Alcohol Experiences Viewed Mutoscopically: Newly Incident Drinking of Twelve- to Twenty-Five-Year-Olds in the United States, 2002–2013

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ABSTRACT. Objective: This study sought to discover recent age-specific and cohort-specific patterns of newly incident drinking of alcoholic beverages among young people in the United States, with identification of age at peak risk, cohort by cohort, and age by age. **Method:** Data are from the U.S. National Surveys on Drug Use and Health 2002–2013, with 12 independent successive replications of nationally representative surveys ($n \approx 420,000$ 12- to 25-year-olds). Drinking was assessed via confidential computer-assisted self-interviews. **Results:** Looking across age strata, we found rising age-specific drinking incidence rates across adolescence to a plateau at age 16–18 years and made a new discovery of a statistically robust and highly reproducible dip in incidence at age

19–20 years, followed by the major peak at age 21 years, with sharply reduced incidence thereafter. Evaluated using an epidemiological mutoscope view, individual cohorts showed a congruent pattern, with starting age held constant. A completely different pattern was seen in age-specific prevalence estimates that showed monotonic linear increases. **Conclusions:** The novelty seen here, with multiple replications, is a set of clearly nonlinear, age-specific drinking incidence patterns not documented in prior studies. Evidence of noncongruent prevalence patterns is provided. We hope these simple examples will be useful in teaching the epidemiology of alcohol drinking. (*J. Stud. Alcohol Drugs*, 77, 405–412, 2016)

DESPITE THE FEDERALLY RECOMMENDED legal minimum drinking age of 21 years in the United States, underage drinking is very common (Brown et al., 2009). Previous comprehensive reviews have described a consistent linear increase in the prevalence of drinking from early adolescence to young adulthood (Brown et al., 2009; Keyes et al., 2011). In contrast, there is little population-based evidence about the incidence of drinking beyond the description of a similar linear increase from early adolescence to young adulthood based on recalled age at onset (Keyes et al., 2011). Recently, there has been a body of literature documenting the frequent occurrence of heavy drinking on 21st birthday celebrations in the United States, even among law-abiding youths who intentionally delay their first drink to age 21 years (Neighbors et al., 2009; Rutledge et al., 2008). In this study, we sought to provide empirical evidence about age-specific incidence of alcohol drinking in adolescents and young adults using data from large national surveys, with due attention to newly incident drinking before and after age 21 years.

Epidemiological mutoscope view

In Table 1 of his classic study of tuberculosis death rates (reproduced here as Figure 1), Wade Hampton Frost pre-

sented age-grouped death rates for the 1880 birth cohort, as well as for later birth cohorts, across 5- to 10-year intervals (Frost, 1939). When this cross-tabular approach is applied to annually repeated cross-sectional surveys, we call it an “epidemiological mutoscope” view of a cohort’s development. That is, the mutoscope view is gained when successive cross-sectional panel surveys of population experience are repeated with new samples (panels) drawn, survey year by survey year (Seedall & Anthony, 2015).

One useful mutoscope view of cohort development can be constructed as a set of statistically independent, age-specific incidence estimates based on newly incident cases (e.g., those who became cases within an interval of 12 months before assessment), divided by those who were at risk at the start of the interval (Seedall & Anthony, 2013). Repeated in panel survey fashion over a short span of time—with new independent replication samples for each survey—the resulting age-specific estimates can convey age-specific and cohort-specific variations, holding constant period (time; year). In some instances, the resulting trace of cross-sectional estimates can be used to help substantiate nonlinearities via multiple replications—before major investments in longitudinal studies are made to probe for observed nonlinear relationships. When displayed in year-by-age tables, the column-wise estimates from these cross-sectional surveys depict time-related patterns, with *age* held constant. The row-wise estimates depict age-related patterns, with *time* held constant.

The diagonal-wise view of these tables holds constant cohort (approximate birth year), in a fashion that provides the epidemiological mutoscope view, with improved resolu-

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Age	1880	1890	1900	1910	1920	1930
TABLE 1						
<i>Death rates * per 100,000 from tuberculosis, all forms, for Massachusetts, 1880 to 1930, by age and sex, with rates for cohort of 1880 indicated</i>						
<i>*They were obtained as follows: For the years 1910, 1920 and 1930—based on U. S. Mortality Statistics—deaths from tuberculosis, all forms. For the years 1880, 1890 and 1900 the rates used are calculated from data compiled by the late Dr. Edgar Sydenstricker from the state records. Because of differences of classification in deaths, it has been necessary to base the rates on the deaths recorded as “tuberculosis of the lungs” to get comparable data for these years. The rate calculated from the state records for “tuberculosis of the lungs” has been multiplied by a factor based on the proportion such deaths bore to those from tuberculosis, all forms. This factor varied with the year and age considered.</i>						
Males						
0-4.....	760	578	309	209	108	41
5-9.....	43	49	31	21	24	11
10-19.....	126	115	90	63	49	21
20-29.....	444	361	288	207	149	81
30-39.....	378	368	296	253	164	115
40-49.....	364	336	253	253	175	118
50-59.....	366	325	267	252	171	127
60-69.....	475	346	304	246	172	95
70+.....	672	396	343	163	127	95
Females						
0-4.....	658	595	354	162	101	27
5-9.....	71	82	49	45	24	13
10-19.....	265	213	145	92	78	37
20-29.....	537	393	290	207	167	92
30-39.....	422	372	260	189	135	73
40-49.....	307	307	211	153	108	53
50-59.....	334	234	173	130	83	47
60-69.....	434	295	172	118	83	56
70+.....	584	375	296	126	68	40

FIGURE 1. Reproduction of Table 1 in late Professor Wade Hampton Frost's work on tuberculosis mortality that shows the seeds of the idea of a fine-grained mutoscope table (Frost, 1939). Estimates for prevalence of recently active drinking and cumulative incidence proportions are presented online in supplementary materials that accompany this article (Tables B and C). The estimated cumulative incidence proportion at age 12 years is larger than the other estimates because its numerator includes 12-year-olds with drinking onset in childhood (i.e., before the 12-month interval before the survey assessment date). These “very early childhood-onset drinkers” always appear in the numerators for each age-specific estimated “lifetime occurrence” proportion. This is not the case for the prevalence estimate of recently active drinking, for which the numerator consists of newly incident drinkers plus past-onset drinkers who continued to drink during the 12-month interval before the date of assessment. The numerators for the age-specific incidence rate estimates are limited to newly incident drinkers.

tion of the cohort developmental process as time passes. Why “mutoscope”? Herman Casler, in the 19th century, gave this name to his mechanical “flip book” of cross-sectional snapshots viewed in rapid succession to depict objects in motion. That is, each series of cohort-specific snapshot estimates along the diagonals presents a dynamic view of each cohort's incidence experience across age and time interval, with period constrained. An interesting question is whether the forward progress of each cohort's experience and the cross-sectional, age-specific patterns are congruent (Seedall & Anthony, 2015). Sometimes, the mutoscope pattern is not the same as the age-specific pattern (e.g., see Chandra et al., 2016).

This idea of using successive cross-sections to depict developmental process is not new. After age 2 years, the anthropometric growth charts used in U.S. pediatrician offices are generally from cross-sectional data and are used to depict developmental maturation of expected age-specific height and weight values.

In contrast to repeated-measures longitudinal research on a single sample as time passes, this epidemiological mutoscope view constrains two threats to validity. There is no sample attrition from time point to time point. In addition, measurement reactivity is constrained, in that responses to research assessments at $t - 1$ might influence responses to research assessments at time t (Seedall & Anthony, 2015).

A mutoscope view of youthful drinking behaviors in the 21st century

In epidemiology, there is general interest in drinking of alcoholic beverages by adolescents and adults, given health consequences (Bauer et al., 2014; Kanny et al., 2015). Adversities because of underage drinking might be increasing, via apparent downward shifts in mean age when starting to drink, as can be seen in three studies in the United States (Keyes et al., 2011; U.S. Substance Abuse and Mental Health Services Administration [SAMHSA], 2012, 2014).

Our interest in the phenomenon of underage drinking prompted us to develop an epidemiological mutoscopic view of the risk of becoming a newly incident underage drinker in the 21st century with derivation of meta-analysis summaries, and to compare incidence and prevalence estimates. In prior research, age bins generally have been created based on minimum drinking ages (e.g., ages 12–17 years, 18–20 years, and 21 years and older, as in Johnson & Gerstein, 1998; Johnston et al., 2015; Keyes et al., 2008). In a departure from most prior research on this topic, we contrast paired age bins (e.g., a bin of 18- to 19-year-olds) with individual age bins (e.g., age 18–20 years) to probe for potential nonlinearities.

Accordingly, the main research aim is to use an epidemiological mutoscope approach to estimate drinking incidence

TABLE 1. Incidence versus prevalence

Incidence and prevalence are epidemiology's two most important morbidity survey parameters. Prevalence varies as a function of incidence and duration (Doull, 1948, 1962). As pointed out by Professor Morton Kramer, one of James Doull's students,

"Since prevalence is a function of incidence and duration of disease, comparison of prevalence . . . between various population groups, social classes, age, race, and sex groups cannot be interpreted until we know the role of the basic variables-incidence and duration-in producing a given prevalence situation" (Kramer, 1957).

Ten years later, a thoughtful discussion by the late Professor Rema Lapouse stressed the importance of incidence for studies seeking to draw inferences about cause-effect relationships, which is the core mission of epidemiology:

"Prevalence . . . measure[s] the size of the disease problem and as such [can be] useful in planning services. [Prevalence is], however, a fallible indicator of the risk of acquiring any chronic disease including psychiatric disorder. Since prevalence is a function of incidence and duration, any factors affecting duration of disease will similarly influence its prevalence Thus, long-term, nonfatal, noncurable diseases which limit migration produce a pile-up of cases and a rise in [prevalence]. Survivorship, mobility, and duration may, in turn, be associated with demographic factors. Consequently an association between these factors and prevalence may occur even though demographic factors bear no relationship to the genesis of disease. The only suitable measure applicable to the search for possible causes of disease is the incidence rate" (Lapouse, 1967).

This background material should help clarify our attempt to estimate incidence of drinking, with prevalence estimates presented solely as a comparison. In the process, we are providing some useful examples for colleagues who will appreciate the difference between these two important, yet different, parameters, including those who teach alcohol epidemiology and research methods.

among 12- to 25-year-olds during 2002–2013. Secondary aims are (a) to evaluate whether estimated drinking incidence patterns are congruent with estimated drinking prevalence patterns and (b) to evaluate potential advantage of fine-grained, age-specific estimates in lieu of less refined age bins. We have been reminded that some readers might not appreciate the distinctions we are drawing between *incidence* (as a rate) and *prevalence* (as a proportion). Table 1 clarifies this distinction, wherein we liberally used material on this topic as it was originally published many years ago by Professors Morton Kramer (1957) and Rema Lapouse (1967).

Method

Estimates from this research tap a public use data set known as the Restricted-Data Analysis System (R-DAS), which has enabled online analyses of data from recent U.S. National Surveys on Drug Use and Health (NSDUH). NSDUH participation required child assent (12- to 17-year-olds) and parental or adult consent, all obtained according to institutional review board-approved protocols.

Details about NSDUH are shown in supplementary Table A, in online monographs (Inter-university Consortium for Political and Social Research, 2016), and in many published articles (e.g., U.S. SAMHSA, 2012, 2015; Seedall & Anthony, 2015). A brief overview is provided here.

Study population and sample

Each year (from 2002 to 2013), NSDUH study populations were composed of noninstitutionalized civilian community residents ages 12 years and older, with multistage area

probability sampling designed for U.S. nationally representative samples (more than 60,000 participants annually) and over-sampling of 12- to 17-year-olds. With confidentiality and re-identification protections, R-DAS data sets include large NSDUH subsamples organized in year-pairs, with six independently drawn replication samples (organized as 2002–2003, 2004–2005, . . . , 2012–2013), each with more than 50,000 12- to 25-year-olds. (In the United States, after age 25 years, drinking initiation drops to a near-zero value ([U.S. SAMHSA, 2014])). Participation levels, lowest to highest, were 74% (2007) to 79% (2002).

Assessment and measures

During NSDUH fieldwork, participants completed confidential audio computer-assisted self-interviews (ACASI), with standardized multi-item modules on alcohol and other health topics. Alcohol items assessed month and year of first drink, which identified newly incident drinkers, as well as recency of use and lifetime history of use. Newly incident drinkers are individuals who had their first full drink during the 12 months before the assessment date.

Analysis approach

R-DAS analyses yield age-specific estimates for age, age-pairs, and year-pairs. Year-pair and age can be aligned for mutoscope tables, with year-pair in the rows, age-pair in columns, and diagonal cells providing mutoscope views of adjacent cohorts. That is, a cross-sectional snapshot estimate for 12- to 13-year-olds in 2002–2003 is followed by a cross-sectional snapshot estimate for 14- to 15-year-olds in 2004–2005, and so on. (Here, approximations are required

TABLE 2. Age- and cohort-specific risk estimates for newly incident drinking (%) per year-pair. Data from U.S. National Surveys on Drug Use and Health 2-year restricted data analysis system (unweighted $n \approx 420,000$ 12- to 25-year-olds)^a

Panel A. Point Estimates							
Age	12-13	14-15	16-17	18-19	20-21	22-23	24-25
Year-Pair							
2002 or 2003	6.2	19.3	27.9	29.4	32.6	13.0	6.1
2004 or 2005	6.1	19.4	27.4	30.1	31.3	13.3	2.5
2006 or 2007	5.2	18.4	27.2	32.0	34.4	14.0	4.7
2008 or 2009	5.1	17.2	25.8	30.0	35.4	16.1	4.8
2010 or 2011	4.6	16.1	24.2	29.2	37.7	17.0	5.9
2012 or 2013	3.4	14.2	23.5	27.8	35.8	17.5	4.2
Meta-analysis estimate^b	5.1	17.4	26.0	29.7	34.6	15.0	4.6
Panel B. 95% Confidence Interval							
2002 or 2003	5.6, 6.7	18.4, 20.3	26.5, 29.3	27.3, 31.6	29.7, 35.7	10.7, 15.7	4.5, 8.3
2004 or 2005	5.6, 6.6	18.4, 20.3	26.0, 28.9	28.1, 32.1	28.7, 34.1	10.9, 16.1	1.6, 3.9
2006 or 2007	4.8, 5.7	17.4, 19.4	25.9, 28.6	30.0, 34.1	31.8, 37.2	11.5, 16.9	3.4, 6.4
2008 or 2009	4.6, 5.6	16.3, 18.1	24.5, 27.2	28.1, 32.0	32.8, 38.2	13.4, 19.2	3.4, 6.9
2010 or 2011	4.1, 5.1	15.3, 17.0	23.1, 25.5	27.3, 31.1	35.0, 40.6	14.2, 20.2	4.2, 8.3
2012 or 2013	3.1, 3.9	13.4, 15.1	22.4, 24.7	26.0, 29.6	33.4, 38.2	14.8, 20.6	2.8, 6.2
Meta-analysis estimates^b	4.2, 6.0	15.8, 19.1	24.5, 27.5	28.6, 30.8	32.7, 36.4	13.5, 16.6	3.9, 5.8

^aCells with the same shade trace the experience of individual cohort-pairs; ^bmeta-analytic summary estimates using DerSimonian & Laird (1986) random effect model.

for birth cohort and year-pair values; NSDUH releases neither birth date nor assessment date.)

For each mutoscope table cell, incidence is estimated as analysis-weighted numbers of newly incident drinkers divided by analysis-weighted numbers of those at risk to start drinking (i.e., with no drinking before entry into a 12-month window before assessment). Corresponding prevalence estimates are analysis-weighted numbers of recently active drinkers (i.e., with one or more drinks within the interval), divided by analysis-weighted numbers of all individuals. Estimated cumulative incidence proportions for drinking among cohort members who survived and participated in cross-sectional surveys are weighted number of ever drinkers, divided by weighted numbers of all individuals (i.e., so-called lifetime prevalence critiqued by Streiner et al., 2009). R-DAS analysis weights account for sample selection probabilities and post-stratification adjustment factors that yield U.S. census subpopulation counts.

Standard errors and 95% confidence intervals (CIs) are from complex survey delta methods. Final analysis steps involved the creation of meta-analytic summary estimates using Stata software (StataCorp LP, College Station, TX). In meta-analyses, variances are from random effects approaches

(DerSimonian & Laird, 1986; Higgins et al., 2003). A constrained regression approach (Harper, 2015), with 2010/2011 and 2012/2013 (period) values constrained to be equal, was used in a post-estimation confirmation of our assumption about null period-related changes (Harper, 2015). More technical details about meta-analysis and the constrained regression are available in the supplementary material provided online with this article.

Results

Online supplementary Table A describes the study population (Collaborative Research on Addiction at NIH, 2014) in terms of year-pair, sex, and ethnic self-identification. Table 2 shows mutoscopic alignment of year-pair and age-pair bins (top panel shows point estimates; bottom panel shows 95% CI).

Viewed mutoscopically, Table 2's main diagonal starts with a 6.2% drinking incidence estimate for 12- to 13-year-olds assessed in 2002–2003 (95% CI [5.6, 6.7]). As for the independently drawn sample of 14- to 15-year-olds assessed in 2004–2005, estimated incidence is 19.4% (95% CI [18.4, 20.3]). Subsequent estimated cohort-pair incidence rates

peak at age 20–21 years (during 2010–2011), followed by a statistically robust reduction in incidence at age 22–23 years in 2012–2013 (17.5%; 95% CI [14.8, 20.6]).

When drinking-onset experiences of other cohort-pairs are traced mutoscopically down each diagonal, a congruent general pattern can be seen. In addition, experiences of the oldest cohorts show magnitude of drinking incidence dropping toward values previously observed for each year-pair's 12- to 13-year-olds.

The last row of Table 2 shows useful meta-analysis summary estimates derived by treating Table 2's year-pairs as six independent replications. Meta-analyzed, estimated drinking incidence increases monotonically, reaches a peak at age 20–21 years, and then drops. Supplementary Figures A and B show meta-analytic forest plots.

Enriched incidence patterns are shown in Table 3, which re-casts Table 2 estimates and shows fine-grained age values. Here again, mutoscopic views of Table 3 diagonals generally are congruent with each year's pattern of age-specific estimates for early adolescence. Thereafter, a more gradual increase is seen between age 16 and 18 years, followed by a clear drop in incidence at age 19 and 20 years, just before peak incidence at the legal drinking age of 21 years. Thereafter, incidence decreases sharply, falling to quite a low value at age 25 years. Using the constrained regression approach, we found evidentiary support for estimated age effects, but no such support for cohort or period, with 2010/2011 and 2012/2013 values constrained.

In our comparison of prevalence with incidence estimates, the estimated prevalence of recently active drinking shows a monotonic increase to age 21 years, followed by a plateau value just above 80% (online supplementary Table B). Estimated cumulative incidence proportions for these ages (so-called lifetime prevalence) follow congruent patterns, with somewhat larger point estimates (online supplementary Table C). The mutoscopic view reveals similar patterns for each cohort. In contrast, estimated age-specific annual incidence rates follow Table 3's nonlinear patterns. These contrasts are shown in Figure 2, which presents the age-specific meta-analytic summary estimates for incidence, the prevalence of recently active drinking, and the cumulative incidence proportion at each age.

Discussion

The most surprising discovery of this epidemiological study is an apparent dip in annual incidence of underage drinking at age 19–20 years, before which drinking incidence showed consistent increases, followed by peak incidence at age 21 years after the dip. This age-specific pattern can be seen in epidemiological mutoscope views (Table 3 diagonals), in the conventional year-by-year views, and in meta-analytic summaries. With three different estimation approaches, Figure 2 may prove to be useful in teaching basic

differences seen in contrasts of age-specific incidence rates, prevalence proportions, and cumulative incidence proportions that sometimes are called “lifetime prevalence proportions,” even though they are more akin to “attack rates” or “cumulative incidence proportions” among survivors observed during or at the end of a disease outbreak (Streiner et al., 2009).

Does drinking incidence truly dip at age 19–20 years, or is this a consistently seen measurement artifact? If valid, this dip followed by a peak at age 21 years might be a manifestation of heterogeneity in the at-risk population of never drinkers, with shifting balance of subgroups age by age: (a) a subgroup vulnerable to underage drinking, most of whom encounter a first chance to drink before age 19 years; (b) those committed to lifetime abstinence; and (c) “law-abiding” adolescents committed to postponement of drinking onset until legal age is reached, previously described as “21st birthday drinking virgins” (a group of young people with presumed lower risk for unhealthy drinking behaviors but perhaps with special vulnerability for heavy drinking at 21st birthday celebrations, as noted by Neighbors et al. [2009] and Rutledge et al. [2008]). It is possible that 19- and 20-year-olds are less willing to disclose underage drinking in face-to-face interviews and might be more prone to socially desirable responding than is true for young people at other ages.

We judge that measurement artifacts of this type might be constrained by the NSDUH ACASI approach, as used to overcome unwillingness to disclose behavior that might otherwise be hidden in more conventional face-to-face interviews (U.S. SAMHSA, 2012). Nevertheless, if there is serious interest in this previously undocumented age-specific pattern, future research projects might require biological assays for ethanol consumption, with mixture models designed to probe for heterogeneity among the 19- and 20-year-old never drinkers. In this research arena, relatively short-term longitudinal research on never drinkers at age 18 years might be informative, provided theoretically important challenges of measurement reactivity and differential loss-to-follow-up can be addressed.

As for limitations, we note that the NSDUH sampling frame does not encompass institutions (e.g., prisons and long-term care), but this exclusion might be trivial in the present investigation. NSDUH participation levels are at respectable levels, acceptable but not ideal.

We should note a possibility that the reliability and validity of recalled experience of first full drink vary with age. Nonetheless, we do not consider our findings biased by this possibility because (a) experience of first full drink is measured with extremely high reliability among young people age 12–25 years, relative to other behaviors and reports from older adults (U.S. SAMHSA, 2012; Shillington et al., 2012); and (b) the recall period is tightly constrained to the past 12 months. Indeed, we consider this a major strength of our study compared with previous studies that relied on

TABLE 3. Age- and cohort-specific risk estimates for newly incident drinking (%) per year-pair: Data from U.S. National Surveys on Drug Use and Health 2-year restricted data analysis system (unweighted $n \approx 420,000$ 12- to 25-year-olds)^a

Age	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Panel A. Estimated Incidence														
Year-pair														
2002/3	3.6	8.8	15.4	24.2	27.8	28.1	32.0	25.5	24.4	41.5	18.9	6.7	8.0	4.1
2004/5	3.2	9.0	15.8	23.6	27.0	27.9	32.2	26.8	21.3	42.1	17.5	8.2	3.1	1.7
2006/7	3.0	7.5	14.9	22.3	26.7	27.9	33.6	29.5	24.4	45.0	19.4	7.0	5.6	3.6
2008/9	3.0	7.2	14.0	20.6	26.5	25.0	31.5	27.7	23.6	48.2	23.1	8.9	7.3	2.4
2010/1	2.3	6.8	12.3	20.4	24.9	23.5	31.1	26.3	22.1	54.1	23.2	8.2	7.9	3.6
2012/3	1.9	5.0	10.9	18.0	22.8	24.5	29.3	25.4	19.7	52.2	22.0	11.7	4.2	4.2
Meta-analysis estimate ^b	2.8	7.4	13.9	21.5	25.9	26.1	31.5	26.8	22.4	47.3	20.5	8.1	5.8	3.0
Panel B. 95% Confidence Interval														
2002/3	3.1, 4.3	8.0, 9.7	14.3, 16.7	22.7, 25.8	25.9, 29.8	26.0, 30.2	29.3, 34.7	22.4, 28.7	20.9, 28.4	37.0, 46.1	14.9, 23.6	4.6, 9.5	5.5, 11.6	2.5, 6.5
2004/5	2.7, 3.7	8.1, 10.0	14.6, 17.0	22.1, 25.2	25.3, 28.9	25.7, 30.3	29.8, 34.8	23.9, 29.8	18.1, 24.8	37.8, 46.4	14.0, 21.6	5.5, 11.9	1.7, 5.6	0.8, 3.4
2006/7	2.5, 3.6	6.8, 8.4	13.7, 16.1	20.8, 23.9	24.9, 28.6	26.0, 29.9	31.0, 36.3	26.3, 32.9	21.0, 28.1	40.8, 49.2	15.6, 23.9	4.6, 10.7	3.7, 8.5	2.2, 5.9
2008/9	2.5, 3.6	6.4, 8.1	12.9, 15.1	19.2, 22.1	24.8, 28.3	23.2, 26.9	29.1, 34.1	24.9, 30.7	20.5, 26.9	44.1, 52.4	18.9, 27.8	6.0, 13.0	4.8, 10.9	1.3, 4.4
2010/1	1.9, 2.8	6.0, 7.7	11.3, 13.3	19.1, 21.8	23.3, 26.6	21.7, 25.3	28.6, 33.7	23.7, 29.1	19.3, 25.2	49.9, 58.3	18.9, 28.2	6.0, 11.1	5.3, 11.7	1.7, 7.4
2012/3	1.5, 2.4	4.3, 5.7	9.9, 12.0	16.7, 19.3	21.3, 24.4	22.7, 26.3	27.1, 31.7	22.7, 28.3	17.0, 22.7	48.6, 55.7	18.2, 26.3	8.4, 16.1	2.4, 7.4	2.4, 7.2
Meta-analysis estimate ^b	2.3, 3.3	6.2, 8.6	12.3, 15.4	19.6, 23.4	24.4, 27.4	24.4, 27.7	30.4, 32.7	25.6, 28.0	20.9, 23.9	43.1, 51.4	18.6, 22.5	6.8, 9.4	4.1, 7.5	2.1, 3.9

^aCells with the same shade trace the experience of individual cohort-pairs. In Table 2, the age 20–21 incidence estimate has a smaller confidence interval than is seen here, mainly because of the larger number of 20- to 21-year-olds compared with age 21 only. ^bMeta-analytic summary estimates using DerSimonian & Laird (1986) random effect model.

FIGURE 2. Comparison of meta-analytic summary estimates for age-specific prevalence of drinking and estimated age-specific annual incidence. Data from United States National Surveys on Drug Use and Health, 2002–2013 ($n \approx 420,000$ 12- to 25-year-olds). CI = confidence interval.

long-term recall of older adults. We judge these potential limitations as not apt to introduce major biases in this study.

In closing, we hope that this epidemiological mutoscope view of youthful drinking sheds new light on the incidence of underage drinking and might motivate public health interventions to reduce potentially harmful consequences, in addition to research directions described herein. These examples might help new alcohol researchers and epidemiology students learn about the differences between incidence rates and prevalence proportions, the contrasts between age- and cohort-specific depictions of drinking incidence, and the possibilities for estimation of annual incidence in the cross-sectional survey context. The supplementary tables and figures provided online with this article such as the meta-analysis forest plots may also be helpful to students and teachers.

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