Reducing the Global Burden of Hazardous Alcohol Use: A Comparative Cost-Effectiveness Analysis*

DAN CHISHOLM, PH.D.,† JÜRGEN REHM, PH.D.,† MARK VAN OMMEREN, PH.D.,† AND MARISTELA MONTEIRO, M.D.†

Department of Health System Financing, Expenditure and Resource Allocation and Department of Mental Health and Substance Abuse, World Health Organization, Geneva, Switzerland

ABSTRACT. **Objective:** Intervention strategies are available for reducing the high global burden of hazardous alcohol use as a risk factor for disease, but little is known about their potential costs and effects at a population level. This study set out to estimate these costs and effects. **Method:** Analyses were carried out for 12 epidemiological World Health Organization subregions of the world. A population model was used to estimate the impact of evidence-based personal and nonpersonal interventions—including brief physician advice, taxation, roadside random breath testing, restricted sales access and advertising bans. Costs were measured in international dollars (I$); population-level intervention effects were gauged in terms of disability-adjusted life years (DALYs) averted. Average and incremental cost-effectiveness ratios (CERs) were computed. **Results:** The most costly interventions to implement are brief advice in primary care and roadside breath testing of drivers. In populations with a high prevalence of heavy drinkers (more than 5%, such as Europe and North America), the most effective and cost-effective intervention was taxation (more than 500 DALYs averted per 1 million population; CER < I$500 per DALY averted). In populations with a lower prevalence of heavy drinking, however, taxation is estimated to be less cost effective overall than other, more targeted strategies, such as brief physician advice, roadside breath testing and advertising bans. **Conclusions:** The most efficient public health response to the burden of alcohol use depends on the prevalence of hazardous alcohol use, which is related to overall per capita consumption. Population-wide measures, such as taxation, are expected to represent the most cost-effective response in populations with moderate or high levels of drinking, whereas more targeted strategies are indicated in populations with lower rates of hazardous alcohol use. (*J. Stud. Alcohol* **65:** 782-793, 2004)

A RECENT GLOBAL comparative risk assessment (CRA) by the World Health Organization (WHO) identified alcohol use as a leading cause of mortality and disability, contributing 58 million or 4% of all disability-adjusted life years (DALYs) lost globally and ranking in the top five risk factors for disease burden (Ezzati et al., 2002; Rehm et al., 2004; WHO, 2002). Such a finding prompts the question of what can be done to reduce this burden and at what cost? A number of interventions have been evaluated and shown to be effective in reducing alcohol use (Babor et al., 2003), yet their level of implementation remains low in all but a handful of countries, and their comparative impact on population-level health has not been assessed.

To address these issues in a comparative, global framework, it is necessary not only to determine the costs and effects of existing strategies but also to establish cost-effective interventions to reduce exposure. Generalized cost-effectiveness analysis—and its implementation via a WHO work program called CHOICE (CHOosing Interventions that are Cost Effective; Tan Torres et al., 2003)—brings a societal perspective to the valuation of costs and effects and is intended to inform policy makers by broadly identifying personal and nonpersonal interventions that are very cost effective, those that are not cost effective and those that fall in between. The present article applies this approach to interventions for reducing the global burden of hazardous alcohol use.

Method

Setting

Analyses of costs and effects were carried out at the level of WHO regions (Africa [Afr], The Americas [Amr], Eastern Mediterranean [Emr], Europe [Eur], South East Asia [Sear], Western Pacific [Wpr]), each of which was subsequently split into subregions according to rates of adult and child mortality (WHO, 2002; see Table 1). For example, subregions with the suffix "A" have very low levels of child and adult premature mortality, and subregions with the suffix "D" have high levels of child and adult premature mortality. Because rates of alcohol use were very low in the WHO Emr region (a stable prevalence rate of less

Received: April 16, 2004. Revision: July 6, 2004.

*The views expressed in this article are those of the authors and not necessarily those of the organizations they represent.

†Correspondence may be sent to Dan Chisholm, CEP / FER / EIP (Room 3169), World Health Organization, 1211 Geneva, Switzerland, or via email at: ChisholmD@WHO.int. Jürgen Rehm is with the Center for Addiction and Mental Health, Toronto, Canada, and the Addiction Research Institute, Zurich, Switzerland. Mark Van Ommeren is with the Department of Mental Health and Substance Abuse, World Health Organization, Geneva, Switzerland. Maristela Monteiro is with the Pan American Health Organization, Washington, DC.

TABLE 1. Current epidemiology of heavy alcohol use

	Mortality			Prevalence (by adult age group)[b]						Epidemiological rates (all ages)				
Region/ subregion[a]	Child	Adult	Sex	15-29	30-44	45-59	60-69	70-79	80+	Incid.	Prev.	Rem.	Case-fatal.	Dur. (yrs)
Africa														
AfrD	High	High	Male	7.0%	9.1%	9.0%	8.1%	6.0%	6.0%	0.24%	1.73%	7.66%	1.28%	9.4
(e.g., Nigeria, Senegal)			Female	2.0%	3.7%	3.9%	1.7%	1.3%	1.3%	0.19%	1.40%	7.85%	1.28%	9.4
AfrE	High	V. high	Male	13.7%	19.5%	16.9%	14.9%	11.1%	11.1%	1.23%	7.48%	7.70%	2.29%	8.3
(e.g., Botswana, Kenya)			Female	4.2%	5.8%	6.4%	4.8%	3.1%	3.1%	0.36%	2.40%	7.70%	2.30%	8.2
The Americas														
AmrA	V. low	V. low	Male	23.8%	19.6%	15.5%	10.1%	7.0%	7.0%	1.49%	12.88%	8.13%	0.34%	10.7
(e.g., Canada, U.S.A.)			Female	7.7%	4.9%	4.3%	3.3%	3.0%	3.0%	0.38%	3.74%	8.31%	0.33%	10.5
AmrB	Low	Low	Male	10.9%	12.3%	11.7%	8.7%	3.7%	3.7%	0.84%	6.74%	7.69%	0.53%	10.9
(e.g., Brazil, Mexico)			Female	7.4%	8.1%	7.0%	6.2%	3.3%	3.3%	0.53%	4.55%	7.75%	0.30%	11.3
AmrD	High	High	Male	2.5%	2.4%	2.4%	1.7%	0.9%	0.9%	0.15%	1.26%	7.56%	0.57%	10.9
(e.g., Ecuador, Peru)			Female	3.3%	3.4%	2.9%	2.4%	1.6%	1.6%	0.21%	1.73%	7.62%	0.51%	11.0
Europe														
EurA	V. low	V. low	Male	17.8%	20.4%	20.6%	13.8%	9.7%	9.7%	1.67%	14.08%	8.32%	0.37%	10.2
(e.g., France, Norway)			Female	16.4%	13.6%	16.5%	10.6%	8.2%	8.2%	1.24%	11.05%	8.47%	0.35%	10.2
EurB	Low	Low	Male	11.0%	11.0%	9.1%	7.1%	4.0%	4.0%	0.77%	6.77%	7.78%	0.45%	10.8
(e.g., Armenia, Poland)			Female	8.4%	9.0%	7.4%	5.7%	4.7%	4.7%	0.62%	5.51%	7.97%	0.41%	10.8
EurC	Low	Low	Male	31.1%	25.0%	30.6%	20.7%	11.2%	11.2%	2.67%	19.26%	7.92%	0.81%	9.8
(e.g., Estonia, Russia)			Female	14.1%	11.6%	14.2%	9.2%	6.2%	6.2%	1.03%	9.19%	8.18%	0.48%	10.3
South East Asia														
SearB	Low	Low	Male	0.9%	3.0%	0.4%	0.3%	0.0%	0.0%	0.11%	0.86%	8.74%	0.60%	9.8
(e.g., Indonesia, Thailand)			Female	1.1%	0.8%	0.8%	0.5%	0.0%	0.0%	0.06%	0.54%	7.58%	0.37%	11.5
SearD	High	High	Male	0.8%	2.5%	0.3%	0.1%	0.0%	0.0%	0.08%	0.67%	8.81%	0.59%	9.7
(e.g., India, Nepal)			Female	1.2%	0.4%	0.4%	0.0%	0.0%	0.0%	0.04%	0.41%	7.75%	0.47%	11.3
Western Pacific														
WprA	V. low	V. low	Male	7.0%	5.6%	6.9%	4.6%	3.1%	3.1%	0.48%	4.71%	8.35%	0.26%	10.4
(e.g., Australia, Japan)			Female	3.1%	2.5%	3.1%	1.9%	1.4%	1.4%	0.20%	2.09%	8.49%	0.23%	10.5
WprB	Low	Low	Male	7.7%	8.5%	8.5%	7.7%	6.0%	6.0%	0.63%	5.61%	7.94%	0.42%	10.4
(e.g., China, Vietnam)			Female	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.00%	0.04%	6.75%	0.19%	13.9

Notes: Incid. = incidence; Prev. = prevalence; Rem. = remission; Case-fatal. = case-fatality; Dur. = duration; V. high = very high; V. low = very low. [a]Full list of member states by subregion and mortality stratum available at http://www.who.int/whr/2002/MembersETC.pdf. [b]Source: Comparative Risk Assessment for Alcohol (Rehm et al., 2004).

than 1% of the adult population), this region was excluded from subsequent analyses.

Epidemiology of hazardous alcohol use

This economic analysis relates to the risk factor of hazardous (or heavy) alcohol use, which is defined as an average rate of consumption of more than 20 g pure alcohol daily for women and more than 40 g daily for men (Babor et al., 2003; English et al., 1995). Rates of hazardous alcohol use in different subregions were taken from the recent CRA (Rehm et al., 2003a,b, 2004; Table 1), as were case fatality rates from which the following relative risks of mortality were derived: 2.5 for men and women 15-44 years of age; 1.3 for men and 1.4 for women in older age groups (Rehm et al., 2001). Remission rates were derived with reference to an average duration of 10.9 years to recovery (Sobell et al., 2000). For disease burden calculations, the level of disability associated with time spent as a heavy drinker also needs to be specified. On a 0-1 scale where 1 equals full health, a health state valuation of 0.846 was derived for hazardous alcohol use (equivalent to a disability weight of 0.154, this time where 0 equals no disability), which is a weighted average based on the severity breakdown of hazardous drinkers from the CRA (80% hazardous, 20% harmful) and preference values for these health states from the Dutch disability weight study (0.89 and 0.67, respectively; Stouthard et al., 2000).

Population model of intervention effectiveness

Intervention effectiveness was determined through a state transition population model (PopMod; Lauer et al., 2003) that traces the development of a subregional population, taking into account births, deaths and the specified risk factor. Key transition rates include the incidence of hazardous alcohol use in the population, case-fatality and remission. In addition, a health state valuation is specified for time spent at risk or as a heavy drinker.

Two epidemiological scenarios were modeled over a lifetime (100 years) analytic horizon: (1) no interventions available to reduce hazardous alcohol use (natural history) and (2) the population-level impact of each specified intervention implemented for a period of 10 years (after which epidemiological rates and health state valuations move back to natural history values). The difference represents the population-level health gain (expressed in DALYs averted) as a result of implementing the intervention. In accordance with the CRA (Rehm et al., 2003b, 2004), DALYs were discounted at 3% and age weighted, with sensitivity analyses performed on the impact of removing these weights.

Estimation of intervention effects

A recent review of measures to reduce alcohol misuse (Ludbrook et al., 2002) assessed the quality of evidence for four types of interventions specifically aimed at reducing hazardous alcohol use (the findings coincide with a number of other reviews; e.g., Babor et al., 2003): (1) brief interventions; (2) law enforcement (e.g., random breath testing [RBT] of drivers); (3) policy and legislative interventions, including taxes on alcohol sales, drink-driving laws, restricted licensing outlets and advertising control; and (4) mass media/awareness campaigns.

Taxation on alcoholic beverages. Excise taxation on alcoholic beverages primarily affects the incidence of drinking by reducing consumption, with effects measured in terms of price elasticity, which relates the change in consumption to the size of the price increase (Table 2). Price elasticities, adjusted downwards by one third to reflect reduced price responsiveness among heavy drinkers, were derived with respect to preferred type of alcoholic beverage (beer, wine, distilled spirits) in the 12 subregions, which was constructed from country-level data contained in WHO's Global Alcohol Database (WHO, 2003). Baseline price elasticities ranged from -0.3 for the most preferred beverage category to -1.0 for the next preferred category to -1.5 for the least preferred (Babor et al., 2003; Ornstein and Levy, 1983; sensitivity analysis around these elasticities was performed). Both the current rate of tax—expressed as an add-on percentage of supplier price—as well as increases (of 25% and 50%) to the current rate were evaluated, adjusting for observed or expected level of unrecorded use (taken as a close proxy measure for untaxed consumption) as a result of illicit production and smuggling (see Table 2). In regions with rates of unrecorded consumption already over 50% (e.g., African subregion AfrD and South-East Asian subregion SearD), tax increases can actually have a regressive impact on incidence if they are accompanied by a rise in the already high level of unrecorded (and therefore untaxed) consumption. For estimating the natural history scenario, incidence rates were increased by the percentage change for current taxation.

Drink-driving legislation and RBT. Drink-driving laws and enforcement influence fatal and nonfatal traffic injuries among both hazardous alcohol users and other subgroups of the population (passengers, pedestrians). Two independent effects on alcohol-related traffic injuries were assessed (Table 3): (1) drink-driving laws, which are estimated to reduce traffic fatalities by 7% if widely implemented within a region (Shults et al., 2001) or, for estimation of the natural history scenario, a fraction of this percentage based on the current level of implementation (WHO, 2003); (2) enforcement via RBT, which is estimated to reduce fatalities by a further 6%-10% in high-income subregions implementing such a strategy now and by 18% for the effect of full implementation (Peek-Asa, 1999; Shults et al., 2001); the impact on nonfatal injuries was estimated to be a smaller reduction of 15%.

Reduced hours of sale (retail outlets). Access to and availability of alcohol can be dramatically reduced through prohibition and rationing, but there are considerable challenges in implementing and sustaining such strategies. A more modest strategy is to reduce hours of sale among retail outlets (no sales for a 24-hour period at the weekend), which has been shown in Scandinavia to reduce consumption and alcohol-related harm (Leppänen, 1979; Nordlund, 1984; Norström and Skog, 2003). On the basis of these studies, a modest reduction of 1.5%-3.0% in the incidence of hazardous drinking and 1.5%-4.0% in alcohol-related traffic fatalities was modeled, depending on the subregional pattern of drinking (largest effects in subregions with the highest levels of hazardous drinking occasions; Rehm et al., 2004).

Advertising bans. Public health interest in the impact of a comprehensive ban on alcohol advertising (television, radio and billboards) is increasing, although available evidence from econometric studies suggests its effect on consumption is modest at best, arguably as a result of the continuing presence of other alcohol marketing strategies such as product placement or event sponsorship. Here, we illustrate the potential effect of a comprehensive advertising ban by modeling a 2%-4% reduction in the incidence of hazardous alcohol use on the basis of the latest international time-series analysis (Grube and Agostinelli, 2000; Saffer, 2000; Saffer and Dave, 2002), again adjusted for subregional variations in patterns of drinking.

TABLE 2. Effect of taxation on the incidence of hazardous alcohol use

WHO region	Prevalence (by preferred beverage) Most pref.	Next pref.	Least pref.	Rate of taxation (by preferred beverage) Most pref.	Next pref.	Least pref.		Price increases (elasticities)[a] -0.3 Most pref.	-1.0 Next pref.	-1.5 Least pref.	Consump. untaxed		Effect on incid. of hazardous alcohol use[b]
Africa													
AfrD	79%	16%	5%	36%	41%	35%	(Curr.)	-5.3%	-19.4%	-25.9%	77.4%	(Curr.)	-1.9%
	Beer	Spirits	Wine	45%	51%	44%	(Curr. + 25%)	-6.2%	-22.6%	-30.4%	85.1%	(Curr. + 10%)	-1.5%
				54%	62%	53%	(Curr. + 50%)	-7.0%	-25.4%	-34.4%	89.0%	(Curr. + 15%)	-1.2%
AfrE	49%	30%	21%	28%	50%	38%	(Curr.)	-4.4%	-22.2%	-27.5%	47.4%	(Curr.)	-7.7%
	Beer	Spirits	Wine	35%	63%	48%	(Curr. + 25%)	-5.2%	-25.6%	-32.2%	52.1%	(Curr. + 10%)	-8.1%
				42%	75%	57%	(Curr. + 50%)	-5.9%	-28.6%	-36.3%	54.5%	(Curr. + 15%)	-8.7%
The Americas													
AmrA	59%	28%	13%	37%	82%	13%	(Curr.)	-5.4%	-30.0%	-11.5%	11.7%	(Curr.)	-11.6%
	Beer	Spirits	Wine	46%	103%	16%	(Curr. + 25%)	-6.3%	-33.7%	-14.0%	12.9%	(Curr. + 10%)	-13.1%
				56%	123%	20%	(Curr. + 50%)	-7.1%	-36.8%	-16.3%	13.5%	(Curr. + 15%)	-14.4%
AmrB	53%	30%	17%	16%	49%	22%	(Curr.)	-2.8%	-21.9%	-18.0%	29.2%	(Curr.)	-7.9%
	Beer	Spirits	Wine	20%	61%	28%	(Curr. + 25%)	-3.3%	-25.3%	-21.6%	32.1%	(Curr. + 10%)	-8.8%
				24%	74%	33%	(Curr. + 50%)	-3.9%	-28.2%	-24.8%	33.6%	(Curr. + 15%)	-9.8%
AmrD	58%	39%	3%	26%	21%	25%	(Curr.)	-4.1%	-11.6%	-20.0%	21.7%	(Curr.)	-5.9%
	Spirits	Beer	Wine	33%	26%	31%	(Curr. + 25%)	-4.9%	-13.9%	-23.8%	23.9%	(Curr. + 10%)	-6.8%
				39%	32%	38%	(Curr. + 50%)	-5.6%	-16.0%	-27.3%	25.0%	(Curr. + 15%)	-7.7%
Europe													
EurA	41%	41%	18%	13%	20%	42%	(Curr.)	-2.3%	-11.1%	-29.6%	9.9%	(Curr.)	-9.8%
	Wine	Beer	Spirits	16%	25%	53%	(Curr. + 25%)	-2.8%	-13.3%	-34.4%	10.9%	(Curr. + 10%)	-11.4%
				20%	30%	63%	(Curr. + 50%)	-3.3%	-15.4%	-38.7%	11.4%	(Curr. + 15%)	-12.9%
EurB	45%	30%	25%	29%	13%	12%	(Curr.)	-4.5%	-7.7%	-10.7%	34.0%	(Curr.)	-4.6%
	Spirits	Beer	Wine	36%	16%	15%	(Curr. + 25%)	-5.3%	-9.3%	-13.0%	37.4%	(Curr. + 10%)	-5.3%
				44%	20%	18%	(Curr. + 50%)	-6.1%	-10.9%	-15.3%	39.1%	(Curr. + 15%)	-6.0%
EurC	68%	21%	11%	65%	13%	25%	(Curr.)	-7.9%	-7.7%	-20.0%	36.2%	(Curr.)	-5.8%
	Spirits	Beer	Wine	81%	16%	31%	(Curr. + 25%)	-9.0%	-9.3%	-23.8%	39.8%	(Curr. + 10%)	-6.4%
				98%	20%	38%	(Curr. + 50%)	-9.9%	-10.9%	-27.3%	41.6%	(Curr. + 15%)	-7.0%
South East Asia													
SearB	88%	12%	0%	30%	40%	0%	(Curr.)	-4.6%	-19.0%	0.0%	35.7%	(Curr.)	-4.1%
	Spirits	Beer	Wine	38%	50%	0%	(Curr. + 25%)	-5.5%	-22.2%	0.0%	39.3%	(Curr. + 10%)	-4.5%
				45%	60%	0%	(Curr. + 50%)	-6.2%	-25.0%	0.0%	41.1%	(Curr. + 15%)	-5.0%
SearD	89%	11%	0%	40%	25%	0%	(Curr.)	-5.7%	-13.3%	0.0%	79.1%	(Curr.)	-1.4%
	Spirits	Beer	Wine	50%	31%	0%	(Curr. + 25%)	-6.7%	-15.9%	0.0%	87.0%	(Curr. + 10%)	-1.0%
				60%	38%	0%	(Curr. + 50%)	-7.5%	-18.2%	0.0%	91.0%	(Curr. + 15%)	-0.8%
Western Pacific													
WprA	47%	34%	18%	25%	35%	8%	(Curr.)	-4.0%	-17.3%	-7.4%	19.7%	(Curr.)	-7.3%
	Beer	Spirits	Wine	31%	44%	10%	(Curr. + 25%)	-4.8%	-20.3%	-9.1%	21.7%	(Curr. + 10%)	-8.4%
				38%	53%	12%	(Curr. + 50%)	-5.5%	-23.0%	-10.7%	22.7%	(Curr. + 15%)	-9.5%
WprB	88%	11%	1%	17%	9%	11%	(Curr.)	-2.9%	-5.5%	-9.9%	26.8%	(Curr.)	-2.4%
	Spirits	Beer	Wine	21%	11%	14%	(Curr. + 25%)	-3.5%	-6.7%	-12.1%	32.2%	(Curr. + 10%)	-2.7%
				26%	14%	17%	(Curr. + 50%)	-4.1%	-7.9%	-14.2%	30.8%	(Curr. + 15%)	-3.2%

Notes: pref. = preferred; Consump. = consumption; incid. = incidence; Curr. = current. [a]Price increase due to tax (%tax/[1+%tax]) * elasticity * 2/3 (heavy drinkers less responsive). [b]Sum of (prevalence * price increase) for each drink type * (1 - % untaxed consumption).

Brief interventions. Brief interventions, such as physician advice provided in primary health care, which involve a small number of education sessions and psychosocial counseling, were modeled to influence the prevalence of hazardous drinking by increasing remission and reducing disability. Efficacy reviews of brief interventions reveal an estimated 22% net reduction in consumption among hazardous drinkers (Babor et al., 2003; Higgins-Biddle and Babor, 1996; Moyer et al., 2002), which would have the effect of shifting the entire distribution of hazardous drinking downwards if applied to the total population at risk (a reduction in overall prevalence of 35%-50%, equivalent to a 14%-18% improvement in the rate of recovery over no treatment at all). However, after taking into account real-world effect modifiers, including treatment adherence (70%) and target coverage in the population (50% of hazardous drinkers), population-level remission rates were estimated to be between 4.9% and 6.4% better than natural history rates. In addition, an expected reduction in the number of heaviest drinkers while in treatment (but prior to remission) resulted in a small gain in the average level of disability (treated health state valuation was 0.858, an improvement of 1.3% after adjusting for coverage and adherence). For downward adjustment of rates of remission—in order to estimate the null scenario in the three high-income subregions where brief interventions are used

TABLE 3. Effectiveness of drink-driving legislation and enforcement

Region/ subregion	Gender	Attributable fractions: Deaths attrib. to traffic accidents[a]	Attributable fractions: Traffic deaths attrib. to alcohol use[b]	Full enforcement (effectiveness): Averted traffic deaths[c] (DD law + RBT)	Full enforcement (effectiveness): Deaths avertable by DD/RBT[d]	Full enforcement (effectiveness): Nonfatal traffic injury multiplier[e]
Africa						
AfrD	Male	2.2%	19.3%	7% + 18%	0.15%	1.12
	Female	1.1%	8.3%		0.03%	1.11
AfrE	Male	2.1%	38.7%	7% + 18%	0.29%	1.12
	Female	1.0%	11.9%		0.04%	1.13
The Americas						
AmrA	Male	2.4%	31.0%	7% + 18%	0.27%	1.14
	Female	1.2%	14.9%		0.06%	1.17
AmrB	Male	4.4%	47.1%	7% + 18%	0.74%	1.14
	Female	1.5%	14.5%		0.08%	1.15
AmrD	Male	2.6%	33.1%	7% + 18%	0.31%	1.13
	Female	1.1%	9.2%		0.04%	1.14
Europe						
EurA	Male	1.7%	37.5%	7% + 18%	0.23%	1.17
	Female	0.6%	18.2%		0.04%	1.19
EurB	Male	1.5%	44.6%	7% + 18%	0.24%	1.14
	Female	0.5%	13.6%		0.03%	1.14
EurC	Male	2.2%	63.6%	7% + 18%	0.50%	1.14
	Female	0.8%	27.9%		0.08%	1.14
South East Asia						
SearB	Male	7.8%	25.5%	7% + 18%	0.72%	1.11
	Female	2.3%	5.4%		0.05%	1.11
SearD	Male	3.7%	16.0%	7% + 18%	0.21%	1.11
	Female	1.5%	3.6%		0.02%	1.12
Western Pacific						
WprA	Male	1.8%	26.7%	7% + 18%	0.17%	1.09
	Female	0.9%	12.6%		0.04%	1.11
WprB	Male	3.6%	19.9%	7% + 18%	0.26%	1.14
	Female	1.8%	8.8%		0.06%	1.14

Notes: Attrib. = attributable; DD = drink-driving; RBT = random breath testing. [a]Source: Global Burden of Disease Study (GBD) 2000 (www.who.int/evidence/bod); %s for all age groups shown here only (age-specific values used in analysis). [b]Source: Comparative Risk Assessment for Alcohol (Rehm et al., 2004); %s for all age groups combined shown here (age-specific values used in analysis). [c]Source: Peek-Asa, 1999; Shults et al., 2001. [d]Computation = traffic-related fraction of all deaths * alcohol-related fraction of traffic deaths * avertable traffic deaths. [e]Source: GBD 2000 (www.who.int/evidence/bod); see text for derivation.

now—a current coverage rate of 12.5% for AmrA and half this level in EurA and WprA were used.

Evidence for the effectiveness of mass media or school-based awareness campaigns was weak in terms of both methodological quality and their effect on consumption (as opposed to transfer of information or knowledge alone) (Babor et al., 2003; Foxcroft et al., 1997, 2003; Ludbrook et al., 2002). An intervention that has very low measured effect (but nonnegligible costs of implementation) cannot be considered a cost-effective policy option, and therefore mass media and school-based awareness campaigns were omitted from the foregoing analysis.

Estimation of intervention costs

Costs covered in the analysis include program-level costs associated with running the intervention, such as administration, training and media, and patient-level costs, such as primary care visits. An ingredients approach made up of the following components was used.

- *Program-level resource inputs* used in the production of an intervention at a level above that of the patient or health care facility cover administrative functions as well as resources devoted to such preventative programs as enforcement of drink-driving legislation by police officers (Johns et al., 2003). Estimated quantities of resources required were obtained from costing experts in each of the subregions and validated against the literature. Final estimates were derived with reference to the prevailing characteristics of the subregion—for example, the efficiency of tax systems or strength of antidrinking sentiment (advertising bans, restricted sales).
- *Patient-level resource inputs* used in the provision of a given health care intervention are relevant in this analysis only to brief interventions. An average rate of four primary care visits over 1 year was estimated for the intervention itself (includes initial assessment, educative sessions and follow-up), plus an additional resource of 0.33 outpatient visits (20% × 1.67 visits) and 0.25 inpatient days (5% × 5 days) (see, for example, Fleming et al., 2000). These resource inputs were applied to the 50% of prevalent hazardous alcohol users in receipt of brief advice in Year 1 and, be-

cause we model an enduring effect for 10 years, also in Year 6; and to the 50% of incident cases in Years 2-5 and 7-10.

- *Unit costs* of program-level and patient-level resource inputs include the salaries of central administrators, capital costs of vehicles and equipment and the cost per outpatient visit. Data were obtained from a review of literature supplemented by primary data from several countries and subsequently converted into international dollars (I$), using international prices for traded goods and a regression-based approach to establish the price of nontraded goods in each subregion (Adam et al., 2003; Johns et al., 2003). One I$ buys the same quantity of health care resources in China or India as it does in the United States.

Fully worked cost templates for all interventions over the 10-year implementation period, discounted at 3% to give an estimated total cost per year, can be found on the WHO-CHOICE website (www.who.int/evidence/cea).

Uncertainty analysis

Population-level estimates of intervention cost and effect are inherently imbued with uncertainty, with respect to both analytical choices (such as the use of age weighting) and data. A series of one-way sensitivity analyses were initially performed to assess the impact on baseline results of discounting and age weighting. Best and worse case scenarios were then generated, incorporating upper and lower estimates of total intervention cost (+/- 20% patient-level resource costs, +/- 10% program-level costs) and effectiveness (upper/lower range elasticities for tax [+/- 30%], +/- 20%-30% intervention effect for other strategies). Finally, baseline data (with pessimistic and optimistic scenarios as lower and upper ranges) were entered into an analytical software package (MCLeague; Tan Torres et al., 2003) that performs a probabilistic uncertainty analysis using Monte Carlo simulation.

Results

Population-level effects of interventions

The comparative effectiveness of the different intervention strategies is presented in Table 4. There are clear differences with respect to gender, with considerably greater averted burden seen in the male population. With the exception of RBT, approximately two thirds of the total population-level health gain from interventions was among men. The proportion for RBT rises to 80%-90% principally because the percentage of deaths and injuries attributed to traffic accidents is much higher among men.

A clear difference in terms of standardized effect—DALYs averted per year per 1 million population—is also seen between subregions with high rates of hazardous alcohol use (prevalence in total population > 5%: African subregion AfrE; American subregions AmrA and AmrB; European subregions EurA,B,C), moderate rates (prevalence 2%-5%; Western Pacific subregions WprA,B) and low rates (< 2% prevalence; African subregion AfrD; American subregion AmrD; and South East Asian subregions SearB,D). In subregions with a high prevalence of hazardous drinking, the most effective single interventions were taxation and brief interventions, averting between 500 and 2,000 DALYs per 1 million population. Remaining control strategies—RBT, reduced hours of sale at the weekend and a comprehensive advertising ban—mainly produced effects in the range 250-750 DALYs per 1 million population. In subregions with low and moderate rates of hazardous drinking, single interventions realized total population health gains in the range 10-400 DALYs averted per 1 million population. Taxation was the most effective strategy in American subregion AmrD and Western Pacific subregion WprA, whereas the greatest health gain in African subregion AfrD and South East Asia SearB,D was enforcement of drink-driving laws. In the remaining subregion WprB (includes China), policies aimed at restricting supply and marketing of alcohol—restricted access at weekends and a comprehensive advertising ban—were estimated to generate greater health gains than other interventions. Results for the male population in five illustrative subregions are shown in Figure 1.

Population-level costs of interventions

Table 4 also shows the cost per capita of each intervention (plus two illustrative combination strategies). Brief advice in primary care and RBT are the most costly interventions to implement in all subregions. The relatively high cost of brief advice stems from a combination of patient-level costs in the provision of the intervention itself (I$180-210 per treated case in high-income subregions AmrA, EurA and WprA and I$30-50 elsewhere), screening costs (I$1.00-1.40 per capita in high-income subregions and I$0.05-0.30 elsewhere) and program costs associated with training primary care providers. Enforcement of drink-driving regulations through RBT campaigns is costly in human resources (four enforcement officers per checkpoint), vehicles and equipment. For the remaining three strategies considered here (taxation, restricted access to sales outlets and advertising bans—each implemented at a per capita cost of I$0.05-0.50), costs relate to legislation activities and administration and enforcement of laws once passed.

Average and incremental cost effectiveness of interventions

Combining costs and effects data (see Table 4) reveals that taxation is the most cost-effective strategy in six subregions with a high prevalence of heavy drinkers (each

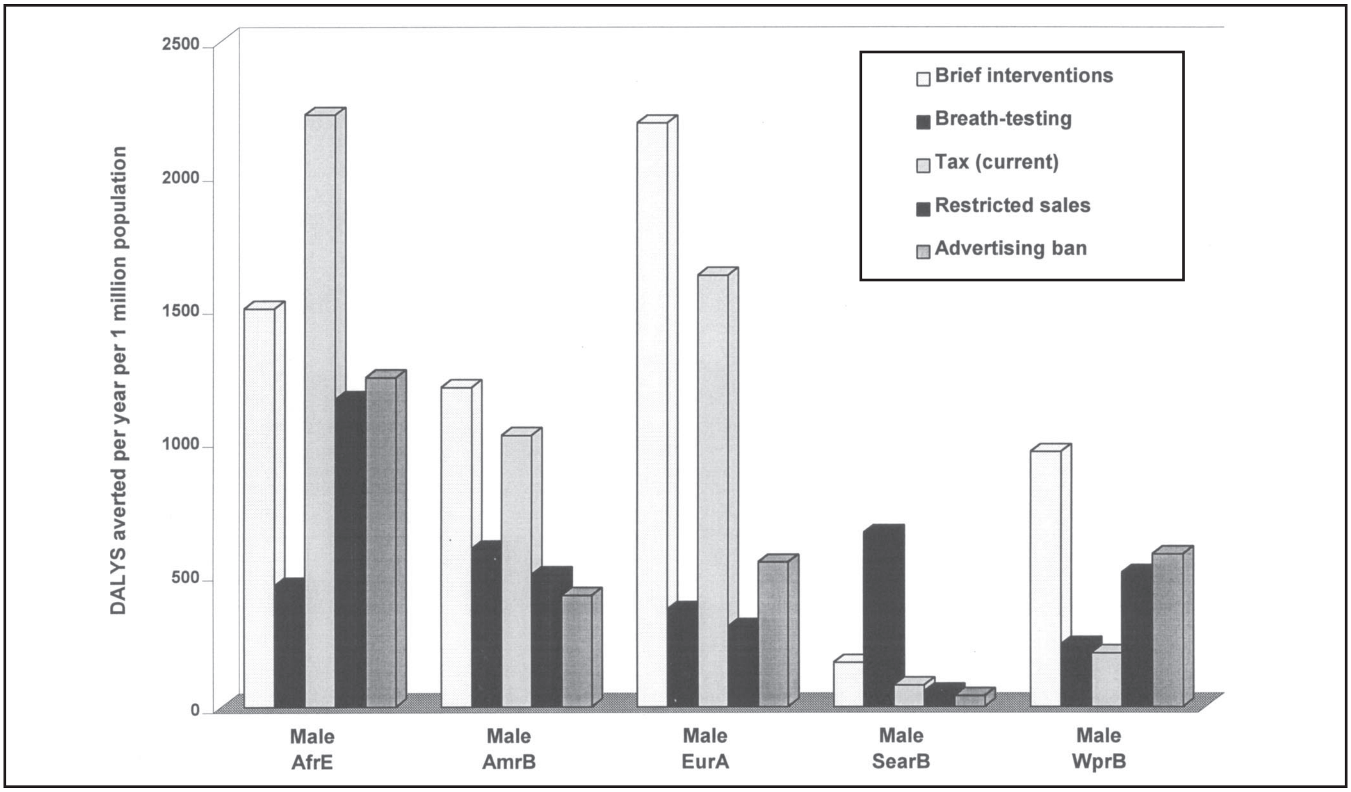

FIGURE 1. Intervention effectiveness in five WHO subregions (healthy life years gained per 1 million male population)

DALY averted by current taxation costs I$100-600, and I$90-500 if taxation rates are increased by 50%). Of the remaining population strategies, advertising bans "dominated" restricted access to sales outlets in that they had greater effect but cost less to implement; RBT had the highest cost per DALY averted (range I$650-4,500). Extensive treatment coverage (50%) of heavy drinkers with brief physician advice had an an average cost-effectiveness ratio (CER) of I$400-2,500.

In the other six subregions, taxation was the most cost effective in Western Pacific subregion WprA (but at a less favorable ratio of costs to effects; I$1,368) but not elsewhere. RBT was the most cost-effective strategy where rates of hazardous alcohol use are very low (South East Asia SearB and SearD; average CER: I$420-550). Brief advice was most cost effective in African subregion AfrD and American subregion AmrD (CER: I$600-700). Advertising bans or restricted access to sales outlets had the lowest expected costs per healthy life year gained in Western Pacific subregion WprB (I$200-250 per DALY averted).

The final set of values in Table 4 shows incremental CERs in relation to the current tax situation. The incremental CERs for increased taxation rates are modeled to equal zero because estimated costs of implementation (compared with the situation of no taxation) are the same as those for current taxation (i.e., additional health gains are achieved at a negligible extra cost). In subregions with a higher prevalence of hazardous alcohol use, moving away from, or adding to, taxation policies alone (for instance, by also implementing an advertising ban and/or brief advice in primary care) carries an incrementally greater cost per DALY averted as relatively less cost-effective interventions are implemented. In European subregion EurA, for example, the incremental CER for adding an advertising ban to alcohol taxation would be close to I$300 (not much more than the I$258 for taxation alone) but I$1,700 if brief advice was made widely available as well. In subregions with low rates of hazardous drinking, interventions other than taxation are either dominant (that is, they have lower costs but larger effects than current taxation) or have a more favorable CER (for example, the incremental CER for moving from current taxation to RBT in South East Asia subregions SearB and SearD is I$50-150, well below the CER of I$2,000-4,000 for current taxation).

Uncertainty analyses

Substitution of the baseline discount rate of 3% with values of 0% and 6% had only a small impact on results, altering total costs and average CERs for all interventions upward by 13% and downward by 11%, respectively. The removal of age weighting had a more appreciable impact

TABLE 4. Total population-level costs, effects and cost effectiveness of interventions to reduce hazardous alcohol use

	Africa		The Americas			Europe			South East Asia		Western Pacific	
	AfrD	AfrE	AmrA	AmrB	AmrD	EurA	EurB	EurC	SearB	SearD	WprA	WprB
Example countries	Nigeria Senegal	Botswana Kenya	Canada U.S.A.	Brazil Mexico	Equador Peru	France Norway	Armenia Poland	Estonia Russia	Indonesia Thailand	India Nepal	Australia Japan	China Vietnam
Income category	Low	Low	High	Mid	Mid	High	Mid	Mid	Mid	Low	High	Low
Total population (million)	294.1	345.5	325.2	430.9	71.2	411.9	218.5	243.2	293.8	1,241.8	154.4	1,532.9
Hazardous alcohol users (million)	4.5	17.2	26.8	24.3	1.1	51.7	13.3	33.9	2.0	6.7	5.2	43.2
Hazardous alcohol users per 1,000 population	15.3	49.9	82.5	56.3	14.9	125.4	60.7	139.3	7.0	5.4	33.8	28.2
Intervention cost (I$m per 1m popn p.a.)[a]												
Taxation												
Current	0.17	0.15	0.44	0.24	0.21	0.45	0.28	0.21	0.12	0.07	0.47	0.13
Current + 25%	0.17	0.15	0.44	0.24	0.21	0.45	0.28	0.21	0.12	0.07	0.47	0.13
Current + 50%	0.17	0.15	0.44	0.24	0.21	0.45	0.28	0.21	0.12	0.07	0.47	0.13
Breath testing	0.29	0.20	0.48	0.59	0.34	0.61	0.74	0.51	0.16	0.08	0.83	0.23
Restricted access	0.13	0.09	0.16	0.15	0.17	0.27	0.22	0.14	0.06	0.04	0.25	0.06
Advertising ban	0.12	0.09	0.14	0.14	0.15	0.27	0.15	0.14	0.05	0.04	0.24	0.06
Brief physician advice	0.19	0.39	3.55	0.63	0.21	4.44	0.63	1.25	0.11	0.08	1.89	0.27
Highest tax + ad ban	0.27	0.22	0.56	0.36	0.34	0.69	0.41	0.33	0.16	0.10	0.67	0.18
Highest tax + ad ban + brief advice	0.46	0.60	3.97	0.97	0.55	4.96	1.01	1.53	0.27	0.18	2.48	0.43
Intervention effect (DALYs per 1m popn p.a.)[b]												
Taxation												
Current	99	1,506	1,224	806	196	1,365	442	1,137	64	17	258	104
Current + 25%	74	1,589	1,366	899	226	1,576	503	1,243	71	13	301	121
Current + 50%	64	1,688	1,489	987	254	1,764	564	1,349	77	10	340	138
Breath testing	145	308	261	378	185	247	161	460	392	146	150	168
Restricted access	112	779	250	383	117	251	320	689	45	40	68	260
Advertising ban	104	837	470	331	106	459	300	616	33	25	127	296
Brief physician advice	320	987	1,353	997	300	1,889	1,024	2,111	135	105	546	494
Highest tax + ad ban	164	2,475	1,919	1,291	353	2,178	847	1,925	108	35	458	425
Highest tax + ad ban + brief advice	473	3,407	3,212	2,245	641	3,988	1,832	3,954	238	136	983	901
Average CER (I$ per DALY)[c]												
Taxation												
Current	1,719	97	361	295	1,068	333	624	185	1,855	4,227	1,803	1,237
Current + 25%	2,288	92	323	264	928	289	548	169	1,677	5,783	1,546	1,065
Current + 50%	2,662	87	297	241	826	258	489	156	1,531	7,346	1,368	937
Breath testing	2,022	656	1,845	1,554	1,847	2,467	4,566	1,108	421	547	5,527	1,345
Restricted access	1,188	119	636	392	1,447	1,087	703	200	1,413	1,097	3,672	240
Advertising ban	1,135	106	306	434	1,435	594	511	224	1,590	1,409	1,855	197
Brief physician advice	601	398	2,624	629	691	2,351	612	592	812	742	3,455	536
Highest tax + ad ban	1,663	90	290	280	975	317	481	172	1,501	2,977	1,455	419
Highest tax + ad ban + brief advice	974	177	1,236	431	854	1,244	554	388	1,130	1,315	2,528	482
Incremental CER (I$ per DALY)[d]												
Breath testing	2,671	Domd	Domd	Domd	Domd	Domd	Domd	Domd	141	53	Domd	1,522
Restricted access	Domt	74	290	206	508	164	416	161	2,942	Domt	1,134	Domt
Advertising ban	Domt	87	395	198	637	201	864	138	2,131	Domt	1,752	Domt
Brief physician advice	104	Domd	24,073	2,039	Domt	7,607	604	1,068	Domt	61	4,936	348
Highest tax + ad ban	1,579	79	165	257	858	291	326	153	987	1,745	1,004	152
Highest tax + ad ban + brief advice	778	240	1,775	507	759	1,718	531	470	864	894	2,786	383

Notes: m = million; popn = population; p.a. = per annum; DALYs = disability-adjusted life years; CER = cost-effectiveness ratio. Domd (dominated): Intervention has higher costs and lower effects than tax; Domt (dominant): Intervention has lower costs and larger effects than tax. [a]Costs are expressed in discounted international dollars and include program costs as well as patient-level costs (where applicable). [b]Age-weighted and discounted (3%) DALYs averted per year, relative to null scenario of no intervention. [c]Total cost per year/total DALYs averted per year. [d]Incremental CER, relative to current taxation; incremental CERs for increased tax are zero since additional health gain is achieved at negligible extra cost.

on results, reducing total health gain estimates by 10%-22% across subregions, which reflects the fact that many alcohol-related illnesses and injuries occur relatively early in life (Rehm et al., 2004; WHO, 2002). Use of unadjusted DALYs (no discounting or age weighting) increases total effectiveness by 43%-59% across subregions and thereby renders interventions more cost effective (average CERs fall by 31%-37%). Under the best-case scenario, total costs were 10%-20% lower and total effects 20%-30% higher than base case results, thereby improving the average cost per DALY averted by one third. Results for the worst-case scenario were more extreme, increasing the average cost per unit of health outcome by 50%-65%. The average CER for RBT in European subregion EurA (baseline value: I$2,467), for example, ranged from I$1,579 to I$3,947. The rank order of cost effectiveness was unchanged (summary table available from the authors upon request).

Entering these data ranges into a stochastic uncertainty analysis reveals the uncertainty around point estimates. Figure 2 provides a cloud graph for each single intervention strategy and a range of combined intervention strategies in European subregion EurA, illustrating areas of greatest overlap but also order-of-magnitude differences in the total costs and effect of different combinations (for example, the combination of a 50% increase in tax plus an advertising ban [F2] is much more cost effective than the combination of brief advice and RBT [F1]). The bold arrowed line reveals the incremental cost-effectiveness expansion path as successively less efficient strategies are added into the mix of implemented interventions.

Discussion

At least since Holder et al.'s (1991) "first approximation" for different treatment modalities for alcoholism, there has been an evident need to generate cost-effectiveness evidence capable of informing alcohol public health policy. A key impediment to the generation of such an evidence base has been the absence of a standard measure of intervention effectiveness. Recent attempts to overcome this constraint have used cost-utility and cost-benefit analyses to derive comparable ratios of cost per effect (Fleming et al., 2000; Miller and Levy, 2000; Wutzke et al., 2001). Completed analyses to date, however, have been restricted to established market economies and therefore have limited generalizability to other countries or regions with differing epidemiology, cost structures and health systems in place.

While beholden to the limits of summary measures of population health (such as the DALY), the present analysis offers a novel approach to the generation of economic evidence capable of broadly informing alcohol public health policy in a wide range of epidemiological settings. Resulting estimates of cost effectiveness—pitched in order-of-magnitude terms—can inform policy makers not only in relation to the efficiency of existing strategies, but also by identifying priorities for alcohol control in the future (Babor et al., 2003). In this respect, it should be noted that, in each of the subregional populations, the most efficient interventions for reducing hazardous alcohol are projected to show a favorable ratio of cost to effect (each DALY averted by these efficient strategies costs less than average annual income per capita, a threshold for an intervention to be considered very cost effective that was proposed by the Commission on Macroeconomics and Health; WHO, 2001).

The first key conclusion to be drawn from this analysis is that, in populations with high rates of hazardous alcohol use, both individual-based interventions, such as brief physician advice, as well as population-wide measures, such as taxation on alcoholic beverages, can have a notable impact on population health. Of these, taxation has the most sizeable and least resource-intensive impact on reducing the current public health burden of hazardous alcohol use. Increasing tax rates from current levels appears to be a viable and favorable option from both a public health and an economic point of view, even after allowing for an estimated increase of 10%-15% in illicit production or smuggling. Based on the limited available evidence to date, effects from other public health control strategies, such as reduced hours of sale and advertising bans, are anticipated to be smaller than those generated by taxation.

The second key finding is that, in populations with low rates of hazardous drinking, intervention strategies targeted at particular subgroups of the drinking population, such as drivers who drink or primary care attendees with already high levels of alcohol consumption, appear to be more cost effective than population-wide strategies like taxation. In South East Asia, for example, RBT is estimated to be the single most cost-effective intervention because it is expected to reduce the number of fatal and nonfatal traffic injuries, a leading contributor to overall disease burden in this region. The impact of taxation, by contrast, is diluted, both by the distribution of the fixed costs of administering and enforcing alcohol tax legislation across a smaller target population of drinkers and by underlying drinking patterns (over 85% of all consumption of alcohol in this region is contained in a single preferred drink category, distilled spirits, which diminishes the scope for reducing consumption of less preferred but more elastic categories of alcoholic beverage).

The use of a sectoral cost-effectiveness approach with whole subregions of the world as the unit of analysis clearly places important limits on its application to specific country contexts in which demographic or epidemiological characteristics, as well as treatment costs and coverage, may not coincide with estimates for the subregion as a whole. The present regional analysis can therefore be seen as a baseline from which countries can start to contextualize to their own particular sociocultural setting. Such a process of contextualization is already underway in a number of de-

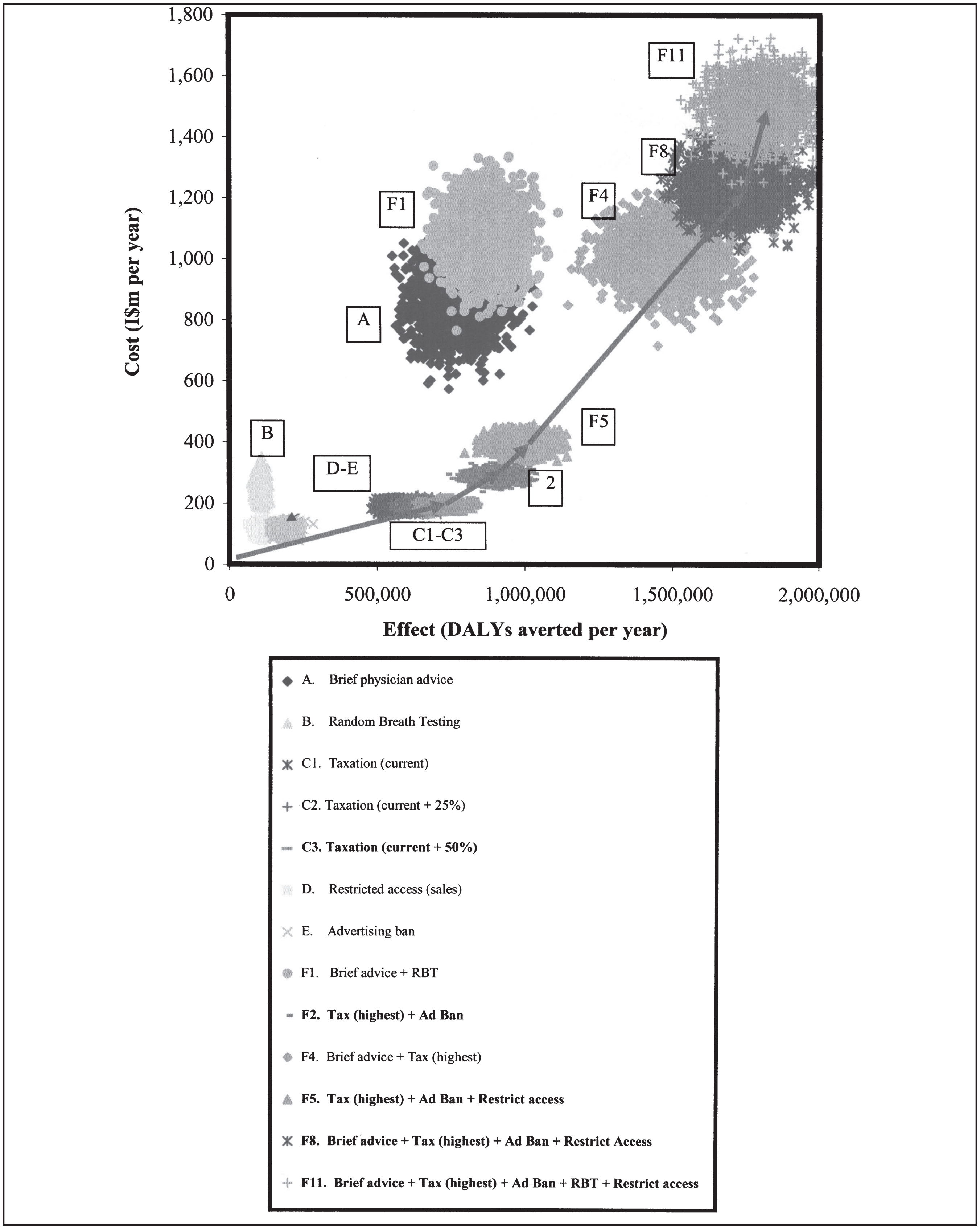

FIGURE 2. Cloud graph showing uncertainty around costs and effectiveness of interventions for heavy alcohol use (European subregion: EurA)

veloped and developing countries. Extrapolation of intervention effect sizes from relatively information-rich countries to other sociocultural settings evidently impinges on the precision and generalizability of derived estimates of population-level health gain. Greatest confidence can be placed in interventions with better supporting evidence of effective coverage in different subregions, such as taxation, and least confidence (wider uncertainty) in those yet to be widely implemented or researched, including reduced weekend hours of sale or a comprehensive ban on advertising. More conclusive research studies are required before firm policy recommendations can be made for the two latter intervention strategies, particularly in such moderate-drinking populations as China, where their use appears to be indicated. On the other hand, there is an appreciable evidence base to suggest that mass media and school-based awareness campaigns represent poor value for money because their effect has been shown to be low (Babor et al., 2003; Foxcroft et al., 1997, 2003; Ludbrook et al., 2000).

Although WHO-CHOICE pursues a societal perspective, considerable challenges remain in the appropriate measurement of certain societal costs and effects falling outside the boundaries of the health system (Tan Torres et al., 2003). The present analysis has thus not been able to successfully capture potential increases in (workforce and household) productivity among heavy drinkers following intervention, nor does it incorporate the economic consequences of alcohol-related crime, violence and harm reduction. Patient and informal carer time spent seeking or providing care and support was also not valued. Inclusion of these (modest) additional costs and (substantial) incremental effects could be expected to improve the CER of all interventions but to a variable and currently unknown degree. Government revenues arising from taxation were excluded because they represent transfer payments within society, but this omission should not detract from the principle that taxation can reap fiscal benefits for governments as well as health benefits for their populations.

Acknowledgments

The authors warmly acknowledge the following colleagues who have actively contributed to the conceptual and methodological development of generalized cost-effectiveness analysis: Taghreed Adam, Rob Baltussen, David Evans, Raymond Hutubessy, Ben Johns, Jeremy Lauer, Christopher Murray and Tessa Tan Torres.

References

Adam, T., Evans, D.B. and Murray, C.J.L. Econometric estimation of country-specific hospital costs. Cost-Effect. Resource. Allocat. **1:** 3, 2003 (available at: www.resource-allocation.com).

Babor, T., Caetano, R., Casswell, S., Edwards, G., Giesbrecht, N., Graham, K., Grube, J., Gruenewald, P., Hill, L., Holder, H., Homel, R., Österberg, E., Rehm, J., Room, R. and Rossow, I. Alcohol: No Ordinary Commodity: Research and Public Policy, New York: Oxford Univ. Press, 2003.

English, D.R., Holman, C.D.J., Milne, E. et al. The Quantification of Drug Caused Morbidity and Mortality in Australia 1995, Canberra, Australia: Department of Human Services and Health, 1995.

Ezzati, M., Lopez, A.D., Rodgers, A., Vander Hoom, S., Murray, C.J. and Comparative Risk Assessment Collaborating Group. Selected major risk factors and global and regional burden of disease. Lancet **360:** 1347-1360, 2002.

Fleming, M.F., Mundt, M.P., French, M.T., Manwell, L.B., Stauffacher, E.A. and Barry, K.L.. Benefit-cost analysis of brief physician advice with problem drinkers in primary care settings. Med. Care **38:** 7-18, 2000.

Foxcroft, D.R., Ireland, D., Lister-Sharp, D.J., Lowe, G. and Breen, R. Longer-term primary prevention for alcohol misuse in young people: A systematic review. Addiction **98:** 397-411, 2003.

Foxcroft, D.R., Lister-Sharp, D. and Lowe, G. Alcohol misuse prevention for young people: A systematic review reveals methodological concerns and lack of reliable evidence of effectiveness. Addiction **92:** 531-537, 1997.

Grube, J. and Agostinelli, G. Alcohol Advertising and Alcohol Consumption: A Review of Recent Research, Berkeley, CA: Prevention Research Center, 2000.

Higgins-Biddle, J.C. and Babor, T.F. Reducing Risky Drinking. Report prepared for the Robert Wood Johnson Foundation, Farmington, CT: University of Connecticut Health Center, 1996.

Holder, H., Longabaugh, R., Miller, W.R. and Rubonis, A.V. The cost effectiveness of treatment for alcoholism: A first approximation. J. Stud. Alcohol **52:** 517-540, 1991.

Johns, B., Baltussen, R. and Hutubessy, R. Programme costs in the economic evaluation of health interventions. Cost-Effect. Resource Allocat. **1:** 1, 2003 (available at: www.resource-allocation.com).

Lauer, J.A., Rohrich, K., Wirth, H., Charette, C., Gibble, S. and Murray, C.J.L. PopMod: A longitudinal population model with two interacting disease states. Cost-Effect. Resource Allocat. **1:** 6, 2003 (available at: www.resource-allocation.com).

Leppänen, K. Valtakunnallisen lauantaisulkemiskokoeilun vaikutuksista alkoholijuomien myyntiin (Effects of national Saturday closing experiment on alcohol sales). Alkoholipolitiikka **44:** 20-21, 1979.

Ludbrook, A., Godfrey, C., Wyness, L. et al. Effective and Cost-Effective Measures to Reduce Alcohol Misuse in Scotland: A Literature Review, Aberdeen, Scotland: Health Economics Research Unit, 2002.

Miller, T.R. and Levy, D.T. Cost-outcome analysis in injury prevention and control: Eighty-four recent estimates for the United States. Med. Care **38:** 562-582, 2000.

Moyer, A., Finney, J.W., Swearingen, C.E. and Vergun, P. Brief interventions for alcohol problems: A meta-analytic review of controlled investigations in treatment-seeking and non-treatment-seeking populations. Addiction **97:** 279-292, 2002.

Nordlund, S. Effekten av lørdagsstengningen ved Vinmonopolets butikker (Effects of Saturday closing of the wine/liquor monopoly outlets). Alkoholpolitik-Tidsskrift for nordisk alkoholforskning **1:** 221-229, 1984.

Norström, T. and Skog, O.-J. Saturday opening of alcohol retail shops in Sweden: An impact analysis. J. Stud. Alcohol **64:** 393-401, 2003.

Ornstein, S.I. and Levy, F. Price and income elasticities and the demand for alcoholic beverages. In: Galanter, M. (Ed.) Recent Developments in Alcoholism, Vol. 1, New York: Plenum Press, 1983, pp. 303-345.

Peek-Asa, C. The effect of random alcohol screening in reducing motor vehicle crash injuries. Amer. J. Prev. Med. **16** (Suppl. No. 1): 57-67, 1999.

Rehm, J., Gutjahr, E. and Gmel, G. Alcohol and all-cause mortality: A pooled analysis. Contemp. Drug Probl. **28:** 337-361, 2001.

Rehm, J., Rehn, N., Room, R., Monteiro, M., Gmel, G., Jernigan, D. and Frick U. The global distribution of average volume of alcohol consumption and patterns of drinking. Europ. Addict. Res. **9:** 147-156, 2003a.

Rehm, J., Room, R., Monteiro, M., Gmel, G., Graham, K., Rehn, N., Sempos, C.T. and Jernigan, D. Alcohol as a risk factor for global burden of disease. Europ. Addict. Res. **9:** 157-164, 2003b.

Rehm, J., Room, R., Monteiro, M., Gmel, G., Graham, K., Rehn, T., Sempos, C.T., Frick, U. and Jernigan, D. Alcohol. In: World Health Organization (Ed.) Comparative Quantification of Health Risks: Global and Regional Burden of Disease Due to Selected Major Risk Factors, Geneva, Switzerland: World Health Organization, 2004.

Saffer, H. Alcohol Consumption and Alcohol Advertising Bans, Working Paper 7758, Cambridge, MA: National Bureau of Economic Research, 2000.

Saffer, H. and Dave, D. Alcohol consumption and alcohol advertising bans. Appl. Econ. **34:** 1325-1334, 2002.

Shults, R.A., Elder, R.W., Sleet, D.A., Nichols, J.L., Alao, M.O., Carande-Kulis, V.G., Zaza, S., Sosin, D.M., Thompson, R.S. and Task Force on Community Preventive Services. Reviews of evidence regarding interventions to reduce alcohol-impaired driving. Amer. J. Prev. Med. **21** (Suppl. No. 4): 66-88, 2001.

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.

Stouthard, M.E., Essink-Bot, M.L. and Bonsel, G.L. on behalf of the Dutch Disability Weights Group. Disability weights for diseases: A modified protocol and results for a Western European region. Europ. J. Publ. Hlth **10:** 24-30, 2000.

Tan Torres, T., Baltussen, R.M., Adam, T. et al. Making Choices in Health: WHO Guide to Cost-Effectiveness Analysis, Geneva, Switzerland: World Health Organization, 2003.

World Health Organization. Macroeconomics and Health: Investing in Health for Economic Development. Final Report of the Commission on Macroeconomics and Health, Geneva, Switzerland: World Health Organization, 2001.

World Health Organization. The World Health Report 2002: Reducing Risks, Promoting Healthy Life, Geneva, Switzerland: World Health Organization, 2002.

World Health Organization. Global Alcohol Database (available at http://www3.who.int/whosis/alcohol), accessed May 28, 2003.

Wutzke, S.E., Shiell, A., Gomel, M.K. and Conigrave, K.M. Cost-effectiveness of brief interventions for reducing alcohol consumption. Social Sci. Med. **52:** 863-870, 2001.