HHS Public Access

Author manuscript

Alcohol Clin Exp Res. Author manuscript; available in PMC 2017 April 01.

Published in final edited form as:

Alcohol Clin Exp Res. 2016 April ; 40(4): 816–825. doi:10.1111/acer.13028.

Taking the first full drink: Epidemiological evidence on male-female differences in the United States

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Abstract

Background—This research extends prior epidemiological estimates for the United States (US) and re-examines a previously described male excess in alcohol drinking. Its aim is to estimate fine-grained age-specific *incidence* of becoming a drinker among 12- to 24-year-old US males and females, and to compare incidence estimates with prevalence proportions.

Methods—The study population is 12-to-24-year-old non-institutionalized US civilian residents. Estimates are from 12 successive US National Surveys on Drug Use and Health (NSDUH), with nationally representative samples drawn each year from 2002 to 2013 and assessed via computer-assisted self-interviews (n~=390,000). Analysis-weighted incidence and prevalence estimates are generated using the NSDUH Restricted-Data Analysis System for six year-pairs. Meta-analysis derived summary estimates are provided, treating each year-pair as a replication.

Results—In this 21st century evidence, there no longer is male excess of incidence with respect to underage drinking. Indeed, in mid-adolescence, there is a clear female excess for the risk of becoming an underage drinker. Meta-analytic summaries disclosed no other male-female differences in incidence. Nevertheless, a male excess in prevalence of recently active drinking can be seen after age 19 years.

Conclusions—This new evidence from the US shows that the so-called ‘gender gap’ in risk of becoming a drinker has narrowed to the point of there being no gap at all. Indeed, in mid-adolescence, risk of starting to drink is greater for females than for males.

Keywords

alcohol drinking; incidence; male-female difference

1. Introduction

In a recent comprehensive review of the world literature on male-female differences in the occurrence of alcohol use and its consequences, Eron and Karpyak (2015) drew attention to

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Conflict of interest: none

an often-observed male excess, with a few noteworthy exceptions (Erol and Karpyak, 2015). One exception can be seen in a 'convergence' or narrowing of the 'gender gap' with respect to estimated prevalence of recently active drinking in the United States (US) and in European countries, for which a broad range of cultural, social, and psychological explanations have been offered (Keyes et al., 2011; Wilsnack et al., 2009).

With respect to the narrowed gender gap, there is no definitive evidence to favor one explanation versus another at present. Many scholars appear to favor social and cultural influences associated with changing social roles and role expectations for women since World War II, which might be particularly salient in the US, western Europe, and possibly Japan and China. For example, in recent multi-national research on the chance to try alcohol during adolescence and young adulthood, there was a robust male excess only in three countries: Lebanon, Nigeria, and Mexico. For the rest of the 15 participating countries, females were just as likely as males to have had the chance to drink alcohol, including the US, western Europe, Japan, and China (Wells et al., 2011).

Against this background of unresolved choices between alternative explanations for the narrowed gender gap in drinking prevalence, it can be said that the convergence of drinking prevalence proportions is determined by the balance of two basic epidemiological parameters: (1) drinking incidence rates (i.e., population estimates for the risk of starting to drink), and (2) duration or persistence of drinking, once it starts (Cheng et al., in press; Freeman and Hutchison, 1980; Kramer, 1957; Lapouse, 1967). Until recently, there has been no clear empirical evidence pointing toward which of these two basic epidemiological parameters might account for the observed narrowing of the historically observed 'gender gap' in drinking prevalence. An initial contribution was made by Seedall & Anthony, who studied US epidemiological estimates for 12-to-17-year-old adolescents, as a group, and found a 2.1% female excess in adolescent drinking incidence rates, with girls being more likely to start drinking before age 18 years compared to boys, based on aggregate national survey data from 2002 to 2009 (Seedall and Anthony, 2013).

This research project picks up where the Seedall-Anthony investigation left off, drawing upon recently gathered US survey data through 2013 in order to address several gaps in existing evidence. First, this project seeks fine-grained age-specific estimates of drinking incidence rates in adolescents as well as young adults, with an expectation that the previously reported female excess might be concentrated in the early years of adolescence, and might not be seen during later adolescence or early adulthood before age 25 years. Second, this study engages a 'mutoscope' approach to construct estimates for successive birth cohorts, making it possible to compare cohort experiences over time with corresponding age-specific patterns of drinking incidence rates (Cheng et al., in press). The approach also clarifies reproducibility of age- and cohort-specific patterns, given that reproducibility has become an important but often ignored aspect of scientific progress (Open Science Collaboration, 2015). Third, corresponding population estimates are produced for prevalence of recently active drinking. The comparison of drinking incidence rates with drinking prevalence estimates makes it possible to check on male-female differences in duration or persistence of drinking, once drinking starts.

The research project is focused on male-female differences in drinking incidence rates estimated for the US in recent years. We were unable to find recent data on fine-grained age-specific and cohort-specific drinking incidence for other countries. Nonetheless, our discussion section includes some results from recent surveys of young people living in European countries. These results provide a check on whether the US experience might be unique.

We appreciate that some readers will be disappointed that our research project is not ambitious with respect to its probes for theoretical explanations as might account for male-female differences in drinking behaviors. We focus strictly upon patterns observed in sex-specific estimates for the risk of becoming a newly incident drinker, age by age, and cohort by cohort. With others, we share a view that cross-sectional survey research rarely yields definitive evidence about cause-effect relationships, primarily due to possible reciprocal influence processes and uncertainty about temporal sequencing, even when there are no omitted variables and no model mis-specification. This study's focus on age and sex means that constraints are imposed on these sources of uncertainty. For example, newly incident drinking is not plausible as an influence on one's age or male-female status *per se*.

We also appreciate that some readers might be concerned about our focus on a subset of the drinking population – namely, adolescents and young adults who are 12-to-24-years-old at the time of drinking onset and assessment. As it happens, in the US, newly incident drinking after age 24 years is too rare to provide statistically precise fine-grained age-by-age drinking incidence estimates even in large population samples (Cheng et al., in press). Due to our focus on drinking incidence, this empirical research report does not speak to drinking behaviors during the middle or later adult years, nor does it speak to processes that might influence a narrowing of the gender gap beyond the early adult years. Nevertheless, as noted in our discussion section, some important health and social implications are faced when newly incident drinking occurs below the legal minimum drinking age. These implications help to justify a research focus on underage drinking.

2. Materials and methods

2.1 Study Population and Sample

This study's estimates are from the US National Surveys on Drug Use and Health (NSDUH) conducted each year from 2002 through 2013, for which the study population was designated to include all non-institutionalized community residents of the US aged 12 years and above. The sampling approach involved multi-stage probability sampling, with oversampling of 12-17 year olds. In contrast to school or household surveys of adolescents, the NSDUH sample includes young people irrespective of school attendance, and its sampling frame includes non-household group quarters such as homeless shelters. All NSDUH participants were recruited via child assent (12-17 year olds) and parental or adult consent, based upon protocols approved by cognizant human subjects protection committees. More details about NSDUH are shown in online monographs and many published articles (Cheng et al., in press; Seedall and Anthony, 2015; United States, 2012, 2015) (HTTP://WWW.ICPSR.UMICH.EDU/ICPSRWEB/ICPSR/SERIES/64).

This research's estimates tap a public use data archive known as the Restricted-Data Analysis System (R-DAS), which enabled online analyses of data from recent National Surveys on Drug Use and Health (NSDUH). With confidentiality and re-identification protections, R-DAS datasets have included large NSDUH sub-samples organized in year-pairs, with six independently drawn replication samples (organized as 2002-3, 2004-5, ..., 2012-13). For the same reason, the exact unweighted sample size is not provided in the output and, therefore, is unknown. Approximate sample sizes can be derived via a method developed by Vsevolozhskaya & Anthony (Vsevolozhskaya and Anthony, 2014), from which it can be seen that roughly 390,000 12-24 year olds are in the aggregate sample (2002-2013), with roughly 65,000 12-24 year olds in each of the six year-pairs. (In the US, after age 24, drinking initiation drops to a near zero value (Cheng et al., in press; United States, 2014)). Values from these approximations can be compared to NSDUH descriptions of separately sub-sampled public use data, which indicate that each year's dataset includes around 55,000 participants, with approximately 2/3rds at 12-to-25-years-of-age (United States, 2015). Participation levels, lowest to highest, were 74% (2007) to 79% (2002). Soon after completion of our analyses, the R-DAS system was assigned to a new contractor and its use has been suspended until the new contractor can complete its reprogramming, which is planned for late Spring 2016. An internet search for R-DAS will show that it no longer is available for online analyses.

2.2 Assessment and measures

In general, most often within the participant's home, NSDUH assessments have been completed as confidential audio computer-assisted self-interviews designed to promote reliability, accuracy, and truthfulness of participant reports about potentially sensitive behaviors and characteristics. During the assessment module on alcohol, each participant has been asked about the lifetime history of drinking experiences, including questions about the month and year of drinking onset and the most recent drinking occasion, whenever these events occurred within 24 months prior to the date of assessment. Each newly incident drinker can be identified as one who had their first full drink no more than 12 months prior to the survey assessment date. Examples of a full drink given by the NSDUH includes “a can or bottle of beer, a glass of wine or a wine cooler, a shot of liquor, or a mixed drink with liquor in it”. NSDUH questions explicitly explained that “We are not asking about times when you only had a sip or two from a drink.”

These alcohol module standardized questions were asked consistently from 2002 to 2013. Recently active drinkers have been identified as those for whom the most recent drinking occasion occurred during that same 12-month interval.

Age has been derived via self-reported date of birth relative to assessment date. Sex is based on participant responses that indicate male or female (with no allowance for gender identities such as trans-gender). NSDUH drew upon dwelling unit roster information to create variables for age and sex on rare occasions when a participant skipped survey items on these characteristics.

2.3 Analysis

An incidence estimate for becoming a drinker for the first time in any given survey year can be approximated by placing each year's analysis-weighted number of newly incident drinkers in the numerator, and dividing by a person-year count that has been calculated by adding the analysis-weighted number of newly incident drinkers to the analysis-weighted number of never drinkers as of the survey assessment date. R-DAS provided the required variables as RECALC_B and ELGALC_B.

The corresponding prevalence proportion is the analysis-weighted number of recently active drinkers (those who consumed alcohol in the 12 months prior to assessment), divided by the analysis-weighted number of all persons. By standard definitions in NSDUH alcohol epidemiology reports, the numerator in the prevalence proportion includes all newly incident drinkers plus all persons who had started drinking in prior years and whose duration of drinking had extended into the interval of 12 months just prior to the survey assessment date. Cross-tabulations via the R-DAS were used to produce incidence and prevalence estimates for this report. Male-female differences in incidence estimates were estimated using the ‘Run Comparison of Percents’ function on R-DAS which enabled two-group comparisons with due attention to the complex survey design and sample weight. Variance estimates and 95% confidence intervals (CI) for this study are based on the Taylor series approximation that is appropriate for complex survey data (Vsevolozhskaya and Anthony, 2014).

Consistent with a research approach described elsewhere (Cheng et al., in press; Deandrea et al., 2013; Seedall and Anthony, 2015), this study's method is one that constrains recall and reporting errors such as methodological ‘telescoping’ via the use of information about month and year of drinking onset as it has occurred during a relatively short span of 12 months prior to the assessment in each cross-sectional survey of the community respondents, with sampling and analyses designed to yield nationally representative estimates. (Here, ‘telescoping’ refers to the generic survey research methods artifact and not to the alcohol field's more recently introduced concept of ‘telescoping’ as applied to accelerated time from first drink to first drinking problem.)

The derived incidence estimates are displayed in a set of time-by-age cross-tabulations, such that the time-specific rows depict sets of cross-sectional age-specific estimates, *with time (years) held constant*. The columns depict sets of cross-sectional time-specific estimates, *with age held constant*. The diagonals depict sets of cross-sectional estimates, studied across time, *with cohort held constant*, and provide a ‘mutoscope view’ of each cohort's forward progress across time. This type of table layout originated with Johns Hopkins University Professor Wade Hampton Frost's posthumously published study of tuberculosis mortality rates (Frost, 1939), which Seedall and Anthony (2015) described in the first published article on the mutoscope approach. As applied to annual field survey estimates of incidence, the approach avoids two theoretically plausible threats to validity found in longitudinal research with repeated measurements of the same individuals: (a) sample attrition and loss of longitudinal participants over time, and (b) measurement reactivity such that answers to assessments at each follow-up might be influenced by assessment processes at baseline or prior follow-up. Seedall and Anthony (2015) provide the first and most complete description of the mutoscope approach, which has been applied in a series of recent publications (e.g.,

(Cheng et al., in press; Seedall and Anthony, 2015). Cheng and colleagues explain and illustrate differences between the mutoscope approach and a different approach known as age-period-cohort analysis (Cheng et al., in press). In brief, the APC approach typically requires use of a constrained regression model for analysis of data gathered over a span of 20-30 or more years, often organized in units of 5-years, and via regression, the APC analyses hold period and age constant to estimate effects of being a member of a cohort, hold cohort and age constant to estimate period effects, and hold period and cohort constant to estimate age effects. The mutoscope approach is focused upon a short interval of time (here, 2002-2013) such that a period effect is generally ignorable, and answers the question of whether the pattern of over-time experience of each birth cohort, re-sampled in successive years, is or is not congruent with the pattern of cross-sectionally viewed age-specific estimates.

Because many readers are confused about what can be learned via the mutoscope approach versus what can be learned via APC constrained regression analyses, it has become customary to present the mutoscope estimates as well as the APC constrained regression estimates. Whereas the short period from 2002-2013 impedes formal age-period-cohort analyses as one might use for spans of data from 20 or 30 years, for this project we turned to the constrained regression approach, and specified an equality constraint for the 2010-11 and 2012-13 (period) values. The result is a post-estimation confirmation of our assumption about null period effects with respect to drinking incidence during the relatively short span of time from 2002 through 2013 (Harper, 2015).

Final analysis steps involved the generation of meta-analysis summaries of sex- and age-specific estimates using Stata software (Stata Corp, 2013), with each NSDUH year-pair treated as an independent replication (Deandrea et al., 2013; DerSimonian and Laird, 1986). The Cochran's Q and I^2 statistics were used to evaluate heterogeneity across replications (Higgins et al., 2003). When heterogeneity across replications was observed (i.e., Cochran's Q chi-squared test $p<0.05$ and $I^2>50\%$), a random effects estimator was substituted for the default fixed effect estimator. We appreciate that readers generally are familiar with meta-analyses that combine estimates from various published studies on the same topic. In this instance, the purpose of meta-analysis is to produce an accurate and robust summary estimate for each sex- and age-stratum, year by year, across the successive NSDUH replication samples.

An alternative to meta-analysis is a data pooling approach that treats every year or year-pair of NSDUH data as exchangeable units of a single study. Our concern is that the data-pooling approach generally ignores potential sources of variation (e.g., minor variations in survey approach in 2002 relative to 2013), as well as the fact that analysis weights for the early years of NSDUH have been derived from US census values from 2000, whereas analysis weights for the most recent years have been based on the US census completed in 2010. In contrast, our project's meta-analysis approach accommodates these sources of variation, and acknowledges heterogeneity across year-pairs.

One previous report has compared these two approaches. The conclusion was that the meta-analysis approach can be superior to the data pooling approach in terms of statistical robustness (Deandrea et al., 2013).

Readers interested in a more detailed description of the constrained regression for APC analyses as compared with the mutoscope approach might wish to read a prior alcohol epidemiology contribution cited above (Cheng et al., in press). The same article explains the meta-analysis approach (Cheng et al., in press).

3. RESULTS

The estimated sex- and age-specific risk of becoming a newly incident drinker is conveyed via the drinking incidence estimates shown in Table 1, year-pair by year-pair. Panel A presents results for females and Panel B for males. Age-specific meta-analysis summary estimates are shown at the bottom of each Panel. Corresponding 95% CIs are shown in Table 2.

Because the focus of this paper is on male-female difference, it may be beneficial to look at male-female differences and 95% CI before a detailed description of sex- and age-specific patterns. Table 3 discloses a set of statistically robust female excess values at age 15 for all survey entries. The age-specific meta-analysis summary estimates for 13-through-16-year-olds show larger drinking incidence estimates for females relative to males, with 14-to-15-year-old girls about 25% more likely to initiate drinking compared to same-age boys. Parity follows until a robust male excess can be seen at age 20. The mutoscope view gained by looking down the diagonals show general congruence of cohort experiences and age-specific estimates. That is, as we trace the experience of each cohort across successive years (in each table's diagonal entries), we can see the same patterns that one sees in each set of cross-sectionally derived age-specific estimates, year by year. In this instance, the cross-sectional age-specific estimates are reflective of the dynamically changing experiences of the cohorts moving forward through adolescence toward young adulthood.

According to the cross-sectionally derived age-specific meta-analysis summary estimates for females in the US, an estimated 2.9% start drinking at age 12 years (Table 1 and Figure 1). The corresponding estimate for age 13 is larger, at 8%, followed by an increment of more than 7% such that the drinking incidence estimate is 15.5% at age 14. Then, steady increments build toward initial peak values at age 17 years (26.3%) and 18 years (31.3%), followed by a statistically robust dip in annual incidence at age 19 years (26.9%) and age 20 (20.8%). At the minimum legal drinking age (21 years), the annual incidence estimate is 49.2%. That is, the apparent implication is that almost 50% of those who abstained to the legal age then start drinking at age 21 years. Thereafter, there are marked declines in the incidence estimates: 20.4% at age 22, 7.9% at 23 years, and 4.6% at 24 years.

Viewed column-wise, estimates in Table 1 show minimal variations in this general age-specific pattern. Viewed down each diagonal, the mutoscope view shows each female cohort following the same general pattern.

Corresponding incidence estimates for males disclose a pattern not appreciably different from the female pattern when 95% CI are taken into account (Table 1 Panel B). For example, the meta-analysis point estimate for 21-year-old males is just above 45%, relative to the corresponding 49% estimate observed for 21-year-old females, but the 95% CI overlap considerably.

Table 4 (for point estimates) and Table 5 (for 95% CI) shift perspective from incidence estimates to prevalence proportions. In contrast with the more dynamically varying incidence estimates, estimated prevalence of recently active drinking shows a monotonic increase from age 12 to 21 years for both males and females, followed by a plateau. The prevalence estimates disclose no robust female excess. Indeed, a consistent male excess in prevalence of recently active drinking is observed at and after age 20 years.

Figure 1 displays the age-specific meta-analysis summary estimates for both incidence and prevalence, as well as the male-female contrast. In line with the tabled values, the age-specific incidence and prevalence patterns stand in stark contrast with one another. With no male-female differences in incidence estimates after age 19 years, an implication of the robust male excess in prevalence of recently active drinking seen at and after age 20 years is that males are more likely to persist in their drinking, once drinking starts, as compared to females.

More details about the experience of specific cohorts and cross-cohort consistency are shown in supplementary tables and figures. For example, Supplementary Figure 1 displays age-specific drinking incidence estimates for each female cohort, with a suggestion that 12-to-15-year-olds from more recent cohorts might be experiencing lower incidence rates, whereas Supplementary Figure 2, for males, shows the 1990-1 cohort as one with relatively higher drinking incidence, especially at age 21. Supplementary Figures S3 and S4 display forest plots for the meta-analysis summaries of drinking incidence. Supplementary Tables S4 and S5 provide estimates for cumulative incidence proportions, showing that by age 17 years, an estimated 60% of boys and girls have had a first full drink on at least one occasion. By age 21 years, an estimated 90% have had at least one full drink.

Findings from the constrained regression models are consistent with our assumption of little or no period variations in these incidence estimates, and with what the mutoscope view suggests. Namely, estimated ‘effects’ of period and of cohort are null. Estimated age-associated variations are in line with patterns described in Tables 1 and 2.

4. DISCUSSION

In this study's estimates for incidence of becoming an underage drinker in the US, there is little evidence of the ‘gender gap’ that was seen a few decades ago in prevalence estimates and adult retrospective age-of-onset incidence re-constructions (Keyes et al., 2008; Keyes et al., 2011; Keyes et al., 2010). Instead, there now is a general male-female parity, and in early-mid adolescence, an apparent female excess is seen in the estimated incidence of starting to drink.

For both males and females, the largest incidence estimate is seen at the legal minimum drinking age at 21 years, when roughly 50% start drinking legally, conditional on no prior underage drinking. In addition, for both males and females, there is a previously undocumented dip in incidence estimates for the 19-to-20-year olds, as would be the case if some adolescents deliberately delay drinking onset until the legal age. Then, after age 21 years, the estimated incidence for starting to drink drops markedly. Pending confirmation via independently gathered epidemiological evidence, we might have discovered a 'legal minimum drinking age effect' in the form of peak incidence at the legal age (given no prior underage drinking), preceded and followed by below-expected incidence estimates, with the expected value based on what can be forecast based on prior incidence estimates for early-mid adolescence (Cheng et al., in press).

The diagonals of Tables 1 and 2 disclose a cohort-wise mutoscope view that is generally congruent with the age-specific view obtained by looking across age values, column by column. In Figure 1, the display of incidence estimates along with the more commonly seen prevalence estimates shows what are distinctly different patterns and conclusions based on these two different epidemiological parameters for drinking experiences (Cheng et al., in press).

These findings should be interpreted with limitations in mind. First, the self-report assessment is from an audio computer-assisted self-interview, and cannot be regarded as a perfect measurement tool (Penne et al., 1998). With respect to the dip in incidence at age 19-to-20-years, we acknowledge possible existence of a pool of underage drinkers who will not acknowledge drinking until they have reached the legal minimum drinking age. Nevertheless, we have no reason to surmise that this pool shows marked growth during the two years between age 18 and age 21. Second, prior research suggests minimum differential survival or mortality rates related to drinking initiation among young people, but left-censoring of underage drinkers might be present, given possibilities of alcohol-related death and survey non-participation biases (Dawson, 2000). Third, cross-sectional survey snapshot estimates provide a mutoscope view of independently sampled cohort experiences over time, but are not the same as estimates of intra-individual changes as can be observed in longitudinal follow-ups of a single sample (Seedall & Anthony, 2015). Fourth, inherent to the study design, data points ranged from one to six for each cohort; the oldest and youngest cohorts could not be fully evaluated.

Notwithstanding limitations such as these, these epidemiological estimates should possess reasonably high internal and external validity, with results readily generalizable to the US source population of non-institutionalized individuals aged 12-24 years (Penne et al., 1998). Via study design, it has been possible to constrain various potential sources of error faced in other studies, such as age-of-onset recall errors in studies based on retrospection over long spans of time, as well as measurement reactivity errors in longitudinal studies with repeated measures (i.e., influence of repeating the same measure at time t, t+1, t+2, etc.).

Recent estimates from the European School Survey Project on Alcohol and Other Drugs (ESPAD) indicate that the United States is not the only country with a reversal of the traditional male excess in the occurrence of teenage drinking. Based on the 2011 ESPAD

report of a cohort of students born in 1995, girls were more likely to have had drunk alcoholic beverages by the age of 15 or 16 in seven out of 34 participating countries–namely, Latvia, Hungary, Russian Federation (Moscow sample), Lithuania, Estonia, Ukraine, and Monaco under an assumption of no survey design effect on variances (Cheng and Anthony, In preparation; Hibell et al., 2012). Under a more plausible assumption that ESPAD survey design effects had created a 77% effective sample size of the actual number of males and females surveyed, five countries show a statistically robust female excess (Latvia, Hungary, Russian Federation, Lithuania, Estonia).

Considered substantively, the findings invite some speculations. For example, when there is an observed absence of a male excess in drinking incidence, the explanation might involve US social norms that previously promoted male drinking relative to female drinking, such as drinking to demonstrate masculinity (Wilsnack et al., 2000; Wilsnack et al., 2009). In this study's evidence, the appearance of a female excess of becoming an underage drinker is most prominent at 14 and 15 years of age, when there are concurrently evolving socio-cultural conditions or processes such as differential exposure of females in the early teens to alcohol advertising, increasing access to alcohol via romantic partners, or changes in gender expectations that include ‘masculinizing’ of female roles (Keyes et al., 2008; Kuhn, 2015; Schwartz, 2013).

Secular shifts in motives or reasons for drinking may be at play, as well as variations in peer and parental influences (Seedall and Anthony, 2015; Wilsnack et al., 2000). As more mid-adolescent girls start to drink, there can be an acceleration of incidence via same-age peer influence or social sharing (e.g., collectively experienced drinking exposure opportunities or peer-to-peer sharing of alcoholic beverages). In research on adolescents in 13 European countries, male-female differences in drinking motives were observed across stages of adolescence. For example, at age 14-to-16-years, girls were more likely than boys to drink alcohol to cope with emotions. This difference was not present in earlier or later adolescence. In contrast, boys were more likely than girls to drink for social and enhancement reasons during mid- and late-adolescence (Kuntsche et al., 2015).

Irrespective of the explanations, there is a clear sign of potential public health importance in this study's evidence of relatively high incidence of underage drinking in both girls and boys, as well as the newly observed female excess at mid-adolescence. Effective prevention and intervention for underage drinking, especially among early-adolescent girls, is needed in order to reduce potential adverse consequences that include risk-taking behaviors, injuries, initiation of other drug use, teen pregnancies, and various pathogenetic processes and conditions that can emerge when ethanol exposure starts during puberty (Brown et al., 2009; Hermos et al., 2008; Hingson et al., 2009; Jackson, 2010; Salas-Wright et al., 2015).

The finding that age-specific prevalence and incidence estimates can lead to quite different conclusions about male-female differences in drinking behaviors also deserves some discussion. First, the female early teen excess is not apparent in the prevalence estimates. Second, incidence estimates show male-female parity from age 20 and onward, whereas prevalence estimates show a male excess. The implication is that early adolescent females are more likely to initiate drinking, while male drinkers are more likely than female drinkers

to persist in their drinking during these years (to the extent that prevalence varies as a function of incidence and duration), for which explanations can be drawn from a broad range of biological, pharmacological, and socio-cultural domains (Keyes et al., 2008; Kuhn, 2015). From a population perspective, incidence estimates provide information that is directly pertinent to the risk of becoming a drinker, as well as the causal influences on the risk processes. In contrast, prevalence estimates are useful to gauge the extent of drinking, but leave considerable ambiguity with respect to causal influences. A correlate of drinking prevalence might be a determinant of drinking persistence (operating after drinking has been initiated) when it has nothing whatsoever to do with the risk of starting to drink in the first place. In this respect, prevalence analyses yield ambiguous evidence about what might be accounting for underage drinking onsets or male-female differences, while incidence analyses speak directly and more definitively about these determinants.

As has been true in many areas of epidemiological research, this study disclosed similarities across successive cohorts studied during a relatively short span of time, but its incidence estimates disclosed differences in relationships that have not been seen in prior prevalence investigations. In this instance, this new epidemiological evidence opens up previously unaddressed questions for future research, and sets the stage for new studies to shed light on the mechanisms that might account for the complete closure of the previously documented alcohol ‘gender gap’ and the emergence of what appears to be a robustly reproducible female excess in the early-mid adolescent years.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Grant support and acknowledgment

The authors are grateful to the United States Department of Health and Human Services, Substance Abuse and Mental Health Services Administration for making the data publicly available. We also wish to thank the National Institute of Drug Abuse (NIDA T32 DA021129 [HGC] and K05DA015799 [JCA]) and Michigan State University to fund the current analysis. Authors are grateful for valuable technical support from Mr. Karl Alcover.

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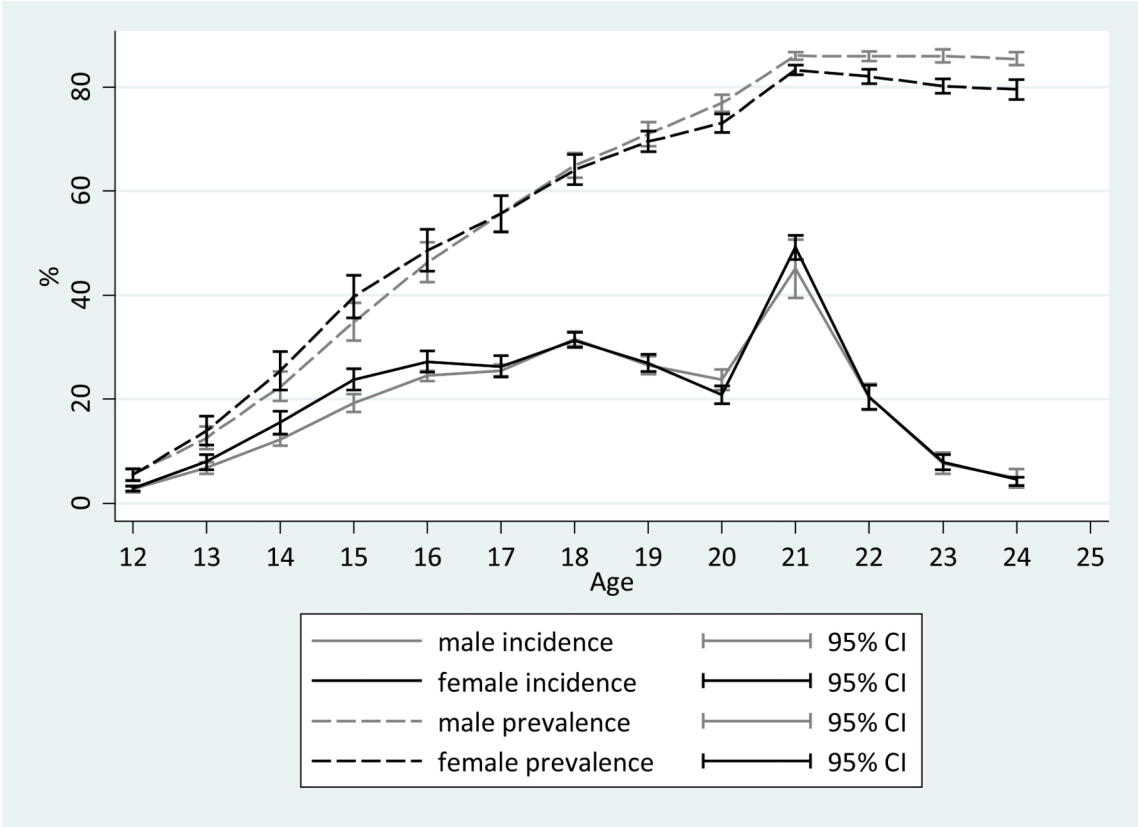

Figure 1.

Comparison of Meta-analytic Summary Estimates for Sex- and Age-Specific Prevalence of Recently Active Drinking and Annual Incidence of Drinking. Data From United States National Surveys on Drug Use and Health 2-Year Restricted Data Analysis System, 2002-2013 (Unweighted n˜390,000 12-24 Year Olds)

Table 1

Sex-, Age-, Cohort-, and Time-Specific Incidence Estimates for Newly Incident Drinking. Data From United States National Survey on Drug Use and Health 2-Year Restricted Data Analysis System (Unweighted n~390,000 12-24 Year Olds).[a]

age	12	13	14	15	16	17	18	19	20	21	22	23	24
year-pair	Panel A: Estimated Incidence Among Females (%/year)												
2002-3	3.7	9.4	17.8	27.8	31.0	29.4	33.3	27.4	21.3	43.9	19.3	7.7	4.8
2004-5	3.3	9.9	19.0	25.3	29.1	28.1	33.8	28.0	20.6	45.3	17.4	9.2	2.8
2006-7	2.7	8.3	16.4	24.5	27.9	27.7	34.6	29.7	23.9	46.7	19.9	4.8	4.3
2008-9	3.0	7.8	15.1	22.7	26.2	25.1	30.9	26.3	20.6	52.4	23.0	9.2	7.5
2010-1	2.6	7.2	13.1	22.6	25.9	22.7	29.4	25.4	21.1	52.7	25.7	8.6	9.0
2012-3	2.1	5.3	11.9	20.1	23.9	25.4	28.3	26.0	19.0	53.2	20.5	13.7	4.1
Meta-analysis estimate [b]	2.9	7.9	15.5	23.8	27.2	26.3	31.3	26.9	20.8	49.2	20.4	7.9	4.6
Panel B: Estimated Incidence Among Males (%/year)													
2002-3	3.6	8.2	12.9	20.8	24.6	26.8	30.7	23.4	27.9	38.4	18.4	5.2	12.6
2004-5	3.0	8.1	12.6	22.0	25.1	27.7	30.9	25.3	22.1	37.8	17.6	6.6	3.6
2006-7	3.3	6.8	13.4	20.1	25.4	28.2	32.8	29.3	24.9	43.0	18.9	10.6	7.6
2008-9	3.0	6.6	12.9	18.7	26.8	25.0	32.1	29.1	26.5	43.5	23.1	8.5	7.0
2010-1	1.9	6.5	11.5	18.3	23.9	24.2	32.7	27.2	23.1	55.6	20.6	7.6	6.5
2012-3	1.8	4.7	9.9	16.0	21.8	23.5	30.3	24.9	20.4	51.0	23.8	9.5	4.3
Meta-analysis estimate [b]	2.7	6.8	12.2	19.3	24.5	25.5	31.6	26.5	23.8	45.1	20.4	7.6	6.2

[a.] Adjacent cells with the same shade trace the experience of individual cohort-pairs.

[b.] Meta-analysis summary estimates with each year-pair treated as independent replication. For 12-17 year olds, heterogeneity across replications motivated use of the random effects variance estimation approach.

Table 2

95% Confidence Intervals for Age-, Cohort-, and Time-Specific Incidence Estimates for Newly Incident Drinking. Data From United States National Survey on Drug Use and Health 2-Year Restricted Data Analysis System (Unweighted n~390,000 12-24 Year Olds).[a]

age	12	13	14	15	16	17	18	19	20	21	22	23	24
year-pair	Panel A: 95% Confidence Intervals of Estimated Incidence Among Females (%/year)												
2002-3	3.0, 4.6	8.2, 10.8	16.0, 19.8	25.4, 30.3	28.2, 33.9	26.5, 32.4	29.5, 37.4	23.3, 32.0	16.7, 26.7	38.0, 50.0	14.1, 25.8	5.1, 11.4	2.9, 7.7
2004-5	2.7, 4.2	8.7, 11.3	17.2, 20.9	23.1, 27.5	26.5, 31.8	25.0, 31.4	30.2, 37.6	24.0, 32.4	16.6, 25.2	39.8, 50.8	13.1, 22.7	6.0, 14.1	1.3, 5.9
2006-7	2.1, 3.4	7.1, 9.6	14.7, 18.2	22.3, 27.0	25.4, 30.6	25.0, 30.5	30.8, 38.6	25.4, 34.4	19.3, 29.0	41.0, 52.4	15.2, 25.6	2.7, 8.5	2.6, 7.1
2008-9	2.3, 3.9	6.7, 9.1	13.4, 16.9	20.7, 24.9	23.8, 28.8	22.6, 27.7	27.5, 34.5	22.4, 30.6	16.6, 25.2	46.6, 58.3	17.6, 29.5	5.5, 15.0	4.4, 12.6
2010-1	2.0, 3.4	6.1, 8.4	11.6, 14.7	20.6, 24.8	23.5, 28.4	20.1, 25.4	26.3, 32.8	22.0, 29.1	17.5, 25.4	47.2, 58.1	19.4, 33.2	5.7, 12.7	5.3, 14.8
2012-3	1.5, 2.8	4.4, 6.3	10.5, 13.6	18.2, 22.1	21.7, 26.1	22.8, 28.2	25.2, 31.5	22.3, 30.0	15.6, 22.9	47.9, 58.3	15.6, 26.4	9.0, 20.1	1.8, 9.0
Meta-analysis estimate [b]	2.4, 3.3	6.5, 9.4	13.3, 17.7	21.7, 25.9	25.2, 29.3	24.3, 28.3	29.9, 32.8	25.3, 28.6	19.1, 22.6	46.9, 51.5	18.2, 22.7	6.4, 9.4	3.4, 5.7
	Panel B: Confidence Intervals of Estimated Incidence Among Males (%/year)												
2002-3	2.8, 4.5	7.1, 9.5	11.5, 14.5	18.9, 22.9	22.1, 27.2	23.9, 30.0	27.1, 34.5	19.3, 28.0	22.4, 34.1	31.8, 45.6	12.7, 25.8	2.3, 11.0	7.4, 20.7
2004-5	2.3, 3.8	7.0, 9.5	11.2, 14.1	19.9, 24.3	22.8, 27.6	24.7, 31.1	27.4, 34.6	21.3, 29.8	17.3, 27.7	31.2, 44.9	12.3, 24.6	3.0, 14.0	1.5, 8.8
2006-7	2.7, 4.2	5.8, 8.0	11.9, 15.1	18.1, 22.3	23.1, 28.0	25.4, 31.2	29.4, 36.3	24.7, 34.3	19.9, 30.6	37.0, 49.2	13.0, 26.6	5.8, 18.5	4.0, 14.1
2008-9	2.2, 4.0	5.5, 7.9	11.4, 14.5	16.8, 20.8	24.4, 29.4	22.5, 27.6	28.8, 35.6	25.4, 33.0	22.0, 31.5	37.8, 49.4	17.0, 30.7	4.5, 15.4	3.6, 13.1
2010-1	1.5, 2.5	5.4, 7.7	10.1, 13.0	16.4, 20.3	21.8, 26.2	21.9, 26.7	29.2, 36.4	23.2, 31.6	19.1, 27.7	49.5, 61.5	15.5, 26.9	4.5, 12.4	3.4, 12.2
2012-3	1.3, 2.4	3.8, 5.7	8.6, 11.4	14.3, 17.8	19.7, 24.1	21.3, 26.0	27.1, 33.8	21.2, 29.0	16.5, 25.0	46.1, 55.9	18.4, 30.3	5.4, 16.3	1.9, 9.7
Meta-analysis estimate [b]	2.1, 3.4	5.7, 7.9	11.1, 13.2	17.5, 21.0	23.5, 25.4	24.4, 26.6	30.2, 33.0	24.8, 28.2	21.8, 25.7	39.5, 50.7	17.9,23.0	5.6, 9.7	4.0, 8.3

[a.] Adjacent cells with the same shade trace the experience of individual cohort-pairs.

[b.] Meta-analysis summary estimates with each year-pair treated as independent replication. For 12-15, 21, and 24 year olds, heterogeneity across replications motivated use of the random effects variance estimation approach.

Table 3

Estimated Male Excess in Incidence of Newly Incident Drinking. Data From United States National Survey on Drug Use and Health 2-year Restricted Data Analysis System (Unweighted n~390,000 12-24 Year Olds).[a]

Age	12	13	14	15	16	17	18	19	20	21	22	23	24
Year-pair	**Panel A: Estimated Male Excess in Incidence (%/year)**												
2002-3	-0.1	-1.2	**-4.9**	**-7.0**	**-6.4**	-2.6	-2.6	-4.0	6.6	-5.5	-0.9	-2.5	**7.8**
2004-5	-0.3	-1.8	**-6.4**	**-3.3**	**-4.0**	-0.4	-2.9	-2.7	1.5	-7.5	0.2	-2.6	0.8
2006-7	0.6	-1.5	**-3.0**	**-4.4**	-2.5	0.5	-1.8	-0.4	1.0	-3.7	-1.0	5.8	3.3
2008-9	-0.0	-1.2	-2.2	**-4.0**	0.6	-0.1	1.2	2.8	5.9	**-8.9**	0.1	-0.7	-0.5
2010-1	-0.7	-0.7	-1.6	**-4.3**	-2.0	1.5	3.3	1.8	2.0	2.9	-5.1	-1.0	-2.5
2012-3	-0.3	-0.6	-2.0	**-4.1**	-2.1	-1.9	2.0	-1.1	1.4	-2.2	3.3	-4.2	0.2
Meta-analysis estimate [b]	-0.2	**-1.1**	**-3.3**	**-4.5**	**-2.6**	-0.4	0.1	-0.5	**2.9**	**-3.9**	-0.4	-1.0	1.2
	Panel B: 95% Confidence Interval												
2002-3	-1.3, 0.9	-3.0, 0.6	**-7.3, -2.5**	**-10.2, -3.8**	**-10.2, -2.6**	-6.9, 1.7	-8.1, 2.7	-10.3, 2.1	-1.1, 14.3	-14.7, 3.7	-9.6, 7.8	-7.5, 2.5	**0.9, 14.7**
2004-5	-1.4, 0.6	-3.6, 0.0	**-8.8, -4.0**	**-6.4, -0.2**	**-7.6, -0.4**	-4.8, 4.2	-8.0, 2.2	-8.7, 3.3	-5.1, 8.3	-16.3, 1.3	-7.4, 8.0	-9.1, 3.9	-3.1, 4.7
2006-7	-0.3, 1.7	-3.2, 0.2	**-5.4, -0.6**	**-7.6, -1.2**	-6.1, 1.1	-3.5, 4.5	-7.0, 3.4	-7.0, 6.2	-6.2, 8.2	-12.0, 4.6	-9.5, 7.5	-0.9, 12.5	-2.0, 8.6
2008-9	-1.5, 0.3	-2.9, 0.5	-4.6, 0.2	**-6.9, -1.1**	-2.9, 4.1	-3.7, 3.5	-3.6, 6.0	-2.8, 8.4	-0.5, 12.3	**-17.1, -0.7**	-8.8, 9.2	-7.7, 6.3	-6.5, 5.5
2010-1	-1.1, 0.5	-2.3, 0.9	-3.7, 0.5	**-7.1, -1.5**	-5.3, 1.3	-1.9, 5.1	-1.6, 8.2	-3.7, 7.3	-3.8, 7.8	-5.1, 11.1	-14.0, 3.8	-6.1, 4.1	-8.7, 3.7
2012-3	-0.5, 0.3	-2.0, 0.8	-4.1, 0.1	**-6.7, -1.5**	-5.0.2, 1	-5.4, 1.6	-2.5, 6.7	-6.5, 4.3	-4.2, 7.0	-9.3, 5.1	-4.7, 11.3	-11.7, 3.5	-4.5, 5.1
Meta-analysis estimate [b]	-0.5, 0.1	**-1.8, -0.4**	**-4.8, -1.8**	**-5.7, -3.3**	**-4.0, -1.2**	-2.0, 1.2	-2.0, 2.1	-2.8, 1.9	**0.2, 5.5**	**-7.3, -0.5**	-3.9, 3.1	-3.5, 1.5	-0.9, 3.3

[a] Bold font denotes robust differences when alpha is set at 0.05. Adjacent cells with the same shade trace the experience of individual cohort-pairs.

[b] Meta-analytic summary estimates using fixed effects model except for age 14 where random effects model was used based on heterogeneity statistics (heterogeneity chi-squared = 13.17 [degree of freedom = 5], p = 0.022; I^2= 62.0%).

Table 4

Sex-, Age-, Cohort-, and Time-Specific Estimates for the Prevalence of Recently Active Drinking. Data From United States National Survey on Drug Use and Health 2-Year Restricted Data Analysis System (Unweighted n~390,000 12-24 Year Olds).[a]

Age	12	13	14	15	16	17	18	19	20	21	22	23	24
Year-pair	**Panel A. Estimated Prevalence of Recently Active Drinking Among Females (%)**												
2002/3	7.3	17.7	29.4	46.2	55.3	61.6	66.7	70.9	74.3	81.9	80.7	78.1	76.8
2004/5	6.2	17.0	30.4	42.8	52.7	60.1	67.8	71.1	73.8	82.5	79.8	79.2	76.9
2006/7	5.8	15.3	27.6	41.7	49.3	56.3	66.4	72.0	75.3	82.7	81.1	80.0	78.7
2008/9	5.6	13.0	24.8	39.0	47.8	52.9	64.6	70.4	74.0	84.8	83.8	79.6	82.2
2010/1	4.4	12.1	22.1	36.5	44.8	51.2	59.9	66.0	71.7	84.3	82.6	81.9	80.5
2012/3	3.6	8.9	18.6	32.0	41.8	51.8	59.2	66.7	69.0	83.7	84.1	82.5	81.8
Meta-analysis estimate [b]	5.5	14.0	25.5	39.7	48.6	55.7	64.1	69.6	73.1	83.3	82.1	80.2	79.5
	Panel B. Estimated Prevalence of Recently Active Drinking Among Males (%)												
2002/3	7.3	16.0	25.8	39.2	50.3	60.5	68.0	72.0	79.4	86.1	86.2	85.3	83.8
2004/5	6.0	14.7	24.8	38.8	49.9	59.2	67.1	73.7	79.0	86.0	84.5	83.8	83.9
2006/7	6.3	12.6	24.7	36.5	50.6	58.1	66.9	72.4	76.5	86.6	85.2	87.6	85.3
2008/9	6.0	12.5	23.0	35.1	45.4	54.6	63.6	72.7	76.3	85.9	87.8	85.5	87.7
2010/1	4.1	11.2	19.2	32.0	42.8	52.5	63.8	69.5	76.4	86.2	85.6	87.7	86.5
2012/3	4.0	8.6	17.2	27.7	38.8	49.5	59.8	65.5	73.9	85.4	85.7	85.8	85.3
Meta-analysis Summary [b]	5.6	12.6	22.4	34.9	46.3	55.7	64.9	71.0	76.9	86.0	85.9	86.1	85.5

[a.] Adjacent cells with the same shade trace the experience of individual cohort-pairs.

[b.] Meta-analytic summary estimates (random effects modeling).

Table 5

95% Confidence Intervals of Sex-, Age-, Cohort-, and Time-Specific Estimates for the Prevalence of Recently Active Drinking. Data From United States National Survey on Drug Use and Health 2-Year Restricted Data Analysis System (Unweighted n~390,000 12-24 Year Olds).[a]

Age	12	13	14	15	16	17	18	19	20	21	22	23	24
Year-pair	**Panel A. 95% Confidence Intervals of Estimated Prevalence Among Females (%)**												
2002/3	6.4, 8.4	16.2, 19.4	27.5, 31.4	44.2, 48.3	53.2, 57.5	59.5, 63.6	64.3, 69.0	68.6, 73.2	71.8, 76.6	79.9, 83.8	78.6, 82.7	76.0, 80.0	74.7, 78.7
2004/5	5.3, 7.3	15.5, 18.6	28.5, 32.4	40.8, 44.9	50.5, 54.9	57.8, 62.3	65.3, 70.1	68.7, 73.3	71.7, 75.9	80.5, 84.3	77.8, 81.7	77.2, 81.1	74.6, 79.0
2006/7	4.9, 6.8	13.8, 16.9	25.8, 29.6	39.5, 43.9	47.2, 51.4	54.2, 58.3	64.0, 68.7	69.8, 74.1	73.1, 77.4	80.4, 84.7	78.9, 83.1	77.9, 81.9	76.4, 80.9
2008/9	4.7, 6.7	11.6, 14.5	22.9, 26.8	36.9, 41.0	45.7, 50.0	50.8, 55.0	62.2, 66.8	68.0, 72.7	71.6, 76.2	82.8, 86.6	81.8, 85.6	77.3, 81.6	80.4, 83.8
2010/1	3.6, 5.5	10.8, 13.4	20.4, 23.9	34.5, 38.6	42.7, 47.0	48.8, 53.5	57.3, 62.3	63.5, 68.4	69.1, 74.1	82.3, 86.1	80.4, 84.5	79.8, 83.8	78.3, 82.5
2012/3	2.9, 4.5	7.8, 10.1	16.9, 20.4	30.0, 34.0	39.8, 43.8	49.6, 53.9	56.7, 61.6	64.1, 69.3	66.6, 71.4	81.6, 85.5	82.3, 85.8	80.4, 84.5	79.9, 83.6
Meta-analysis estimate [b]	4.4, 6. 6	11.2, 16.8	21.8, 29.2	35.6, 43.8	44.6, 52.6	52.1, 59.2	61.2, 67.0	67.6, 71.6	71.3, 74.9	82.4, 84.3	80.6, 83.5	78.9, 81.6	77.6, 81.5
	Panel B. 95% Confidence Intervals of Estimated Prevalence Among Males (%)												
2002/3	6.3, 8.4	14.5, 17.5	24.1, 27.6	37.3, 41.1	48.3, 52.3	58.4, 62.6	65.9, 70.1	69.7, 74.3	77.1, 81.5	84.3, 87.7	84.2, 88.0	83.2, 87.1	81.9, 85.6
2004/5	5.0, 7.1	13.3, 16.3	23.1, 26.6	36.8, 40.9	47.7, 52.0	57.1, 61.3	64.8, 69.2	71.5, 75.9	76.9, 81.1	83.9, 87.8	82.1, 86.5	81.8, 85.7	81.7, 85.9
2006/7	5.4, 7.3	11.2, 14.1	23.0, 26.5	34.6, 38.6	48.6, 52.7	55.9, 60.3	64.6, 69.2	69.6, 75.0	74.1, 78.7	84.7, 88.3	83.2, 87.0	85.9, 89.1	83.1, 87.3
2008/9	5.0, 7.3	11.1, 14.0	21.3, 24.8	33.1, 37.1	43.3, 47.4	52.5, 56.6	61.5, 65.7	70.5, 74.7	74.0, 78.4	84.0, 87.6	86.1, 89.4	83.5, 87.4	85.9, 89.3
2010/1	3.4, 4.9	9.9, 12.6	17.6, 20.9	30.1, 34.1	40.7, 44.9	50.4, 54.6	61.3, 66.1	67.1, 71.7	74.2, 78.6	84.2, 87.9	83.7, 87.3	85.8, 89.4	84.4, 88.4
2012/3	3.2, 5.0	7.4, 9.9	15.6, 18.9	25.9, 29.6	36.7, 40.9	47.4, 51.6	57.3, 62.2	62.8, 68.0	71.6, 76.1	83.5, 87.1	83.7, 87.4	83.7, 87.6	83.2, 87.1
Meta-analysis Summary [b]	4.5, 6.7	10.4, 14.7	19.6 25.3	31.3, 38.5	42.5, 50.1	52.3, 59.1	62.5 673	68.7, 73.3	75.3 78.6	85.3, 86.8	85.0, 86.9	84.8,87.2	84.2, 86.7

[a.] Adjacent cells with the same shade trace the experience of individual cohort-pairs.

[b.] Meta-analytic summary estimates (random effects modeling).