Substance use disorder among older adults in the United States in 2020

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ABSTRACT

Aims This study aimed to project the number of people aged 50 years or older with substance use disorder (alcohol/illicit drug dependence or abuse) in the United States in 2020. **Design** Logistic regression models were applied to estimate parameters predicting past-year substance use disorder using the 2002–06 National Survey on Drug Use and Health data. We applied these parameters to the projected US 2020 population to estimate the number of adults aged 50 or older with substance use disorder in 2020. **Setting** Non-institutionalized US residences. **Participants** Representative sample of the US civilian, non-institutionalized population. **Measurements** Substance use disorder is classified based on criteria in the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition. **Findings** Due to the large population size and high substance use rate of the baby-boom cohort, the number of adults aged 50 or older with substance use disorder is projected to double from 2.8 million (annual average) in 2002–06 to 5.7 million in 2020. Increases are projected for all examined gender, race/ethnicity and age groups. **Conclusions** Our estimates provide critical information for policymakers to allocate resources and develop prevention and treatment approaches to address future needs of the US older adult population with substance use disorder.

Keywords Alcohol, illicit drugs, older adults, projection, substance use disorder.

INTRODUCTION

Substance use disorder (SUD, alcohol or illicit drug dependence or abuse) and substance misuse are associated with numerous health and social problems [1–4] and increase the risk of hospitalization, nursing home placement and death among older adults [5–10]. Moreover, 90% of older adults use prescription and over-the-counter medications, and many medications interact adversely with alcohol or illicit drugs [5–7]. At least 25% of older adults use psychoactive medications with abuse potential [10]. In addition, older adults experiencing emotional and social problems (e.g. bereavement, loneliness, social isolation) and medical problems (e.g. chronic pain, insomnia, dementia, depression or anxiety) are at greater risk for substance use [5–9]. The same problems may also be aggravated by SUD [5–9]. Despite varying definitions of older adults, these studies generally indicate that age-related physiological, psychological and social changes among older people increase the impact of substance use.

This study defines older adults as people aged 50 years or older.

However, SUD among older adults is often under-diagnosed, misdiagnosed, undertreated or untreated [11–21]. Health professionals tend to overlook SUD among older adults, attributing the symptoms instead to dementia/Alzheimer's disease, depression or other problems common among older adults [12–21]. Moreover, older adults are more likely to hide their substance use problems and are less likely to ask for help than younger adults [11–21]. Furthermore, drug and alcohol treatment programs designed specifically for older adults are not available widely in the United States. Only 7% of substance abuse treatment facilities reported having a program or group designed specifically for seniors in 2006 [22], although older adults with SUD have been shown to respond well to age-specific, supportive and non-confrontational group treatment, and these individuals can recover and maintain an improved quality of life [11–21].

There has been growing concern and recognition that as the baby-boomers age, the consequences of their substance use will place a tremendous burden on US healthcare delivery and financing systems, families and society [22,23,25–28]. Compared to earlier cohorts, baby-boomers (born from 1946 to 1964) have much higher rates of illicit drug use [23]. Moreover, the population size of the baby-boom generation is larger than any earlier cohorts [24]. Three statistical projection studies that took account of these factors forecast large increases in the prevalence of substance use and SUD among older adults as the baby-boom cohort ages [25–27]. The number of people aged 50 or older in need of treatment for drug abuse was estimated to increase from 147 000 in 1995 to 911 000 in 2020 [26]. The number of people aged 50 or older in need of illicit drug or alcohol abuse treatment was estimated to increase from 1.7 million in 2000–01 to 4.4 million in 2020 [25]. The number of marijuana users aged 50 or older was expected to increase from 719 000 in 1999–2001 to 3.3 million in 2020 [27]. These studies [25–27] were based on the National Survey on Drug Use and Health (NSDUH) data collected prior to 2002.

The NSDUH is the primary annual source of information on the use of illicit drugs, alcohol and tobacco in the civilian, non-institutionalized population in the United States. [29,30]. Since 2002, important methodological improvements have been made in the NSDUH [29]. Incentive payments of $30 for each respondent were initiated, data collection quality control procedures were improved and sample weight calibration was shifted from the 1990 to the 2000 decennial census. These changes enhanced the quality of the data, improved the response rates and increased the reporting of substance use by adults [29,30].

Therefore, the current study sought to generate more precise projections of the number of adults aged 50 or older with SUD in 2020 using the 2002–06 NSDUH data and applying the Census Bureau's recent updated national population projections for the year 2020. In addition to the advantages resulting from the methodological improvement since 2002, the large combined sample size of older adults from the 2002–06 NSDUHs makes it possible to generate more precise estimates than the previous papers [25–27]. Furthermore, the larger sample used in this study enabled us to examine possible cohort effects and to test a key assumption underlying the projection approach used in this study and previous papers [25–27], namely that SUD among different cohorts can be predicted adequately using a single model. The estimates generated in this study will provide critical information to policymakers for planning resources and developing treatment infrastructures to address the needs of the US older adult population with SUD over the next decade.

METHODS

Data source

This study examined data from the 2002–06 NSDUHs, a series of annual cross-sectional nationally representative surveys of the US civilian, non-institutionalized population aged 12 years or older conducted by the Substance Abuse and Mental Health Services Administration (SAMHSA). The 2002–06 NSDUHs provide estimates for all 50 States plus the District of Columbia. The first-stage sampling units of the 2002–04 NSDUHs were clusters of census blocks called area segments, while the first stage of selection for the 2005–06 NSDUHs was census tracts (within sampled census tracts, adjacent census blocks were combined to form the second-stage sampling units or area segments). In each of the selected area segments, all eligible dwelling units were listed and a sample of these was selected. In these sample units (households or units within group quarters), sample people aged 12 or older were selected randomly using pre-determined selection probabilities [29–30]. Data are collected by interviewers in personal visits to households and non-institutional group quarters. The interview averages approximately an hour. Audio computer-assisted self-administered interviewing (ACASI) is used, providing respondents with a private, confidential way to record answers. Further description of the data source is available from the SAMHSA website [30].

Criteria for substance use disorder (SUD)

SUD is classified based on the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM-IV) criteria [31]. The NSDUH includes a series of questions designed to measure these criteria within the 12 months prior to interview [30]. Studies evaluating the quality of NSDUH estimates of SUD have shown good validity and reliability [32–33].

Analytical approach

Two analysis steps were conducted to estimate the number of older adults with SUD in 2020. First, logistic regression models were applied to determine parameter estimates that characterize the relationships between the best sets of independent variables and the outcome, past-year SUD, among the older adult population (defined as age 50 or older) based on the combined 2002–06 NSDUH data. Secondly, we applied the parameters estimated from these models to the projected US population for the 2020 to estimate the number of older adults with SUD in 2020.

Logistic regression models among people aged 50 or older in 2002–06

As people who have not used alcohol by age 33 are expected to have an extremely low probability of having SUD [34], we developed high-risk and low-risk models separately to improve the quality of our estimates. Logistic regression models were utilized to examine characteristics associated with past-year SUD among people aged 50 or older who had never used alcohol or initiated use after the age of 32 (low-risk model, $n = 5235$; at the time of the survey interview, 4646 sampled older adults had never used alcohol and 13 of them had past-year SUD; 589 sampled older adults had initiated alcohol use after the age of 32 and four of them had past-year SUD) and among people aged 50 or older who initiated alcohol use before the age of 33 (high-risk model, $n = 25\,525$).

During the model building, we considered only characteristics that were known by the age of 32 and could be assumed to be generally stable as people age beyond the age of 32. We examined age (continuous variable), gender (male, female), race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic other or Hispanic), years of education (<12, 12 or >12), age at first alcohol use (=16, 17–20 or 21–32 for high-risk model only), and age at first illicit drug use (=16, 17–20, 21–32 or did not use before the age of 33 for high-risk model only) indicating the earliest age at initiation of marijuana, cocaine, heroin, hallucinogens, inhalant or non-medical use of pain relievers, tranquilizers, stimulants or sedatives. The Hosmer–Lemeshow (HL) goodness-of-fit tests for survey data were applied to determine the adequacy of the fit of the models [35]. The analyses used SUDAAN software [36] to adjust for the complex sample design and sampling weights of the NSDUH.

Models examining cohort effects

We examined cohort effects (born 1945 or earlier, born 1946–50 or born 1951–56) in these logistic regression models we built as described above because an underlying assumption of our projection method is that SUD among different cohorts can be predicted adequately using a single model. We also examined cohort effects in these logistic regression models among sampled people aged 26 or older who initiated alcohol use before the age of 33 and who will be 50 years old or older in 2020 (born 1945 or earlier, 1946–50, 1951–56 or 1957–70).

Projections to the population aged 50 or older in 2020

To construct a sample representative of the population aged 50 years or older in 2020, we first combined the samples aged 32 or older from the 2002 NSDUH, aged 33 or older from the 2003 NSDUH, aged 34 or older from the 2004 NSDUH, aged 35 or older from the 2005 NSDUH and aged 36 or older from the 2006 NSDUH ($n = 83\,429$). Secondly, for this combined sample, we increased the age (at the time of the survey interview) of each respondent by adding 18 for the 2002 NSDUH respondents, 17 for the 2003 NSDUH respondents, 16 for the 2004 NSDUH respondents, 15 for the 2005 NSDUH respondents and 14 for the 2006 NSDUH respondents. These steps allowed us to utilize the alcohol and illicit drug use history and other stable characteristics of the sampled cohorts from the 2002–06 NSDUHs who will be 50 or older in 2020.

To better reflect the US older adult population in 2020, we adjusted the analysis weights so that estimates from this constructed sample would match the Census Bureau's recent mid-level projection of the US population aged 50 or older in 2020 by age, gender, race and Hispanic origin [37]. The analysis weights also were adjusted to account for differential mortality rates among people with SUD based on the results of US studies by Neumark and colleagues [38,39].

Based on the parameters estimated from the two logistic regression models, a predictive probability was assigned to each respondent in this 2020 population sample. Then, we tabulated the weighted sums of the predicted probabilities representing the estimated prevalence in 2020. We computed standard errors of the projections using a jack-knife procedure, helping to account for bias and variance associated with the modeling and prediction. More details on these methods have been described in a previous study [25].

RESULTS

Logistic regression models among people aged 50 or older

Table 1 shows the sample sizes for the regression models and the projection analyses. Among people aged 50 or older who had never used alcohol or first used it after age 32 (the group described by the low-risk model), gender, race/ethnicity and education were not associated significantly with past-year SUD; thus, these variables were not considered in this model. Table 2 presents the results of our final low-risk model. The HL test indicates that this model has no evidence of lack of fit (HL $\chi^2_{(8)} = 7.17$, $P = 0.52$). With each additional year of age, older adults who had not initiated alcohol use prior to age 33 or never used alcohol were 0.91 times [odds ratio (OR) = 0.91, 95% confidence interval (CI) = 0.86–0.95] less likely to have past-year SUD.

Table 3 shows the results of our final high-risk model. The HL test indicates that this model has no evidence of lack of fit (HL $\chi^2_{(8)} = 4.95$, $P = 0.76$). With each additional

Table 1 Sample sizes for low-risk and high-risk regression models for past-year substance use disorder and 2020 projections, by levels of variables in models.

Variables	Sample for regression models (age 50 or older in 2002–06)		Sample for projections (age 50+ in the year 2020)
	Sample size	Sample cases with past-year substance use disorder	
Low-risk model[a]			
Total	5235	17	9784
High-risk model[a]			
Total	25 525	1066	73 645
Gender			
Male	12 583	790	35 414
Female	12 942	276	38 231
Race/ethnicity			
White non-Hispanic	21 518	841	58 058
Black non-Hispanic	1981	121	6796
Other non-Hispanic	724	39	2801
Hispanic	1302	65	5990
Education			
<12 years	3897	181	9293
12 years	8613	329	23 968
>12 years	13 015	556	40 384
Age at first alcohol use (years)			
≤16	8937	638	36 573
17–20	11 083	340	26 526
21–32	5505	88	10 546
Age at first illicit drug use (years)			
≤16	1258	196	18 372
17–20	3123	289	13 907
21–32	3084	202	6995
33+ or never	18 060	379	34 371

[a]The low-risk sample was comprised of all respondents who either initiated alcohol use after the age of 32 or never have used alcohol, and the high-risk sample was comprised of all respondents who had initiated alcohol use prior to the age of 33. Source: SAMHSA, Office of Applied Studies, National Household Survey on Drug Abuse, 2002–06.

Table 2 Low-risk final model: logistic regression model for past-year substance use disorder among people aged 50 or older who initiated alcohol use after the age of 32 or never have used alcohol.

Variables	Substance use disorder versus no substance use disorder n = 5235
	β (SE of β); OR (95% CI)
Intercept	0.44 (1.50)
Age*	−0.10 (0.03); 0.91 (0.86–0.95)

*$P < 0.001$; Hosmer–Lemeshow (HL) goodness-of-fit test: HL $\chi^2_{(8)} = 7.17$, $P = 0.52$, indicating the model has no evidence of lack of fit. Source: SAMHSA, Office of Applied Studies, National Survey on Drug Use and Health, 2002–06. SE: standard error; OR: odds ratio; CI: confidence interval.

year of age, older adults were 0.97 (OR = 0.97, 95% CI = 0.96–0.98) times less likely to have past-year SUD. Male older adults were 2.32 times (OR = 2.32, 95% CI = 1.92–2.79) more likely to have past-year SUD than their female counterparts. Older adults with fewer than 12 years of education were 47% (OR = 1.47, 95% CI = 1.17–1.86) more likely to have past-year SUD than those with more than 12 years of education. Compared with people who first used alcohol at age 21–32, older adults who had initiated alcohol use by age 16 or at age 17–20 had a greater likelihood (OR = 2.05, 95% CI = 1.51–2.77; OR = 1.49, 95% CI = 1.11–2.01, respectively) of having past-year SUD. In contrast to people who did not use illicit drugs before age 33, older adults who initiated illicit drug use by age 16 were more than four times (OR = 4.21, 95% CI = 3.23–5.50) more likely to have past-year SUD; those who initiated illicit drug use at 17–20 or 21–32 were almost three times (OR = 2.92, 95% CI = 2.31–3.68; OR = 2.58, 95% CI = 2.04–3.27, accordingly) as likely to have past-year SUD.

Models examining cohort effects

Cohort was neither associated with past-year SUD nor interacted with other examined covariates among people

Table 3 High-risk final model: logistic regression model for past-year substance use disorder among people aged 50 or older who initiated alcohol use before the age of 33.

Covariates	Substance use disorder versus no substance use disorder n = 25 525 β (SE of β); OR (95% CI)
Intercept	−2.81 (0.40)
Age*	−0.03 (0.01); 0.97 (0.96–0.98)
Sex*	
Male	0.84 (0.09); 2.32 (1.92–2.79)
Female	
Race/ethnicity	
Non-Hispanic white	
Non-Hispanic black	0.13 (0.14); 1.14 (0.87–1.51)
Non-Hispanic other	−0.20 (0.26); 0.82 (0.49–1.37)
Hispanic	0.02 (0.18); 1.02 (0.72–1.44)
Education**	
<12	0.39 (0.12); 1.47 (1.17–1.86)
12	0.14 (0.09); 1.16 (0.96–1.39)
>12	
Age at first alcohol use (years)*	
≤16	0.72 (0.15); 2.05 (1.51–2.77)
17–20	0.40 (0.15); 1.49 (1.11–2.01)
21–32	
Age at first illicit drug use (years)*	
≤16	1.44 (0.14); 4.21 (3.23–5.50)
17–20	1.07 (0.12); 2.92 (2.31–3.68)
21–32	0.95 (0.12); 2.58 (2.04–3.27)
Did not use before the age of 33	

*$P < 0.0001$; **$P < 0.01$. Hosmer–Lemeshow (HL) goodness-of-fit test: HL $\chi^2_{(8)} = 4.95$, $P = 0.76$; indicating the model has no evidence of lack of fit. Source: SAMHSA, Office of Applied Studies, National Survey on Drug Use and Health, 2002–06. SE: standard error; OR: odds ratio; CI: confidence interval.

aged 50 or older who had never used alcohol or first used it after age 32, among people aged 50 or older who initiated alcohol use before age 33, or among sampled people aged 26 or older who initiated alcohol use before age 33 and who will be 50 years old or older in 2020 (results available on request). These findings are consistent with our underlying assumption that a single set of predictors can be used to project the number of people aged 50 or older with past-year SUD across the multiple cohorts relevant to this study.

Projections to the 2020 population

As shown in Table 4, the population aged 50 or older is expected to increase 39% from 83.2 million in 2002–06 to 115.6 million in 2020, directly reflecting the projections from the Census Bureau. Particularly, the Hispanic

population aged 50 or older is expected to more than double from 6.1 million to 13.0 million during this time period. We applied the regression results to the projected population in 2020 and found that the rate of past-year SUD among people aged 50 or older was 4.9%, 44% higher than the rate in 2002–06. The number of adults aged 50 or older with past-year SUD is projected to more than double from approximately 2.8 million (annual average, 95% CI: 2.6 million–3.0 million) in 2002–06 to approximately 5.7 million (95% CI: 5.0 million–6.5 million) in 2020. Increases are projected for all examined gender, race/ethnicity and age groups. The number of non-Hispanic whites aged 50 or older with past-year SUD is expected to almost double from 2.2 million (95% CI: 2.1 million–2.4 million) in 2002–06 to 4.3 million (95% CI: 3.7 million–5.0 million) in 2020. The number of Hispanics aged 50 or older with past-year SUD is expected to triple from 0.2 million (95% CI: 0.1 million–0.3 million) to 0.6 million (95% CI: 0.5 million–0.7 million) during this time-period. The number of adults aged 50–59 with past-year SUD is projected to increase 61% from 1.9 million (95% CI: 1.8 million–2.1 million) in 2002–06 to 3.1 million (95% CI: 2.8 million–3.5 million) in 2020. The number of adults aged 60–69 with past-year SUD is expected to more than triple from 0.6 million (95% CI: 0.5 million–0.7 million) to 1.9 million (95% CI: 1.6 million–2.3 million) during this time-period.

DISCUSSION

This paper forecasts the prevalence of SUD among adults aged 50 or older in 2020. Our results indicate that the number of adults aged 50 or older with past-year SUD is projected to more than double from approximately 2.8 million (annual average) in 2002–06 to approximately 5.7 million in 2020, resulting from the combined effects of a 39% population increase and a 44% increase in the rate of past-year SUD. Based on the most recent nationally representative data on substance use and the Census Bureau's most recent projection for the US population aged 50 or older in 2020, our projected number (5.7 million) is approximately 30% greater than the previous projection based on the 2000–01 NSDUHs [25] and the Census Bureau's earlier projection.

For several reasons, the number of people aged 50 or older who need alcohol or illicit drug treatment in 2020 is likely to exceed our projected 5.7 million. First, our estimates do not include older adults residing in nursing homes and other institutions who may have high exposure to abusable prescription medications and are often overlooked in screening for SUD [10]. Secondly, despite the use of state-of-the-art methods to enhance privacy and confidentiality and to promote candid reporting during the NSDUH interview, respondents may under-

Table 4 Estimated 2002–06 and projected 2020 prevalence of past-year substance use disorder among people aged 50 or older.

Domains of interest	2002–2006 Estimates			2020 Projections		
	Population (1000s)	Percentage of population reporting past-year substance use disorder (SE)	Number of people (in 1000s) reporting past-year substance use disorder (95% CI)	Population (1000s)	Percentage of population reporting past-year substance use disorder (SE)	Number of people (in 1000s) reporting past-year substance use disorder (95% CI)
Total	83 157	3.4 (0.12)	2805 (2608–3016)	115 570	4.9 (0.31)	5693 (4982–6500)
Gender						
Male	38 142	5.4 (0.23)	2073 (1909–2251)	53 796	7.5 (0.55)	4059 (3483–4721)
Female	45 015	1.6 (0.12)	731 (631–848)	61 774	2.6 (0.28)	1634 (1312–2033)
Race/ethnicity						
White, non-Hispanic	65 897	3.4 (0.14)	2236 (2065–2422)	82 747	5.2 (0.38)	4329 (3710–5044)
Black, non-Hispanic	7937	3.8 (0.46)	301 (237–383)	12 012	5.0 (0.60)	602 (467–773)
Other, non-Hispanic	3233	2.2 (0.55)	73 (45–117)	7769	2.5 (0.52)	191 (123–296)
Hispanic	6090	3.2 (0.48)	194 (144–261)	13 042	4.4 (0.47)	572 (457–714)
Age group (years)						
50–59	35 888	5.4 (0.22)	1940 (1788–2105)	42 342	7.4 (0.39)	3120 (2795–3479)
60–69	23 300	2.6 (0.23)	609 (512–723)	38 211	5.1 (0.42)	1937 (1625–2305)
70–79	16 604	1.2 (0.18)	199 (148–268)	23 057	2.3 (0.25)	523 (413–661)
80–89	6773	0.8 (0.23)	53 (30–93)	9238	1.1 (0.15)	98 (73–130)
90 or older	593	0.6 (0.41)	3 (1–14)	2722	0.6 (0.11)	15 (10–23)

Source: SAMHSA, Office of Applied Studies, National Household Survey on Drug Abuse, 2002–06. CI: confidence interval; SE: standard error.

report their substance use and SUD symptoms [40]. Thirdly, we classified SUD based on DSM-IV criteria. The DSM-IV criteria were developed and validated in young and middle-aged samples and might not be as valid for older people, for whom criterion-related issues may differ from those of younger adults due to age-related differences in pharmacokinetics, physiology-related variations in substance tolerance and social circumstances such as employment status and living arrangement [12,28]. The DSM-IV criteria may not identify older adults with significant problems but without the specific symptoms necessary for SUD.

Our results indicate that the number of adults aged 50–59 with past-year SUD is projected to increase 61% from 1.9 million in 2002–06 to 3.1 million in 2020. The number of adults aged 60–69 with past-year SUD is expected to more than triple from 0.6 million to 1.9 million during this time-period. These estimates indicate an urgent need to expand the availability of substance abuse treatment services for older adults. Effective treatments for older adults with SUD include supportive and non-confrontational approaches, cognitive–behavioral approaches, slower treatment pace and approaches tailored to older patients' unique psychosocial and health needs [11–21]. Through treatment and recovery, older adults can have better quality of life and health status [11–21]. Unfortunately, only 7% of substance abuse treatment facilities in the United States in 2006 reported having a special program or group designed specifically for older adults [22].

Researchers have reported the effectiveness of integrating primary care with substance abuse treatment programs [46–49]. Providing substance abuse services in primary care settings would be particularly helpful for older adults because they tend to have multiple comorbid conditions and visit their physicians regularly and because SUD, like other chronic illnesses, requires early intervention and continued care [50]. As SUD among older adults is often underdiagnosed, misdiagnosed, undertreated or untreated [11–21], primary care physicians can play significant roles in screening for substance use problems in older adults, with approaches such as SBIRT (Screening, Brief Intervention and Referral to Treatment) [41–45].

This study has several limitations. First, the classification of SUD was not based on clinical diagnoses by psychiatrists or psychologists but on responses to standardized questions self-administered in the presence of a survey interviewer, which may result in some misclassifications. Secondly, we did not make a separate projection for the number of older adults with illicit drug use disorder as we found a significant interaction effect between the cohort variable and age at first illicit drug use in the model predicting past-year illicit drug use disorder, indicating that early illicit drug use among the pre-baby-boom cohort was associated with a much greater risk of later illicit drug use disorder than among the baby-boom cohort. Thus, we recommend that researchers not use the current methodology with an assumption of similar prediction across cohorts to project illicit drug use disorder unless cohort differences can be adequately accounted for in models. Finally, due to the nature of the cross-sectional data, the NSDUH did not provide information on the patterns of relapse and remission of substance use problems. To better understand the life-course of substance use problems and to better distinguish age, cohort and time-period effects, longitudinal studies are needed to help project ageing baby-boomers with SUD over the next decade.

Our projection indicates that substance abuse treatment need among older adults will increase dramatically during the next decade as the baby-boom generation ages. Given the continuing high rates of illicit drug use among subsequent cohorts, increases in treatment need are expected to continue beyond 2020. With much of the current US substance abuse treatment separated from primary care and focused upon younger patients, increased treatment availability and more integrated approaches are needed to address substance abuse problems fully among tomorrow's older adults.

Declarations of interest

None.

References

1. Mokdad A. H., Marks J. S., Stroup D. F., Gerberding J. L. Actual causes of death in the United States, 2000. *JAMA* 2004; **291**: 1238–45.
2. Darke S., Degenhardt L., Mattick R. *Mortality Amongst Illicit Drug Users: Epidemiology, Causes, and Intervention.* Cambridge: Cambridge University Press; 2007, p. 20–40.
3. Adrian M., Barry S. J. Physical and mental health problems associated with the use of alcohol and drugs. *Subst Use Misuse* 2003; **38**: 1575–614.
4. Rehm J., Room R., Graham K., Monteiro M., Gmel G., Sempos C. T. The relationship of average volume of alcohol consumption and patterns of drinking to burden of disease: an overview. *Addiction* 2003; **98**: 1209–28.
5. Reid M. C., Anderson P. A. Geriatric substance use disorders. *Med Clin North Am* 1997; **81**: 999–1016.
6. Reid M. C., Boutros N. N., O'Connor P. G., Cadariu A., Concato J. The health-related effects of alcohol use in older persons: a systematic review. *Subst Abuse* 2002; **23**: 146–64.
7. American Geriatrics Society. *Clinical Guidelines for Alcohol use Disorders in Older Adults.* Available at: http://www.americangeriatrics.org/products/positionpapers/alcoholpf.shtml (accessed 8 January 2008).
8. Geriatric Mental Health Foundation. *Substance Abuse and*

Misuse among Older Adults. Available at: http://www.gmhfonline.org/gmhf/consumer/factsheets/substnabuse_factsheet.html (accessed 8 January 2008).

9. Moore A. A., Whiteman E. J., Ward K. T. Risks of combined alcohol/medication use in older adults. *Am J Geriatr Pharmacother* 2007; **5**: 64–74.

10. Simoni-Wastila L., Yang H. K. Psychoactive drug abuse in older adults. *Am J Geriatr Pharmacother* 2006; **4**: 380–94.

11. Epstein E. E., Fischer-Elber K., Al-Otaiba Z. Women, aging, and alcohol use disorders. *J Women Aging* 2007; **19**: 31–48.

12. Sattar S. P., Petty F., Burke W. J. Diagnosis and treatment of alcohol dependence in older alcoholics. *Clin Geriatr Med* 2003; **19**: 743–61.

13. Lynskey M. T., Day C., Hall W. Alcohol and other drug use disorders among older-aged people. *Drug Alcohol Rev* 2003; **22**: 125–33.

14. Brower K. J., Mudd S., Blow F. C., Young J. P., Hill E. M. Severity and treatment of alcohol withdrawal in elderly versus younger patients. *Alcohol Clin Exp Res* 1994; **18**: 196–201.

15. Booth B. M., Blow F. C., Cook C. A., Bunn J. Y., Fortney J. C. Age and ethnicity among hospitalized alcoholics: a national study. *Alcohol Clin Exp Res* 1992; **16**: 1029–34.

16. Peterson M., Zimberg S. Treating alcoholism: an age-specific intervention that works for older patients. *Geriatrics* 1996; **51**: 45–9.

17. Schonfeld L., Dupree L. W., Dickson-Euhrmann E., Royer C. M., McDermott C. H., Rosansky J. S. *et al.* Cognitive-behavioral treatment of older veterans with substance abuse problems. *J Geriatr Psychiatry Neurol* 2000; **13**: 124–9.

18. Royer C. M., Dickson-Fuhrmann E., McDermott C. H., Taylor S., Rosansky JS, Jarvik LF. Portraits of change: case studies from an elder-specific addition program. *J Geriatr Psychiatry Neurol* 2000; **13**: 130–3.

19. Gomberg E. S. Treatment for alcohol-related problems: special populations: research opportunities. *Recent Dev Alcohol* 2003; **16**: 313–33.

20. Blow F. C., Walton M. A., Chermack S. T., Mudd S. A., Brower K. J. Older adult treatment outcome following elder-specific inpatient alcoholism treatment. *J Subst Abuse Treat* 2000; **19**: 67–75.

21. Neve R. J., Lemmens P. H., Drop M. J. Drinking careers of older male alcoholics in treatment as compared to younger alcoholics and to older social drinkers. *J Stud Alcohol* 1997; **58**: 303–11.

22. Substance Abuse and Mental Health Services Administration. Office of Applied Studies. *National Survey of Substance Abuse Treatment Services (N_SSAT): 2006.* Data on Substance Abuse Treatment Facilities, DASIS Series: S39, DHHHS publication no. (SMA) 07-4296, Rockville, MD. 2007.

23. Johnson R. A., Gerstein D. R. Initiation of use of alcohol, cigarettes, marijuana, cocaine, and other substances in US birth cohorts since 1919. *Am J Public Health* 1998; **88**: 27–33.

24. Koenig H. G., George L. K., Schneider R. Mental health care for older adults in the year 2020: a dangerous and avoided topic. *Gerontologist* 1994; **34**: 674–9.

25. Gfroerer J., Penne M., Pemberton M., Folsom R. Substance abuse treatment need among older adults in 2020: the impact of the aging baby-boom cohort. *Drug Alcohol Depend* 2003; **69**: 127–35.

26. Gfroerer J. C., Epstein J. F. Marijuana initiates and their impact on future drug abuse treatment need. *Drug Alcohol Depend* 1999; **54**: 229–37.

27. Colliver J., Compton W. M., Gfroerer J. C., Condon T. Projecting drug use among aging baby boomers in 2020. *Ann Epidemiol* 2006; **16**: 257–65.

28. Patterson T. L., Jeste D. V. The potential impact of the baby-boom generation on substance abuse among elderly persons. *Psychiatr Serv* 1999; **50**: 1184–8.

29. Substance Abuse and Mental Health Services Administration. *Results from the 2002 National Survey on Drug Use and Health: National Findings* (Office of Applied Studies, NHSDA Series H-22, DHHS Publication no. SMA 03-3836). Rockville, MD: Substance Abuse and Mental Health Services Administration; 2003.

30. Substance Abuse and Mental Health Services Administration. *National Survey on Drug Use and Health.* Available at: http://www.oas.samhsa.gov/nsduh.htm (accessed 1 January 2008).

31. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*, 4th edn. Washington, DC: American Psychiatric Association; 1994, p. 181–3.

32. Grucza R. A., Abbacchi A. M., Przybeck T. R., Gfroerer J. C. Discrepancies in estimates of prevalence and correlates of substance use and disorders between two national surveys. *Addition* 2007; **102**: 623–9.

33. Jordan B. K., Karg R., Batts K. R., Epstein J. F., Wiesen C. A clinical validation of the national survey on drug use and health assessment of substance use disorders. *Addict Behav* 2008; **33**: 782–98.

34. Chen K., Kandel D. B. The natural history of drug use from adolescence to the mid-thirties in a general population sample. *Am J Public Health* 1995; **85**: 41–7.

35. Hosmer D. W., Lemeshow S. *Applied Logistic Regression.* New York: Wiley; 1989.

36. Shah B., Barnwell B., Bieler G. *SUDAAN User's Manual.* Version 9.1 edn. Research Triangle Park, NC: Research Triangle Institute; 2005.

37. US Census Bureau. *U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin. 2004.* Available at: http://www.census.gov/ipc/www/usinterimproj/ (accessed 6 December 2007).

38. Neumark Y. D., Van Etten M. L., Anthony J. C. 'Drug dependence' and death: survival analysis of the Baltimore ECA sample from 1981 to 1995. *Subst Use Misuse* 2000; **35**: 313–27.

39. Neumark Y. D., Van Etten M. L., Anthony J. C. 'Alcohol dependence' and death: survival analysis of the Baltimore ECA sample from 1981 to 1995. *Subst Use Misuse* 2000; **35**: 533–49.

40. Harrison L., Huges A., editors. *The Validity of Self-Reported Drug Use: Improving the Accuracy of Survey Estimates.* NIDA Research Monograph 167, NIH publication no. 97-4147. Rockville, MD: National Institute on Drug Abuse; 1997.

41. Substance Abuse and Mental Health Services Administration. Center for Substance Abuse Treatment. *Substance Abuse among Older Adults. Treatment Improvement Protocol (TIP) Series 26.* DHHS Publication no. (SMA) 98-3179. Rockville, MD: Substance Abuse and Mental Health Services Administration, Center for Substance Abuse Treatment; 1998.

42. Substance Abuse and Mental Health Services Administration. Center for Substance Abuse Treatment. *Brief Intervention and Brief Therapies for Substance Abuse.* Treatment Improvement Protocol (TIP) Series 34. DHHS Publication

no. (SMA) 99-3353. Rockville, MD: Substance Abuse and Mental Health Services Administration, Center for Substance Abuse Treatment; 1999.

43. Substance Abuse and Mental Health Services Administration, Center for Substance Abuse Treatment. *Screening, Brief Intervention, and Referral to Treatment*. Available at: http://sbirt.samhsa.gov/about.htm (accessed 8 August 2008).

44. Barnes H. N., Samet J. H. Brief interventions with substance-abusing patients. *Med Clin North Am* 1997; **81**: 867–79.

45. Schorling J. B., Buchsbaum D. G. Screening for alcohol and drug abuse. *Med Clin North Am* 1997; **81**: 845–65.

46. Lewis D. C. The role of the generalist in the care of the substance-abusing patients. *Med Clin North Am* 1997; **81**: 831–43.

47. Weisner C., Mertens J., Parthasarathy S., Moore C., Lu Y. Integrating primary medical care with addiction treatment. *JAMA* 2001; **286**: 1715–23.

48. Friedmann P. D., Zhang Z., Hendrickson J., Stein M. D., Gerstein D. R. Effect of primary medical are on addiction and medical severity in substance abuse treatment programs. *J Gen Intern Med* 2003; **18**: 1–8.

49. Kim T. W., Samet J. H., Cheng D. M., Michaael R. W., Safran D. G., Saitz R. Primary care quality and addiction severity: a prospective cohort study. *Health Serv Res* 2007; **42**: 755–72.

50. McLellan A. T., Lewis D. C., O'Brien C. P., Kleber H. D. Drug dependence, a chronic medical illness: implications for treatment, insurance, and outcomes evaluation. *JAMA* 2000; **284**: 1689–95.