of use. Alcohol use is normative at some point in development among youths or adults in many societies and cultural groups around the world; however, alcohol use often occurs earlier than the age of legally or socially accepted use. It is not normative or acceptable for young children to drink alcohol in most societies. Alcohol use typically becomes acceptable and common sometime during the end of the second decade or the beginning of the third decade of life in drinking societies.

Human development can be described in terms of particular domains or levels of functioning or change (eg, brain development, language development, social development, and puberty) or in terms of major eras of development (eg, prenatal period, infancy, and adolescence). Changes also can be described in relation to developmental tasks and issues characteristic of a given period (eg, school achievement, identity, autonomy, and rites of passage) or changing developmental contexts (eg, home, peer groups, preschool, schools and classrooms, and college).

What Is Changing in Development?

Many kinds of changes can be observed in development; there are changes in form, function, organization, and context. There are changes in the structure, function, and organization of the brain and changes in appearance, strength, language, self-control, attitudes, motivation, how individuals spend their time, where and who they spend it with, and expertise. Many developmental scientists describe the major kinds of changes that occur over time, particularly in the first 3 decades of life, in terms of changes in context, developmental processes or behavior, and developmental tasks. These contexts, processes, and tasks are often described for particular age periods bounded by important transitions, such as birth, school transitions, and puberty.

The most common categories marking developmental time periods are probably the following: prenatal development (conception to birth), early childhood (birth to ~5 years of age, including infancy, toddler, and preschool periods), middle childhood (from school entry to the beginning of puberty, ie, ~4–5 years through ~8–10 years of age), adolescence (early, middle, and late, often encompassing secondary school and the second decade of life, ie, ~8–10 years through ~18–20 years of age), and the transition to adulthood (~18–25 years of age). The boundaries of developmental eras are not fixed, for multiple reasons, including the following: development itself is a continuous process that does not have precisely defined beginning and ending points; there are many individual differences in the timing and pace of change; and there are cultural, national, and historical differences in the definitions of these developmental periods and in the timing of major transitions, such as when school begins. Broad cohort changes in developmental timing also occur for multiple reasons, including changes in diet, exercise, contexts, and cultural practices. For example, it has been widely noted that milestone markers of pubertal development are occurring at earlier ages in modern societies, whereas entry into full adult status has been delayed.[53] As a result, adolescence or the time between childhood and adulthood has increased, whereas the middle childhood years have decreased. Some developmental theorists have argued that a new epoch of development between adolescence and adulthood, sometimes termed "emerging adulthood," has been created by the combined influences of biological and societal changes that have produced earlier physical maturation and later adult status.[60]

As contexts change, the nature of supports, challenges, and complexity of life for individuals often changes. As children grow older, they spend less time at home and with parents and more time with peers, in school, and in the community. Monitoring by responsible adults also varies across contexts. The opportunities for observing alcohol use and access to alcohol vary across contexts in relation to age and development.

The contexts in which children spend their time change over the course of individual development and also over historical time. These contexts include physical environments (eg, home, playground, school, city, and farm), relationships (eg, family and peer groups of various kinds), cultural groups (eg, ethnic, religious, and social), and media or virtual environments (computer games, Internet, music, radio, and television).

In a living system as complex as a human individual, development involves a variety of changes across many levels. Vulnerabilities, risks, supports, protective influences, and contexts all change and, from their complex interplay, the observable measurable patterns of an individual's life and behavior emerge. It is tempting to describe the behavior of an individual as though it resulted solely from the motives, thoughts, desires, and actions of the individual observed. However, individual behavior carries influences from many past interactions within and across persons and contexts, at many levels of interaction. Moreover, current behavior is often constrained or afforded by current contexts and circumstances. Current alcohol use is influenced by availability, price, cultural and subcultural norms, adult monitoring (both that institutionalized via community law enforcement and school rules and that performed at the family level), and peer reinforcement, as well as by individual motives, desires, expectancies, values, and vulnerabilities.

Significance of Developmental Tasks

Throughout the world, parents and other adults have developed expectations and standards about what children should be doing to move toward successful roles in the family and society, often called developmental tasks.[61] Children come to share these expectations (and sometimes rebel against them). Some of these develop-

TABLE 2 Examples of Developmental Tasks

Early childhood
Attachment bonds with caregivers
Talking and learning the language of the family
Compliance with simple commands of adults
Middle childhood
School adjustment and academic achievement (eg, learning to read, to write, and to multiply)
Getting along with peers (eg, acceptance and making friends)
Rule-abiding behavior at home and at school
Adolescence
Academic achievement (more-advanced topics; graduating from high school)
Making and maintaining close friends
Law-abiding behavior in society
Emerging or early adulthood
Higher education or work attainment
Establishing romantic relationships and responsible sexual behavior
Responsible parenting (when one becomes a parent)

mental tasks are physical milestones, and many are social achievements. Some are universal and others are highly specific to a culture or region. Judgments based on these achievements are rendered by parents, self, and society regarding how development is proceeding and how it will proceed in the future. Table 2 provides examples of widely held developmental task expectations from early childhood to early adulthood.

In early childhood, adults expect children to learn to communicate in the language of their group, to walk, to obey simple rules, and to listen to adults. In most societies, children 6 or 7 years of age are expected to go to school, to behave appropriately, to learn to read, to write, and to perform arithmetic, to get along with others, and to show respect for authority. As children become adolescents, academic/work expectations increase in complexity and responsibility, youths are expected to learn and to follow the rules and laws that govern conduct in adult society, and they begin to learn about responsible dating and romantic social conduct in their community and culture. Learning to drive a car and passing a driving test are milestones for many youths, as are rites of passage involving acceptance as a committed member of a religious community. Many parents also consider it important for a child to contribute to the family or community through chores or good deeds, or at least not to destroy and to harm others or community property. Many of these expectations are codified in religious texts and early writings about the education of children, and they also are evident in screening measures for healthy development.

Acceptable performances in these tasks represent important milestones in the eyes of the stakeholders for positive child development, including parents, teachers, other community members, and children themselves. Failing in these domains by not meeting expectations may have serious consequences for children's current and future opportunities, peer reputation, social support, self-esteem, and relationships with their parents.

Alcohol may interfere with or facilitate developmental task achievement in multiple ways. Alcohol use by adults who play a key role in child development (eg, parents and teachers) can undermine the achievement of developmental tasks by the children in their care. In addition to prenatal or postnatal exposure to alcohol, alcohol use by adults can interfere with parenting, contribute to poverty, increase the risk of exposure to deviant peers, and in other ways increase the general level of adversity and risk faced by a child.

Alcohol use by children may have lasting effects on competence in age-salient developmental tasks that represent the foundation on which progress in future tasks depends, by interfering with school attendance or concentration, by ruining relationships, and by potentially damaging brain function or altering brain development. However, alcohol use that is acceptable in society and facilitates social functioning (perceived or actual) may have positive influences on developmental tasks. It is crucial to know how alcohol use alters the achievement of developmental tasks, because success or failure in these tasks plays such a salient role in individual development and in the future of a community.

In societies in which alcohol use is pervasive and widely accepted behavior for adults, it could be argued that appropriate alcohol use itself is an important developmental task.[48] It is not clear whether parents approach the issue of responsible alcohol use (whether they view this as abstinence or socially appropriate use) as a developmental task for their children. If they do, adults should actively teach their children responsible adult use or prepare them with the skills to achieve responsible adult use (or to achieve abstinence).

Developmental Transitions and Scaffolding

Windows of vulnerability and opportunity have been noted in development, often reflecting periods of particularly concentrated change in individuals, their contexts, and interactions of individuals and contexts.[53,54,56,57] In biological and cultural evolution, supportive roles probably coevolved with these windows of vulnerability. In developmental theory, scaffolding refers to the supports and guidance provided by parents, mentors, or organizations to help children function effectively beyond their independent capabilities or despite their vulnerabilities.[62] Vygotsky[62] popularized this idea in his theory of learning, particularly in the concept of a zone of proximal development, referring to the range of behavior of which a child is capable when supported by others, particularly teaching adults.

Transitions into school, into adolescence, out of the home for the first time, into college, into marriage or parenthood, and into other new situations have been viewed as periods of vulnerability or opportunity, when much of an individual's life is in flux. Families, religions, and societies often provide young people with extra support during these transitions, in the form of extra attention, rituals, activities, or structured experiences to support successful transitions.

There is some concern in contemporary US society that children are not being provided with the level of support or scaffolding that they need to make successful transitions into adolescence and adulthood.[53,56,57] In the case of alcohol use, there are specific concerns regarding

insufficient monitoring of young people and inadequate support for young adolescents who are maturing earlier and encountering increasing risks for alcohol use in diverse ways, including media exposure, disrupted families, and increased alcohol use among deviant peers.[20,53]

Historical Changes in Development and the New Maturity Gaps

As noted above, historical changes occur in the timing of physical and social development and in the timing of transitions to new contexts.[53,63,64] Children in modern industrialized societies grow taller and mature earlier than did young people in the same societies in earlier times, probably because of changes in diet and health in modern societies. At the same time, it takes much longer for young people to become established adults in contemporary societies, taking on full adult responsibilities in work and family life. Education and training last longer than they did previously, and more education is needed for many job opportunities. Young people often marry later, if at all, and have fewer children than did the generations of their parents and grandparents. This combination of earlier sexual maturity and delayed adult status has extended the period of development termed adolescence (often referring to the period from the beginning of puberty to the establishment of adult roles and status). It has also created what may be the widest "maturity gap" in human history (the time between reaching sexual maturity and reaching social maturity).

There is another kind of maturity gap that also might have been created by the earlier onset of puberty and sexual maturation. As young adolescents become sexually mature, with hormonal and related brain changes in reward systems and motivation, there seems to be an increase in risk-taking behaviors and changes in emotional intensity, but there is little evidence that the executive control systems associated with higher cognitive processes are maturing any earlier.[53] The executive functioning gains that track brain development and changes in brain connectivity in the first, second, and third decades of life do not seem to have accelerated. Therefore, a maturity gap might have emerged between the early-maturing changes of emotional/motivational systems, perhaps related to earlier onset puberty, and the later-maturing cognitive executive control functions provided by more slowly developing neurocircuits.[53,54,58] Scientists in the MacArthur Network on Adolescence and Psychopathology compared the results of this gap to "starting the engines without a skilled driver."[53]

As these adolescent maturity gaps widen, the developmental period that used to be called middle childhood or "latency" (the time between the beginning of school and puberty) has decreased. While writers lament the loss of childhood or describe the "hurried child,"[65] capital markets and media are responding rapidly to younger pubescent children, with clothing lines for "tweens" and special Internet sites, movies, and other products tailored to children in elementary school with the interests of adolescents.[53,66] There is growing concern that tweens may acquire the attitudes and behaviors of their older peers in relation to alcohol as well as clothing and dance moves.[33]

Development or Experience?

Some changes over the life course are the result of experience, some are the result of development, and some result from both. Learning to drive a car requires experience, but driving skills also depend on physical size, reflexes, judgment, and other aspects of human behavior that develop as the brain and body mature. A 10-year-old child with 2 years of driving experience is not likely to be the same kind of driver as an 18- or 25-year-old adult with the same experience, because the average capabilities that typical 10-, 18-, and 25-year-old individuals brings to the experience are so different (biologically, socially, and cognitively). Moreover, a novice driver is probably less safe driving on ice and snow than is an experienced driver. State driver-licensing agencies, insurance companies, and rental car companies all implicitly encode developmental differences in their rules and prices. They base those rules on age and passage of a skill-based driving test, rather than developmental maturity, because it is easier to document age and skills than developmental readiness. Similarly, laws allowing youths to purchase or to drink alcohol are based on presumed maturity according to age, because this is easier to assess. When parents allow their own adolescent children to drive the family car is a different matter and is very likely to be influenced by what the parents know about that particular child in terms of maturity, driving skills, risk-taking behavior, and driving history and also their assessment of the particular situations (eg, current weather conditions, reasons for driving, who is going to be in the car, and time).

One of the most important roles of adults in the socialization of children and youths is to provide supports until the immature or novice individual is able to do something consistently without support. Parents also monitor the lives of their children for danger. Parents have long known that development can be uneven, creating hazardous maturity gaps. Toddlers who have just learned to walk and adolescents who have just learned to drive have in common a surge in risks for accidents related to a disjunction between the capabilities of doing something new that is exhilarating and the judgments about when, where, and how fast to do it that come from experience. It is the job of adults to scaffold these gaps with the supports (or monitoring) necessary to protect the young person from harm but foster the development of adaptive competence.[56,57] Adults can provide external structures and executive functioning to children, in the form of monitoring, rules, discipline, and organized activities. Graduated driver licenses in some states attempt to reduce the risks of novice driving by adolescents by setting rules about when, with whom, and where beginning drivers can drive.

Interplay of Genes and Environments in Development

The traditional notion of "nature versus nurture" gradually has been replaced by the recognition that genes

and environments do not influence development independently but rather interact inextricably in development. Epigenesis is an important idea in the contemporary understanding of the ways in which genes and environments in dynamic interaction produce development.

The idea of epigenesis came originally from embryology, referring to the processes by which 1 kind of cell differentiates into specialized cells and systems in a developing organism.[67] More specifically, epigenesis refers to environmentally influenced control of gene transcription that is long-lasting and can be inherited across cell divisions over the life span of the individual.[68] This term has come to refer more broadly to the dynamic and complex processes by which genes and environments interact over the life course to produce a functioning and adapting individual.[69] These dynamic processes explain how the same genes can result in widely varying outcomes, depending on gene regulation (which genes are on and off when) and other kinds of gene-environment interactions, with the result that the lives of even monozygotic twins diverge over the course of development.

At a molecular level, the best studied means of epigenetic control is through DNA methylation, a process by which the addition of methyl groups to promoter/regulatory regions of DNA serves to suppress the transcription of genes regulated by those regions.[67,69–71] This environmentally influenced "regulation through repression" increases progressively during development as cells become progressively locked into differentiated states. Through such gene repression, environmental influences can be imprinted on DNA, resulting in lasting alterations in phenotype that can be passed along to daughter cells with subsequent mitotic divisions. Under some circumstances, epigenetic regulation may be transmitted from parents to offsprings, findings reminiscent of the Larmarckian notion of acquired traits being inherited across generations.

Environmental factors induce epigenetic regulation through alterations in the microenvironment around specific cells, including growth factors, neurotransmitters, and energy supplies, as well as circulating levels of hormones, cytokines, and viruses. These aspects of the microenvironment may be influenced in turn by characteristics of the external environment that range widely from stressors to nutritional status and maternal care. For instance, provision of methyl group-rich supplements (eg, folic acid and vitamin B_{12}) in the diet of pregnant and lactating mice induced increases in DNA methylation in their offspring, with the offspring also exhibiting lower incidence rates of obesity and diabetes mellitus, attenuated tumor susceptibility, and a darker coat color.[72] As another example, rat pups raised by mothers who exhibit low levels of maternal licking and grooming have greater levels of methylation in the promoter region of the gene coding for a stress hormone receptor (the glucocorticoid receptor). Because of this methylation-induced suppression of the *GR* gene, offspring of low-licking mothers have lower levels of glucocorticoid receptor expression in the hippocampus, a region where glucocorticoid receptors form part of a feedback system terminating stress responses. Functionally, these offspring are more reactive behaviorally and neurally to stressors and take longer to recover from stressors, compared with offspring of high-licking mothers.[73]

Through environmentally induced epigenetic regulation, lasting effects of the environment can be exerted on the propensity for particular genes to be expressed. Research has just begun to relate specific environmental events to particular epigenetic changes even in simple animal models, much less in humans. However, research provides evidence that epigenetic regulation is environmentally influenced and increasingly expressed during development in humans, as in laboratory animals. For instance, studies of epigenetic regulation in identical twins revealed epigenetic differences between twin pairs in middle age that were not apparent early in life, as well as more epigenetic variation between twin pairs who had spent less time together in their lives, relative to pairs who had been associated more closely.[74] Epigenetic regulation through methylation-induced repression "represents an entire level of cellular information on top of the DNA sequence"[68] and provides a critical link between genes and the environment as phenotypic expression is elaborated dynamically during development.

Genes respond to environmental signals as well as to other genes, and this responsiveness explains some of the extraordinary variation in human development and adaptability. Moreover, because no 2 organisms could possibly have exactly the same experiences, the course of development is probabilistic. Development is also constrained by the human genome and an individual's DNA; only genes that are present can be regulated. Humans do not mature into mice, and identical twins are likely to resemble each other in many ways, no matter how different their nurturance may be.

There is increasing attention to the epigenetic features of neural and behavioral development,[69,75] including complex behavior such as alcohol use.[76] Of particular interest here is emerging interest in specific genes that may interact with experience over the course of development to increase or to decrease the likelihood of alcohol use and AUD and interest in the effects of ethanol exposure on gene expression across development. There is keen interest in identifying the chemical processes, brain functions, and behaviors that are serving as intermediaries of gene-environment interactions, because the genes of 1 person do not interact directly with the genes of other people or directly with the external environment. Behaviors that may serve such as intermediaries or "endophenotypes"[67,69] of interest include poor impulse control and sensation-seeking. These behaviors might be influenced by genes and poor environments in the course of development and eventually moderate the likelihood of a teenager accepting an offer to go drinking with a friend.

An example of gene moderation of drinking behavior is provided by functional polymorphisms in the alcohol-metabolizing enzymes alcohol dehydrogenase and mitochondrial aldehyde dehydrogenase. Individuals (of Asian descent) with 1 or 2 specific variants at these alleles

have lower risks for alcoholism, which suggests moderating effects.[77] These results represent 1 of the most thoroughly documented examples of possible protective effects for specific populations.[78]

Distinguishing gene-environment interactions in human development is extremely difficult, for reasons of complexity as well as ethics. Therefore, animal models offer an important method for learning about development and alcohol.

Animal Models of Development

Development from birth to maturity consists of a range of ontogenetic transitions and challenges for both developing humans and developing young of other species. For instance, although adolescence is sometimes considered a developmental phase specific to humans, young from other mammalian species similarly undergo an adolescent transition from a state of dependence to the relative independence of adulthood, during which they need to attain skills to permit survival away from parental caretakers and to acquire the social circumstances to permit propagation of the species.[79] Research has revealed notable coherences between fundamental neural, hormonal, and behavioral characteristics of human adolescents and adolescents from other species, ranging from primates to rodents.[54,58,79] For example, to the extent that across-species data are available, considerable similarities are seen between humans and other mammalian species in terms of the brain sculpting that occurs during adolescence; such transformations are particularly pronounced in mesocorticolimbic regions of the forebrain.[79] Moreover, certain adolescent-characteristic behaviors, including increases in risk-taking and sensation- or novelty-seeking[80,81] and an increased focus on social interactions with peers,[82,83] are evident not only for human adolescents but also for their counterparts in other species.

Behavioral and neural similarities evident among adolescents from a variety of species seemingly represent, in part, highly conserved developmental traits of adaptive significance. Risk-taking has been suggested to increase the probability of reproductive success for male individuals of a variety of species, including humans,[84] as well as to facilitate the emigration of sexually maturing adolescents away from genetic relatives,[85] thereby avoiding inbreeding and the lower viability associated with inbred offspring.[86] Such potential adaptive significance may explain why risk-taking has been highly conserved in adolescence despite its high cost, with risky behaviors being primary sources of the elevated mortality rates evident among adolescents of many species, including humans.[87] Contributing to adolescent risk-taking are the propensity to drink substantial amounts of alcohol, a tendency seen in human adolescents[8] and adolescents of other species,[88] and the various adverse consequences resulting from that drinking.[21,89]

Considerable similarities seen across species in neural, behavioral, and hormonal characteristics of these developmental transitions provide sufficiently promising evidence of face and construct validity to support the judicious use of animal models of adolescence and other developmental transitions.[79] Despite some across-species similarities, no other species demonstrates anything near the full complexity of human brain, behavior, and cognition seen at any time of life. Many critical areas of human development (eg, the impact of advertising on alcohol intake and ethnic differences in acceptability of alcohol use across age and gender) are not amenable to study with animal models. The appropriateness of animal models differs considerably according to the aspect of human development to be modeled. Although animal models typically provide at best only simplified assessments of the dynamic interrelationships among genetic factors, brain function, behavior, and the environment during ontogeny, empirical studies with animal models can be used to address key issues that are ethically inappropriate or challenging to examine in human youths. For example, animal models can be used to examine the ontogeny of sensitivity and tolerance to ethanol, to determine potential long-lasting neurocognitive and behavioral consequences of early alcohol exposure, and to assess the impact of expression changes in particular brain regions or puberty-associated hormonal alterations on age-specific behaviors and environmental sensitivities. Although simplified and restricted in which domains can be modeled, research using animal models can extend findings and fill difficult-to-address gaps in the human literature, contributing to our understanding of the dynamics of the brain-behavior-environment interrelationships that lead to excessive alcohol consumption in adolescence and the potential lasting consequences of that consumption.

PRINCIPLES OF DEVELOPMENTAL PSYCHOPATHOLOGY

Focus

The conceptual framework of the National Institute on Alcohol Abuse and Alcoholism advisory group to the Underage Drinking Research Initiative was grounded in developmental psychopathology, which has become the prevailing perspective for understanding and addressing behavioral problems and disorders in multiple disciplines.[90–93] At the heart of this perspective are a set of core assumptions widely held by developmental psychopathologists and derived in large part from common features of contemporary developmental theories.[91,94–101] These principles guided the organization and recommendations of the working group, as set forth in articles in this supplement, as well as in other publications.[34] In this section, we highlight these guiding principles (adapted from the work of Masten[93]) and their implications for addressing the problem of underage drinking.

Developmental Principle

Behavior emerges in a developing organism and therefore a developmental perspective is essential for understanding, preventing, and treating the causes, problems, and consequences associated with problematic behavior and psychopathological conditions. To understand or to attempt to change behavior in a person (or animal), a developmental approach is necessary, particularly

during the early years of development, when there are periods of concentrated or rapid transformation. This principle has numerous corollaries. Development arises from complex interactions and coactions among genes, internal systems, people, and contexts at multiple levels.[69,102] Models that try to incorporate multiple aspects of these interactions resort to compound terminology to convey the multiple levels and dynamic nature of development, such as "biopsychosocial systems model," "neurobehavioral development," or "gene-environment interplay." Different DNA sets, different gene expressions, and different experiences of development all combine to produce variations among people, including identical twins.

The development of snowflakes provides a simple model of how context matters for development. Individual snowflakes develop from simple molecules into infinite variations on a 6-sided theme because the exact conditions in which any 2 snowflakes develop are never the same (and snowflakes do not skip school, go to the mall, break up with a romantic partner, search the Internet, drive drunk, or in myriad other ways influence the nature of their own developmental conditions and experiences, as do human individuals).

The course of individual development can take many directions. There are multiple pathways toward and away from problems and disorders, multiple causes, multiple paths to the same disorder, and different outcomes of the same risk exposure. The concepts of equifinality and multifinality in developmental psychopathology refer to multiple pathways leading toward the same disorder or multiple outcomes from the same risk factor; equifinality refers to multiple pathways with the same outcome, and multifinality refers to multiple outcomes or branching paths from the same beginning point.[95]

Development shows periods of continuity and orderly change, but there also are periods of discontinuity and transformation. Some transformations involve developmental progressions and cascades, in which 1 behavior leads to another or 1 behavior leads to a change in context, which in turn influences behavior. Periods of rapid change and transformation create windows of vulnerability and opportunity for altering the course of development to a different developmental pathway. When systems are unstable, there is more opportunity for change, good or bad. Developmental perspectives are likely to inform the nature and timing of interventions, with the aim of interrupting developmental progressions and cascades or taking advantage of developmentally relevant leverage for change (such as peer influence).

There are likely to be multiple risks and causes to be considered in explaining alcohol use and AUD, as well as multiple roads toward and away from problems related to alcohol. Alcohol problems can develop for intact "normal" individuals and individuals whose development is impaired by some kind of illness, damage, or other nonnormality; the causes of alcohol problems among normal individuals, compared with impaired individuals, are likely to differ. People with very different genotypes and backgrounds may end up with the same form of AUD. There are likely to be multiple risky roads (not just 1 road) to some variant of AUD. Children who share the same risk factor for alcohol use problems, such as a father with alcohol dependence, would be expected to have different outcomes, varying from abstinence to limited use to dependence. Differences in genotypes, family relationships, social conditions, experiences, the interactions of these factors, and many other influences could contribute to variations in outcomes for children with the apparently same risk factor. Alcohol use can alter development in multiple ways. Predicting alcohol use, dependence, and recovery are probabilistic enterprises.[103] Gene-environment interactions are likely to be involved in causes of AUDs. Aggression and attention problems in early childhood could lead to peer rejection and reading problems, which could contribute subsequently to school dropout and affiliation with deviant peer groups that encourage substance abuse. Prevention and treatment of AUDs are likely to require attention to individual differences and multiple levels of influence. Developmental perspectives are likely to inform the nature and timing of interventions, for example, to interrupt developmental progressions and cascades, to identify developmental periods of greater viability (when levels of risk are developmentally lower and approachability is likely to be greater, such as in middle childhood), or to use developmentally relevant leverage for change (such as peer influence).[61,104,105]

Normative/Expected Principle

Psychopathological conditions are defined in relation to normative/expected development in cultural and historical contexts. The definition of behavior problems and disorders, as well as judgments about whether and how such behavior is damaging to individuals or society, depends on a basic shared understanding of normal human development, what is expected at different times, and what is acceptable or not acceptable at a particular age. There can be a disjunction between normative behavior and acceptable behavior in a social group or society, as noted above. When normative behaviors change, judgments about what is expected and what is acceptable also are likely to change.

There is normative and nonnormative underage drinking, and there are related normative expectations about underage drinking. Normative patterns and expectations about drinking change over time and vary in cultural subgroups within societies. It is possible for underage drinking to be deviant in the sense of earlier than typical or deviant in the sense of disapproval by the cultural group or society to which one belongs.

It is also possible for underage drinking to be (1) expected/normative and approved, (2) expected/normative and disapproved, or (3) unexpected/nonnormative and disapproved. The combination of unexpected/nonnormative and approved is unlikely for drinking, as in the situation of drinking by very young children, which is both unexpected/nonnormative and disapproved. Alcohol use problems and disorders involve assessments of impairment and deviance that depend on developmental task expectations for adaptive functioning that are based on age, gender, culture, and historical context.

Systems Principle

Human individuals are living systems; therefore, behavior problems and disorders emerge from complex interactions among systems within individuals and also between an individual and the multiple systems in which the life of the individual is embedded. Human individuals are complicated organisms who live and grow as a result of many interactions within the person and between the person and the environment.[99,106] Dynamic change is the nature of living, developing systems; however, living systems also maintain their own coherence, viability, and stability, even as they develop.

In developmental systems theory, epigenesis refers to the emergence of complex organisms from multiple levels of bidirectional interactions. This concept, which came from embryology, now broadly refers to all of the interactions and coactions, within and across levels, between genes, neurons, behavior, and contexts, which together and sequentially produce an increasingly organized and differentiated organism in the developing phenotype or person.[69,97] Individual development is the form that emerges from bidirectional system interactions across multiple levels, constrained by the nature, timing, context, and other features of these interactions.[97] It is interesting to note that it is only in recent years that the bidirectionality of the developmental systems view has been widely appreciated, although the concept of epigenesis has been present for a long time. Vertical bidirectionality is now recognized along with horizontal bidirectionality. There is growing attention to top-down as well as bottom-up influences in the interactions across levels of analysis.[102] For example, there is intense interest in the role of experience in influencing gene expression, as well as the bottom-up effect of gene expression on development.[67,75] Because of these interactions and complexities, development is not fixed or certain but probabilistic. Human individuals are self-regulating in many ways at multiple levels, but much of their self-regulation develops as children mature. Infants are highly dependent on caregivers for multiple aspects of regulation, including temperature, food, arousal level, and sleep. Over the course of childhood and adolescence, self-regulation improves and becomes less dependent on caregivers and more dependent on the self and peers.

As humans develop, they become more complex and their behavior is more differentiated in relation to the context. Bronfenbrenner[107] described the ecology of human development in terms of the larger systems that influence human development, many extending well beyond the family. People interact with each other and with the larger systems in which they live, including school systems, peer systems, social systems, and even the solar system (which influences behaviors such as sleep). Some influences of systems outside the family on individuals are direct (eg, peers interacting with a child or jet lag), and others are indirect (eg, the father is fired from his job and becomes depressed and irritable toward the child).

Underage drinking is likely to be influenced in multiple ways by multiple genes and their coactions, individual differences in personality and cognition, family functioning, community values and supports, media messages, friends, peer group norms, romantic partners, school norms, opportunities, historical trends in economics or culture, religious beliefs, and social policies, among many other kinds and levels of system interactions. Underage drinking and AUD emerge from the complex interplay of individuals and contexts at multiple levels over time. The salience of a particular level of interaction may vary during development; for example, peer influence on alcohol use becomes salient during late childhood or early adolescence, whereas parental influence begins much earlier. Interventions to change underage drinking could be directed at many aspects of these interacting systems, and it is clear that timing matters.[108]

Multilevel Principle

Psychopathological processes occur within and across multiple levels of functioning, from molecular or genetic to family, peer, cultural, or solar systems; therefore, multiple disciplines and multiple levels of analysis are often required for a complete understanding of causes and consequences. Many levels of interactions need to be considered to understand or to change the behavior and development of an individual, from molecules to media. The title of the influential volume *Neurons to Neighborhoods: The Science of Early Childhood Development*[109] captures the importance of a multilevel accounting of development. There is growing interest in delineating the processes that link levels, that is, multilevel dynamics in developmental psychopathology.[102]

A full accounting of the causes, consequences, and methods of preventing or decreasing underage drinking would include multiple levels of analyses and their interactions, requiring the collaborative efforts of multiple disciplines. Extensive research pertinent to underage drinking is completed or underway.[32,34] There is multidisciplinary research on genetic vulnerability, dispositional vulnerabilities, gene expression, gene-environment interactions, brain development, age-related ethanol sensitivities, family and peer processes, cognitive development, general and specific risk/protective factors (for onset, progression, desistance, and severity), the roles of media, society, culture, and religion, and interventions that do and do not show promise. Interventions to change individual behavior related to alcohol use or dependence or to change systems that interact with individuals can be directed at many levels, at different systems, and at system interactions. Integrating good science and theory across multiple levels provides a better basis for designing more-effective interventions to prevent and to ameliorate the occurrence and consequences of underage drinking.

Agency Principle

The human organism is an active agent in development. Human individuals play an important role in their own development, through, for example, their behavior, their influence on other people, their choices, the risks they take, the peers they choose as friends, the media

they choose to engage, and what they choose to ingest and when. In other words, children are active agents in their own lives, not passive receivers of experience, education, or socialization. Children take an active role in the shaping of their own lives, by their actions and by their reactions and interactions with other people. Moreover, as children grow older, their agency increases along with their growing capacity for self-control and planning, problem-solving abilities, mobility, and access to other people and the media. Fourteen-year-old youths have more capacity to influence the direction of their lives than do 14-month-old children, because they have more capacity for problem-solving, more independent mobility, more choice about who they spend their time with and how they spend it, and better understanding of options, choices, and the consequences of their actions.

Underage drinking arises not in a passive organism but in one that is thinking, motivated, self-regulating, and in many other ways actively and dynamically interacting with the people and objects in the environment. The development of self-regulation, planning, motivation, decision-making, risk-taking, friendship, and other manifestations of agency are important aspects of an understanding of the development of alcohol use and its consequences. It also is important to understand how alcohol use may alter the processes of agency in development, altering the quality or nature of decision-making or actions that could have great consequences for the future.

Mutually Informative Principle

Variations in adaptation, including successful and unsuccessful development, normal and deviant behavior, and resilience and maladaptation, are important for understanding pathological and normal development. Studies of deviant and normal development are mutually informative, which means that the study of normal development informs the study of abnormal development, and vice versa. In the case of underage drinking, it is important to understand who does not drink as well as who does, pathways to abstinence and appropriate drinking as well as roads to problematic drinking, protective factors as well as risk factors, the causes of desistance and recovery as well as the causes of initiation and progression, positive as well as negative effects, and outcomes of underage normative drinking as well as nonnormative drinking.

Longitudinal Principle

Prospective longitudinal studies are essential for understanding the interplay of the systems that influence development and the many possible pathways toward and away from psychopathological conditions. Longitudinal studies are crucial for understanding developmental problems and disorders. Cross-sectional data can be misleading in multiple ways, including the masking of dramatic turning points and individual differences in the timing and pace of development. Similarly, studies that gather retrospective reports to generate conclusions about development and the pathways leading to disorders are risky and require confirmation. Conclusions based on such evidence must be regarded only as plausible hypotheses until they are confirmed in prospective studies.

Longitudinal data are necessary to study changes within individuals, to study progression from one behavior to another, and to determine whether intervention effects persist over time. For many reasons, preventive interventions and effective treatments need to be designed and evaluated from a developmental/longitudinal perspective.

Longitudinal studies are important for studying antecedents and consequences of alcohol use and AUDs, for elucidating the early signs of trouble, and for ascertaining whether interventions work and whether the effects persist or dissipate. AUDs could be classified, assessed, and diagnosed from a longitudinal/developmental perspective. This approach is likely to be more fruitful for understanding and addressing AUDs than an approach that considers only current or very recent behavior.

CONCLUSIONS

Developmental patterns in alcohol use, consequences, predictors, and moderators present a convincing case in favor of a developmental approach to underage drinking. Underage drinking is a complex issue, deeply embedded in the developmental, multilevel, dynamic processes operating over time within and between individuals and their contexts. This complexity presents a challenging agenda for those who seek to prevent this problem and to reduce the burden of its effects on individuals, families, and communities. Nonetheless, rapid advances in developmental theory, knowledge, and technologies at multiple levels of analysis (from measuring genes to imaging the brain in action to statistically analyzing growth and change) are making it feasible to examine the processes of development in relation to many problems of great public concern.[102,110] Advances in developmental science across multiple disciplines are opening new horizons for research on underage drinking, conceptualized as a developmental problem, with the potential for innovative advances in developmentally informed and developmentally strategic solutions. The persuasive *Surgeon General's Call to Action to Prevent and Reduce Underage Drinking*[111] underscores not only the importance of the task but also the quintessentially developmental nature of the action agenda. The time has come for a developmentally informed and sensitive research agenda regarding the causes, consequences, prevention, and treatment of underage drinking.

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SUPPLEMENT ARTICLE

Early Developmental Processes and the Continuity of Risk for Underage Drinking and Problem Drinking

Robert A. Zucker, PhD[a,b], John E. Donovan, PhD[c], Ann S. Masten, PhD[d], Margaret E. Mattson, PhD[e], Howard B. Moss, MD[f]

[a]Department of Psychiatry and [b]Addiction Research Center, University of Michigan, Ann Arbor, Michigan; [c]Western Psychiatric Institute and Clinic, University of Pittsburgh, Pittsburgh, Pennsylvania; [d]Institute of Child Development, University of Minnesota, Minneapolis, Minnesota; [e]Treatment and Recovery Research Branch, National Institute on Alcohol Abuse and Alcoholism, Bethesda, Maryland; [f]Office of the Director, National Institute on Alcohol Abuse and Alcoholism, Bethesda, Maryland

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ABSTRACT

Developmental pathways to underage drinking emerge before the second decade of life. Many scientists, however, as well as the general public, continue to focus on proximal influences surrounding the initiation of drinking in adolescence, such as social, behavioral, and genetic variables related to availability and ease of acquisition of the drug, social reinforcement for its use, and individual differences in drug responses. In the past 20 years, a considerable body of evidence has accumulated on the early (often much earlier than the time of the first drink) predictors and pathways of youthful alcohol use and abuse. These early developmental influences involve numerous risk, vulnerability, promotive, and protective processes. Some of these factors are not related directly to alcohol use, whereas others involve learning and expectancies about later drug use that are shaped by social experience. The salience of these factors (identifiable in early childhood) for understanding the course and development of adult alcohol and other drug use disorders is evident from the large and growing body of findings on their ability to predict adult clinical outcomes. This review summarizes the evidence on early pathways toward and away from underage drinking, with a particular focus on the risk and protective factors and the mediators and moderators of risk for underage drinking that become evident during the preschool and early school years. It is guided by a developmental perspective on the aggregation of risk and protection and examines the contributions of biological, psychological, and social processes within the context of normal development. Implications of this evidence for policy, intervention, and future research are discussed.

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Key Words
aggregation of risk, susceptibility, alcoholism, early childhood risk

Abbreviations
SUD—substance use disorder
AUD—alcohol use disorder
ADHD—attention-deficit/hyperactivity disorder
COA—child of alcoholic
5-HT—serotonin

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Address correspondence to Robert A. Zucker, PhD, Addiction Research Center, University of Michigan Medical School, Rachel Upjohn Building, 4250 Plymouth Rd, Ann Arbor, MI 48109-5740. E-mail: zuckerra@umich.edu

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SEVERAL BASIC THEMES provide guidance for developing a perspective on the timing, processes, and experiences in earlier life relevant to the acquisition, use, and problem use of alcohol. First, much of the causal structure underlying youthful alcohol use and abuse is not specific to alcohol and in particular is either directly or indirectly the result of the development of externalizing and internalizing behaviors.[1–3] Family history of antisocial behavior, child maltreatment, and other negative life experiences are well-established precursors of later alcohol problems and alcohol use disorders (AUDs). These predictors are nonspecific risks for alcohol involvement, because they also predict a broad array of other problematic outcomes, including problems of undercontrolled or dysregulated behavior such as conduct problems, impulsivity, attention problems, aggressiveness, antisocial personality disorder, and depressive spectrum disorders.

Second, at the same time that children develop behavior problems not specific to alcohol, they acquire knowledge about the existence of alcohol as an object in the social environment. Learning about alcohol includes developing beliefs about alcohol on the basis of an awareness of its special characteristics as a drug (how it produces changes in cognition, feeling, and behavior) and its place in social relationships (who uses it and why) and, ultimately, developing expectancies about its use. To a large degree, these cognitive variables regulate when and how much consumption takes place and shape recognition of the appropriate circumstances for desistance from use.

Third, in tandem with the development of behaviors and beliefs related to alcohol, other developmental changes that influence behavior occur within the individual and in the social context. As the brain is developing, consumption of beverage alcohol interacts with changing brain structures and functions related to appetite, reward, planning, and affective and behavioral control. These neurobehavioral processes proceed from the interplay of genes and experience, in many cases operating through intermediate endophenotypes.[4] The latter are traits or biological indicators that are genetically simpler than the diagnostic phenotype and are more proximal to the genetic influence but are part of the vulnerability pathway for the disorder.

Fourth, social environmental influences in the family, peer group, school, community, and larger macrosystems of society also play a significant role in modeling alcohol intake and the contexts of acceptable use. At the cultural

level, social norms specify the age grades and social roles within which alcohol use/heavy use is acceptable and the situations in which it is unacceptable, and these social norms have been incorporated into legal norms that specify the appropriate sanctions for violations of alcohol use regulations.

Fifth, this multilevel dynamic interplay of biological, psychological, and social processes shapes not only risk but also normal development.[5] Normal development has the potential to alter risk parameters and pathways of behavior profoundly and even to move at-risk children into a different, nonproblem pathway. The present review focuses on processes of risk for underage and adult drinking that emerge before adolescence (generally defined as before the second decade of life). We recognize that puberty may be well underway for some young people <10 years of age; however, our focus is on early and middle childhood and processes that generally precede pubertal development and the social changes that characterize adolescence.

BRIEF DEVELOPMENTAL PORTRAIT OF THE UNDER-10 PERIOD

The years before 10 years of age encompass all of the growth and development from conception to the beginnings of adolescence. These years are often divided into prenatal development, infancy, early childhood or the toddler and preschool years, and middle childhood. Key contexts after birth include attachment relationships, the family and home, the family neighborhood, day care, and preschool settings, kindergarten and the early primary grades of school, playgrounds, peer play groups, school classrooms, and, increasingly, the media worlds afforded by television, music, electronic toys and games, computers, and movies (Table 1).

The pace of development during the first 10 years of life is astonishing, from conception to fetuses to children who can manipulate their parents, play card games, build elaborate castles from sand or blocks, cruise the Internet, hit a baseball, gossip, read and write stories, understand other people, and feel guilty about breaking the rules. The human brain undergoes remarkable growth and change, in structure, organization, and function, over this period. During these years, fundamental self-regulation and social regulation systems develop, including the regulation of sleep, stress, and behavior.

During these years, many of the most-basic human systems for adapting to the world are developing, including ways we perceive and learn, solve problems, communicate, regulate emotion and behavior, respond to stress, and get along with other people. What we call "personality" is taking shape as a result of individual differences in genetically influenced temperament, experience, and their complex interactions over time. All of these adaptive systems continue to change with development and experience throughout the life course. By 10 years of age, however, many fundamental adaptive systems of the human organism, both those embedded in the person and those embedded in relationships and connections to the social world, have assembled and exhibit some stability. Children arrive at the transitions and challenges of adolescence with the personality and human and social capital they have accumulated in childhood, as well as their record of achievements and failures in meeting the various developmental tasks of childhood. Therefore, it is not surprising that many of the influential factors associated with early drinking emerge and are shaped during the first decade of life.

TABLE 1 Developmental Periods, Transitions, Contexts, and Tasks of the Under-10 Period

Developmental periods (and key transitions)
Prenatal (conception)
Infancy (birth)
Toddler and preschool years (upright locomotion and preschool entry)
Middle childhood (transition to elementary school)
Key contexts of development
Prenatal environment
Caregiver relationships
Family
Day care
Preschool
Kindergarten
Primary grades of elementary school
Peer play and activity groups
Friendships
Media
Neighborhood
Developmental tasks and issues
Attachment
Understanding and speaking the language of the family
Understanding, speaking, reading, and writing the language of the culture/school
Sitting, walking, skipping, and other developmental motor milestones
Compliance with rules for conduct and impulse control
Toilet training
Playing with peers
Acceptance among peers in key community or school contexts
School adjustment
Learning to read

This review has 6 sections. In the first section, we describe how core developmental processes, such as behavioral and emotional dysregulation, function as predisposing risk factors for youthful alcohol use. In the second section, we review other non–alcohol-specific risk factors that enhance drinking risk. In the third section, we describe alcohol-specific risk factors in childhood that are associated with subsequent alcohol use. In the fourth section, we summarize what is known about risk and resilience developmental pathways, either toward or away from problematic alcohol use. In the fifth section, we describe briefly the next-step tasks needed for the formulation of policy in this area. In the sixth section, we outline the implications of existing knowledge for the development of focused interventions. In addition, we identify critical gaps, problems, and questions that need to be addressed as part of a new developmental research agenda for understanding and addressing the problems of underage drinking, both as problems in their own right and as precursors in the pathway to later alcohol problems and AUDs.

PREDISPOSING CHILDHOOD RISK FACTORS

This section presents findings on nonspecific factors that predict likelihood for subsequent alcohol involvement, such as behavioral dysregulation/undercontrol (including factors such as conduct disorder, attentional deficits, and aggressiveness); other childhood psychopathology; environmental influences such as family, peer, and school relationships; and precocious puberty.

Emergence of Behavioral and Emotional Dysregulation and Predisposition to Alcohol Involvement

Newborns emerge into the world with cries of greater or lesser intensity, lasting for shorter or longer periods of time, and with quicker or slower responses to the caretaking agents who attempt to soothe and to comfort them. If the comforting (feeding, handling, and being engaged by the caretaker) is sufficient, then the infant begins to display signs of satisfaction and relaxation. If it is not, then the affective expression continues. The display of emotion, its intensity, and the degree to which it is capable of being modulated are basic characteristics of the human organism for display of displeasure, discomfort, and pain on one hand and pleasure, comfort, and happiness on the other. These are basic temperamental characteristics that serve signaling (communicative) functions, facilitate social engagement, and serve as organismic motivators either to sustain current activity or to drive us to seek a change of state.[6,7] Such differences are observable even at birth and form the substructure for later, more-differentiated feelings of happiness, self-satisfaction, sadness, and anxiety.

Parallel to the emergence of emotionality and the existence of individual differences in affective expression, a developmental sequence is present for the emergence of motoric behavior and for attention. We know that there are fetal differences in activity levels even before birth, and such variations are quickly evident after birth. Infants vary in how much they move, as well as how quickly they respond to stimuli of light, sound, and touch. Some respond more quickly than others. Similarly, very early differences are evident in the degree to which children sustain focus or attention on an object and shift focus when a new set of stimuli are presented and in the amount of information they can retain. Such differences reflect the rudiments of a behavioral regulation and control system on one hand and an attentional regulation and control system on the other, which ultimately determine the ability to plan, to inhibit responses while reflecting on alternative plans, and to access a broad array of information used in deciding whether it is wiser to carry out or to inhibit a particular action. These regulation functions are essential to such basic processes as learning, planning, and forethought. When they function poorly, or when the social environment makes it difficult for them to develop (such as in homes where there is abuse and violence), social achievement and academic achievement are more difficult, and risk for substance use disorders (SUDs) is substantially elevated. In fact, one of the most prominent theories for the development of AUD and other SUDs posits the importance of a central dysregulatory trait, involving delayed or deficient development of behavioral, emotional, and cognitive regulation, in the early emergence of SUDs.[8] The dysregulation is identifiable as "difficult" temperament in infancy and early childhood and as an array of behavioral and neuropsychological deficits in adolescence. A substantial body of evidence supports the validity of this dysregulatory hypothesis.[9,10]

The processes we have described here are basic to the development of all children and are relevant to the many tasks of adolescence and adult life. Although we do not yet understand fully the mechanisms of impact of behavioral regulation and attentional control, these domains seem to be highly relevant to the acquisition and maintenance of alcohol use, as well as the progression into problem use. Given the centrality of these processes to relationships, to purposive behavior, to making choices, and to desistance, it is not surprising that they also are tied to the emergence of alcohol problems. The choice to use alcohol for the first time (ie, drinking onset) is a cognitive choice (regarding whether this is a wise act and what the consequences are of doing so at any particular time). It also is a behavioral act and is more likely to take place among young people who act impulsively and who are interested in new sensations and new experiences. Finally, it is an emotional act, driven to some degree by one's sense of satisfaction or discontent with the world as one knows it before drinking. The possibility that a drink can create a change is more attractive if one is unhappy with one's self and one's social relationships.

Substance abuse researchers have been aware of these non–alcohol-specific processes for some time, which has led to the search for the traits that underlie them. In the past 20 years, an increasing amount of evidence from longitudinal studies has identified 2 such traits that are detectable very early in life, that predict alcohol (and to some degree other drug) involvement, and that seem to be markers of an underlying genetic diathesis for early use, heavy use, problem use, and AUD. This work, coming from 6 long-term prospective studies,[11–15] provides a remarkable convergence with the genetic literature in demonstrating that externalizing (aggressive, impulsive, and undercontrolled) and to a lesser degree internalizing (anxious, sad, and depressive) symptoms appearing in early childhood are predictive of SUD outcomes 15 to 20 years after the first appearance of the non–drug-specific behavioral risk (see ref 3 for a review of this work). Moreover, these traits are known to be relatively stable over the course of childhood and adolescence,[16,17] with the individuals showing the greatest continuity of problems also being the most likely to develop the more chronic and more severe forms of SUDs in adulthood.[18,19]

Neurobiological and Cortical Development of Regulatory Systems

At the neurocognitive level as well, a number of constructs have been identified as being important to risk. Executive functioning entails the ability to regulate behavior to context and to maintain a goal set; it relies on

multiple constituent functions.[20] This is a multicomponent construct, including such elements as response suppression/inhibition (the ability to suppress strategically a prepotent or prepared motor response), working memory (itself multicomponent), set shifting (shifting from one task set or "set of rules" to another), and interference control (inhibition of a relatively dominant response system to allow another system to operate).[21] These capacities are represented to a large degree in parallel frontal-subcortical-thalamic neural loops. Important structures include the right inferior frontal cortex to basal ganglia (response inhibition[22]), dorsolateral prefrontal cortex and associated structures (working memory[23]), and anterior cingulate cortex. These networks are heavily subserved by catecholamine innervation. To the extent that they translate directly into behavioral differences, they have relevance to a spectrum of activities that increase or decrease risk. They relate to wisdom in choice of peers, understanding of the importance of context for appropriate drinking behavior, and the ability to resist peer pressure to drink when negative drinking consequences are likely (such as increasing intoxication and the inability to get to school or work the next day and to function adequately).

Extensive theories as long as a generation ago attempted to link aspects of executive control to alcoholism risk, but findings supporting this linkage have been mixed.[7,24–26] More-recent work[27] suggests that the risk element is related primarily to response inhibition. In addition, Finn et al[28] theorized that auditory working memory moderates temperamental risk for alcoholism. Other neuropsychological theories of individual vulnerability to alcoholism are numerous, but most are at a low level of specificity.[8] It is essential to develop (and to test) models with a higher level of specificity.

Closely intersecting these processes is the domain of motivation, particularly reward responsivity. Reward response involves dopaminergic pathways in the mesocortical and mesolimbic pathways that are closely related to those involved in executive control. The literature clearly indicates that executive and reward responses influence one another,[6] both in development and dynamically. Extensive research suggests that at both the behavioral and neural levels, substance use problems are associated with dysregulation of reward responsivity, such that the subcortical involuntary elements (subserved by limbic and striatal circuitry) over-respond to salient drug-associated stimuli and the normal cortical control (via frontal circuitry) over this response is impaired or inhibited, leading to excessive risk-taking behavior.[29–31] Furthermore, there is preliminary evidence for dysregulation of reward-related circuitry in at-risk populations even before alcohol and illicit drug use occurs.[32]

During the developmental period in which alcohol use and alcohol problems escalate, neural alterations occur in the frontal executive and reward systems involved in impulse and emotion regulation. The dorsolateral prefrontal cortex (important to executive functioning as well as motivation) is one of the last brain regions to mature, with myelogenesis continuing at least until early adolescence and potentially into early adulthood.[33] Progressive increases in the white matter of this region during childhood and adolescence have been demonstrated.[34] These developmental changes directly affect impulse and emotion regulation. It is known that, throughout childhood, there are developmental gains in the ability to suppress or to inhibit prepotent responses and in the ability to suppress irrelevant information.[35] Social and emotional skills, such as the ability to discriminate emotional facial expressions, also develop throughout childhood and early adolescence, with associated changes in amygdala responsivity.[36] Furthermore, during the period from childhood through adolescence, the prefrontal cortex gains greater efficiency in its inhibitory control over the amygdala and other limbic structures involved in emotion and reward responses.[37,38] In addition to these structural brain changes, both human and animal studies indicate that there is an alteration in mesocorticolimbic dopamine systems in the brains of adolescents.[39] Dopamine input to the prefrontal cortex peaks during adolescence in nonhuman primates,[40] and dopamine binding, primarily in the striatum but also in the nucleus accumbens (important for reward responsivity), peaks during adolescence.[41]

Understanding, at the neural activation level, how these mechanisms operate is crucial to a full explanation of individual risk using neurocognitive and neurobehavioral models. The developmental significance of these changes is substantial when superimposed on a social structure that is supportive of alcohol use. Extensive evidence from neuroimaging studies indicates that alcohol and other substances of abuse have acute and lasting effects on these frontolimbic and frontostriatal systems that are implicated in impulse control and reward responsivity.[42–44] Such effects are thus superimposed on this developing circuitry. Major issues not yet addressed concern the relative importance of the amount and timing of alcohol (and other drug) exposure in bringing about such changes, the degree to which other environmental exposures (eg, stress) also play a role, and the degree to which early neurocognitive vulnerabilities interact with the drug exposure in producing change. An understanding of these processes requires a multilevel/multisytem explanatory structure.

Genetics of Dysregulation

The strong evidence reviewed above for temperamental individual differences in behavioral regulation and control is paralleled at the genetic level by evidence from a number of heritability studies indicating that one of the core pathways of genetic risk for SUDs involves a major common externalizing/disinhibitory factor.[1,2,45] A number of molecular genetic studies also support this relationship, with genetic variants in the serotonergic system having received the largest amount of work to date. Serotonin (5-HT) is believed to operate as a regulator, with increased 5-HT being associated with inhibition of behavior[46] and genetic variants of tryptophan hydroxylase, the rate-limiting enzyme in the biosynthesis of serotonin, being associated with anger-related traits.[47] Genetic variants in monoamine oxidase A, specifically involving the *MAOA* promoter, have

been associated with impulsive aggression,[48] antisocial alcoholism,[49] and impulsive antisocial behavior in the context of childhood maltreatment.[11] The 5-HT_{1B} receptor has been linked to antisocial alcoholism in humans[50] and to increased impulsive aggression in mice.[51] Other potential candidate genes with apparent relationships to the externalizing/undercontrol domain include *GABRA2*, associated with conduct disorder and drug use disorder in childhood and adulthood and alcohol dependence in adulthood,[52,53] and *DRD4*, associated with attention-deficit/hyperactivity disorder (ADHD).[54]

In addition to this major common genetic pathway, a number of more-specific factors have been identified, whose level of influence and role in the development of SUD vary across the different drugs of abuse. For AUD, by far the majority of these have involved genes linked to the metabolism of alcohol; however, given the heterogeneity of the phenotype, it would not be surprising if other pathways of genetic control are also uncovered.

Environmental Influences on Regulational and Attentional Risk Development and Protective Factors

Environmental experiences such as stress, arousal, nurturance, and other aspects of social interaction (eg, physical abuse or observed family conflict) affect the brain either directly through changes in the development of neural networks or through the production of hormones that alter their development. The brain is thus the arena within which gene-behavior-environment interactions ultimately take place. A critical question is the following: what sites seem to have a predispositional vulnerability, both to impairment and to alcohol-seeking behavior?

Substantial basic science literature demonstrates, in animal models, strong effects of maternal rearing characteristics on the development of the biological stress response systems and the drug reinforcement pathways of the brain.[55,56] Adverse environmental exposures can influence strongly the ontogenic development of the limbic-hypothalamic-pituitary axis and the mesolimbic dopamine reward pathways of the brain. The evidence suggests increasingly that adverse socioenvironmental influences, acting in concert with genetic factors, alter the physiologic reactions to stressors and to later exposure to alcohol and other drugs of abuse, as well as predicting the cognitive and behavioral responses to later prevention interventions.

An impressive body of preclinical research has demonstrated, at least in rats, that the ontogeny of the stress response system is regulated in part by maternal factors during early life. Groundbreaking work by Levine[55] demonstrated that at least 3 aspects of maternal behavior in rats play a role in the regulation of the limbic-hypothalamic-pituitary axis during development, that is, tactile stimulation, feeding behavior, and passive contact. The maternal factors have important analogues in human maternal care and attachment. Also in the rat model, Liu et al[57] investigated how variations in maternal care affect offspring responses to stress across the lifespan, and they elucidated the epigenetic mechanisms through which variations in maternal stress response behavior are transmitted from one generation to the next, independent of genetic influences. This group also demonstrated that early environmental stress and maternal rearing behavior predict not only the ontogeny of the stress response circuitry but also the ontogeny of the mesolimbic dopamine reward pathway that underlies drug reinforcement.[56] Studies in nonhuman primates and humans have confirmed that exposure to early-life stressors alters the response to stress and its underlying circuitry in adults. This observation was confirmed in women who had experienced childhood abuse. A history of childhood abuse was found to predict neuroendocrine stress reactivity, which was enhanced by exposure to additional stressors in adulthood. This work has some parallels with the longitudinal behavioral literature on the long-term effects of child abuse, but its correspondence is not perfect. In a long-term study by Widom et al[58] of children who were abused and/or neglected at ≤11 years of age and evaluated 20 years later, childhood neglect but not abuse was related to later alcohol abuse for women but neither neglect nor abuse was related for men. Later analyses showed that graduation from high school served as a protective factor for the women's later alcohol symptoms.[59] Work needs to be performed to resolve these inconsistencies.

More generally, the attentional regulation and control system seems to be subject to the effects of early environmental experience, and an increasing body of evidence suggests that the interactional experiences affecting this system's development also play a role in the development of drinking behavior. Early stress has lasting effects on brain areas and neurochemical systems involved in impulse control and reward circuitry, systems that increase the risk for alcoholism by facilitating the onset of drinking, maintenance of drinking behavior, and relapse. Recent work by Nigg et al[60] showed that poor response inhibition contributes uniquely to early drinking onset and problem use, over and above the usual family risk variables, and plays a predictive role separate from that of behavioral undercontrol.

Emotional display and its obverse, emotional regulation, reflect a process of social transaction between infants and their caretakers.[61] Changes in emotional display and ability to regulate have been shown to be influenced by the degree of attentiveness and responsiveness of the mother and, as the infant grows older, by the mother's broader social environment, including her relationships with the father and with other adults in her support network,[62,63] and her own previous social experience, including her own history of abuse or other trauma. Eiden et al[63] also showed the contribution that fathers make to this process, even early in the life of the child. Alcoholic fathers are lower in sensitivity and higher in negative affect toward their children than are nonalcoholic fathers, and this parenting behavior predicts the reciprocal effect (ie, lower infant responsivity to the parents). Paternal depression, antisocial behavior, and aggression also were associated with lower sensitivity.

Rearing environments characterized by greater warmth, moderate discipline, and less stress are the most effective in instituting lower levels of externalizing behavior in children and adolescents[19] and, ultimately, in producing lower

drug involvement in adolescence.[64] The circumstances of "mismatch" between parents and children are of greatest interest here, because they offer the greatest opportunity for the dampening of risky child temperament on one hand and the greatest potential for altering the developmental course in a destructive way on the other. Parents who are responsive to their children's needs gradually increase the self-regulatory capacities of the children.[65] Conversely, parents who are aggressive toward their children and who create a conflict-laden family climate diminish the children's capacity to regulate and to control their own behavior.[16,19]

From the perspective of prevention, perhaps the most promising preclinical finding is that the effects of an adverse rearing environment are reversible. Enrichment of the rearing environment enhances the functioning of the frontal cortex of the brain, including the medial prefrontal cortex, which provides inhibitory regulation of limbic-hypothalamic-pituitary axis responses to stress. Furthermore, environmental enrichment reverses the effects of maternal separation on stress reactivity in the rat model.[56] Consistent with this preclinical finding is the observation that childhood interventions can offset the cognitive and emotional developmental risks associated with family stress and children who demonstrate the most-profound deficits show the greatest improvements with intervention.

OTHER NONSPECIFIC CHILDHOOD RISK FACTORS FOR ALCOHOL INVOLVEMENT

A number of antecedent risk factors in childhood that predict the early onset of drinking and the development of alcohol problems and AUDs in adolescence or adulthood have been identified. Many of these involve higher-order constructs such as behavioral undercontrol, dysregulation, and negative affectivity. They are assessed variously through personality measures, symptom counts, and even formal child psychiatric diagnoses. In addition to these individual factors, 2 socialization domains have been identified consistently as risk factors, one involving neglectful or poor parenting and the other involving earlier exposure to alcohol and other drug use by parents and by peers. As noted in the following review, predictors in these domains have been replicated many times over.

Other antecedent risk factors that do not fall so readily into these domains have also been identified, including early childhood sleep problems, attention problems, and deficits in reading achievement. In the neurophysiologic domain, investigators have also suggested that the P300 waveform of event-related brain potential is a marker of a risk endophenotype for SUDs.[66] P300 appears ~300 milliseconds after presentation of a discrete auditory or visual stimulus. The measure has a variable latency, depending on the complexity of the eliciting task and the processing speed of the individual. The measure is conceptualized as reflecting a memory-updating process in response to stimulus-driven changes in memory representations. It is thought to index the allocation or updating of working memory, as well as a cortical orienting reflex.[67] Reduction in the amplitude of the P300 potential has been hypothesized to be an endophenotype for SUDs, possibly reflecting central nervous system disinhibition.[66] Because much of this work has not yet been replicated and because the predictors do not fall so easily into the aforementioned domains, they have received less attention. Nevertheless, these findings are robust and need to be considered in any comprehensive explanation of the early development of risks for drinking and for progression into drinking problems and AUDs.

The multiplicity of factors identified here and their substantial overlap suggest that (1) a clearer understanding regarding the core individual vulnerabilities and which are secondary needs to be established, (2) the manner in which individual and environmental factors interact needs to be specified more clearly, and (3) a better understanding of sequencing is required. The following sections provide a detailed account of the pertinent studies.

Antecedent Predictors of Onset of Drinking in Childhood (Initiation Before 13 Years of Age)

Previous longitudinal research on children tended to focus on adolescent, young adult, or adult, rather than child, alcohol use outcomes. Where childhood initiation has been studied, the focus has been on substance use more generally (alcohol, tobacco, or marijuana use), rather than solely on alcohol use, because of the generally low rates of use by children.[68–70] Significant antecedent predictors of children's substance use initiation in those studies included lower prosocial family processes (monitoring, rules, and parent-child attachment), deviant peer affiliation, peer drug use, parental tolerance of substance use, parental drug abuse, child overactivity, child social skills deficits, and single-parent families.

Among the few studies examining antecedent predictors of child alcohol use are those by Baumrind[71] and Bush and Iannotti.[72] In her study of children tested at 4 to 5, 9 to 10, and 14 years of age, Baumrind[71] reported that earlier ages of onset of alcohol use were associated with less social assertiveness for both genders. For girls, earlier onset also correlated with less parental responsiveness and less encouragement of the child's individuality at age 4 and with less parental monitoring and lower socioeconomic status at age 9. For boys, earlier onset of alcohol use correlated with less parental encouragement of independence and individuality at age 4 and with less individuation and self-confidence at age 9. When alcohol use occurred during the early elementary school years, the child was generally introduced to the substance by an adult, usually a parent or close family member. Later ages of initiation generally involved peer instigations. Bush and Iannotti,[72] in their study of a largely black sample of fourth-graders, found that child socialization, as rated by other students, did not predict the onset of alcohol use without parental permission.

Childhood Predictors of Early-Onset Drinking After Childhood

When early onset was defined as initiation by 14 or 15 years of age, rather than onset in childhood, a number of studies found early predictors. These included studies predicting early onset of drinking (compared with later onset), as well as those using survival analyses to predict

the age of first use. Studies involved both high-risk and population samples. In the high-risk Seattle Social Development Study,[73] for example, earlier age of alcohol initiation was predicted by the following predictors at 10 to 11 years of age: white ethnicity, greater parental drinking, less bonding to school, and having more friends who drink. In a high-risk study of boys from Pittsburgh,[74] age of onset of alcohol use (use of ≥1 standard drink per episode) through 15 years of age was predicted by antisocial disorder (conduct disorder or oppositional-defiant disorder) but not ADHD or negative-affect disorder (anxiety or mood disorder). An earlier analysis of that sample, using a lower threshold of any alcohol use, found that the number of conduct disorder symptoms from mothers' reports for children 10 to 12 years of age and children's executive cognitive functioning were not related to alcohol use at 12 to 14 years of age.[75] In a community-based, high-risk sample of families,[76] parental alcoholism and mothers' ratings of children's sleep problems, trouble sleeping, and being overtired at 3 to 5 years of age predicted onset of alcohol use by 12 to 14 years of age. Parental alcoholism also predicted onset of drunkenness by 12 to 14 years of age. The authors interpreted the sleep problems measure as an indicator of instability of biological rhythms, as well as of social dysregulation. Finally, Dobkin et al[77] found, in a lower-socioeconomic status sample of boys from Montreal, Canada, that ratings of fighting and hyperactivity at 6 years of age and ratings of their aggressiveness and friends' aggressiveness at 10 years of age predicted drunkenness at 13 years of age. Age of onset of drunkenness (by 15 years of age) was predicted for these boys by teachers' ratings of higher novelty-seeking and lower harm avoidance at 6 and 10 years of age.[14]

For population samples, studies suggested that factors very similar to those found in high-risk samples also predicted early initiation of use. Among 10- to 12-year-old abstainers selected from the Minnesota Twin Family Study, antecedent predictors of alcohol use initiation at 14 years of age were conduct disorder, oppositional-defiant disorder, and any externalizing disorder but not major depressive disorder or ADHD.[78] In another study with the same sample, King et al[79] found that the same externalizing factors predicted regular use, ever being drunk, and heavy drinking at 14 years of age. Several other studies provided significant overlap with the Minnesota findings but also extended the network of predictors. In the Ontario Child Health Study, children rated by teachers as having conduct disorder at 8 to 12 years of age were more likely to be regular drinkers 4 years later.[80] In a study of a birth cohort of children in New Zealand, Lynskey and Fergusson[81] found that conduct problems at 8 years of age predicted usual intake of alcohol, maximal intake of alcohol, and alcohol-related problems experienced before 15 years of age (even controlling for gender, family socioeconomic status, parental illicit drug use, and parental conflict, which also relate to later alcohol use). In this sample, attention-deficit behaviors in childhood were not related to alcohol behaviors and problems at 15 years of age (similar to results found by McGue et al[78]).

Early-onset alcohol use (by 14 years of age) was predicted in the Finnish Twin Study by a number of social contextual factors assessed at 11 to 12 years of age, including lower parental monitoring and worse home environment. Individual difference measures, including greater behavior problems and fewer emotional problems, as well as gender, also predicted this outcome.[82] Genetic analyses showed that shared environmental influences predominated as influences on drinking initiation in early adolescence. Finally, the Great Smoky Mountain Epidemiologic Study of Youth tested children at 9, 11, and 13 years of age; antecedent predictors of having initiated alcohol use 4 years after baseline assessment were greater depression, less separation anxiety, and greater generalized anxiety.[83]

A number of investigators have found a relationship between early pubertal maturation in girls and early-onset alcohol use.[84–86] This relationship is usually explained by precocious affiliation with older, drinking peers, but the possible interplay between the social facilitation that drinking peer involvement creates and the biological changes that may make alcohol use more pleasurable or reinforcing has not been evaluated. Although adrenarche typically occurs before 10 years of age and menarche typically occurs after 10 years of age (but before 10 years of age among precociously maturing girls), the consequences of these pubertal processes alter development in lasting ways that are highly salient during adolescence. These relationships are discussed in more detail in another article in this issue.[87]

Childhood Predictors of Drinking in Middle Adolescence

Several studies have linked childhood functioning to later adolescent alcohol consumption levels. For example, in the Woodlawn Study,[88] teacher ratings of aggressiveness in first grade predicted more-frequent use of alcohol at 16 to 17 years of age for black boys (but not girls). There was also a trend for shyness to be related to less alcohol use for boys but not girls. In a follow-up study of children diagnosed as having ADHD and control subjects, childhood symptoms of inattention measured at 5 to 12 years of age were predictive of frequency of drunkenness and alcohol problems in adolescence.[89] In contrast to the findings of Kellam et al[88] for a large general population sample, Hill et al[90] studied families at high risk for alcoholism because of their dense family history of alcoholism. They found that age of onset of regular drinking with negative consequences was predicted by greater extraversion, deficits in reading achievement, reduced P300 (visual and auditory), and greater postural sway.

Childhood Predictors of Adolescent Problem Drinking

To date, only 2 groups have examined early childhood predictors of problem drinking assessed within adolescence. Both studies involved high-risk samples. In the Seattle Social Development project,[73] the strongest predictors of problem drinking at 16 years of age were younger age of initiation of drinking and being male. The effects of other predictors at 10 to 11 years of age (parents' drinking, friends' drinking, school bonding,

and perceived harm of drinking) were mediated by age of initiation. In another report on the Michigan Longitudinal Study high-risk sample, Wong et al[91] observed that, although the normal pattern of increases in behavioral control over the course of childhood was present in the sample, a slower rate of increase in behavioral control from preschool age through middle childhood predicted more drunkenness and more problem alcohol use in adolescence.

Earlier Childhood Predictors of Young Adult Problem Drinking/Alcohol Dependence

A number of studies evaluated children as young adults and assessed their experience of alcohol problems. Pulkkinen and Pitkanen,[92] for example, found in a sample of Finnish children that aggressiveness at 8 years of age was predictive of problem drinking at 26 years of age for boys but not for girls, whereas social anxiety at 8 years of age was predictive for girls but not for boys. Similarly, in a community sample in New York, childhood aggression at 5 to 10 years of age, assessed as anger, sibling aggression, noncompliance, temper, and nonconforming behavior, was related to *Diagnostic and Statistical Manual of Mental Disorders, Revised Third Edition,* alcohol abuse at 16 to 21 years of age.[93] Other evidence for the predictive power of childhood undercontrol comes from a birth cohort study of children from Dunedin, New Zealand,[10] which found that boys (but not girls) who were undercontrolled (impulsive, restless, or distractible) at 3 years of age were more than twice as likely as control children to exhibit a diagnosis of alcohol dependence at 21 years of age. The 1 study that did not replicate the undercontrol findings was also a birth cohort study from New Zealand, the Christchurch Health and Development Study.[94] There, conduct problems at 7 to 9 years of age did not relate to *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition,* alcohol dependence at 21 to 25 years of age. Although it is impossible to know what the sample differences might be that led to these divergent findings, a review by Zucker[3] of 6 other longitudinal studies, some population-based and some high-risk, indicated that the relationship of undercontrol to adult alcohol problem use is extraordinarily robust (all 6 studies replicated the finding), which in turn suggests that the findings of Fergusson et al[94] are anomalous.

It remains to be determined which facets of undercontrol are responsible for this predictive relationship. Although the undercontrol relationship is a robust one, other facets of cognitive control also seem to predict the early drinking outcome. A study of boys (n = 122) recruited in prenatal clinics in a small community outside Stockholm, Sweden,[95] found that lower ability to concentrate at 10 years of age and lower levels of school achievement at 10 years of age were related to hazardous use of alcohol before 21 years of age and at 36 years of age. (Hazardous use was defined on the basis of police register data on public drunkenness and drunk driving and high levels of reported alcohol intake.) Similarly, as noted earlier, Nigg et al[60] found that poor response inhibition also predicted early initiation of drunkenness and problem use, even controlling for conduct problems (as an index of behavioral undercontrol).

In addition to individual difference factors, early contextual influences predict later problem alcohol use. Data from the New York Longitudinal Study[96] showed that parental conflict over childrearing and maternal rejection of the child, both assessed at child age of 3, were significant predictors of greater (more-severe) alcohol involvement at child age of 19.

The work of Guo et al[97] extends the conceptual framework of predictors in a more-integrated fashion. Those authors used a social development model that included individual difference, family, and neighborhood factors to predict AUD outcomes in adulthood. They assessed internalizing disorders, externalizing disorders, male gender, delinquency, unclear family rules, poor family monitoring, less bonding to school, living in a neighborhood with more troublemakers, having antisocial friends, having friends who drink frequently, bonding to antisocial friends, greater intentions to use alcohol, and more-favorable attitudes toward alcohol at 10 years of age. They found that a model integrating all of these factors was predictive of *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition,* alcohol abuse and dependence at 21 years of age.

Childhood Predictors of Adult Alcohol Use and Disorders

Studies linking childhood data to follow-up data collected later than young adulthood are rare. In the Terman Life-Cycle Study, low conscientiousness and high sociability ratings at 12 years of age were related modestly to alcohol involvement at 40 to 50 years of age.[98] Among Hawaiian elementary schoolchildren evaluated at an average age of 45 years, higher teacher ratings of extraversion and lower ratings of emotional stability were associated with greater adult alcohol intake.[99] Cloninger et al[12] reported that Swedish children who were rated higher in novelty-seeking and lower in harm avoidance and reward dependence at 11 years of age were more likely to be involved in alcohol abuse (defined as registration with the Swedish Temperance Board, arrests for drunkenness or driving while intoxicated, or treatment for alcoholism) at 27 years of age. In the Danish Longitudinal Study of Alcoholism,[100] measures of motor development in the first year of life (muscle tone at day 5, inability to sit without support at 7 months, and inability to walk at 1 year) were related to the diagnosis of alcohol dependence at 30 years of age. In the age 42 follow-up evaluation of black children who were first studied in first grade as part of the Woodlawn Study,[101] a diagnosis of adult alcohol abuse or dependence was associated with lower math achievement scores in first grade and lower ratings of shyness for boys only and with mother's regular alcohol use for both genders. Lastly, in the Stockholm prenatal study referred to above, Wennberg and Bohman[95] found that psychologist ratings at 4 years of age predicted outcomes not just at the end of adolescence but also well into adulthood. Extrovert/aggressive ratings at age 4 were correlated with frequency of intoxication at age 25 (r = 0.27; $P <$ .05), and extrovert/outgoing ratings were correlated

with lifetime alcohol problems to age 36 ($r = 0.22$; $P < .05$).

ALCOHOL-SPECIFIC RISK FACTORS IN CHILDHOOD

In contrast to the previous section, the focus here is on alcohol-related factors that predict risk for later alcohol use and abuse, as well as those that predict actual drinking and drinking outcomes. Although these 2 sets of variables often overlap, they are not always the same. This section presents data on the rates of alcohol use among children, on the development of alcohol-related beliefs and expectancies in childhood, on the social contexts encouraging children to use alcohol, and on the several mechanisms through which children in alcoholic families are at risk of early-onset and later problems.

Level of Alcohol Use in the Population

Alcohol is the most used and also the most abused drug in US society. According to data from the National Institute on Alcohol Abuse and Alcoholism,[102] a large majority of US adults (75.3%) have tried alcohol at some point in their lives, and a clear majority (61.1%) have had a drink in the past year (42.1% are light drinkers, 14.2% are moderate drinkers, and 4.8% are heavier drinkers). Men are more likely than women to be current drinkers (67.6% vs 55.1%) and are substantially more likely to be moderate drinkers (21.6% vs 7.3%) or heavier drinkers (5.6% vs 4.0%). College graduates are more likely to be current drinkers than are adults with less education. Non-Hispanic white and Hispanic individuals are more likely to be current drinkers than are non-Hispanic black and other non-Hispanic individuals. Adults living in the South are more likely to be abstainers than are adults from other regions of the country.

Data from the 2001–2002 National Epidemiologic Survey on Alcohol and Related Conditions showed substantial variation in the rates of current alcohol abuse and alcohol dependence across subsets of the US population.[103] Overall, 8.5% of US adults exhibited either alcohol abuse or dependence. Alcohol dependence in the past 12 months was seen for 5.4% of men and 2.3% of women. White, Native American, and Hispanic individuals had significantly higher rates of alcohol dependence (3.8%, 6.4%, and 4.0%, respectively) than did Asian American individuals (2.4%). Although religious background is not covered in federally sponsored surveys, alcohol dependence has historically been higher among Catholics and liberal Protestants than among fundamentalist Protestants and Jews. As a result of these variations in adult alcohol use and abuse, children's exposure to alcohol use in the home varies as a function of region of the country, parental education, religious denomination of the parents, and ethnic/racial background.

Rates of Alcohol Use and Abuse Among Children

Lifetime Alcohol Use

There is currently little good information on how many children have ever had experience with alcohol, either from retrospective recall by adolescents or from surveys of children themselves. Retrospective reports of age at the first drink are not very reliable for this life stage. Age of onset generally increases as older adolescents are questioned.[104,105] For example, in national data from the 2005 Youth Risk Behavior Survey, the proportions of respondents who stated that they drank alcohol before age 13 decreased from 33.9% for 9th-grade students to 19.3% for 12th-grade students.[106] These are not cohort effects but rather are evidence of "forward telescoping," as shown by the fact that similar proportions of students in these grades reported drinking before age 13 in each of the 5 previous surveys (1995, 1997, 1999, 2001, and 2003) that asked this question. Similar findings were also obtained in the national Monitoring the Future surveys, comparing eighth-graders and 12th-graders across multiple annual surveys regarding their reported incidence rates of alcohol use by sixth grade.[107] Therefore, determination of average or modal age of initiation of alcohol use on the basis of retrospective recall is problematic. Results vary depending on the age of the population sampled, the number of years since initiation, and the age categories presented as responses and cannot be used with any confidence to characterize the level of current alcohol use in the child population. Surveys of children asking about current or recent drinking are more likely to capture normative data on ages of onset than are retrospective recall reports provided by adolescents or adults.

Large-scale epidemiologic surveys of alcohol use that include children ≤10 years of age are extremely rare, however. According to the most-recent Partnership Attitude Tracking Study (sponsored by the Partnership for a Drug-Free America), which surveyed a national probability sample of nearly 2400 US elementary school students in 1999, 9.8% of fourth-graders, 16.1% of fifth-graders, and 29.4% of sixth-graders had had more than just a sip of alcohol in their lives.[108] Data on the use of alcohol in the past year (rather than lifetime) has been reported annually by PRIDE Surveys.[109] According to the 2003–2004 summary of school district surveys performed across the United States, 4.2% of fourth-graders, 5.6% of fifth-graders, and 8.7% of sixth-graders had had a beer in the past year.[110] Slightly more had had wine coolers (4.4%, 6.7%, and 10.3%, respectively), and approximately one half as many reported drinking liquor in the past year (1.9%, 2.8%, and 5.2%, respectively). These data, although based on a large sample of children from many school districts across the country, reflect a convenience sample rather than a representative national sample and therefore contain an unknown level of bias. Clearly, national surveillance efforts need to be directed toward monitoring the alcohol involvement of children starting in grade 4. Initiating surveillance in grade 8 (as in the Monitoring the Future study) or grade 9 (as in the Youth Risk Behavior Survey) or at age 12 (as in the National Survey of Drug Use and Health) is simply too late.

Comparison of US and European children's experience with alcohol is possible to a very limited extent. Information on the number of 11-year-old US children who have at least tasted alcohol comes from a World

Health Organization survey of health behavior in 11-, 13-, and 15-year-old schoolchildren that was conducted in 1997–1998 with 120 000 students in 28 countries, including countries in all parts of Europe, Canada, and the United States.[111] Rates of having at least tasted alcohol varied widely across countries. The proportions of 11-year-old children who had at least tasted alcohol (averaged across genders) ranged from 91% in Slovakia to 85% in Scotland, 78% in England, 73% in Ireland, 71% in Sweden, 69% in Canada and Greece, 63% in Germany, 59% in Austria, 57% in Poland, 52% in France, 44% in Israel, 40% in Switzerland, and ~35% in Norway. Ever experience with alcohol was reported by 62% of 11-year-old boys and 58% of 11-year-old girls in the United States. These US prevalence rates ranked 16th among the 28 countries studied. In most countries, more male than female 11-year-old children had at least tasted alcohol.

Alcohol Problems in Children

Although there are anecdotal reports and clinical reports of alcoholic children,[112,113] the little available evidence suggests that few children exhibit problematic levels of involvement with alcohol such as alcohol abuse or dependence. In the few studies that have examined this, the incidence of diagnosed AUDs at ≤12 years of age is close to 0 cases in the general population.[114] Subclinical levels of alcohol problems in childhood are somewhat more prevalent. For example, Chen et al[115] found that 4.8% of fifth-graders in Baltimore, Maryland, had already experienced ≥1 alcohol problem.

Early Alcohol Use Onset as Risk Factor for Later Problems

It is critical to develop better information regarding the extent of alcohol experience among US children, because younger ages of onset of alcohol use are associated with a greater likelihood of developing both problem drinking in adolescence[73,116–118] and alcohol abuse or dependence in adulthood.[119–121] Although studies do not agree on whether alcohol use in childhood (≤12 years of age) or in early adolescence (13–14 years of age) carries greater risk, they do agree that early alcohol use predicts later problematic drinking. Given this linkage between the early onset of drinking and later alcohol problems, it is also crucial to develop a better understanding of the factors that influence the initiation of alcohol use in childhood.

In addition to the increased risk for later alcohol problems, early-onset drinking has been shown to be related to a variety of other problematic outcomes. Onset of drinking by 10 to 12 years of age is associated with absences from school, drinking and driving, and marijuana and other illicit drug use in grade 12.[118] Onset by grade 7 (12–13 years of age) was found to be related to more school problems, more delinquent behavior, more smoking, and more illicit drug use in grade 12, compared with later onset, and to smoking, illicit drug use, drug selling, and criminal behavior at age 23.[116] In a follow-up study in grade 10, those who began drinking by the autumn of grade 7 reported more recent drinking, drunkenness, and alcohol or drug problems and were more likely to have initiated sexual intercourse, to have had >2 partners, and to have gotten pregnant (or gotten someone pregnant).[122] Methodologic problems in this area involve the use of retrospective reports, variability in the definition of "early onset" across studies, apparent use of age of onset as a substitute for examination of a larger array of alcohol "landmark" behaviors that may be of relevance for later alcohol problems (eg, regular use and first drunkenness), and the absence of questions regarding context of first use (eg, use as part of religious services or ceremonies, with family members, or with friends).

Development of Children's Beliefs and Expectancies About Alcohol

The developmental process through which children's attitudes toward alcohol are transformed from "tastes yucky" to "tastes great, less filling" has been largely unexplored. Relatively little is known about the milestones along this transition in orientation toward alcohol.[123]

Preschool-aged children's ability to identify alcoholic beverages by smell increases with age and is associated with the level of alcohol use by their parents.[124,125] This ability increases throughout childhood, with greater accuracy of identification with age from 6 years through 10 years of age.[126,127]

By 6.5 to 7.5 years of age, the majority of children can demonstrate the concept of "alcohol" by correctly labeling photographs of bottles of alcoholic beverages and by being able to explain the difference between clusters of bottles of alcohol and clusters of other bottles. Younger children (4.5–6.5 years of age), although they could label individual bottles correctly, could not explain how the bottles were grouped. Fossey[127] replicated the original bottle-grouping task used by Jahoda and Cramond[126] and found that older children did better than younger children in grouping actual bottles.

Learning about alcohol in childhood involves more than identifying it by smell or grouping bottles. Children also learn that alcohol use is an activity in which adults typically engage. An early form of alcohol expectancies consists of "alcohol schemas," which were measured at 3 to 5 years of age with a task in which children were presented with drawings of child and adult figures in common social situations (eg, 2 adults on a sofa in front of a fireplace, a family eating dinner, and a man watching television) and were asked what kind of beverages the figures were drinking (alcoholic versus nonalcoholic).[128] Alcoholic beverages were attributed to adults more often than to children pictured and to men more often than to women. In other words, even in preschool, children know the norms about drinking in the adult culture, namely, adults drink alcoholic beverages and children do not and men drink more than women. As might be anticipated, these drinking attributions were more evident for children of alcoholics (COAs) than for children of nonalcoholic parents.[128]

A more-recent study demonstrated similar alcohol schemas by using a shopping paradigm.[129] Children 2 to

6 years of age were observed role-playing as adults shopping for a social evening with friends in a miniature grocery store stocked with 73 different products, including beer, wine, and cigarettes. Sixty-two percent of the children bought alcohol for this adult situation, and those with parents who drank at least monthly were more likely to do so.

Affective components of children's alcohol schemas also vary as a function of age. Studies of normal samples over a 20-year period showed that children's ratings of adults depicted drinking alcohol are basically neutral at age 6 and become more negative up through 10 years of age.[126,127] Additional research with this same paradigm showed that these attitudes become more positive between 10 and 14 years of age.[130] Between third and seventh grade, significantly more children say it is "okay" for people to drink alcohol.[131]

Children have also been shown to have definite beliefs about the characteristics of drinkers and the behavioral effects of drinking by 10 years of age.[127,132–134] Girls, particularly in the younger grades (kindergarten and third grade), were found to provide more coordinated, psychological, and causal responses than boys when asked to explain why men and women described in the vignettes were drinking.[133]

Children's expectancies about the effects of alcohol on drinkers are also generally negative[124] but become more positive as the children become older[134] and as they move into adolescence.[132] Early expectancies emphasize the affective dimension (positive versus negative), with effects such as wild, dangerous, rude, and goofy being chosen, whereas later expectancies incorporate a pharmacologic dimension (sedation versus arousal), exemplified by wild, dangerous, talkative, and cool.[132] In the age range from 8 years to 12 years, positive and negative expectancies increase concurrently, presenting evidence of increasing ambivalence regarding the effects of alcohol.[131] Positive expectancies have been shown to predict onset of drinking in adolescence,[135] although studies linking child expectancies to adolescent drinking are currently lacking. These data suggest that, although relatively few children have initiated drinking at these ages, there is the development of attitudes, beliefs, and expectancies that place them at increasing risk for movement into alcohol use.

Childhood Social Contexts That Facilitate Drinking

In childhood, children are exposed to alcohol use through a number of social mechanisms, including drinking by their parents and other adults in the family context, as well as alcohol use by adolescents and adults that is portrayed in the mass media (television, movies, print media, and advertising). In the absence of their own experience with alcohol, this vicarious learning is the major influence on their attitudes toward alcohol and their expectancies about the effects of drinking.

Home

Parents constitute the major source of children's exposure to alcohol use. Research over the past 40 years is consistent in indicating that children are more likely to eventually become drinkers if their parents are drinkers. Among children, self-reports of alcohol use correlate significantly with the children's perceptions of their parents' drinking.[136]

In addition to modeling alcohol use through their own drinking, parents increase the likelihood of their child's drinking through having alcohol available and accessible in the home and through active encouragement of child experimentation with alcohol. Research has shown that, when children are asked where they got their first drink of alcohol, they overwhelmingly cite their parents or home as the source. For example, among third- through sixth-grade children participating in the Bogalusa Heart Study in 1993–1994 who had ever tried alcohol, the majority first tried it with someone in the family (78%), 8% tried it alone, 8% tried it with someone their own age, and 6% tried it with someone older than themselves.[137] Fifty-six percent reported that they got the alcohol from someone in their family, 32% drank from someone else's drink, 6% took it from home, and 6% got the alcohol from another child (see also refs 131 and 135). In a community survey of children in Oregon,[138] few of the children, especially in the younger grades (grades 1–4), who had ever tried alcohol had done so without their parents' knowledge. There is currently little research on subcultural, religious, or regional variations in parents' beliefs about the appropriateness of introducing their children to alcohol in the home.

Mass Media

In addition to their observation of parental drinking, children learn about alcohol use and its effects through their exposure to movie and television content and advertisements. The alcohol industry spends more than $1.6 billion per year on advertising in radio, television, magazines, newspapers, and billboards.[139] The alcohol industry routinely exposes adolescents 12 to 20 years of age to high levels of alcohol advertising, through the placement of advertisements at times when adolescents are most likely to be watching or listening, in magazines they are likely to read, on radio stations to which they are likely to listen, and during television programs in which they are likely to be interested. For example, in 2003, teens saw twice as many advertisements for beer, >3 times as many advertisements for alcopops (sweet-flavored alcoholic drinks), and 50% more advertisements for spirits in magazines, on a per-capita basis, than did adults ≥35 years of age.[140]

There is less evidence, however, that children are exposed to alcohol advertisements to the same degree as adolescents. First, magazine and radio audience data do not include children <12 years of age; therefore, their exposure to alcohol advertisements in these media cannot be measured. Second, children <12 years of age may be less exposed to magazine advertisements because of their reading levels and reading choices (books rather than magazines, or magazines with advertising restrictions). Third, a Center on Alcohol Marketing and Youth report from 2005 suggested that children 2 to 11 years of age are underexposed to alcohol advertisements on tele-

vision, relative to their prevalence in the overall population.[140] They are exposed to less than one half as many television alcohol advertisements as are 12- to 20-year-old youths. This does not mean that they are not exposed, however. On average, children 2 to 11 years of age saw 99.4 alcohol advertisements on television between January 2004 and October 2004 (81% for beer and ale, 11% for spirits, 5% for alcopops, and 3% for wine, calculated from data in that article). At this rate, the average child could have seen almost 1200 alcohol advertisements on television before age 12 (assuming similar rates across years).

Alcohol advertisements are not the only source of alcohol portrayals on television. Portrayals of alcohol use and its (lack of) consequences are pervasive on television programs aired in prime time (8–11 PM), when children may be watching. Estimates from the 1998–1999 season indicated that 71% of sampled episodes included alcohol use by characters on the shows.[141] Most disturbing was the finding that 38% of shows with a TV-G rating (appropriate for most children) depicted alcohol use. More episodes characterized drinking as a positive experience than as a negative experience. Negative consequences were portrayed or mentioned in only 23% of episodes.

Children's animated films have also been analyzed for alcohol content. All G-rated, animated films that were released by 5 major studios between 1937 and 1997 and were available on videotape were reviewed for episodes of tobacco and alcohol use.[142] Of the 50 films reviewed, 50% included alcohol use, which was portrayed by 63 characters for a total of 27 minutes. Seven of the 50 films depicted effects of alcohol use (eg, drunkenness, passing out, losing balance, or falling), but none addressed any of the negative health consequences of alcohol use.

In a study of fifth- and sixth-grade students,[143] greater awareness of beer advertisements (ability to identify correctly the brand names for still photographs from current television commercials) was related significantly to greater intentions to drink as an adult through its relationship to more-positive beliefs about alcohol (a mediated path). A recent study of 10- to 14-year-old nondrinkers found that the level of exposure to alcohol use in motion pictures predicted whether the subjects were drinkers 1 to 2 years later.[144] Considerably more research is necessary, however, to determine the linkage of media exposure to drinking and children's initiation of alcohol use. Of major importance is determination of the impact of media exposure as a function of parental modeling of alcohol use in the home.

Children in Alcoholic Families: A Special Early-Risk Population

Prevalence

According to National Longitudinal Alcohol Epidemiologic Survey data,[145] ~9.7 million children ≤17 years of age, or 15% of the children in that age range, were living in households with ≥1 adult classified as having a current (past-year) diagnosis of alcohol abuse or dependence. Approximately 70% of those children were biological children, foster children, adopted children, or stepchildren. That is, 6.8 million children meet the formal definition of COAs, although not all are exposed to the same level of risk for use, problem use, and AUD. As far as socialization risk is concerned, these figures reflect only acute (past-year) exposure to ≥1 alcoholic adult. According to other data from the National Longitudinal Alcohol Epidemiologic Survey,[145] 43% of the <18-year-old population, or slightly less than one half of all children, were exposed to a currently or previously alcoholic adult in the household. The figure for just COAs was 30% of the <18-year-old population, but even this represents an enormous population at risk. The sheer size of this group indicates that any approach to risk identification will be extremely complex politically and will need to differentiate considerably the risk variability among these families. It is essential that this be done, given the magnitude of the problem. COAs are 4 to 10 times more likely to become alcoholics themselves.[146] They are also at elevated risk for earlier drinking onset[147] and earlier progression to drinking problems.[119]

Genetic Risk

Although the observation that alcoholism runs in families has been known for centuries, it has only been within the past generation that definitive studies have been conducted. Studies have involved children with an alcoholic biological parent who were raised by nonalcoholic adoptive parents,[148] thus enabling a test of the separate influences of genetics and environment on the development of alcoholism. Despite the lack of modeling of alcohol abuse in the home, these adopted children were still significantly more likely to develop alcoholism later in life than were control children with no genetic risk for alcoholism.

Although studies such as this establish the baseline relationship of family risk to later disorder, ongoing research is working to identify the specific aspects of genetic risk that produce this outcome and to identify environmental factors that moderate or mediate the influence of genetic risk for alcoholism. It is essential to keep in mind that some of the elevated risk is attributable to exposure and socialization effects found in alcoholic households, some to genetically transmitted differences in responses to alcohol that make drinking more pleasurable and/or less aversive, and some to elevated transmission of risky temperamental and behavioral traits that lead COAs into greater contact with earlier- and heavier-drinking peers.

Factors Involved in Familial Transmission

Familial alcoholism status (being "family history positive") is heavily used as a proxy for "alcoholism risk" on one hand and "socialization risk" on the other hand, but the familial designation is more precisely a proxy for multiple but more-specific risk factors, not all of which may be present in all cases. A positive family history implies elevated genetic risk, on average, although the alcoholic genetic diatheses might not have been passed on to a particular child. One may be a COA without being undercontrolled or having an ADHD diagnosis.

Socialization risk involves familial exposure but, given the high divorce rates in this population, evaluating the level of socialization risk is complex, because it involves not only quantification of the duration of exposure to the actively alcoholic parent but also determination of the developmental period during which the exposure took place. Some developmental periods have the potential to produce more vulnerability than others.[16] In addition, a substantial amount of assortative mating occurs in alcoholic families,[149] that is, alcoholic men often marry women with alcoholism. When assortment is present, risk exposure is multiplied and COA effects become a function of genetic risks, individual parent risks, and the synergistic risks created by impaired marital interactions.[16]

The potential for indirect socialization effects is also higher in alcoholic families. Parental psychopathological conditions have been documented as a risk factor for poorer parental monitoring,[150] which leads to a higher probability of involvement with a deviant peer group, including earlier exposure to alcohol- and other drug-using peers.

COA risk is not simply risk for the development of an AUD.[151] Given what is known about the elevated psychiatric comorbidities among COAs, being a COA is also a marker of elevated risk for a variety of behavioral and cognitive deficits, including ADHD, behavioral undercontrol/conduct disorder, delinquency, lower IQ, poor school performance, low self-esteem, and others.[152] Furthermore, the evidence strongly implicates some of these non–alcohol-specific characteristics as being causal to both problem alcohol use and elevated risk for AUD.[11,153] In a community study of high-risk families, Wong et al[76] found that parental alcoholism was a significant predictor of early-onset alcohol use and drunkenness (both by age 14) but that early sleep problems, possibly an indicator of a central regulatory deficit, represented an independent predictor of drinking outcomes. Similarly, in a longitudinal study monitoring boys with and without parents with a SUD, Tarter et al[8] found that the effect of the father's and mother's SUD on a son's diagnosis of SUD at age 19 was mediated by neurobehavioral disinhibition (operationalized as the sum of disruptive behavior disorder symptoms on the Structured Clinical Interview for DSM Disorders), social maladjustment, and drug use frequency at age 16. Other studies investigating the mediators of these effects included that by Hill et al,[90] which showed not only that children in high-risk families had an earlier age of initiation of regular drinking with negative consequences than did children in low-risk families but also that this relationship was mediated by the temperament variable of extraversion.

These factors implicate the COA population as a large and important component of the underage drinking population. It is essential to determine which components of that family risk envelope are the strongest mediators of the underage drinking outcome. Given the overlap of socialization and genetic risks in all of these studies, it is essential to determine which components of the risk designation are the strongest mediators of underage drinking and which may be considered as proxies for other mechanisms. As specific genes that carry alcoholism risk are identified, investigators will be better able to model the interactions between social environment and genetic vulnerability that very well may be taking place.[11] Such studies are essential.

Fetal Alcohol Exposure

An additional potential risk for early-onset drinking and for the development of risk factors for later alcohol problems is the exposure of the child to alcohol in utero. Given the assortative mating that occurs, in which alcoholic men marry women with the same problem, some children will be affected not only by genetic and socialization risks but also by risks arising from the teratogenic effects of alcohol exposure during fetal development. These teratogenic risks can occur even at levels of alcohol intake during pregnancy that are not symptomatic of maternal alcoholism. Although it is still not clear what level of alcohol intake is safe during pregnancy, research reveals that even relatively modest levels of alcohol intake can have negative effects on the developing fetus. Depending on the level of alcohol exposure and the timing (trimester) of exposure, these effects can be morphologic, growth-related, neurologic, and behavioral and reflect a spectrum of alcohol-related neurodevelopmental disorders (fetal alcohol spectrum disorders). Prenatal alcohol exposure effects on development have been extensively studied in both humans and animals.[154–160] Findings relevant to this report are the effects of prenatal exposure to alcohol on response inhibition, attention, executive functioning, delinquent behavior, and school achievement in childhood, all of which are themselves risk factors for later alcohol problems.

In 1974–1975, as part of the Seattle Longitudinal Study on Alcohol and Pregnancy, 1529 pregnant women were interviewed in their fifth month regarding their demographic characteristics, nutrition, use of tobacco, alcohol, and caffeine, and use of medications. In 1989–1990, 464 families, reflecting a spectrum of maternal drinking during pregnancy, were evaluated when the children were 14 of age.[160] The mother's alcohol intake during pregnancy, and hence the child's prenatal exposure to alcohol, significantly predicted adolescent experiences of the negative consequences of drinking (ie, personal and social difficulties resulting from alcohol use, such as getting into a fight, neglecting responsibilities, or having a bad time), even controlling for family history of alcoholism, current parental drinking, and several parenting variables. Family history of alcoholism was not a significant predictor when prenatal alcohol exposure was controlled for statistically. A later follow-up study of this sample found that prenatal exposure to alcohol and family history of alcoholism predicted young adult (age: 21–24 years) scores on the Alcohol Dependence Scale.[161]

There are a number of ongoing longitudinal studies of cohorts of children exposed prenatally to alcohol that should soon have data on the adolescent alcohol involvement of the children (eg, the Maternal Health Practices and Child Development Project) and should be able to test the generality of these results. In the meantime,

there is ample evidence that prenatal exposure to alcohol has effects on a number of risk factors for later alcohol abuse and dependence.

DEVELOPMENTAL UNFOLDING OF RISK AND RESILIENCE

Risk Aggregation

There is considerable evidence, from both the child and adult literature, that risks are correlated at the individual and familial levels and at the neighborhood level. At the individual level, the literature has increasingly acknowledged the clustering of comorbid symptoms, social dysfunction, and alcoholism severity among adults.[162] In fact, such assortment has been one of the driving forces for the notion that subtypes of disorders need to be demarcated. In the same vein, the association of severe alcoholism with poverty has a long and visible history,[163,164] and analyses at the microenvironmental level have documented an association between neighborhood disadvantage and alcoholism rates.[165] The most common explanation of this has been that poverty, and the neighborhood structure in which it is embedded, drive the alcoholism (ie, a top-down explanation). What has been less clear is the degree to which individual processes are also at work; some evidence suggests that there are, at least for children from antisocial alcoholic families. Antisocial alcoholic men are more likely to marry/partner with antisocial and heavy-drinking/alcoholic women.[166] The families they create are more likely to be disadvantaged in their capacity to socialize offspring. Antisocial alcoholism is also associated with downward social mobility,[167] and offspring in these families, even early in life, seem to be developmentally more disadvantaged; that is, they have more learning disabilities and intellectual deficits than do offspring from alcoholic but not antisocial families.[27] A risk cumulation theory suggests that, as these factors continue to cumulate, they produce a risk structure that moves the child into peer networks high in aggression, negative mood, and substance use, thus providing familial, neighborhood, and peer structures that act in concert to encourage the development of (1) an expectancy structure that is positive toward use and abuse of alcohol and other drugs, (2) very early onset for such use, and (3) a stable repertoire of behaviors that are prototypic for the eventual emergence of abuse/dependence.

Research is needed to determine the degree to which such a risk aggregation structure is synergistic for the development of risk. For example, normative studies of adolescence have shown the enhanced effects on drug use and the timing of onset when family conflict, association with deviant peers, and poor academic performance are clustered.[168]

Resilience and Risk

Key Developmental Pathways

As indicated earlier in this review, considerable evidence indicates that later use can be predicted from developmental patterns evident well before 10 years of age, which suggests that children have already started down developmental paths leading toward early use and abuse of alcohol.[108,150] In most cases, these paths also lead to other problems associated with alcohol use, such as smoking, drug use, delinquency, school dropout, and depression. In some cases, high-risk pathways are so well established that these pathways are clear targets for preventive interventions,[18] although it should always be remembered that these are probabilistic pathways and not certain roads to underage drinking. In fact, there are children who seem to be on the same pathways who do not begin to drink early or who take a turn for better development; such children serve as a powerful reminder that this is a risk pathway and not a "certainty pathway." It is important to understand the processes leading away from this pathway, as well as the processes leading children to continue down this road. Two major pathways of risk for underage drinking (and other related problems of adolescence) are (1) the antisocial behavior (externalizing) pathway and (2) the emotional distress (internalizing) pathway.

Externalizing Pathway

There is mounting evidence that there are children who show early difficulties with self-control of impulses and attention, manifest unusually high levels of aggression during the preschool years, and develop early academic problems related to their behavior once they begin school.[18,19,169] These children often live in disadvantaged families with poor discipline and few resources. Their parents often have mental health or behavior problems, such as alcohol abuse or antisocial personality. They show multiple problems in multiple domains related to self-control and compliance. These children are often described as stress reactive, with high negative emotionality or difficult temperaments. During late childhood and early adolescence, a proportion of these children disengage from school, begin to associate with deviant peers, engage in increasingly risky behaviors, and escalate in delinquent behavior. At some time during the transition to adolescence, these youths are at high risk for early alcohol use, as well as other behaviors in the problem behavior spectrum such as substance abuse, early and risky sexual activities, and truancy.

Internalizing Pathway

A second pathway implicated by the longitudinal data on risk for underage drinking that may have its beginnings in childhood involves depressive spectrum disorder symptoms and related antecedents, including anxiety and shy/inhibited personality.[10,88] Evidence is weaker for this internalizing pathway in relation to earlier alcohol use, although there seems to be a link between depression in adolescence and risk for alcohol initiation.[83] However, the evidence is considerably stronger for an internalizing pathway to AUD.[150]

Low-Risk Pathways

Implicitly, patterns of risk also implicate patterns of lower risk for underage drinking, although these pathways have not been as well defined. Children who have

a record of success in age-salient developmental tasks throughout childhood, with the benefits afforded by good self-regulation skills and effective parents, and who handle stress well, engage and succeed in school, and associate with prosocial peers who engage in little risky or antisocial behavior presumably are on a low-risk path with respect to early alcohol use. One community high-risk study documented this pathway for a group of children who start out with low levels of the risky externalizing and internalizing traits and are born into environments with less family adversity.[170] As shown in Fig 1, the pattern of adaptation for these "nonchallenged" children remains stably better from age 3 into their early teens. Another group of children, who similarly began with low levels of the externalizing and internalizing traits but were born into higher-adversity, alcoholic, and sometimes antisocial alcoholic homes, showed a similar pattern of relative stability of lower levels of impulsivity and aggressiveness throughout early and middle childhood and early adolescence. These children were called "resilient" by Zucker et al.[170] However, they also showed some evidence of "weathering" over time, at least with regard to internalizing traits. Anxiety, sadness, and depression levels remained low during the preschool and early school years and then began to increase, approaching the levels found among more-vulnerable children by early adolescence. The authors suggested that the exposure to more family adversity over long periods eventually "wore away" the sunnier disposition these children had when they were younger.

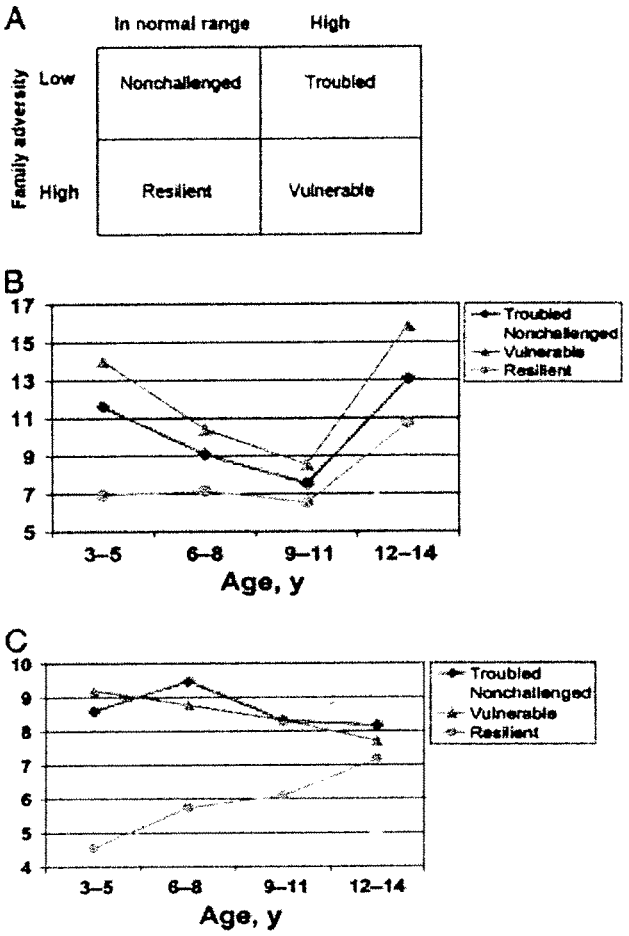

FIGURE 1
Typology of child risk and family adversity and changes in externalizing and internalizing symptoms in the different risk/adversity groups over time. A, Shown is a 2 × 2 matrix of child individual differences in psychopathology (child risk level) and family adversity level, during the preschool years. (Reproduced with permission from Zucker RA, Wong MM, Puttler LI, Fitzgerald HE. Resilience and vulnerability among sons of alcoholics: relationship to developmental outcomes between early childhood and adolescence. In: Luthar S, ed. *Resilience and Vulnerability: Adaptation in the Context of Childhood Adversities*. New York, NY: Cambridge University Press; 2003:79.) B, Child Behavior Checklist (CBCL) externalizing symptom scores for different risk/adversity groups. (Reproduced with permission from Zucker RA, Wong MM, Puttler LI, Fitzgerald HE. Resilience and vulnerability among sons of alcoholics: relationship to developmental outcomes between early childhood and adolescence. In: Luthar S, ed. *Resilience and Vulnerability: Adaptation in the Context of Childhood Adversities*. New York, NY: Cambridge University Press; 2003:88.) C, CBCL internalizing symptom scores for different risk/adversity groups. (Reproduced with permission from Zucker RA, Wong MM, Puttler LI, Fitzgerald HE. Resilience and vulnerability among sons of alcoholics: relationship to developmental outcomes between early childhood and adolescence. In: Luthar S, ed. *Resilience and Vulnerability: Adaptation in the Context of Childhood Adversities*. New York, NY: Cambridge University Press; 2003:88.)

Protective Factors

In contrast to antecedent risk factors, there has been little attention paid to positive antecedent factors. Two kinds of positive factors have been delineated in the literature on risk, competence, and resilience, that is, promotive factors, which are generally associated with better outcomes across levels of risk or adversity (main effects, in statistical terms), and protective factors, which are associated with better outcomes particularly in the context of higher risk or adversity (moderator effects, in statistical terms).[61] Some factors, such as parenting, have been widely implicated as both promotive and protective factors. Considerable literature evidence implicates good-quality parenting as a promotive factor with respect to many positive developmental outcomes; at the same time, parenting quality seems to play a special protective role under very risky or hazardous conditions.

Many of the most widely studied promotive and protective factors in human development are bipolar in nature, reflecting dimensions of variation along a continuum with a desirable to undesirable range. Parenting is a classic example, because good parenting can be viewed as promotive or protective and bad parenting can be viewed as a risk or vulnerability factor for underage drinking and many other outcomes among children. With continuously distributed predictors, it is often difficult to determine "where the action is" along a continuum. Distinguishing a risk factor from a promotive factor or a vulnerability factor from a protective effect is a challenging problem, given that these may be arbitrary labels for one or the other end of a dimension that has influences on development across the range of observable differences. In studies in which only a high-risk sample is examined, one cannot distinguish a promotive factor from a protective factor or a risk factor from a vulnerability factor. Without a low-risk group, one cannot establish whether the factor of interest has comparable effects across all levels of risk, rather than a special role among high-risk people.

For alcohol use, factors that predicted fewer problems

would be viewed as promotive factors and factors that moderated the effects of risk or adversity on problem outcomes would be viewed as protective factors. For example, a protective factor may be associated with attenuated (lower than expected) alcohol-related outcomes for the general level of risk for alcohol use or AUDs present. Among children living in poverty in bad neighborhoods, surrounded by deviant peers who encourage underage drinking (where risk for underage drinking seems to be high), effective parenting may be particularly important and may have protective effects beyond the generally positive effects of good parenting on child outcomes. Relatively few studies in the alcohol literature have focused on establishing moderators of risk, particularly in longitudinal analyses for children <10 years of age. The data exist, but the field has not yet addressed this issue aggressively.

NEXT-STEP TASKS: DATA NEEDS RELEVANT TO POLICY IN THIS AREA

It is clear from the present review that there is a lack of national surveillance data on child and early adolescent alcohol use, covering children and preadolescents in grades 4 through 7. Extant data suggest that there are nontrivial numbers of children who have had some experience with alcohol in these grades. Instituting an ongoing series of nationwide surveys of children's alcohol experience is critical for a number of reasons. First, it is necessary to determine the prevalence of alcohol use in this population, to monitor both the need for and the success of prevention efforts in elementary schools. Second, alcohol use onset is one of the initial stages in the progression to illicit drug use.[171] Knowing how many children have experience with alcohol thus serves as an indicator of the number potentially at risk for illicit drug use. Third, as noted above, onset of alcohol use in childhood predicts alcohol problems in adolescence, as well as alcohol abuse and dependence in adulthood.[73,119]

Although it is clear that early-onset drinking is problematic, it is also clear that some parents think that children should be introduced to responsible alcohol use in a family context. The little research on this suggests that early onset is problematic whether it occurs in a family context or occurs in a peer context.[172] More research on whether and how onset context (eg, family versus peer context) matters is very important. Moreover, this issue highlights how little is known about US adults' beliefs about anticipatory socialization regarding alcohol use in childhood.

In addition, although there once was a literature on cultural contexts of drinking and their influencing roles (eg, Irish, Italian, or Jewish traditions),[173,174] there is little current research to indicate whether and how adult norms for child and adolescent drinking vary across ethnic, racial, and religious groups in the United States. Where there is subcultural support in the home for such drinking, it is unlikely that school-based prevention programs that ignore such influences will be effective. Similarly, little is known about protective effects of cultural traditions or contexts on the development of underage drinking.

IMPLICATIONS FOR INTERVENTION

There are a number of points before the initiation of alcohol use in childhood and early adolescence that are implicated in this review as candidates for different types of interventions. Findings indicate that it is essential to consider these developmental pathways of risk. Therefore, prevention efforts can target parents before conception, prenatally or at many points in child development, long before initiation of alcohol use by children. On the basis of this review, we recommend 5 target areas for intervention, as follows.

First, treat alcohol problems in potential parents. Given the importance of genetic risks for alcoholism and socialization risks associated with alcohol problems in parents, adults with alcohol problems who are likely to become parents are an important target for intervention. Examples include (1) an emphasis on treatment for alcoholic parents, to reduce the parents' problem drinking and thereby to reduce children's exposure to such drinking in the home; (2) provision of parental training to instill more-effective parenting practices and to reduce instances of child neglect and maltreatment; and (3) provision of marriage/couples counseling, to ensure that there is less conflict in the home. Such parental training and counseling should be offered as part of the parents' alcoholism treatment. The goal is to make the intergenerational transmission of alcoholism less likely.

Second, boost efforts to reduce prenatal drinking in mothers. Prenatal exposure to alcohol is a risk factor for developmental anomalies such as fetal alcohol syndrome and seems to be a risk factor for problem drinking in adolescence and young adulthood,[161] although additional research is necessary to confirm this. Given the growing evidence of multiple negative consequences of prenatal exposure to alcohol, prevention efforts need to focus on better education and dissemination regarding negative consequences of drinking during pregnancy, greater emphasis and dissemination regarding the need for prenatal care during pregnancy, better screening for women's alcohol use as part of prenatal visits, and greater referral of drinking pregnant women to effective alcohol interventions.

Third, include screening for alcohol use and alcohol risk behaviors in pediatric well-child visits. The studies reviewed above[154–161] also implicate prenatal exposure to alcohol as a factor influencing the development of a variety of other risk factors for alcohol problems, including executive functioning deficits, inattention, poor academic performance, decreased response inhibition, and delinquent behavior (although genetic risks could also figure here). Pediatric well-child care should include screening for prenatal alcohol/drug exposure if prenatal care records are not forwarded from the mother's obstetrician. Among children identified as having prenatal exposure to alcohol, early childhood interventions should be instituted before school entry, targeted toward instilling child and parent behaviors that enhance child functioning in academic tasks, that enhance response inhibition, and that reduce inattention. Screening for ADHD should be part of such interventions, given the

proven benefits of pharmacologic agents in reducing problems associated with this disorder.

Fourth, address high-risk externalizing pathways early. Substantial evidence was cited earlier in our review for the role of externalizing disorders as a risk factor for earlier onset of drinking and the development of alcohol problems in adolescence. Relevant recommendations in this arena are (1) to develop better surveillance systems in the schools, pediatric medicine, social services, and public safety (police), to identify children already displaying evidence of such problems, and (2) to develop programs to enhance or to enable collaboration between alcohol researchers and other developmental researchers in allied fields who may already have successful prevention or intervention programs to reduce conduct problems in children and preadolescents.[17] Important considerations would include determining what ages are likely to provide the most preventive "bang for the buck," what venues are most engaging and least stigmatizing for such interventions, and how barriers to parental involvement in the programs can best be reduced.

Fifth, intervene early in pathways to deviant peer involvement and promote pathways to prosocial peer involvement. Although onset of alcohol use in childhood is less likely affected by affiliation with deviant peers, this is a major risk factor for early adolescent onset of drinking and for movement into problematic drinking in adolescence. Although not reviewed here, affiliation with deviant peers is associated with a variety of family risk factors, including harsh and inconsistent discipline, low levels of parental warmth, less parental support, less parental monitoring, and less parental attachment and identification. The seeds for later affiliation with deviant peers are thus sown early in the school years. Research suggests that the most-effective interventions involve parent education in school family resource centers, rather than child interventions that group and segregate children at risk.

CONCLUSIONS

This review has documented a host of factors and pathways evident before 10 years of age that influence risk for underage drinking and progression into problem use. Some of this research has been in the literature for more than a generation, and much of it has been known for ≥1 decade. Despite the preponderance of evidence, it is still rare for researchers or clinicians to recognize that drinking problems of youths have their beginnings well before alcohol use is initiated. Why would this be the case? Two possibilities occur to us. One is the failure to understand that nonspecific risk factors are at least as important as alcohol-specific risk factors in the early stages of a drinking career, especially when the focus is on understanding what creates risk for onset. The second possibility is that most researchers and clinicians are more comfortable with proximal causes, with the result that more-distal developmental connections between early/middle childhood and adolescence are largely ignored or dismissed. Whatever the explanation, the evidence presented in this review provides a compelling rationale for expanding the causal model for the development of drinking risk into the earlier childhood years and into the parental context that surrounds them.

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The Grim Neurology of Teenage Drinking

By KATY BUTLER

Teenagers have been drinking alcohol for centuries. In pre-Revolutionary America, young apprentices were handed buckets of ale. In the 1890's, at the age of 15, the writer Jack London regularly drank grown sailors under the table.

For almost as long, concerned adults have tried to limit teenage alcohol consumption. In the 1830's, temperance societies administered lifelong abstinence pledges to schoolchildren. Today, public health experts regularly warn that teenage drinkers run greatly increased risks of involvement in car accidents, fights and messy scenes in Cancún.

But what was once a social and moral debate may soon become a neurobiological one.

The costs of early heavy drinking, experts say, appear to extend far beyond the time that drinking takes away from doing homework, dating, acquiring social skills, and the related tasks of growing up.

Mounting research suggests that alcohol causes more damage to the developing brains of teenagers than was previously thought, injuring them significantly more than it does adult brains. The findings, though preliminary, have demolished the assumption that people can drink heavily for years before causing themselves significant neurological injury. And the research even suggests that early heavy drinking may undermine the precise neurological capacities needed to protect oneself from alcoholism.

The new findings may help explain why people who begin drinking at an early age face enormous risks of becoming alcoholics. According to the results of a national survey of 43,093 adults, published yesterday in Archives of Pediatrics & Adolescent Medicine, 47 percent of those who begin drinking alcohol before the age of 14 become alcohol dependent at some time in their lives, compared with 9 percent of those who wait at least until age 21. The correlation holds even when genetic risks for alcoholism are taken into account.

The most alarming evidence of physical damage comes from federally financed laboratory experiments on the brains of adolescent rats subjected to binge doses of alcohol. These studies found significant cellular damage to the forebrain and the hippocampus.

And although it is unclear how directly these findings can be applied to humans, there is some

evidence to suggest that young alcoholics may suffer analogous deficits.

Studies conducted over the last eight years by federally financed researchers in San Diego, for example, found that alcoholic teenagers performed poorly on tests of verbal and nonverbal memory, attention focusing and exercising spatial skills like those required to read a map or assemble a precut bookcase.

"There is no doubt about it now: there are long-term cognitive consequences to excessive drinking of alcohol in adolescence," said Aaron White, an assistant research professor in the psychiatry department at Duke University and the co-author of a recent study of extreme drinking on college campuses.

"We definitely didn't know 5 or 10 years ago that alcohol affected the teen brain differently," said Dr. White, who has also been involved in research at Duke on alcohol in adolescent rats. "Now there's a sense of urgency. It's the same place we were in when everyone realized what a bad thing it was for pregnant women to drink alcohol."

One of two brain areas known to be affected is the hippocampus, a structure crucial for learning and memory. In 1995, Dr. White and other researchers placed delicate sensors inside living brain slices from the hippocampi of adolescent rats and discovered that alcohol drastically suppressed the activity of specific chemical receptors in the region.

Normally, these receptors are activated by the neurotransmitter glutamate and allow calcium to enter neurons, setting off a cascade of changes that strengthen synapses, by helping to create repeated connections between cells, aiding in the efficient formation of new memories.

But at the equivalent of one or two alcoholic drinks, the receptors' activity slowed, and at higher doses, they shut down almost entirely. The researchers, led by Scott Swartzwelder, a neuropsychologist at Duke and at the Veterans Affairs Medical Center in Durham, N.C., found that the suppressive effect was significantly stronger in adolescent rat brain cells than in the brain cells of adult rats.

As might be predicted, the cellular shutdown affected the ability of the younger rats to learn and remember. In other experiments, the team found that adolescent rats under the influence of alcohol had far more trouble than did tipsy adult rats when required repeatedly to locate a platform submerged in a tub of cloudy water and swim to it.

Dr. Swartzwelder said it was likely that in human teenagers, analogous neural mechanisms might explain alcohol "blackouts" — a lack of memory for events that occur during a night of heavy drinking without a loss of consciousness. Blackouts were once thought to be a symptom of advanced adult alcoholism, but researchers have recently discovered just how frequent they are among teenagers as well.

In a 2002 e-mail survey of 772 Duke undergraduates, Dr. White and Dr. Swartzwelder found that

51 percent of those who drank at all had had at least one blackout in their drinking lifetimes; they reported an average of three blackouts apiece.

These averages barely suggest the frequency of blackouts among young adults at the extreme end of the drinking scale. Toren Volkmann, 26, is a graduate of the University of San Diego who, at 14, started drinking heavily almost every weekend and at 24 checked himself into a residential alcohol treatment program.

"It was common for me to basically black out at least once or twice every weekend in late high school and definitely through college, and it wasn't a big deal to me," said Mr. Volkmann, a co-author, with his mother, Chris, of "From Binge to Blackout: A Mother and Son Struggle With Teen Drinking," to be published in August. "I wouldn't even worry about what happened, because I wouldn't know."

Blackouts are usually mercifully brief, and once they are over, the capacity to form new memories returns. But younger rats subjected to binge drinking also displayed subtler long-term problems in learning and memory, the researchers found, even after they were allowed to grow up and "dry out."

In experiments conducted by the Duke team, the reformed rat drinkers learned mazes normally when they were sober. But after the equivalent of only a couple of drinks, their performance declined significantly more than did that of rats that had never tippled before they became adults. The study was published in 2000 in the journal Alcoholism: Clinical and Experimental Research. Other research has found that while drunken adolescent rats become more sensitive to memory impairment, their hippocampal cells become less responsive than adults' to the neurotransmitter gamma-amino butyric acid, or GABA, which helps induce calmness and sleepiness.

This cellular mechanism may help explain Jack London's observation, in "John Barleycorn: Alcoholic Memoirs," that when he was a teenager he could keep drinking long after his adult companions fell asleep.

"Clearly, something is changed in the brain by early alcohol exposure," Dr. Swartzwelder said in an interview. "It's a double-edged sword and both of the edges are bad.

"Teenagers can drink far more than adults before they get sleepy enough to stop, but along the way they're impairing their cognitive functions much more powerfully."

Alcohol also appears to damage more severely the frontal areas of the adolescent brain, crucial for controlling impulses and thinking through consequences of intended actions — capacities many addicts and alcoholics of all ages lack.

In 2000, Fulton Crews, a neuropharmacologist at the University of North Carolina, subjected adolescent and adult rats to the equivalent of a four-day alcoholic binge and then autopsied them, sectioning their forebrains and staining them with a silver solution to identify dead neurons.

All the rats showed some cell die-off in the forebrain, but the damage was at least twice as severe in the forebrains of the adolescent rats, and it occurred in some areas that were entirely spared in the adults.

Although human brains are far more developed and elaborate in their frontal regions, some functions are analogous across species, Dr. Crews said, including planning and impulse control. During human adolescence, these portions of the brain are heavily remolded and rewired, as teenagers learn — often excruciatingly slowly — how to exercise adult decision-making skills, like the ability to focus, to discriminate, to predict and to ponder questions of right and wrong.

"Alcohol creates disruption in parts of the brain essential for self-control, motivation and goal setting," Dr. Crews said, and can compound pre-existing genetic and psychological vulnerabilities. "Early drinking is affecting a sensitive brain in a way that promotes the progression to addiction.

"Let's say you've been arrested for driving while drunk and spent seven days in jail," Dr. Crews said. "You'd think, 'No way am I going to speed and drive drunk again,' because you have the ability to weigh the consequences and the importance of a behavior. This is exactly what addicts don't do."

In another experiment, published this year in the journal Neuroscience, Dr. Crews found that even a single high dose of alcohol temporarily prevented the creation of new nerve cells from progenitor stem cells in the forebrain that appear to be involved in brain development.

The damage, far more serious in adolescent rats than in adult rats, began at a level equivalent to two drinks in humans and increased steadily as the dosage was increased to the equivalent of 10 beers, when it stopped the production of almost all new nerve cells.

Dr. Crews added, however, that adult alcoholics who stop drinking are known to recover cognitive function over time.

The same may hold true for hard-drinking teenagers. In 1998, Sandra Brown and Susan Tapert, clinical psychologists at the University of California, San Diego, and at the Veterans Affairs Medical Center there, found that 15-to-16-year-olds who said they had been drunk at least 100 times performed significantly more poorly than their matched nondrinking peers on tests of verbal and nonverbal memory.

The teenagers, who were sober during the testing, had been drunk an average of 750 times in the course of their young lives.

"Heavy alcohol involvement during adolescence is associated with cognitive deficits that worsen as drinking continues into late adolescence and young adulthood," Dr. Tapert said.

Two M.R.I. scan studies, one conducted by Dr. Tapert, have found that hard-drinking teenagers had significantly smaller hippocampi than their sober counterparts. But it is also possible, the

researchers said, that the heavy drinkers had smaller hippocampi even before they started to drink.

Teenagers who drink heavily may also use their brains differently to make up for subtle neurological damage, Dr. Tapert said. A study using functional M.R.I. scans, published in 2004, found that alcohol-abusing teenagers who were given a spatial test showed more activation in the parietal regions of the brain, toward the back of the skull, than did nondrinking teenagers.

When female drinkers in the group were tested in their early 20's, their performance declined significantly in comparison with nondrinkers, and their brains showed less activation than normal in the frontal and parietal regions.

Dr. Tapert hypothesized that when the drinkers were younger, their brains had been able to recruit wider areas of the brain for the task.

"This is a fairly sensitive measure of early stages of subtle neuronal disruption, and it is likely to be rectifiable if the person stops drinking," Dr. Tapert said.

The good news is that the brain is remarkably plastic, she added, and future studies may show that the teenage brain, while more vulnerable to the effects of alcohol, is also more resilient.

She pointed to test results from the original group of teenagers, recruited from substance abuse treatment centers and brought into the lab when they were 15 by Dr. Brown. When Dr. Tapert retested the teenagers eight years later, those who had relapsed and who continued to get drunk frequently performed the worst on tests requiring focused attention, while those who reported the most hangovers performed the worst on spatial tasks.

On the other hand, the relative handful of teenagers and young adults in the group who stayed sober — 28 percent of the total — performed almost as well, at both the four-year and the eight-year mark, as other San Diego teenagers who had rarely, if ever, had a drink.

Mr. Volkmann, the University of San Diego graduate, was not part of Dr. Tapert's study. While in college, Mr. Volkmann said, he thought he drank for the fun of it. His moment of truth came in the Peace Corps in Paraguay, when he began waking up with sweats and tremors. He discovered he could not control his drinking even when he wanted.

The son of an anesthesiologist and a former teacher in Olympia, Wash., Mr. Volkmann spent a month in a residential treatment program and six months in a halfway house. He has since returned to San Diego.

He said in an interview that he had no way of knowing exactly how drinking affected his overall brain function. But on one point, he is clear.

"My memory is definitely better now," he said. "Every day now, I can count on the fact that when I think back to the night before, I know what happened."