Universal Family-Focused Interventions in Alcohol-Use Disorder Prevention: Cost-effectiveness and Cost-benefit Analyses of Two Interventions

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Estimating total present value of benefit realized by prevention of an alcohol disorder

The following provides a detailed description of the analytic procedure used to estimate the total present value of the benefit realized by prevention of a single alcohol disorder in adolescence.

Statement of General Rationale and Assumptions. Though the cost to intervene requires an investment of monies in the present, the prevention of a case of alcohol-use disorder produces only future benefits by avoiding the costs that would have been incurred had the disorder not been prevented. Because a given amount of money in hand is valued more highly than the same amount to be received in the future, the benefits must be discounted according to when in the future they are expected to be realized. Thus, it is necessary to estimate for each year of age the average benefit (i.e., avoided costs) to be realized by the prevention of a case of alcohol-use disorder by means of an intervention delivered in adolescence.

The analytic procedure required several assumptions. First, it was necessary to choose the number of years across which the average alcohol disordered adult would be expected to produce costs. We assumed that adult alcohol-use disorders could commence as early as age 18, but could extend no longer than age 74.7, the latter number reflecting the decreased life expectancy of alcohol disordered adults (Makela, 1998), which is reduced from the population average of 76.7 (U.S. Bureau of the Census, 1995). Second, for any particular year of age, an adult was considered to be either disordered or not during that entire year of age. Though this assumption was not absolutely necessary it was useful because it substantially reduced the

computational resources required (i.e., fewer iterations required in the computational loops) and because it is consistent with the discounting procedure which is performed on an annual basis. Third, because we are aware of no data that specifies how the societal costs of disordered drinking vary with the age of the disordered individual, we assumed that the cost produced by a currently disordered individual is the same at every year of age. Fourth, we assumed that the costs are produced by currently disordered individuals. This reflects the expectation that the most severe of drinking consequences (e.g., death from automotive accidents or violent crime, personal injury, incarceration, criminal activity) are more likely to occur when one is currently alcohol disordered than after one has ceased to engage in disordered drinking. Fifth, the age of onset of disordered behavior was presumed to be normally distributed, as was the age of cessation for those disordered individuals who later ceased to engage in disordered drinking. The normal curve was considered to be an adequate representation because it reflects what one would expect to see with respect to first rising and then declining rates around a central maximum value in early adulthood, with later life being characterized by less dramatic changes.

Currently disordered persons in each 1-year age cohort. The onset of new alcohol-use disorder cases is presumed to be normally distributed about a mean age, μ_1 = 24.7 years, and with a standard deviation, σ_1 = 8.85 years (Schuckit et al., 1997), for an adult population from age 18 to 74.7. The life expectancy was reduced by two years from the average value of 76.7 (U.S. Bureau of the Census, 1995) to account for the reduced life expectancy for alcohol disordered individuals (Makela, 1998). Following the applied modeling, at a given point in time, the sum across all ages of the cumulative number of individuals of each age who are now or who have ever previously been alcohol disordered, should equal the point estimate of adult lifetime prevalence, 18.17% (Grant & Pickering, 1996) multiplied by the total adult population, 188.9 million (U.S. Bureau of the Census, 1995). Thus, one may solve for the constant coefficient C_1 by satisfaction of the following equation

$$\text{Lifetime Prevalence} \times \text{Population} = C_1 \times \sum_{age1=18}^{74} \sum_{age2=18}^{age1} \left(1 \Big/ \sigma_1 \sqrt{2\pi} \right) e^{-(age2-\mu_1)^2 / 2\sigma_1^2}$$

However, some alcohol disordered individuals subsequently cease to engage in disordered behavior. Of those who do cease, the age of cessation is presumed to be normally distributed with a mean, μ_2 = 34.4 years, and with a standard deviation, σ_2 = 6.20 years (Sobell et al., 2000). Therefore, the number of currently disordered individuals will equal the sum across all ages of the cumulative number of individuals of each age who are now or who have ever previously been alcohol disordered, *minus* the sum across all ages of the cumulative number of individuals of each age who have now or who have previously ceased to engage in disordered behavior. The number of currently disordered individuals will equal the current prevalence rate of 7.41% (Grant et al., 1994) multiplied by the adult population, 188.9 million. The constant coefficient C_2 of the cessation function can be determined through solution of the following equation.

$$\text{Current Prevalence} \times \text{Population} = C_1 \times \sum_{age1=18}^{74} \sum_{age2=18}^{age1} \left(1 \Big/ \sigma_1 \sqrt{2\pi} \right) e^{-(age2-\mu_1)^2 / 2\sigma_1^2} - C_2 \times \sum_{age1=19}^{74} \sum_{age2=19}^{age1} \left(1 \Big/ \sigma_2 \sqrt{2\pi} \right) e^{-(age2-\mu_2)^2 / 2\sigma_2^2}$$

In the above equation one may note that the summation for the cessation function begins with the age of 19. This is because—as previously stated—in the current analysis it is assumed that the earliest age at which an adult could engage in disordered drinking is 18, and currently disordered adults are disordered for an entire year. Thus, for the first year—from age 18 until just before the 19th birthday—there can be no cessation of disordered drinking. Therefore, this term in the series pertaining to the cessation function is eliminated for this year of age.

Having determined the values for C_1 and C_2, one may calculate for any particular age, age_x, the number of currently disordered individuals of age_x, $N(age_x)$, by first summing the cumulative number of disorder onsets occurring by age_x, and subtracting from that sum the cumulative number of disorder cessations occurring by age_x. Specifically,

$$N(age_X) = C_1 \times \sum_{age=18}^{age_x} \left(1 \Big/ \sigma_1 \sqrt{2\pi} \right) e^{-(age-\mu_1)^2 / 2\sigma_1^2} - C_2 \times \sum_{age=19}^{age_x} \left(1 \Big/ \sigma_2 \sqrt{2\pi} \right) e^{-(age-\mu_2)^2 / 2\sigma_2^2}$$

To summarize, the above procedure uses cross-sectional data pertaining to prevalence rates in 1992, and data pertaining to the age of onset (Schuckit et al., 1997) and age of recovery (Sobell et al., 2000) to estimate the number of currently disordered persons of each 1-year age cohort. That is, each $N(age_x)$ pertains to a different cohort of individuals; N(18) is the number of currently disordered individuals among a group of 18 year olds, whereas N(19) is the number of currently disordered individuals of a different age cohort that is one year older. Thus, the variable $N(age_x)$ is similar to a snapshot of the cross-section of the population with respect to age. However, it is assumed that these values will also adequately describe the characteristics of a single, 1-year age cohort (e.g., current day 17 year olds) as they progress through life. Thereby, N(18) is hereafter taken as the number of currently disordered individuals among a 1-year age cohort when it is 18 years of age, and N(19) taken as the number of currently disordered individuals among the same 1-year age cohort one year later when it is 19 years of age. Therefore, the variable $N(age_x)$ can also be viewed as providing longitudinal information about variations in the number of alcohol disorders in a single 1-year age cohort across time.

Number of currently-disordered person-years for each year of age. On average, an individual who is only disordered for a fraction of a year will produce only that same fraction of costs in that year compared to an individual who is disordered for the entire year. As previously noted, for every year of age individuals are considered to be either disordered or not for the entire year. However, the final "year" of life extends from an individual's 74^{th} birthday until age

74.7. Thus, in the last year of life individuals are only disordered for 0.7 years, and so are presumed to produce only 70% of the annual cost of a disordered person of any other age who is presumed to produce costs for an entire year. Therefore, for all but the last year of life the number of years for a given age = age_x, is Years(age_x) = 1. However, for age_x = 74, Years(74) = 0.7. Accordingly, the total number of currently disordered person-years is

$$\text{Total Currently Disorder Person - years} = \sum_{age=18}^{74} N(age) \times Years(age)$$

Average cost per currently disordered person per year. The average cost per currently disordered person per year is the total cost for all currently disordered persons in a year, $148 billion (Harwood et al., 1999), divided by the total number of currently disordered person-years, just calculated.

$$\text{Average Cost per Disordered Person - year} = \frac{\text{Total Cost for all Currently Disordered Persons in a Year}}{\text{Total Currently Disordered Person – years}}$$

Annual alcohol costs at a particular year of age. The total amount of money spent in a year on a particular 1-year age group at a particular age, age_x, is equal to the just calculated average cost per disordered person-year multiplied by the number of disordered Person-years at age_x. That is,

$$\text{Cost}(\text{age}_X) = \text{Average Cost per Disordered Person - year} \times \text{N}(\text{age}_X) \times \text{Years}(\text{age}_X)$$

Future cost avoided in a particular year by prevention of an alcohol disorder. The variable Cost(age_x) provides the total annual cost produced by a 1-year age cohort at a particular age, age_x. However, it still remains to be determined how much the prevention of a single disorder will, on average, yield in avoided costs. At the time a disorder is prevented in adolescence, one does not know at what age disordered behavior would have begun, nor when

or whether this particular case would have then subsequently ceased to engage in disordered behavior. However, the average costs avoided per year by prevention of an alcohol disorder case can be approximated by estimating the number of individuals in a 1-year age cohort who will at some point develop an alcohol disorder, this number being obtained by multiplying the Lifetime Prevalence by the total population (18.17% x 188.9 million) and dividing that product by the number of adult 1-year age cohorts (74.7-18.0 = 56.7). That is,

$$N_{total}(age_x) = \frac{(\text{Lifetime Prevalence} \times \text{Population})}{(\text{Number of adult 1-year age cohorts})}$$

Although the variation in the cost associated with each age will vary as a function of the number of currently disordered persons of that age, the benefit (cost avoided) associated with the prevention of a single disorder will, on average, be equal to the total cost associated with each age divided by the number of individuals of that age cohort who will ever contribute to any costs produced by that 1-year age cohort, or,

$$\text{Benefit}(age_x) = \frac{(\text{Cost}(age_x))}{(N_{total}(age_x))}$$

Total discounted present value of benefit realized by prevention of an alcohol disorder. Finally, these benefits will accrue across the lifespan of the individual for whom an alcohol disorder is prevented. Therefore the total, discounted present value of the benefit realized by prevention of a single alcohol disorder is

$$\text{Total Benefit Present Value} = \sum_{age=18}^{74} \frac{\text{Benefit}(age)}{(1+0.03)^{(age-18)}}$$

or, $119,633 …which includes the effect of discounting at 3% per annum, as recommended by the Panel on Cost-Effectiveness in Health and Medicine (Weinstein et al., 1996).

References

Grant, B.F., Harford, T., Dawson, T., Chou, P., Dufour, M. and Pickering, R. Prevalence of DSM-IV alcohol abuse and dependence: United States, 1992. *Alcohol Health Res. World. 18:* 243-248, 1994.

Grant, B.F. and Pickering, R. Comorbidity between DSM-IV alcohol and drug use disorders: Results from the National Longitudinal Alcohol Epidemiologic Survey. *Alcohol Health Res. World. 20:* 67-72, 1996.

Harwood, H., Fountain, D. and Livermore, G. Economic cost of alcohol and drug abuse in the United States: A report. *Addiction. 94:* 631-635, 1999.

Makela, P. Alcohol-related mortality by age and sex and its impact on life expectancy: Estimates based on the Finnish death register. *Eur. J. Public Health. 8:* 43-51, 1998.

Schuckit, M.A., Jayson, E.T., Smith, T.L. and Bucholz, K.K. Periods of abstinence following the onset of alcohol dependence in 1,853 men and women. *J. Stud. Alcohol, 58:* 581-589, 1997.

Sobell, L.C., Ellingstad, T.P. and Sobell, M.B. Natural recovery from alcohol and drug problems: Methodological review of the research with suggestions for future directions. *Addiction, 95:* 749-764, 2000.

U.S. Bureau of the Census. Statistical Abstract of the United States 1995. Washington, D.C.: U.S. Government Printing Office, 1995.

Weinstein, M.C., Siegel, J.E., Gold, M.R., Kamlet, M.S. and Russell, L.B. Recommendations of the Panel on Cost-Effectiveness in Health and Medicine. *JAMA. 276:* 1253-1258.