

# **Use of Incidence and Prevalence in the Substance Use Literature: A Review**

Li-Tzy Wu  
Samuel P. Korper  
Mary Ellen Marsden  
Charlene Lewis  
Robert M. Bray

DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Substance Abuse and Mental Health Services Administration  
Office of Applied Studies

## **Acknowledgments**

This work was supported by the Office of Applied Studies, Substance Abuse and Mental Health Services Administration, through Contract No. 283-99-9018 with RTI in Research Triangle Park, NC. At RTI, the document was reviewed by Janice M. Brown and Carol L. Council, copyedited by Richard S. Straw, and prepared for publication on the Web by Pamela Couch Prevatt and Teresa F. Gurley. Final document production was provided by Beatrice Rouse at SAMHSA.

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Wu, L.-T., Korper, S. P., Marsden, M. E., Lewis, C., & Bray, R. M. (2003). *Use of Incidence and Prevalence in the Substance Use Literature: A Review*. Rockville, MD: Substance Abuse and Mental Health Services Administration, Office of Applied Studies.

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## **Originating Office**

SAMHSA, OAS, 5600 Fishers Lane, Room 16-105, Rockville, MD 20857

January 2003

# Introduction

An important goal for epidemiological research on psychoactive drug use, abuse, and dependence is to quantify their occurrences (i.e., incidence) and frequencies (i.e., prevalence) in human populations (Anthony & Helzer, 1995). Timing of the occurrences of these events must be clearly specified for calculation of incidence rates and prevalence. Timing of an event's occurrence, such as onset, cessation, relapse, and treatment entry, is a critical variable in helping us understand the processes of initial substance involvement, progression, and cessation. It is particularly crucial in the definition of a risk factor in that the risk characteristic needs to occur before the outcome of interest (Mrazek & Haggerty, 1994). Because risk factors predicting the time of onset, the time to remission or recovery, or other features of time course may all be different, time needs to be well defined and measured as part of the definition of an outcome (Kraemer et al., 1997).

Until recently, little attention has been paid in the research literature to the distinction between the new occurrence and the frequency of substance use, abuse, and dependence. Indeed, many studies have focused exclusively on the proportion of users or abusers within a given time frame. Fewer have considered the number of new occurrences within those time frames. In this paper, we review the use of the terms "incidence" and "prevalence" in the substance use literature and the types of conclusions that are drawn based on these concepts. The literature under review includes both published articles and government documents or reports. This review focuses on understanding the use and definitions of the terms "incidence" and "prevalence" and related conclusions of study findings in the literature, but not on the statistical techniques or methods. The information will suggest some directions for future research on the incidence and prevalence of substance use and abuse.

This review is organized into four sections. Section 1 describes the concepts of incidence and prevalence in epidemiological research. Section 2 presents the review and discussion of the use of the terms "incidence" and "prevalence" in the literature. The literature includes cross-sectional and prospective investigations, covering studies of any substance use, problems related to substance use, and substance use disorders. A summary of the review, including limitations of study designs and implications for future investigations and policymaking, is given in Section 3. In Section 4, we provide suggestions for future research.

# 1. The Concepts of "Incidence" and "Prevalence"

Epidemiology is the study of the distribution and determinants of disease frequency in human populations (MacMahon & Trichopoulos, 1996). It is concerned with the patterns of disease occurrence in human populations and the factors that influence these patterns, particularly the occurrence of the disease as characterized by time, place, and persons (Lilienfeld & Stolley, 1994; Reid, 1960). There are two types of key population measures of disease frequency: prevalence (i.e., what exists or prevails) and incidence (i.e., the frequency of occurrence of events) (MacMahon & Trichopoulos, 1996).

One of the earlier discussions on the concepts and methods of measuring the incidence and prevalence of disease was given by Dorn (1951). According to Dorn, two functions are necessary for the characterization of a population's development: *an increment rate* that determines the rate at which new members enter the population and *a decrement rate* that describes the rate at which members leave the population. The *increment rate* of a population of sick persons is called the *incidence rate* of illness; the *decrement rate* of a population of sick persons is a function expressing the *duration of illness* (Dorn, 1951). The size of the population of sick persons is a joint function of the incidence rate and the duration of illness. Dorn also indicated that a prevalence rate of illness is a measure of the aggregate size of the population of sick persons and is a direct function of the length of the observation interval. Thus, prevalence is the sum of the cases of illness existing at the start of an interval and the new cases developing during the interval.

In medical statistics, Hill (1961) described rates of incidence and prevalence as the most useful morbidity rates. Specifically, Hill stated that the illness existing in a population during a given time interval might be classified into four categories: (1) illnesses beginning during the interval and ending during the interval, (2) illnesses beginning during the interval and still existing at the end of the interval, (3) illnesses existing before the beginning of the interval and ending during the interval, and (4) illnesses existing before the beginning of the interval and still existing at the end of the interval. Thus, the *incidence rate* was defined as the number of illnesses beginning within a specified period of time (i.e., categories 1 and 2) and is related to the average number of persons exposed to risk during that period (i.e., the number of cases of sickness arising in a given interval). The *period prevalence rate* described the total number of cases of sickness that existed during a given interval (i.e., all four categories above) and the *point prevalence rate* showed the number of illnesses existing at a specified point of time (i.e., all four categories above).

Kramer (1957) and Reid (1960) discussed the concepts of incidence and prevalence in relation to epidemiological studies of mental disorders. Consistent with Dorn (1951), Kramer described *incidence* as the number of *new* cases of a disease occurring within a specific period of time. *Prevalence* was defined as the number of cases of a disease present in a population group as of a specified interval of time (i.e., the number of cases existing at the start of an interval plus the new cases developing during the interval). The principles that describe the dynamic relationship of the prevalence and incidence for medical illnesses in population groups also apply to mental disorders. Kramer and Reid both emphasized the use of prevalence and incidence as

mental morbidity indexes and highlighted the importance of understanding the dynamic relationship between the two measures in helping us determine the distribution and determinants of mental illnesses.

Rates of prevalence and incidence provide an estimate of levels of mental morbidity in a population (Reid, 1960). Specifically, the prevalence rate per 1,000 is taken as

$$(No. \text{ of cases ill at one point in time} \div \text{Defined population exposed to risk at that time}) \times 1,000.$$

The incidence rate per 1,000 is defined as

$$(No. \text{ of new cases beginning during a defined period of time} \div \text{Averaged number in a defined population exposed to risk during that time}) \times 1,000.$$

In psychiatry, as in other branches of medicine, epidemiological inquiry is designed to measure the risk of attack by specific disorders within communities and to uncover clues about their origin and mode of spread (Reid, 1960). The dynamic relationships among incidence, prevalence, and duration of the disease are of particular importance to epidemiological investigations. The prevalence of one specific disease at one point in time reflects both the incidence of the illness and its duration, which is influenced by factors affecting mortality or morbidity, prevention programs, and treatment characteristics (Kramer, 1957; MacMahon & Trichopoulos, 1996; Reid, 1960).

Arithmetically, when the condition of the disease is fairly stable and the time unit of measurement is the same, *Point prevalence rate = Incidence rate  $\times$  Average duration* (Reid, 1960). Thus, lifetime prevalence data are of limited value for epidemiological inferences concerning the etiology or risk factors because morbidity and mortality factors of the disease influence the prevalence. The incidence rate measures the rate at which new cases are added to the population of sick persons (Kramer, 1957) and allows investigators to determine whether the probability of developing a disease differs in different populations or time periods or in relationship to suspected etiologic factors (Lilienfeld & Stolley, 1994). Risk factors can be credibly identified only in incidence studies, and those factors are critical to the identification of high-risk groups who can be targeted for intervention programs (Eaton, Kramer, Anthony, Chee, & Shapiro, 1989a).

Anthony and Helzer (1995) discussed the concepts of incidence and prevalence in relation to the epidemiology of psychoactive drug use and dependence. An incidence estimate expresses the risk of becoming the case of drug use (or dependence) for the first time during some span of time. By comparing incidence estimates for different subgroups of a population, it is possible to discriminate conditions of heightened risk and risk factors (Anthony & Helzer, 1995). Lifetime prevalence estimates are not good indicators of measures for risk factor studies, particularly for acute conditions (Anthony & Helzer, 1995). The numerator of the lifetime prevalence rate includes persons who are totally recovered from the condition, those who are in temporary remission, and those who are currently active cases.

Anthony and Helzer (1995) also indicated that a lifetime prevalence value can understate the cumulative probability of becoming a case, with lifetime prevalence comparisons possibly giving a distorted view of high-risk groups, and that point or interval (period) prevalence estimates convey the probability of being a recently active case of drug use (or dependence). Although period prevalence values also are affected by the forces of mortality, they provide useful estimates for the recently active cases that represent the potential burden and caseload for current early intervention and treatment programs (Anthony & Helzer, 1995). Therefore, the efforts of epidemiological studies on substance use should focus on producing valid estimates of the incidence and interval-prevalence rates (Anthony & Helzer, 1995).

Kraemer et al. (1997) made a distinction between a prevalence study and an incidence study. A prevalence study at time  $T$  is a study in which individuals are assessed to determine whether they are experiencing the outcome at that time. An incidence study at time  $T$  investigates individuals free of the outcome at time zero. Prevalence can generally be more easily estimated by a single survey of a population group than incidence. For example, prevalence surveys of mental disorders are designed to estimate the number of individuals with a mental disorder of defined severity in a population at one point in time and are useful in indicating areas of high and low prevalence within a community (Reid, 1960). However, prevalence surveys might not permit investigators to estimate incidence because denominator and numerator data might be unavailable or incomplete.

In an incidence study using a prospective design, measurements of risk factors can be obtained from individuals free of the outcome. These individuals can then be followed to observe the outcome's occurrence. Such cohort or prospective studies allow investigators to follow groups with a particular characteristic (e.g., exposed vs. unexposed to a characteristic) and to observe the incidence of an outcome in each group. The risk for an outcome of interest can then be estimated by comparing the incidence rate of the outcome in the exposed group with the incidence rate in the unexposed group.

Taken together, the terms "incidence" and "prevalence" were described consistently in the early literature. Regardless of mental or medical illnesses, they are key morbidity indexes of illnesses (or conditions) for population groups. To determine *when* an individual is at risk for an event, a study of incidence is preferred over prevalence because the prevalence is determined by incidence and duration of the event.

## 2. Use of Incidence and Prevalence in the Literature

The vast majority of studies on substance use/abuse have used cross-sectional designs with a focus on prevalence. These prevalence studies have generally reported both lifetime and recent prevalence estimates. For example, the National Household Survey on Drug Abuse (NHSDA) reports annually on lifetime, past year, and past month use (OAS, 1999, 2000a), while the National Comorbidity Study (NCS) reported the prevalence of lifetime and 12-month use of a drug (Warner et al., 1995).

### 2.1 Uses in Major Epidemiological Studies

The Summary of Findings from recent NHSDAs (OAS, 1999, 2000a, 2001) use the terms "incidence" and "prevalence" to describe the prevalence of lifetime, past year, and past month use, as well as first-time use or incidence within the year. In the NHSDA series, prevalence cases refer to individuals who reported *any use* of the substance within a specified period of time. Incidence or new use refers to *the first use* of the substance that is determined by self-reported age of first use, year and month of recent new users, the respondent's date of birth, and the interview day. The incidence rate of a specific substance use was defined as the rate of new users per 1,000 potential new users in a given year (i.e., the number of new users divided by the person time of exposure).

These prevalence rates reported in the NHSDA, particularly prevalence estimates for past year or past month use, provide information about trends and patterns of substance use and indicate subgroups needing treatment for a drug use problem. The incidence data identify the number of new users of each drug for each year. The Summary of Findings authors suggested that the incidence data point out the need for an immediate focus on the prevention of substance use among children and adolescents (e.g., OAS, 1999, 2000a). Incidence data also suggest the future burden on the substance abuse treatment systems (e.g., Gfroerer & Epstein, 1999).

The NCS was designed to study the distribution, correlates, and consequences of psychiatric and substance use disorders in the United States (Kessler et al., 1994). The survey used stratified, multistage area probability sampling designs and consisted of a structured psychiatric interview of a nationally representative sample of 8,098 noninstitutionalized residents. In an NCS report, the focus was on the prevalence and correlates of prevalence cases (Warner et al., 1995). Lifetime prevalence of drug use was defined as having tried the drug at least once in a person's life, excluding medical use. Prevalence of 12-month use was referred to any use in the past year. The term "incidence" was not specified in the report. Nonetheless, data on age of onset (i.e., self-reported age of first use) were used to generate cumulative age-at-onset curves to indicate cumulative probability of drug use. The cumulative age-of-onset curves showed a dramatic rise in first use between early adolescence and late adolescence. Warner et al. emphasized some potential limitations of the study. First, the NCS prevalence estimates probably underestimate the true prevalence of drug use in the total population because homeless people and residents of institutional settings were excluded and there was potential underreporting. Second, recall bias in reporting ages of first use could have led to errors in the age-of-onset analysis.

The National Longitudinal Alcohol Epidemiologic Survey (NLAES) was designed to overcome some of the methodological problems inherent in previous population surveys, such as the NCS (Grant, 1996). Specifically, the NLAES diagnoses were based on the most current psychiatric classification (DSM-IV; American Psychiatric Association, 1994). It included a larger sample size than the NCS, covering respondents aged 18 or older (i.e.,  $N = 42,862$ ), and used the more accurate measurement of drug dependence from the Alcohol Use Disorder and Associated Disability Interview Schedule (AUDADIS) (Grant, 1996). The AUDADIS diagnoses of lifetime and 12-month dependence satisfied the clustering and duration criteria of the DSM-IV classifications. Many of the NLAES reports were primarily about the prevalence of drug use or dependence. Two types of prevalence of nonmedical drug use were reported: lifetime and 12-month use. Lifetime drug use was defined as having tried the drug *at least 12 times*; 12-month drug use was defined as any use of the drug at least once during the year preceding the interview among the lifetime users (Grant, 1996).

The term "incidence" generally was not specified or used in the NLAES study reports. Nonetheless, data on age at onset of *first use* were used to estimate the cumulative probability of lifetime drug use (Grant, 1996) and to study the association of early onset of drug use with lifetime drug abuse and dependence (e.g., Grant & Dawson, 1997, 1998). Age of first drug use was found to be a powerful predictor of lifetime drug abuse and dependence; moreover, age of first use of alcohol was a powerful predictor of lifetime alcohol abuse and dependence (Grant & Dawson, 1997, 1998). As with other cross-sectional studies, Grant (1996) emphasized that the self-reported nature of the measures is always subject to some degree of recall bias, and that surveys of household populations are likely to underestimate the true prevalence of drug use and dependence. A prospective or longitudinal study could reduce the extent of recall bias and increase the ability to disentangle the importance of the contribution of age of onset of drug use to the development of drug use disorders (Grant & Dawson, 1997).

The NLAES investigators pointed out some implications for future research. First, to better inform public policy decisions and prevention efforts, it is important to collect data on drug dependence as well as drug use (Grant, 1996; Grant & Dawson, 1998). Second, epidemiological and etiological research needs to be integrated with intervention research (Grant & Dawson, 1997). For example, the use of a prospective study to incorporate prevention efforts targeted toward early onset of alcohol use disorders could examine whether early onset of use is a critical and potentially modifiable risk factor in the development of alcohol use disorders (Grant & Dawson, 1997).

The Monitoring the Future (MTF) study uses a cohort-sequential design in which new cohorts of high school seniors are surveyed annually, and subsamples from each senior class are followed over time, to track drug use trends among America's adolescents (Bachman, O'Malley, & Johnston, 1984; Johnston, O'Malley, & Bachman, 1998, 1999a, 1999b; O'Malley, Bachman, & Johnston, 1984). Such designs make it possible to disentangle true maturation changes from changes due to cohort or historical events (Kandel, 1992). Previous MTF reports have generally focused on prevalence rates of substance use, including lifetime, past year, and past month. Incidence rates have not been reported in the findings for college students and young adults (Johnston et al., 1999a), but have been reported briefly in the findings for secondary school students (Johnston et al., 1998, 1999b). The MTF's operational definition for prevalence is



consistent with what is used in the NHSDA reports. Incidence of use or initiation is based on retrospective self-reports of *grade at first use* (i.e., which grade the student was in when he/she first used the drug). The calculation of the incidence rate was not specified in the report. The incidence rate by grade level was described as the percentage of first use by the end of a particular grade.

Other analyses of substance use and its correlates in the MTF have relied primarily on the prevalence of recent or current use (Bachman, Johnston, & O'Malley, 1981; Bachman et al., 1984, 1991; O'Malley et al., 1984). The incidence data from the MTF found a great deal of variation in the grade of first use for different substances and their peak initiation rates. Such information on the grade of first use provides an important guide to the timing and nature of various interventions in the school, the home, and the larger society (Johnston et al., 1998, 1999b).

The Community Epidemiology Work Group (CEWG) is a network established by the National Institute on Drug Abuse (NIDA) and is composed of researchers from 21 major metropolitan areas of the United States and selected foreign countries that meet semiannually to discuss the current epidemiology of drug use (NIDA, 1999a, 1999b). Multiple sources of information have been used to identify and track the increase and decrease in the availability and the use of illicit drugs, including drug abuse treatment admissions and discharges, drug-related deaths, emergency room drug abuse episodes, public health data, drug-related arrests, survey findings, and ethnographic research data. A number of health indicators are used to assess drug abuse patterns and trends, including drug-related deaths, drug-related emergency department mentions, drug-related treatment admissions, arrestee urinalysis results, and ethnographic reports.

Overall, the CEWG emphasizes patterns and trends of drug "abuse," as reflected by health indicators. Data on drug-related health indicators from the CEWG have typically been presented without making distinctions between first use and continuing use. The term "prevalence" has been used occasionally, but the term "incidence" has generally not been operationally defined in the CEWG reports. At times, local ethnographic reports have indicated an increasing number of persons recently "initiating" drug use. However, the meaning of "initiating" was not specified (e.g., see NIDA, 1999a).

The Drug Abuse Warning Network (DAWN), an ongoing national survey of hospital emergency departments, collects information on patients seeking hospital emergency department treatment related to their use of an illicit drug or nonmedical use of a legal drug (OAS, 1997, 2000b). The DAWN data do not measure the prevalence of drug use, but rather the health consequences of drug use expressed as emergency department visits and drug-related deaths. The term "episode" is used to indicate a drug-related emergency department visit; the term "incidence" typically has not been used in DAWN reports.

The mission of the Office of National Drug Control Policy (ONDCP) is to reduce drug use and its consequences through the following elements: strategy, measurement, and resources (ONDCP, 1999, 2000). Specifically, the elements include developing National Drug Control Strategies and Federal National Drug Control Budgets, suggesting improvement in the management and organization of drug control efforts, and conducting evaluations and

performance measurements to improve program effectiveness. The aim of the ONDCP is to deter new users (incidence) and encourage existing users (prevalence) to stop using (ONDCP, 2000). Most survey findings that were reported by the ONDCP use prevalence rates to indicate the scope or consequences of substance use. Depending on data sources used by the ONDCP (e.g., the NHSDA and MTF), the terms "incidence" and "prevalence" appear to have been used properly.

In addition, the *Pulse Check*, which is published twice annually by the ONDCP, reports trends and patterns in illicit drug use and illicit drug markets (ONDCP, 1998a,1998b). The data are gathered through conversations with ethnographers, epidemiologists, law reinforcement officials, and treatment providers working in the fields of drug use and abuse throughout the United States. Information gathered from each source is summarized in narrative form and is presented by detailed tables.

Because *Pulse Check* summarizes information regarding patterns and trends in the use of heroin, cocaine, marijuana, methamphetamine, and emerging drugs in each of their contact areas over the 6 months prior to the interview (ONDCP, 1998a, 1998b), the available data are mainly *prevalence* rates of illicit drug use. For instance, data from treatment providers tend to be about *recent* changes in drug-related treatment admission rates. Reports from communications with ethnographers and law reinforcement officials have also reflected *current* rates of use and any changes in rates, frequency, characteristics of the use over the past 6 months; characteristics of sellers in the community; and/or typical prices and purity of illicit drugs (ONDCP, 1998a).

Overall, the *Pulse Check* reports use the terms "new users," "first-time users," or "initiates" to indicate incidence cases of illicit drug use (ONDCP, 1998a, 1998b). Unfortunately, operational definitions of these terms are not provided in the reports. Likewise, no specific time point is defined for the term "prevalence." Nonetheless, the *Pulse Check* reports provide valuable current information about trends and patterns of emerging drug use in the United States. Recent findings suggested that (a) there are some new, young heroin users in different cities; (b) crack users are an older cohort than they were in the early 1990s, indicating few new crack users; and (c) methamphetamine use continues to rise in the West and Southwest and in Hawaii (ONDCP, 1998a, 1998b).

We also reviewed the use of the terms "incidence" and "prevalence" in the following documents and reports related to prevention:

- ! *Preventing Adolescent Drug Use: From Theory to Practice* (Goplerud, 1991);
- ! *Reducing Tobacco Use Among Youth: Community-Based Approaches* (Center for Substance Abuse Prevention [CSAP], 1997);
- ! *Prevention of Drug Use Among Children and Adolescents, A Research-Based Guide* (NIDA, 1999c);
- ! *Understanding Substance Abuse Prevention, Toward the 21 Century: A Primer on Effective Programs* (CSAP, 1999); and

! *National Conference on Drug Abuse Prevention Research: Presentations, Papers, and Recommendations* (NIDA, 1998).

These reports reviewed and/or discussed the literature related to prevention strategies or programs, as well as some epidemiological findings on substance use. Study findings of both cross-sectional and prospective designs were mentioned. One of these reports used the term "incidence" and referred to it as "number of new cases" (Goplerud, 1991). Another report (CSAP, 1999) used the term "incidence" to describe the finding of a prevention program, but the definition for incidence was not provided. The extent or magnitude of substance use was typically described in terms of "use" of the substance within a specific period of time (e.g., current, past year, or lifetime). The term "prevalence" was used occasionally and, in some cases, the time frame for the prevalence was not specified. Generally speaking, the terms "incidence" and "prevalence" seem to have been used properly in these prevention documents or reports. On the basis of context, the conclusions drawn in each of these reports appear to be appropriate.

Taken together, major epidemiological studies of substance use and government reports generally focus on the prevalence of substance use/abuse. The term "prevalence" has been applied appropriately in these studies and reports. Because the prevalence of substance use has been studied extensively and described consistently in the literature, the following sections review studies of incidence, including both cross-sectional and prospective investigations. They cover incidence or initiation of any first use, substance-related problems, and substance use disorders.

## **2.2 Studies of Incidence**

Incidence data on problems of substance use or substance use disorders from community studies are relatively rare. Nonetheless, studies have been increasingly using either cross-sectional or prospective data to estimate the incidence or onset of substance use. Depending on the study, "first use" of a substance generally refers to "onset," "initiation," "incidence," "initial use," or "new use."

### **2.2.1 Cross-Sectional Studies of Substance Use**

A number of cross-sectional investigations have studied the incidence, onset, or initiation of substance use using retrospective self-reports of age at first use of the substance (e.g., Chilcoat & Schutz, 1996; DeWit, 1998; DeWit, Adlaf, Offord, & Ogborne, 2000; DeWit, Offord, & Wong, 1997; DuRant, Smith, Kreiter, & Krowchuk, 1999; Escobedo, Anda, Smith, Remington, & Mast, 1990; Gfroerer & Brodsky, 1992; Gfroerer & Epstein, 1999; Johnson & Gerstein, 1998; Johnson, Gerstein, Ghadialy, Choy, & Gfroerer, 1996).

Escobedo et al. (1990) estimated age-specific *incidence of smoking initiation* using data from the 1987 National Health Interview Survey (NHIS) and the Hispanic Health and Nutrition Examination Survey (HHANES) conducted from 1982 to 1984. Specifically, a total of 14,764 respondents aged 18 to 35 interviewed in the 1987 NHIS and a total of 3,123 respondents aged 18 to 35 interviewed in HHANES from 1982 to 1984 were included for statistical analysis. In

both surveys, age of *smoking initiation* was assessed by the question, "How old were you when you *first started* smoking cigarettes *fairly regularly*?" and was restricted to respondents who reported having ever smoked at least 100 cigarettes in his or her life. Age-specific *incidence rate of smoking initiation* was defined as the number of persons who had started smoking cigarettes at that age divided by the number of persons who had not started smoking *regularly* before that age. The investigators found that among all racial/ethnic groups, smoking initiation occurred approximately at age 9, increased rapidly with successive ages after age 11, peaked at 17 to 19, and declined substantially after age 19. Although age-specific *incidence rates* varied slightly by race/ethnicity, the overall shape of the smoking initiation curves were strikingly similar (Escobedo et al., 1990).

Escobedo et al. (1990) suggested several implications for prevention policy. First, school-based smoking prevention programs should begin early and include all grades. Second, smoking cessation programs are needed for adolescents. Third, antismoking strategies for young adults should emphasize both cessation and prevention of smoking initiation. Fourth, persons with low socioeconomic status need greater attention for smoking prevention. However, there were some limitations to the study, such as the use of cross-sectional designs, retrospective self-reports (potential recall bias or underreporting), and the use of combined years of HHANES data.

Gfroerer and Brodsky (1992) combined the samples of the 1985, 1988, 1990, and 1991 NHSDAs to estimate *incidence* or *new users* of illicit drug use in the United States. In brief, self-reported data on the date of birth, date of interview, and age at first use of each drug were used to determine a specific date of first use of each drug for each respondent who reported using that drug (Gfroerer & Brodsky, 1992). Estimates of incidence rates for each drug were made for each year from pre-1962 to 1989 by classifying users into their associated year of first use. Estimates of incidence rates of marijuana and cocaine use also were compared with NHSDA estimates using two other methods. First, the number of new users between 1979 and 1982 was estimated by subtracting the number of lifetime users estimated by the 1979 NHSDA from the number estimated by the 1982 NHSDA. The second method used data assessed from questions on the use of drugs for the first time during the past year.

Estimates from the two other methods were consistent with estimates based on composite estimates, and all suggested that marijuana incidence rates peaked in the mid-1970s and declined thereafter, and that cocaine incidence peaked in the early 1980s and declined thereafter. Gfroerer and Brodsky (1992) discussed potential biases associated with their estimates, including bias associated with survival (e.g., estimates affected by deaths among drug users before 1985); recall bias; and the undercoverage of the NHSDA (e.g., new users under age 12 were not covered in the NHSDA). These investigators also suggested the need for future research to estimate incidence rates for age cohorts and to evaluate the impact of reporting biases on the composite retrospective estimates.

Chilcoat and Schutz (1996) used data from the 1988, 1990, and 1992 NHSDAs to conduct a survival analysis to examine patterns in the onset of hallucinogen use across age groups. *Incidence rates* of hallucinogen use were estimated from self-reported data on age at first use. They found that the period of highest risk of starting hallucinogen use extended from the

mid-teens to the early 20s and that the onset of use was rare after age 25. Data on lifetime prevalence showed the highest rate of hallucinogen use among individuals over 25 years old, although past year use was relatively rare in this age group. The data clearly suggest limited information conveyed by lifetime prevalence estimates. The investigators emphasized the importance of exercising caution when using retrospective self-reports because younger respondents may report onset of use that occurred more recently than that reported by older respondents.

DeWit et al. (1997) used data from the 1990-1991 Ontario Mental Health Supplement Survey to study patterns of onset and cessation of drug use among respondents aged 13 to 35. The *onset of regular or stable drinking* was defined as the self-reported age when the respondent began drinking the most and was restricted to those who had consumed 12 or more drinks of alcohol during any 1-year period in their lifetime. The *onset of nearly daily/daily alcohol use* was defined as the age at which the respondent began drinking alcohol at least 4 to 6 times a week. *Tobacco onset* was defined as the age at which the respondent began smoking cigarettes on a daily basis.

Survival analyses found variations of the risk of onset across drug types (DeWit et al., 1997). Age-specific hazard rates showed that the earliest risk of onset was the first drink of alcohol, followed closely by illicit drug use of prescribed drugs and use of hallucinogens. The risk for cocaine/crack began later at ages 15 to 16. The onset of daily cigarette use and marijuana use began around ages 13 and 14. Several limitations of the study were discussed: recall and reporting bias, sample selective bias (e.g., the sample might not have been representative of past cohorts), and cross-sectional design (e.g., difficulty in studying maturational changes in drug use associated with age). Implications included that prevention programs for youths should begin at different times depending on the drug in question and that programs are needed to help youths who already use to stop as well to delay the onset of first use. The data from the 1990-1991 Ontario Mental Health Supplement Survey also were used to study the onset of drug use and alcohol use disorders (DeWit, 1998; DeWit et al., 2000).

Johnson and Gerstein (1998) studied the *initiation* or *incidence* of alcohol, cigarettes, and other drugs using data from the 1991 to 1993 NHSDAs. Estimations of drug use *incidence rates* were based on respondents' retrospective reports of their age at first use of 11 drugs. The investigators estimated drug use incidence rates by birth cohort. This investigation found dramatic differences in the range and extent of drug use between individuals born before and after World War II and suggested an increase in the incidence of illicit drug use among cohorts born after World War II. Three possible biases were discussed: bias due to differential mortality, bias due to memory errors, and bias due to social acceptability and fear of disclosure. Despite these potential biases, available data suggested that the cohort comparison of drug use incidence seems to be appropriate (Johnson & Gerstein, 1998). A detailed report of these incidence estimates can be found in Johnson et al. (1996).

Gfroerer and Epstein (1999) also used NHSDA data to examine the impact of marijuana initiation on drug abuse treatment need. In their research, the term "initiates" was used to indicate *new users* of marijuana, and the annual number of new users was estimated from data on self-reported age at first use of marijuana. The investigators found that marijuana initiation was

unlikely to occur after age 21, and age at first use of marijuana was significantly associated with treatment need.

Based on data from 1995 North Carolina Youth Risk Behavior Survey (YRBS), DuRant et al. (1999) investigated the relationship between early age of onset of substance use and multiple risk behaviors among sixth to eighth grade students. The term "onset" or "initiation," but not "incidence," was used and was measured by the age of first smoking a whole cigarette, the first drink of alcohol for other than a religious reason, and the first use of marijuana or cocaine. Early onset of tobacco, alcohol, and drug use, particularly tobacco use, was found to be associated with a clustering of health risk behaviors. Limitations of this study included a cross-sectional survey, uncertainty about the causality, and unknown validity of the students' responses (DuRant et al., 1999). Implications for primary health providers and public health professionals also were discussed. First noted was the importance for primary health providers to screen for substance use as early as 9 years of age. Second, the researchers noted that prevention programs need to be initiated during elementary school and continue at least through middle school, with a focus on addressing multiple risk and protective factors.

## 2.2.2 Prospective Studies of Substance Use

An increasing number of studies use prospective data or longitudinal designs to study the onset, initiation, or incidence of substance use. Kandel and colleagues examined longitudinal drug use patterns of initiation, continued use, and discontinuation (Kandel & Logan, 1984; Yamaguchi & Kandel, 1984a, 1984b). Use of any drug fewer than 10 times in a lifetime was considered as nonuse (Yamaguchi & Kandel, 1984b). "*Initiation*" or "*onset*" was used to indicate the *first-time use* of the drug and was defined to include those who began use in a particular year of life.

Kandel and colleagues found important gender differences in temporal developmental stages in the use of licit and illicit drugs from adolescence through young adulthood (e.g., Yamaguchi & Kandel, 1984a). With respect to policy implications, their interpretations of the data point out that (a) prevention of early involvement in legal drugs would reduce the use of marijuana, (b) prevention of early involvement in marijuana use would reduce the use of other illicit drugs, and (c) prevention efforts for all drugs would be more effective if they were targeted at reducing the risk of initiating the use of drugs rather than decreasing use among users (Yamaguchi & Kandel, 1984b).

Based on data from two waves of interviews in the National Institute of Mental Health Epidemiologic Catchment Area (NIMH-ECA) surveys, Ritter and Anthony (1991) studied factors associated with the risk of becoming a cocaine user (i.e., a *new initiator*). Cocaine use was measured by questions that assessed whether the individual had ever been an illicit drug user and had used cocaine on more than five occasions. *Initiation* referred to changes in cocaine use from fewer than six occasions to six or more occasions and was restricted to individuals whose baseline interview data showed no history of cocaine use. Depression during the 1 year follow-up interval, recent marijuana and other illicit drug use, and younger age were found to be associated with risk of initiating cocaine use.

Ritter and Anthony (1991) discussed several possible limitations and unsolved issues, such as generalizability, problems of sample nonresponse and attrition during the follow-up, lack of differentiation of cocaine initiators from those who progressed from initial occasions of use to more than five occasions of use, potential biases in self-reporting, and imperfect length of the follow-up period for study variables (i.e., 1-year follow-up). For future research, the investigators emphasized the use of fine-grained measurement and analysis of time-related events.

Aaron et al. (1995) investigated the *incidence* of substance use and other high-risk health behaviors in adolescents using data from the Adolescent Injury Control Study. At baseline, respondents were asked about the use of cigarettes, alcohol, and other illicit drugs; the survey was repeated 1 and 3 years later. *Incidence* or *initiation* of substance use was defined to include respondents who reported no substance use at baseline and reported the use of the substance during the follow-up. After 3 years of follow-up, the incidence was 15 percent for cigarette smoking, 27 percent for alcohol use, and 6 percent for marijuana use. The study also found an inverse relationship between initiation of cigarette smoking and levels of physical activities among females, as well as an increased likelihood of initiating alcohol use among males participating in competitive sports. The finding on the association of alcohol use and physical activities stood in contrast with the finding of cross-sectional associations (Aaron et al., 1995). The investigators acknowledged the limitation of using self-reported data. No specific implications regarding policymaking or prevention interventions were discussed.

The relationship between drug use initiation and parental monitoring was examined among a sample of 926 urban-dwelling youths (Chilcoat & Anthony, 1996). *Incidence* of drug use was defined as first use of illicit drugs among children who reported *no prior history of use* in previous interviews. A low level of parental monitoring in middle childhood was found to be associated with starting to use marijuana, cocaine, and/or inhalant drugs later in childhood and early adolescent years. Among youths with higher levels of parental monitoring, a reduced risk of starting to use illicit drugs was observed even when holding constant the affiliation with drug-using peers and family type. The investigators indicated that effective monitoring practices might protect children against starting to use these drugs, even when they had been exposed to friends and individuals in their neighborhoods who used drugs. Limitations of the study included the use of self-reports and data from a single informant (i.e., the child) (Chilcoat & Anthony, 1996).

Miller and Miller (1997) examined the influence of socioeconomic status (SES) on marijuana *initiation* using data from the National Youth Survey of youths aged 11 to 17. Marijuana use was assessed at the 1-year follow-up. Marijuana *initiation* was defined to include youths who reported having ever smoked marijuana in the past year among those who reported no use at the time of the initial survey. They found that SES was a significant predictor of marijuana initiation among males and weekly alcohol use was predictive of marijuana initiation for both genders. Miller and Miller (1997) concluded the need to further evaluate the relationship between SES and marijuana use as the relationship has changed over time. The investigators provided no discussion on the implications of their findings for policymaking or prevention interventions.

Reifman, Barnes, Dintcheff, Farrell, and Uhteg (1998) used a three-wave study design to identify new cases of regular (i.e., weekly) and heavy episodic drinkers (i.e., five or more drinks at a time) during the follow-up interval. Specifically, those who drank regularly at wave 2, but did not do so at wave 1, were considered as new cases of regular drinkers. Friends' drinking and low parental monitoring were found to predict the onset of heavier drinking in adolescents. The investigators concluded that prevention programs for the onset of heavier drinking should address different processes of influences involving both parental and peer domains.

Harrell, Bangdiwala, Deng, Webb, and Bradley (1998) used the longitudinal data from the Cardiovascular Health in Children and Youth Study (CHIC I and II) to examine smoking behaviors in children aged 8 to 16 at the first time of data collection. Data on cigarette smoking were assessed five times. For each time point, experimental smoking was assessed by the question: "Have you ever smoked a whole cigarette?" The time when the child first reported having tried smoking was referred to as the *age of initiation of experimental smoking*. White children, those with parents of low educational level, rural children, and boys were found to be at increased risk for early experimental smoking. The investigators suggested that smoking prevention classes should start in elementary school and target disadvantaged youths, and that students in middle school should receive programs to encourage those who have not started smoking to maintain their nonsmoking status and to help the smokers stop smoking.

Kosterman, Hawkins, Guo, Catalano, and Abbott (2000) used a survival analysis to study the patterns and predictors of alcohol and marijuana *initiation* or onset among a sample of 808 youths interviewed annually from 10 to 16 years of age and at age 18. *Alcohol initiation* was defined as the first point at which the youths reported having ever drunk beer, whiskey, gin, or other liquors; *marijuana initiation* was the first point at which the youths reported having ever smoked marijuana. The study found that the risk of alcohol initiation spanned virtually all of adolescence, while the risk for marijuana initiation increased notably with age through the 18<sup>th</sup> year. Predictors of initiation varied somewhat: associates' alcohol use and parents' alcohol use norms predicted alcohol initiation; marijuana use by acquaintances or siblings, parents' family management practices, and adolescents' own norms about marijuana use predicted marijuana initiation.

Kosterman et al. (2000) indicated several implications for prevention efforts. First, prevention efforts should span the entire period of adolescent development. Second, parents can play an important role in delaying initiation through family management and communication of strong family norms against alcohol use. Third, strong personal norms can help inhibit the initiation of behaviors such as marijuana use. Fourth, to prevent initiation of licit and illicit substance use, prevention efforts may need to target parents' family management practices and norms regarding adolescent substance use. Finally, prevention efforts must address the influence of substance use by peers, siblings, and other acquaintances. Limitations of the study included the use of self-reports and a sample of youths from lower-income families with diverse ethnic backgrounds (Kosterman et al., 2000).

In addition to the studies being reviewed in this section, there have been some prospective investigations on the onset or initiation of alcohol, cigarettes, or marijuana (e.g., Bailey, 1992; Brook, Kessler, & Cohen, 1999; Burton, Johnson, Ritter, & Clayton, 1996; Costello, Erkanli,



Federman, & Angold, 1999; Hawkins et al., 1997; Lambert & Hartsough, 1998; Lewinsohn, Rohde, & Brown, 1999; Wu & Anthony, 1999). In these studies, the *onset* or *initiation* of substance use appears to have been defined consistently as first use, but the term "incidence" was not used.

### 2.2.3 Studies of Substance-Related Problems

A few studies have focused on first-time substance-related problems (Caetano, 1997; Clark, Parker, & Lynch, 1999; DeWit, 1998; Wilsnack, Klassen, Schur, & Wilsnack, 1991), and one study used the term "incidence" (Caetano, 1997). Wilsnack et al. (1991) used data from 5-year follow-up interviews to study the onset and chronicity of women's problem drinking. Problem drinking was defined as having at least two of the following: (1) average consumption of one or more ounces of ethanol per day, (2) one or more drinking-related problems in the past 12 months, and (3) one or more alcohol dependence symptoms in the past 12 months. The *onset* of problem drinking was referred to as the change in problem drinking from Time 1 among nonproblem drinkers in 1981 to being a problem drinker at Time 2 in 1986.

At Time 2, 11 percent of the women had developed problem drinking behavior among those with no indicators of problem drinking at baseline. Predictors for the onset of problem drinking included younger age, cohabiting, lifetime use of drugs other than alcohol, and depressive episodes. The researchers concluded that delineating more fully the predictors of change at different stages of problem drinking for specific subgroups of women would allow primary and secondary prevention efforts to be targeted more precisely to the characteristics of drinkers, the social environment, and the extent to which the person had progressed into problem-drinking behavior.

Caetano (1997) reported the prevalence, incidence, and stability of alcohol dependence-related problems based on an adult household sample who were interviewed in 1984 and 1992. The *incidence* of dependence-related problems was the proportion of individuals who did not report a problem in 1984 but did report a problem in 1992 among all individuals who did not report a problem in 1984 but were drinkers in 1992. The results showed that the incidence and stability of dependence-related problems, as well as the stability of social consequences from drinking, were higher among Hispanic men than among white men, and that incidence rates for both dependence-related problems and social consequences also were higher among black and Hispanic women than white women. Two limitations of the study were acknowledged: (a) because the data were collected at two points in time, variation in drinking-problem status between the two points was not assessed (e.g., historical, social, and political factors that characterized the 8 years between two time points; and (b) the statistical analysis did not control for social and demographic factors. The investigator emphasized the need for more research and for increased prevention interventions on Hispanic men.

Clark et al. (1999) examined the onset of substance-related problems from late childhood through early adolescence in boys of fathers with substance use disorder ( $N = 177$ ) and without ( $N = 203$ ). Substance-related problems were defined as any DSM-III-R (APA, 1987) abuse or dependence symptoms associated with alcohol or cannabis. The onset date was determined to the nearest month. Substance-related problems were found to have a median onset of age 14, with

only 25 percent having an onset prior to age 13. The findings showed that antisocial personality disorders predicted onset of alcohol use, marijuana use, and substance-related problems, but attention deficit hyperactivity disorder (ADHD) and negative affect disorders were not significant in predicting the onset in the adjusted model. The investigators suggested that prevention programs focus on disrupting the link between childhood antisocial personality disorders and substance use initiation. They also emphasized some limitations. First, their findings were specific for boys through age 15 years for this developmental period. Second, the sample under study might not have been representative of their populations, and replications of the investigation in other populations are needed.

#### **2.2.4 Studies of Substance Use Disorders**

As compared with studies on substance use, data on the onset or incidence of substance abuse or dependence are rarely presented in the literature. Because of the low occurrence rate of incidence cases of substance dependence, most surveys do not examine a large enough sample to generate meaningful incidence rates. As noted by Regier et al. (1984), the NIMH-ECA study used a 1-year reinterviewed-based longitudinal design to obtain incidence data on Diagnostic Interview Schedule (DIS)-defined DSM-III (APA, 1980) mental disorders. Investigators of the ECA study drew a distinction between *first* incidence and *total* incidence (Eaton et al., 1989b). The numerator of *first incidence* for a specified period stood for individuals who had an occurrence of the disorder for the first time in their lives, and the denominator included only persons who had started the period with no prior history of the disorder. *Total incidence* included all onsets in the period under study (i.e., the first-time onset and recurrent cases).

Investigators of the ECA study reported rates of *1-year first incidence* of DIS/DSM-III alcohol and drug abuse/dependence (Eaton et al., 1989b). A total of 82 new cases of drug abuse/dependence were identified across four ECA sites. There was an inverse relationship between years of age and the onset of drug abuse/dependence, and males had much higher incidence rates than females. With respect to alcohol abuse/dependence, males had higher incidence rates than females, and the highest rates were found among younger and middle-aged adults. The incidence data from the NIMH-ECA study indicate the rarity of first onsets for psychiatric disorders and provide the context for understanding the natural course of disorders (Eaton et al., 1989b).

The 1-year follow-up interval of the ECA design did not allow time for developing a large number of cases to produce stable estimates of incidence, and the exclusion of individuals younger than aged 18 made it impossible to examine incidence in childhood and adolescence (Burke, Burke, Regier, & Rae, 1990). Burke et al. (1990) emphasized the importance of onset occurring anytime in the lifetime and of producing more stable estimates of onset than using only new cases who experienced onset during the 1-year follow-up interval. They examined the pattern of onset for psychiatric disorders for all respondents in the NIMH-ECA. The *onset* of drug and alcohol disorders was not referred to as the first use of the drug. Instead, age at onset for drug abuse/dependence was assessed by the question, "How old were you when you *first* had any of these problems with drugs?" and was restricted to respondents who qualified for a lifetime DSM-III diagnosis of drug abuse or dependence. Similarly, for respondents with a lifetime DSM-III diagnosis of alcohol abuse or dependence, the answer to the question of "first

experience" of specific problems and behaviors related to alcohol use was used to determine the age at onset.

The analysis of the onset pattern of specific disorders in a large population-based ECA sample observed that, for both alcohol and drug abuse/dependence, the risk for both males and females was highest between the ages of 15 and 19 years (Burke et al., 1990). The investigators pointed out several implications of examining the age at onset for both research and public health purposes. For instance, knowing the period of risk for developing a specific disorder may aid in designing cohort studies that attempt to measure the incidence of specific disorders or in planning for prevention and early treatment, and knowing how the onset of the disorders is distributed may help provide information about subtyping or the etiology of the disorders. More importantly, the finding that the peak age at onset for several mental disorders was younger than reported in the literature suggested the need for more attention in both research and clinical practice to the development of disorders in childhood and adolescence (Burke et al., 1990).

Lewinsohn, Hops, Roberts, Seeley, and Andrews (1993) studied the rates of prevalence and incidence of DSM-III-R disorders in high school students aged 14 to 18. The sample was drawn from nine high schools in five communities in west central Oregon. A total of 1,508 students completed Time 1 and Time 2 assessments. Consistent with the ECA study (Eaton et al., 1989b), *first incidence* was the number of students who developed an episode for the first time in their lives divided by the total numbers of students who had never had the disorder at Time 1; *total incidence* was the number who developed an episode at Time 2 divided by the total numbers of students who were not in an episode at Time 1. *Total incidence* was both first-time and recurrent cases. One-year first incidence was found to be 1.9 percent for alcohol abuse/dependence, and 2.3 percent for drug abuse/dependence; for total incidence, the rate was 2.4 percent for alcohol abuse/dependence and 2.5 percent for drug abuse/dependence (Lewinsohn et al., 1993). Additionally, the relapse rate was reported to be 16.0 percent for alcohol abuse/dependence and 6.6 percent for drug abuse/dependence. The relapse rate suggested a higher incidence of alcohol abuse/dependence among those who had a previous disorder from which they had recovered at Time 1 than drug abuse/dependence.

The investigators discussed some limitations of their study. For instance, biases such as the case ascertainment method, nonresponse at Time 1, and attrition between Time 1 and Time 2 might have influenced the rate estimate. In addition, the sample under study may not have been representative of high school students in the United States. High school dropouts and students in institutions were not included in the study. The diagnostic information was based on the single informant (i.e., the students). Lewinsohn et al. (1993) concluded the need to study the long-term consequences of having an episode of mental disorder during adolescence.

On the basis of an ongoing 14-year longitudinal study of adolescents in a community, Giaconia et al. (1994) examined the link between the onset of psychiatric and substance use disorders and later psychosocial functioning. Age at onset of disorders was based on retrospective self-reports by the adolescents at age 18. This in turn was defined as the earliest age at which adolescents who met the lifetime criteria for a DIS-DSM-III-R diagnosis experienced any key symptoms of that disorder. Alcohol abuse/dependence and drug abuse/dependence were found to have similar age of onset, although the lifetime rate of alcohol abuse/dependence was

more than 3 times greater than the rate of drug abuse/dependence. The median onset age for both disorders was 15 years and about one third of youths with either alcohol or drug abuse/dependence reported onset by age 14. The distribution of age of onset showed an increased risk for developing alcohol abuse/dependence among males, but no significant gender difference was observed for drug abuse/dependence.

Consistent with the ECA study of adult samples (Burke et al., 1990), Giaconia et al.'s study confirmed that adolescence was a key risk period for onset of substance abuse/dependence. Limitations of the study included the use of a predominately white working class community sample, which reduced the generalizability of the findings, and potential errors in recall because of the reliance on retrospective reports at age 18 (Giaconia et al., 1994). Nonetheless, the results suggested several directions for future research and clinicians: (a) study factors that contributed to greater risk of onset at ages 14 and 15, (b) examine the impact of treatment in altering the trajectory of disorders that have an early onset, and (c) identify and treat all types of mental disorders early on (Giaconia et al., 1994).

Brown, Lewinsohn, Seeley, and Wagner (1996) examined prospective relationships of cigarette smoking and the total incidence of psychiatric disorders. A sample of 1,709 adolescents was assessed by using semistructured diagnostic interviews on two occasions, approximately 1 year apart. *Total incidence* was defined as the number of first-onset and recurrent cases developing the disorder between Time 1 and Time 2 among those not in a current episode of the disorder at Time 1. Between Time 1 and Time 2, there were 78 and 107 total incidence cases of alcohol abuse/dependence and drug abuse/dependence, respectively. Multiple logistic regression analysis found that smoking status at Time 1 predicted total incidence of drug abuse/dependence and major depression disorder at Time 2, but not alcohol abuse/dependence. The investigators discussed several implications. First, there was a high degree of comorbidity between smoking and psychopathology. Second, the assessment of cigarette smoking should be included in clinical assessments. Third, smoking prevention and cessation programs for adolescents might need to take into account the high rate of psychiatric comorbidity among smokers. Finally, the investigators indicated that it is possible that preventive interventions for cigarette smoking would also reduce the risk for illicit drug abuse and dependence.

The timing of the onset of substance use and dependence as well as associated risk factors were examined in a longitudinal study of children aged 9, 11, and 13 at baseline (Costello et al., 1999). In brief, a representative household sample of 1,420 children recruited from 11 counties in western North Carolina was interviewed annually. The *onset of a psychiatric disorder* was specified as the onset date of the first symptom of the disorder in those who subsequently developed the full syndrome.

Costello et al. (1999) defined the *onset of substance use* as the date at which the child first started using the substance, which included daily smoking, any alcohol use without permission, and any use of other substances. The investigators found that the mean age at first use of any substance was 8.9 years, that use of alcohol without permission came first, followed within 2 years by chewing tobacco, and that daily cigarette smoking began 2 years later. Age of onset of substance abuse/dependence was about 6 years after first use. The onset of substance use also was observed to have occurred after the first symptoms of most psychiatric disorders. This

longitudinal study had some limitations (Costello et al., 1999). First, the oldest age in the analysis sample was 16 years, and the sample had not yet passed through the period of highest risk for the onset of substance use and abuse. Second, the generalizability of the findings was limited by characteristics of participants, who were predominately white and lived in rural areas. A third limitation was the lack of information about peer groups.

Some studies of the onset of substance abuse/dependence have used cross-sectional data (e.g., Burke et al., 1990; Clark, Kirisci, & Tarter, 1998; DeWit et al., 1997, 2000; Wilens, Biederman, Mick, Faraone, & Spencer, 1997).

Wilens et al. (1997) evaluated the association between age at onset of substance use disorders and psychiatric disorders by comparing a sample of adults with ADHD and a sample of non-ADHD controls. The age at onset of substance use disorders was defined as the age at which the number of symptoms endorsed in the Structured Clinical Interview for DSM-III-R report exceeded the DSM-III-R threshold for diagnosis. The age at onset of substance use disorders was found to be significantly younger in adults with ADHD than in non-ADHD controls. Because the onset of ADHD tends to occur several years before the onset of substance use disorders, the findings highlighted the importance of targeting preventive and early intervention strategies at children with ADHD (Wilens et al., 1997). The researchers emphasized the issue of limited generalizability of their findings to other populations and potential biases associated with retrospective recall of the occurrence and onset of specific symptoms.

Clark et al. (1998) studied the effect of adolescent age at onset on the development of substance use disorder. The onset of first use of alcohol and cannabis was properly defined. However, the criteria for defining the age at onset of substance dependence were not provided in the report.

DeWit et al. (1997, 2000) studied the timing of drug use behavior among people participating in a large random probability survey of residents of the province of Ontario in Canada. Age at onset of lifetime alcohol dependence was referred to as the age at which a respondent experienced a third alcohol symptom and when some symptoms had persisted for at least 1 month.

DeWit et al. (2000) reported the highest risk for developing DSM-III-R alcohol disorders among individuals who started using alcohol at ages 11 to 14. The next highest rate occurred for those starting to drink before age 11, followed by those starting to drink at ages 13 and 14; the risk for developing alcohol dependence for those starting to drink at ages 15 to 18 was not significant. The findings indicated that prevention programs effective in delaying alcohol use until age 15 or later will avert substantial alcohol-related harm in later life.

However, because of the use of retrospective data to reconstruct drug use histories, DeWit et al. (2000) emphasized cautious interpretations of the results and some potential limitations. First, distortions of the timing of past drug-related events were likely to occur, particularly those experiencing drug-related problems at the time of assessments and members of older age cohorts. Additionally, underreporting or overreporting of events may have varied systematically with respondents' sociodemographic characteristics. The survey also was influenced by selective bias

because the respondents may not have been representative of past cohorts. Finally, the definition of age at onset of dependence was limited by the uncertainty of whether individuals who had the third symptom were still positive on the first or second symptom.

### 3. Summary

In this paper, we reviewed the use of the terms "incidence" and "prevalence" and the types of conclusions that are drawn based on these concepts. Because the prevalence of substance use has been extensively studied and the studies are generally consistent in defining prevalence, this review focused additional attention on studies related to the concept of incidence.

Generally, the terms "incidence" and "prevalence" appear to have been used properly in the literature. In our literature review, we found *two* studies that used the term "initiation" to indicate "ever used" (Bray, Zarkin, Ringwalt, & Qi, 2000; Epstein, Botvin, & Diaz, 1999). Epstein et al. (1999) used a cross-sectional design to examine the correlates of alcohol use among Hispanic adolescents. The investigators reported that friends' drinking was related to alcohol initiation, consumption, and plans to drink in the future, and concluded that the use of skills-based approaches should be used to prevent alcohol and other drug use. Because their study sample consisted of adolescents in grade 7 and the initiation of alcohol use typically occurred before adulthood, the influence of using "alcohol initiation" to express "lifetime use" on the interpretation of the study findings appears to be minimal. In comparison, the same use of alcohol initiation to express lifetime use in studies on adulthood is likely to result in incorrect interpretations of the findings.

Bray et al. (2000) examined the relationship between marijuana use and high school dropout among 1,392 adolescents aged 16 to 18 years. The term "initiation" was used to denote any use of the substance at any time in a student's life prior to the given age. The researchers concluded that the results suggested a positive association between marijuana initiation and high school dropout. Although the use of the term "initiation" is not consistent with previous research, the investigators acknowledged the rate of the drug use reflecting prevalence. However, to ease the communication among researchers and policymakers and to reduce the likelihood of potential misinterpretations of research findings, the use of the term "initiation" to indicate "ever" use should be avoided.

In addition, this review observed several points that deserve attention. *First*, there is variation in defining (or measuring) lifetime substance use. The great majority of studies defined the lifetime prevalence of substance use as any use in a person's lifetime. Some investigations referred to lifetime use as having tried the substance at least 10 times (Yamaguchi & Kandel, 1984b) or 12 times in one's life (Grant, 1996), or having smoked at least 100 cigarettes in one's life (Escobedo et al., 1990).

*Second*, regardless of prospective or cross-sectional designs, "first use" or "new use" of a substance generally is referred to as "onset," "initiation," "incidence," or "initial use." The majority of studies used the term "onset" or "initiation" to describe the first use of the substance. The term "incidence" tended to be applied in studies that report the "rate" of first drug use (e.g., Aaron et al., 1995; Chilcoat & Schutz, 1996; Gfroerer & Brodsky, 1992; Johnson & Gerstein, 1998), of initiation of regular smoking (Escobedo et al., 1990), of the new occurrence of substance dependence-related problems (Caetano, 1997), or of the first occurrence of substance use disorders (Eaton et al., 1989b; Lewinsohn et al., 1993). In addition, a few studies made

distinctions between the first incidence and the total incidence; the total incidence included the first-time and recurrent cases (Brown et al., 1996; Eaton et al., 1989b; Lewinsohn et al., 1993).

*Third*, the definitions for the initial experience involving first use, regular/heavy use, and substance use disorder varied across studies, particularly for cigarettes and alcohol. Although studies of illicit drugs were relatively consistent in defining the first illicit drug use, the definitions of first use for cigarettes and alcohol varied depending on the frequency of use (e.g., Bailey, 1992; DeWit et al., 1997; Johnson et al., 1996; Reifman et al., 1998). The NHSDA studies distinguished between the age at first *casual* use (i.e., any use) and the age at first *regular* use for cigarettes and alcohol (Johnson et al., 1996; Johnson & Gerstein, 1998). For cigarettes, *first casual use* refers to "when you first tried a cigarette"; *first regular use* refers to "when you first started smoking daily." For alcohol, *first casual use* refers to "when you first had a glass of beer, wine, or a drink of liquor"; *first regular use* refers to "when you first began to drink beer, wine, or liquor at least once a month."

In some studies, the onset of smoking referred to the age of first smoking a cigarette (DuRant et al., 1999; Lambert & Hartsough, 1998; Wu & Anthony, 1999), or it was restricted to those who began smoking cigarettes three or more times a week (Brown et al., 1996). In other studies, smoking initiation was defined to include persons who had started to smoke cigarettes lightly (i.e., smoking less than one pack a month) (Bailey, 1992); to smoke cigarettes heavily (i.e., smoking between at least one pack a day and a half pack to one pack a week) (Bailey, 1992); to smoke cigarettes regularly (i.e., smoked one cigarette and smoked on 5 or more days in the last month) (Escobedo, Reddy, & Giovino, 1998); or to smoke cigarettes daily (Costello et al., 1999; DeWit et al., 1997).

Similarly, the definition used in the literature for the first occurrence of alcohol use varied by the degree of alcohol involvement and/or study designs. The onset of alcohol use generally was determined by the age at the first alcohol drink (e.g., DeWit, 1998; DeWit et al., 1997; Hawkins et al., 1997). On the other hand, DeWit et al. (1997) made the distinction between the onset of *regular or stable* drinking (i.e., the age at which respondent began consuming 12 or more drinks of alcohol during any 1-year period in the lifetime) and the onset of *near daily or daily* drinking (i.e., the age when respondent began drinking alcohol at least four to six times a week). Bailey (1992) defined the onset of *light* alcohol use as drinking only once in a year, regardless of the number of drinks consumed or drinking any amount up to and including two drinks on a typical occasion, and defined *heavy* alcohol use as drinking three or more drinks on a typical occasion. Further, a different definition for onsets of regular and heavy episodic drinking was reported in the literature. *Regular* drinking referred to drinking at least once a week and consuming about one drink per occasion, or less frequent drinking with greater amounts involved, while *heavy episodic* drinking referred to having one or more occurrences of five or more drinks of any beverage at a time in a year (Reifman et al., 1998).

There also was slight variation in the definition for age at onset of substance use disorders. Some studies referred to the age at onset of substance use disorders as the age at which the respondent first experienced any of the problems associated with the drug (Burke et al., 1990), the age when the respondent first experienced any key symptoms of that disorder (Giaconia et al., 1994) or the onset date of the first symptoms of that disorder (Costello et al.,



1999). In comparison, Wilens et al. (1997) defined the age at onset of substance use disorders as the age at which the number of symptoms endorsed in the Structured Clinical Interview for DSM-III-R report exceeded the DSM-III-R threshold for diagnosis. DeWit et al. (1997) defined the age at onset of alcohol dependence as the age when the respondent experienced a third alcohol symptom plus some persistence of the symptoms.

*Fourth*, both cross-sectional and prospective studies have limitations and advantages associated with their designs and sample characteristics. Both cross-sectional and prospective studies provide estimates for prevalence, incidence, and strength of association. Because of the importance of *time* in defining a risk factor, using retrospective recall data from cross-sectional designs to study risk factors or outcomes is likely to be problematic, and the time-varying risk and protective factors typically cannot be determined (Kraemer et al., 1997).

Longitudinal designs are better suited for incidence estimates than cross-sectional designs. They allow for following individuals without specific disorders at initial interview to calculate incidence rates, following those with disorders to calculate remission rates, and following those with disorders in the past to calculate recurrence rates (Regier et al., 1984). In addition, longitudinal designs provide a framework for risk factor analysis (e.g., Anthony & Helzer, 1995; Eaton et al., 1989a; Grant & Dawson, 1997); examining the temporal relationship between two conditions (e.g., Clark et al., 1999; Costello et al., 1999; Ritter & Anthony, 1991; Wu & Anthony, 1999); and determining the effect of an intervention on later outcomes (Giaconia et al., 1994; Grant & Dawson, 1997).

Both cross-sectional and prospective studies are subject to issues of generalizability, recall biases, and reporting errors (e.g., under- or overreporting). Nonetheless, because a cross-sectional study is more likely to survey a nationally representative sample or a large-scale population-based sample than a longitudinal study, the generalizability of the findings to a broader population might be better in a cross-sectional survey of a large-scaled population-based sample. For example, the cross-sectional survey of the NHSDA generates population estimates of substance use, and the NCS cross-sectional survey produces population estimates of psychiatric disorders.

On the other hand, the extent to which recall biases or memory errors affect the study findings is less in longitudinal studies than in cross-sectional studies (Grant & Dawson, 1997). The prospective study or multiple-wave design allows for assessing the consistency between the stated age at first use and the actual use during the follow-up period (e.g., Chilcoat, Dishion, & Anthony, 1995; Hawkins et al., 1997). Nonetheless, both cross-sectional and prospective studies tend to rely on self-reports, which are influenced by under- or overreporting.

Some limitations tend to be unique to longitudinal designs, such as high costs, being time-consuming, loss to follow-up, or attrition (Aaron et al., 1995; Burton et al., 1996; Ellickson & Morton, 1999; Lewinsohn et al., 1993), inconsistency in reporting across different waves of data (Bray et al., 2000), and imperfect duration of follow-up (e.g., too short or too long between two assessments) (Burke et al., 1990; Burton et al., 1996; Caetano, 1997; Ritter & Anthony, 1991).

*Fifth*, incidence data have some advantages over prevalence data. Data on the incidence or age at first use indicate the timing of peak risk for substance use or abuse/dependence (Chilcoat & Schutz, 1996; DeWit et al., 1997; Escobedo et al., 1990; Gfroerer & Epstein, 1999; Kosterman et al., 2000). These data shed light on developmental stages in the use of licit and illicit drugs that provide an important guide to the timing or nature of various interventions (DeWit et al., 1997; DuRant et al., 1999; Grant & Dawson, 1997; Johnston et al., 1998, 1999b; Kandel & Logan, 1984; Yamaguchi & Kandel, 1984a). These data also are crucial for studies on risk factors that help identify high-risk groups for targets of early intervention programs (Chilcoat & Anthony, 1996; Eaton et al., 1989a; Harrell et al., 1998; Ritter & Anthony, 1991). Prevalence measures do not capture the full dynamic of drug use patterns over the life course, such as the number, sequencing, and the timing of drug-related events (DeWit et al., 1997).

Taken together, the results of all studies need to be viewed against their methodological limitations. Until a better measure of incidence for substance use is developed and validated, the use of age at first use to estimate incidence is appropriate and is likely to continue in research on substance use and/or dependence.

## 4. Future Research

The prospective or longitudinal design has some advantages over the cross-sectional design in studying incidence, risk factors, consequences, and the effect of prevention or treatment interventions on later outcomes. Characteristics that are fixed or nonvarying over a person's lifetime and precede the occurrence of any outcome (e.g., sex, race, year of birth, or genotype) can be easily and validly assessed in a cross-sectional study; however, the focus on single-time point assessments that ignore the time-varying nature of some risk and protective factors is an impediment to searching for causal risk factors that have substantial time variability within each individual (Kraemer et al., 1997).

Incidence or onset data based on estimations from cross-sectional studies need to be interpreted with caution. When cross-sectional data are used to estimate the incidence of drug use (e.g., Chilcoat & Schutz, 1996; DeWit, 1998; DeWit et al., 1997, 2000; DuRant et al., 1999; Escobedo et al., 1990; Gfroerer & Brodsky, 1992; Gfroerer & Epstein, 1999; Johnson et al., 1996; Johnson & Gerstein, 1998), data on age at first use of the particular substance or of other substance use-related events need to be properly assessed and defined. The limitations of study designs and the impact of potential sources of biases on the interpretation of study findings should also be emphasized.

Additionally, this review suggests some directions for future research. *First*, to avoid miscommunication across studies and to facilitate our search for the cause and course of substance use and abuse, rigorous research reporting and consistent use of precise terminology across studies are recommended. For example, many factors labeled "risk factors" in the cross-sectional studies have not been shown to precede the corresponding outcome (Kraemer et al., 1997); such labeling should be avoided. *Second*, to move toward a better understanding of the natural course of substance use involvement, focused research for causal risk factors is required. Timing of the occurrence of an event needs to be well-defined and measured (Kraemer et al., 1997).

*Third*, data from the incidence of drug use and drug use disorders have identified the period of heightened risk and the modifiable risk characteristics for targeting prevention efforts among youths; future prospective research incorporating substance use prevention efforts/strategies to at-risk subgroups and examining their impacts on the drug-related outcomes is warranted.

*Fourth*, when data on time-related drug events are available, use of statistical procedures that permit the analysis of time-related events (e.g., survival analysis techniques) are encouraged in order to examine the temporal relationship between two conditions (e.g., the influence of prior illicit drug use and later illicit drug use, or social consequences of prior illicit drug use). The methods of the survival analysis provide a powerful and flexible set of tools for studying research questions about event occurrence (e.g., onset, duration, recovery, relapse, recurrence, or treatment entry) and allow mechanisms for including time-varying predictors and incorporating censored observations in the analyses (Singer & Willett, 1994). For cross-sectional data, the use of statistical procedures, such as matching and multivariate regression techniques, to adjust for

confounding variables that may obscure the observed association between two conditions is suggested (Lilenfeld & Stolley, 1994).

*Finally*, in light of increasing cross-sectional studies of first use of substance use-related outcomes, there is a need for methodological investigations to determine the influence of recall and/or reporting biases on incidence estimates of drug-related behaviors.

In summary, variations in the prevalence of an outcome from one time to another reflect changes in incidence, duration of the outcome of interest, or both. Prevalence provides useful data about the number of individuals with a given outcome existing in a community and gives clues about the possible variation in incidence rates. Incidence data are superior to prevalence data for searching risk factors. Retrospective cross-sectional and prospective designs are considered complementary; they are employed consecutively, with leads given by retrospective surveys followed through in more intensive prospective studies (Reid, 1960). Given the high expense and some potential biases of a prospective design, the rationale for conducting such an investigation should be based on leads from prevalence studies and on sound research designs that attend to the methodological issues discussed here.

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