Effects of Minimum Drinking Age Laws: Review and Analyses of the Literature from 1960 to 2000

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ABSTRACT. *Objective:* The goal of this article is to review critically the extant minimum legal drinking age (MLDA) research literature and summarize the current state of knowledge regarding the effectiveness of this policy. *Method:* Comprehensive searches of four databases were conducted to identify empirical studies of the MLDA published from 1960 to 1999. Three variables were coded for each study regarding methodological quality: (1) sampling design, (2) study design and (3) presence or absence of comparison group. *Results:* We identified 241 empirical analyses of the MLDA. Fifty-six percent of the analyses met our criteria for high methodological quality. Of the 33 higher quality studies of MLDA and alcohol consumption, 11 (33%) found an inverse relationship; only 1 found the opposite. Similarly, of the 79 higher quality analyses of MLDA and traffic crashes, 46 (58%) found a higher MLDA related to decreased traffic crashes; none found the opposite. Eight of the 23 analyses of other problems found a higher MLDA associated with reduced problems; none found the opposite. Only 6 of the 64 college-specific studies (9%) were of high quality; none found a significant relationship between the MLDA and outcome measures. *Conclusions:* The preponderance of evidence indicates there is an inverse relationship between the MLDA and two outcome measures: alcohol consumption and traffic crashes. The quality of the studies of specific populations such as college students is poor, preventing any conclusions that the effects of MLDA might differ for such special populations. (*J. Stud. Alcohol,* Supplement No. 14: 206-225, 2002)

THE MINIMUM legal drinking age (MLDA) is the most well-studied alcohol control policy in the United States (Wagenaar and Toomey, 2000). The intention of this policy is to lower alcohol use and its associated problems among youth. Following Prohibition, most states established an age-21 MLDA. During the early 1970s, a trend toward lowering the MLDA to age 18, 19 or 20 began in the United States, providing many natural experiments. As a result of research evidence indicating that traffic crashes among youth increased following lowering of the legal age, a citizens' effort began urging states to raise the MLDA back to age 21. In 1984, the federal government enacted the Uniform Drinking Age Act, which provided for the withholding of federal highway funds from states that failed to increase their MLDA (King and Dudar, 1987). By 1988, all states had established an age-21 MLDA. The increase in MLDA across multiple states again provided researchers with many natural experiments to assess effects of these policy changes on alcohol consumption and related problems among youth.

Despite this long history, the debate over the MLDA continues. Part of this debate is whether the age-21 MLDA is really effective in reducing alcohol-related problems. This debate is particularly relevant to college campuses because the majority of students on many campuses are under age 21. Some college administrators argue that the age-21 law

has caused more problems on college campuses, not less (Lonnstrom, 1985).

To determine the overall effect of the age-21 MLDA on youth, including college-age students, the existing research literature should be critically reviewed. The purpose of this review is to summarize all studies available in the peer-reviewed published literature over the past four decades that evaluated the effects of public policies establishing a legal minimum age for purchase and/or consumption of alcoholic beverages. Most studies assessed effects of the MLDA on consumption and alcohol-related problems among all those under age 21—college students and those not in college. Some MLDA studies specifically assessed effects of MLDA changes on college students alone. Given the current discussions on college campuses, we provide a review of the college studies in addition to a summary of the overall MLDA literature. A second objective of this article is to describe key issues in public debates regarding MLDA policies.

Method

We obtained all identified published studies on the drinking age from 1960 to 1999, a total of 132 documents. Comprehensive searches were conducted of four databases to identify studies of interest: ETOH (1960-1999 [National Institute on Alcohol Abuse and Alcoholism's alcohol and alcohol problems science database]), MEDLINE (1966-

TABLE 1. Effects of legal minimum drinking age policies on consumption

Study	Jurisdiction	Quality				Outcome measure	Results	
		Probability sample	Design	Comp. group	College specific		Dir. of relation.	Statistically significant
STUDIES ON LOWERING MINIMUM DRINKING AGE								
Smart and Schmidt, 1975	Toronto:							
	•Grades 7-13	•Yes	•Pre-post	No		•Self-reported proportion of drinkers	↓	Not reported
	•Jr and sr high administrators	•Census (86%)	•Cross-sectional	No		•Students' consumption (perceived)	↓	Not reported
	•Several colleges: First-year students	•No	•Cross-sectional	No	X	•Self-reported consumption		No
	Ontario	Census	Pre-post	No		•Alcohol sales: off-sale		No
						•Alcohol sales: on-sale	↓	Not reported
Bellows, 1980	NE	Not avail.	Time-series	Not avail.		•Consumption (source not specified)		No
Smart and Finley, 1976	Canada: 10 provinces	Census	Pre-post	Yes		•Beer sales		No
Barsby and Marshall, 1977	25 states	Census	Pre-post	Yes		•Spirits sales (relative to legal age population)		No
Smart, 1977	25 states	Census	Longitudinal	Yes		•Alcohol sales (beer)	↓	Yes
Douglas and Millar, 1979	MI	Census	Time-series	No		•Alcohol sales (draft beer)	↓	Yes
McFadden and Wechsler, 1979	MA:							
	•H.S. students in 5 communities	Unclear	Longitudinal	No		•Self-reported consumption		No
	•34 New England colleges	Unclear	Cross-sectional	Yes	X	•Self-reported frequency of consumption	↓	Yes
Wagenaar, 1982a	MI	Census	Time-series	No		•Beer and wine sales (draft beer-temp.)	↓	Yes
Wagenaar, 1982b	ME, NH	Census	Time-series	Yes		•Alcohol sales: ME		No
						•Beer sales (packaged): NH	↓	Yes
Hoadley et al., 1984	48 states	Census	Longitudinal	Yes		•Spirits sales		No
McCornac and Filante, 1984	50 states and DC	Census	Longitudinal	Yes		•Spirits sales		No
STUDIES ON RAISING MINIMUM DRINKING AGE								
Vingilis and Smart, 1981	Ontario:							
	•Grades 7-13	•Yes	•Pre-post	Yes		•Self-reported consumption		No
	•16-19 year olds in 1 city	•Census	•Time-series	No		•Consumption/possession /supply offenses		No
	•H.S. vice-principals	•Census (81%)	•Cross-sectional	No		•Students' consumption (perceived)	↓	Not reported
Wagenaar, 1982a	MI	Census	Time-series	No		•Beer and wine sales (packaged beer)	↓	Yes
Wagenaar, 1982b	ME	Census	Time-series	Yes		•Alcohol sales (beer)	↓	Yes
Hingson et al., 1983	MA: 16-19 year olds	Yes	Longitudinal	Yes		•Consumption/possession offenses	↑	Yes
						Self-reported:		
						•Consumption		No
						•Shift to illicit drug use		No
Hoadley et al., 1984	48 states	Census	Longitudinal	Yes		•Spirits sales		No
Smith et al., 1984	MA: 16-17 year olds	Yes	Longitudinal	Yes		Self-reported:		
						•Consumption		No
						•Shift to marijuana use		No
						•Drinking locations (shift from public to private)		No
Bessmer, 1985	Undergraduates	Not avail.	Pre-post	Not avail.	X	•Self-reported consumption		No
Lonnstrom, 1985	NY: Administrators at 4-year colleges	Census (90%)	Cross-sectional	Not avail.	X	•Self-reported problem drinking	↓	Not reported
Hughes and Dodder, 1986	OK: Intro. sociology classes at 1 university	Yes	Longitudinal	No	X	•Self-reported consumption		No
					X	•Self-reported drinking locations (shift from public to private)		No
Williams and Lillis, 1986	NY:16-20 year olds in 57 counties	Yes	Pre-post	Yes		•Self-reported consumption	↓	Yes
Lillis et al., 1987	NY: 16-20 year olds in 57 counties	Yes	Pre-post	Yes		•Self-reported beer purchases	↓	Yes
Wilkinson, 1987	50 states and DC	Census	Longitudinal	Yes		•Consumption (source not specified)	↓	Yes
Engs and Hanson, 1988	U.S.: Students in health/sociology/ P.E. classes at 56 universities	No	Longitudinal	No	X	•Self-reported proportion of drinkers (all ages)	↓	Yes

Table 1. *Continued*

Study	Jurisdiction	Probability sample	Design	Comp. group	College specific	Outcome measure	Dir. of relation.	Statistically significant
		Quality					Results	
Lotterhos et al., 1988	NC: Undergrads in health classes at 1 university	Yes	Cross-sectional	No	X	•Students intending to increase or not change consumption levels (4 mos before raising MDA)	82%	N/A
Williams and Lillis, 1988	NY: 16-20 year olds in 57 counties	Yes	Longitudinal	Yes		•Self-reported alcohol purchasing	↓	Yes
						•Self-reported consumption	↓	Yes
Arndt, 1989	FL: 7th, 9th and 12th graders in 5 counties	Not avail.	Longitudinal	Yes		Self-reported:		
						•Consumption (12th graders)	↓	Yes
						•Percentage of users (7th and 12th graders)	↓	Yes
George et al., 1989	NY: Intro. psychol. students	No	Longitudinal	Yes	X	Self-reported:		
						•Drinking locations (shift from public to private [incl. autos])		No
						•Frequency of consumption	↓	Yes
						•Quantity of consumption		No
Gonzalez, 1989	FL: Students in undergraduate courses at 9 universities	Yes	Longitudinal	Yes	X	•Self-reported consumption		No
Perkins and Berkowitz, 1989	NY: 1 university	Census (86-90%)	Pre-post	Yes	X	•Self-reported consumption		No
Davis and Reynolds, 1990	NY: Undergraduates at 1 university	Yes	Pre-post	No	X	Self-reported (all ages):		
						•Consumption		No
						•Drinking locations (shift from public to private)		Not reported
Gonzalez, 1990a	FL: Students in undergraduate courses at 1 university	Yes	Longitudinal	Yes	X	•Self-reported consumption		No
Gonzalez, 1990b	FL: Students on spring break	No	Longitudinal	No	X	•Self-reported consumption		No
O'Malley and Wagenaar, 1991	Nationwide: H.S. seniors (cohort followed)	Yes	Longitudinal	Yes		Self reported:		
						•Consumption	↓	Yes
						•Duration/degree of intoxication		No
						•Shift to marijuana		No
						•Drinking locations		No
Gordon and Minor, 1992	NC: Students in undergraduate psych. courses at 1 university	No	Repeated cross-sectional	Yes	X	•Self-reported consumption	↑	Yes
Hughes and Dodder, 1992	OK: Intro. sociol. classes at 1 university	Yes	Longitudinal	No	X	Self-reported:		
						•Consumption		No
						•Drinking locations (shift from public to private)		No
Johnson et al., 1992	Canada: All provinces	Unclear	Time-series	Yes		•Consumption (beer and wine) (source not specified)	↓	Yes
Yu and Shacket, 1998	NY: 10 counties	Yes	Longitudinal	Yes		•Self-reported purchase rates	↓	Not reported
						•Self-reported consumption	↓	Not reported
STUDIES THAT COMPARE STATES WITH HIGH AND LOW MINIMUM DRINKING AGE								
Rooney and Schwartz, 1977	5 states: Seniors from 27 high schools	No	Cross-sectional	Yes		•Self-reported consumption	↑	Not reported
Colon, 1980	50 states and DC	Not avail.	Cross-sectional	Yes		•Consumption (source not specified)		No
Maisto and Rachal, 1980	29 states: High schools	Yes	Cross-sectional	Yes		Self-reported:		
						•Consumption	↓	Yes
						•Access to alcohol	↓	Yes
Schweitzer et al., 1983	35 states	Unclear	Cross-sectional	Yes		•Beer and spirits consumption (source not specified)	↓	Yes
Ornstein, 1984	50 states and DC	Census	Longitudinal	Yes		•Beer consumption	↓	Yes
						•Spirits consumption		No
Coate and Grossman, 1987	Nationwide: 16-21 year olds	Yes	Repeated cross-sectional	Yes		•Self-reported consumption (all ages)	↓	Yes
								No
Coate and Grossman, 1988	Nationwide: 16-21 year olds	Yes	Cross-sectional	Yes		•Self-reported consumption (beer)	↓	Yes

TABLE 1.   *Continued*

Study	Jurisdiction	Probability sample	Design	Comp. group	College specific	Outcome measure	Dir. of relation.	Statistically significant
		Quality					Results	
Mooney et al., 1992	LA and NC: Students in social science courses at 2 universities	No	Cross-sectional	Yes	X	Self-reported (18-22 year olds): •Consumption in controlled locations •Consumption in uncontrolled locations •Overall consumption	↑ ↑	No Yes Yes
Laixuthai and Chaloupka, 1993	Nationwide: H.S. seniors	Yes	Repeated cross-sectional	Yes		•Self-reported consumption	↓	Yes
Mooney and Gramling, 1993	LA and NC: Students in social science courses at 2 universities	Yes	Cross-sectional	Yes	X	•Self-reported consumption		No
Laixuthai, 1994	Nationwide: H.S. seniors	Yes	Repeated cross-sectional	Yes		•Self-reported consumption	↓	Not reported
Grossman et al., 1995	Nationwide: 16-21 year olds and H.S. seniors	Yes	Cross-sectional	Yes		•Self-reported consumption	↓	Yes
Dee, 1999	Nationwide: H.S. seniors in 44 states	Yes	Longitudinal	Yes		•Self-reported consumption	↓	Yes

Notes: Comp. group = comparison group. Dir. of relation. = direction of relationship. Outcome measure and Results pertain specifically to the age group affected by law unless otherwise specified. ↓ Inverse relationship between drinking age and outcome (i.e., drinking age higher, outcome measure lower). ↑ Positive relationship between drinking age and outcome (i.e., drinking age higher, outcome measure higher). Census (X%) = full census attempted but X% participated. Not avail. = dissertation abstracts reviewed only.

1999), Current Contents (1994-1999) and Social Science Abstracts (1983-1999). The entire record for each document was included in the search; thus, any record with any search term in the title, keywords, subject headings, descriptors or abstract fields was identified. Search terms used for each database were as follows (where * is the truncation indicator to include all forms of the root word):

• ETOH: (minimum age OR drinking age OR purchase age OR legal age OR MDA OR MLDA) OR ([teen* OR adolescen* OR young OR college* OR youth* OR student* OR underage* OR minor*] AND [sale* OR enforce* OR deterrence* OR avail* OR access* OR crackdown OR ID OR identification OR compliance])
• MEDLINE and Current Contents: (minimum age OR drinking age OR purchase age OR legal age OR MLDA) OR ([teen* OR adolescen* OR young OR college* OR youth OR student* OR underage* OR minor*] AND [sale* OR enforce* OR deterrence* OR avail* OR access* OR crackdown OR ID OR identification OR compliance])
• Social Science Abstracts: (minimum age OR drinking age OR purchase age OR legal age OR MDA OR MLDA)

In addition, two previous literature reviews were used to identify relevant studies (Wagenaar, 1983a, 1993).

We obtained and reviewed the original document for each study and coded eight key variables for each study. These variables include the jurisdiction studied (i.e., state or province), specific outcome measures analyzed (e.g., self-reported drinking, car crash fatalities) and whether the study was specific to college student populations. In addition, three key indicators of methodological quality were coded for each study. The first is sampling design, distinguishing lower

quality nonprobability sampling versus higher quality probability sampling or census data. The second quality indicator is the research or study design, with lower quality studies consisting of cross-sectional (one time-point) observations only versus higher quality studies that used pre-post (one observation before a policy change and one after), longitudinal (more than 2 but fewer than 20 repeated observations) or time-series (20 or more repeated observations over time) designs. The third quality indicator is whether some form of comparison group was used; studies with no comparison groups are of low quality. Finally, we coded whether the findings were statistically significant. If the results were significant, we coded the direction of the relationship between legal age for drinking and a specific outcome measure.

Effects of drinking age on alcohol consumption

We located 48 published studies that assessed the effects of changes in the legal minimum drinking age on indicators of alcohol consumption (Table 1). In the 48 studies, a total of 78 alcohol consumption outcome measures were analyzed (e.g., sales figures, self-reported drinking). Of the 78 analyses, 27 (35%) found a statistically significant inverse relationship between the legal drinking age and alcohol consumption; that is, as the legal age was lowered, drinking increased, and as the legal age was raised, drinking decreased. An additional 8 analyses that found an inverse relationship did not report significance levels. Of the 78 analyses, only 5 found a positive relationship between the legal drinking age and consumption. In short,

TABLE 2.   Effects of legal minimum drinking age policies on traffic crashes

| Study | Jurisdiction | Quality | | | | Outcome measure | Results | |
		Probability sample	Design	Comp. group	College specific		Dir. of relation.	Statistically significant
						STUDIES ON LOWERING MINIMUM DRINKING AGE		
Williams et al., 1975	MI, WI, Ontario	Census	Longitudinal	Yes		Drivers involved in:		
						•All types of fatal crashes		No
						•SV fatal crashes	↓	Yes
						•Nighttime fatal crashes	↓	Yes
Naor and Nashold, 1975	WI	Census	Longitudinal	Yes		•Fatalities among drivers w/BAC > .05		No
Whitehead et al., 1975	London, Ontario	Census	Longitudinal	Yes		Male drivers:		
						•Alcohol-related crashes	↓	Not reported
						•Nighttime crashes	↓	Not reported
						•Total crashes	↓	Not reported
Bellows, 1980	NE	Not avail.	Time-series	Yes		•Alcohol-related fatal crashes		No
						•Non-alcohol-related fatal crashes (ages not specified)		No
Bako et al., 1976	Alberta	Census	Longitudinal	Yes		•Drivers with BAC >.08 responsible for fatal crashes (ages 15-19)	↓	Not reported
Ferreira and Sicherman, 1976	MA	Census	Time-series	Yes		•Alcohol-related fatalities (all ages)	↓	Yes
						•Driver fatalities	↓	Yes
						•Fatal crashes (drivers 18-20)	↓	Yes
Douglass and Millar, 1979	MI	Yes	Time-series	Yes		Fatal and nonfatal:		
						•SVN crashes: male drivers	↓	Not reported
						•Total crashes (drivers 18-20)	↓	Not reported
						•HBD crashes (drivers 18-20)	↓	Not reported
Brown and Maghsoodloo, 1981	AL	Census	Longitudinal	Yes		•Alcohol-related SV crashes	↓	Yes
Cook and Tauchen, 1984	48 states	Census	Longitudinal	Yes		•Fatalities	↓	Yes
Smith and Burvill, 1986	Australia: 3 states	Census	Pre-post	Yes		•Injuries (males)	↓	Yes
						•Fatalities		No
						•DUI offenses (males)	↓	Yes
						STUDIES ON RAISING MINIMUM DRINKING AGE		
Wagenaar, 1981	MI	Yes	Time-series	Yes		•HBD crashes	↓	Yes
						•SVN male driver crashes	↓	Yes
Vingilis and Smart, 1981	Ontario	Census	Time-series	Yes		•Drinking-driving convictions		No
						•Driver fatalities: alcohol-related		No
						•Driver fatalities: total		No
Williams et al., 1983	9 states	Census	Pre-post	Yes		Drivers involved in:		
						•Nighttime fatal crashes	↓	Yes
						•SVN fatal crashes	↓	Yes
						•All types of fatal crashes		No
Hingson et al., 1983	MA: 16-19 year olds	Census	Pre-post	Yes		•SVN fatal crashes	↓	Yes
						•Total fatal crashes		No
						•Drinking-driving arrests		No
		Yes	Longitudinal	Yes		Self-reported:		
						•Nonfatal crashes		No
						•Frequency of drinking-driving	↓	Yes
						•Proportion reporting drinking-driving		No
Wagenaar, 1983b	ME	Census	Time-series	Yes		Drivers involved in:		
						•Alcohol-related property damage crashes	↓	Yes
						•Injury and fatal crashes		No
Smith et al., 1984	MA: 16-17 year old drivers	Census	Longitudinal	Yes		•SVN fatal crashes		No
						•Total fatal crashes		No
	MA: 16-17 year olds	Yes	Longitudinal	Yes		•Self-reported drinking-driving	↓	Yes
						•Self-reported crashes	↓	Yes
Thiel, 1985	TX	Census	Pre-post	Yes		•Alcohol-related injury/fatality crashes		No
						•Total injury/fatality crashes	↓	Yes
Hoskin et al., 1986	10 states	Census	Pre-post	Yes		•SVN driver fatalities	↓	Yes
Males, 1986	14 states	Census	Longitudinal	Yes		•Nighttime fatal crashes		No
						•All fatal crashes		No

Continued

TABLE 2. *Continued*

| Study | Jurisdiction | Quality | | | | Outcome measure | Results | |
		Probability sample	Design	Comp. group	College specific		Dir. of relation.	Statistically significant
Hughes and Dodder, 1986	OK: Soc. classes at 1 university	Yes	Longitudinal	No	X	•Self-reported drinking-driving		No
MacKinnon and Woodward, 1986	MI, MA, IL	Census	Time-series	Yes		•Driver fatalities (MI, IL)	↓	Yes
Wagenaar, 1986	MI	Census	Time-series	Yes		•SVN injury crashes	↓	Yes
						•HBD injury crashes	↓	Yes
Wagenaar and Maybee, 1986	TX	Census	Time-series	Yes		•SVN crashes (drivers age 18)	↓	Yes
Coate and Grossman, 1987	Nationwide	Census	Longitudinal	Yes		•Fatalities	↓	Yes
DuMouchel et al., 1987	26 states	Census	Longitudinal	Yes		•Nighttime driver fatal crashes	↓	Yes
Lillis et al., 1987	NY	Census	Pre-post	Yes		•Alcohol-related fatal crashes	↓	Yes
						•Alcohol-related injury crashes	↓	Yes
						•DWI arrests	↓	Yes
	NY: 16-20 year olds	Yes	Pre-post	Yes		•Self-reported drinking-driving	↓	Yes
Saffer and Grossman, 1987a,b	48 states	Census	Longitudinal	Yes		•Fatalities	↓	Yes
Weinstein, 1987	48 states	Census	Longitudinal	Yes		•Crash fatalities	↓	Not reported
Wilkinson, 1987	50 states and DC	Census	Longitudinal	Yes		•Fatalities (ages >15)	↓	Not reported
Decker et al., 1988	TN	Census	Time-series	Yes		•SVN driver fatalities	↓	Yes
						•Mean BAC levels of fatally injured drivers	↓	Yes
Engs and Hanson, 1988	U.S.: Students in health/sociology/ P.E. classes at 56 universities	No	Longitudinal	No	X	•Self-reported drinking-driving (all ages)	↓	Yes
Williford, 1988	NY	Not avail.	Pre-post	Yes		•Self-reported drinking-driving	↓	Not reported
Asch and Levy, 1990	47 states	Census	Longitudinal	Yes		•SV driver fatalities	↓	Yes
						•SVN driver fatalities		No
Davis and Reynolds, 1990	NY: Undergraduates at 1 university	Yes	Pre-post	No	X	Self-reported (all ages):		
						•Drinking-driving	↑	Not reported
Legge, 1990	NY	Census	Time-series	Yes		•SVN fatal crashes: male drivers		No
						•All fatal crashes		No
O'Malley and Wagenaar, 1991	13 states	Census	Time-series	Yes		•SVN fatal crashes among drivers < 21(corresponded w/decrease in self-reported consumption)	↓	Yes
Hughes and Dodder, 1992	OK: Intro. sociol. classes at 1 university	Yes	Longitudinal	No	X	•Self-reported drinking-driving		No
Jones et al., 1992	50 states and DC	Census	Longitudinal	Yes		•Driver fatalities		No
						•Pedestrian fatalities		No
Chaloupka et al., 1993	48 states	Census	Longitudinal	Yes		•All fatalities	↓	Yes
						•Nighttime driver fatalities	↓	Yes
						•Fatalities among drivers with BAC >.05	↓	Yes
Durant and Legge, 1993	MI	Census	Time-series	Yes		•SV fatalities (drivers <21)	↓	Yes
						•All fatalities (drivers <21)	↓	Yes
Joksch and Jones, 1993	31 states	Census	Longitudinal	Yes		•Driver fatalities (BAC >0)	↓	Yes
Park, 1994	Multiple states	Not avail.	Cross-sectional	Not avail.		•Drunk-driving (source not specified)	↓	Yes
Figlio, 1995	WI	Census	Time-series	Yes		•Alcohol-related crashes (teens)	↓	Yes
Yu, 1995	NY: Drinking-driving offenders	Yes	Longitudinal	Yes		•Drinking-driving convictions	↓	Not reported
Klepp et al., 1996b	MN: 7th graders in 4 school districts (8 years later)	Census (94%)	Repeated cross-sectional	Yes		•Self-reported drinking-driving	↓	Yes
Ruhm, 1996	48 states	Census	Longitudinal	Yes		•Nighttime fatalities (all ages)		No
						•Fatalities	↓	Yes
Chung, 1997	Not avail.	Not avail.	Time-series	Not avail.		•Interstate and noninterstate drunk-driving fatalities		No
Yu and Shacket, 1998	NY: 16-24 year olds in 10 counties	Yes	Longitudinal	No		•Self-reported drinking-driving rates	↓	Not reported

Table 2. *Continued*

		Quality					Results	
Study	Jurisdiction	Probability sample	Design	Comp. group	College specific	Outcome measure	Dir. of relation.	Statistically significant
STUDIES THAT COMPARE STATES WITH HIGH AND LOW MINIMUM DRINKING AGE								
Maisto and Rachal, 1980	29 states: High schools	Yes	Cross-sectional	Yes		•Self-reported drinking-driving	↓	Yes
Colon and Cutter, 1983	50 states and DC	Census	Cross-sectional	Yes		•Fatalities (all ages)		No
						•Fatal crashes (all ages)		No
Colon, 1984	50 states and DC	Census	Cross-sectional	Yes		•SV fatalities	↑	Yes
Engs and Hanson, 1986	U.S.: Students in health/sociology/ P.E. classes at 72 colleges	No	Cross-sectional	Yes	X	•Self-reported drinking while driving	↓	Yes
						•Self-reported driving after drinking		No
Asch and Levy, 1987	50 states	Census	Cross-sectional	Yes		•All fatalities		No
						•SV fatalities		No
						•SVN fatalities		No
Loeb, 1987	46 states and DC: All ages	Census	Cross-sectional	Yes		•Fatalities (all ages)		No
Kenkel, 1993b	Nationwide	Yes	Cross-sectional	Yes		•Self-reported drinking-driving	↓	Yes
Laixuthai, 1994	Nationwide H.S. seniors	Yes	Repeated cross-sectional	Yes		•Self-reported nonfatal crashes		No
Dee, 1999	48 states	Census	Longitudinal	Yes		•Total fatalities	↓	Yes
						•Driver fatalities	↓	Yes
						•Nighttime fatalities	↓	Yes

Notes: Comp. group = comparison group. Dir. of relation. = direction of relationship. SV= single vehicle. SVN = single vehicle nighttime. HBD = had been drinking. Outcome measure and Results pertain specifically to the age group affected by law unless otherwise specified. ↓ Inverse relationship between drinking age and outcome (i.e., drinking age higher, outcome measure lower). ↑ Positive relationship between drinking age and outcome (i.e., drinking age higher, outcome measure higher). Census (X%) = full census attempted but X% participated. Not avail. = dissertation abstracts reviewed only.

45% of all analyses found that a higher legal drinking age is associated with reduced alcohol consumption.

Of the 78 analyses of alcohol consumption, 21 were the weaker cross-sectional designs, and 57 were pre-post, longitudinal or time-series designs. Of the 21 cross-sectional analyses, 8 (38%) found a significant inverse relationship between legal drinking age and alcohol consumption, whereas only 3 found a significant positive relationship. An additional 4 analyses found an inverse relationship, and 1 found a positive relationship; however, significance levels were not reported. Of the 57 longitudinal analyses (i.e., which we define as any analyses that included repeated measures over time), 19 (33%) found a significant inverse relationship; only 1 longitudinal study found a significant positive relationship. An additional 4 longitudinal analyses found an inverse relationship but did not report significance levels.

Of the 78 analyses of alcohol consumption, 55 (71%) included a comparison group of some kind. For 3 analyses, it was not clear whether a comparison group was used (not avail.). Of the 55 analyses including comparison groups, 23 (42%) found a significant inverse relationship; only 4 found a significant positive relationship. An additional 3 analyses found an inverse relationship, and 1 analysis found a positive relationship but no significance levels were reported. Of the 20 analyses that did not include comparison

groups, 4 found a significant inverse relationship between the legal age and alcohol consumption, and none found a positive relationship. An additional 4 analyses without comparison groups found an inverse relationship but did not report significance levels.

Of the 78 analyses of alcohol consumption, 58 (74%) included probability samples or a complete census of the relevant population, and 11 analyses clearly did not use a probability sample or census. For an additional 9 analyses, it was unclear whether a probability sample or census was used. Of the 58 with a probability sample or census, 20 (34%) found a significant inverse relationship between the legal age and alcohol consumption; only 1 study found a significant positive relationship. An additional 8 studies found an inverse relationship but did not report significance levels, and 26 analyses found no significant relationship. Of the 11 analyses without a probability sample or census, 2 found a significant inverse relationship, and 3 found a significant positive relationship. One additional study found a positive relationship but did not report significance. Of the 9 analyses for which it was unclear whether a probability sample or census was used, 5 found a significant inverse relationship between the legal age and alcohol consumption; none found a significant positive relationship.

Finally, of the 78 analyses of alcohol consumption, only 24 were specific to college student populations. Of the 24

college-specific analyses, 3 (13%) found a significant inverse relationship between the legal age and alcohol consumption, 3 found a significant positive relationship, and 15 found no significant relationship. One additional study found an inverse relationship with no report on significance levels. Of the 54 analyses that were not college specific, 24 (44%) found a significant inverse relationship between the legal age and alcohol consumption. Only 1 found a significant positive relationship. An additional 7 analyses found an inverse relationship, and 1 found a positive relationship but did not report significance levels.

In conclusion, the preponderance of evidence suggests that higher legal drinking ages reduce alcohol consumption. Of all analyses that reported significant effects, 87% found higher drinking ages associated with lower alcohol consumption. Only 13% found the opposite. The evidence is not entirely consistent: Almost half (46%) of the analyses found no association between the legal age and indicators of alcohol consumption. However, focusing on the 33 of the 78 studies of high methodological quality (i.e., those that include a longitudinal design, comparison groups and probability sampling or use of a census) reveals that 11 (33%) of the 33 higher quality studies found a significant inverse relationship between the legal age and alcohol consumption. Only 1 (3%) found a significant positive relationship. Only 3 of these studies of higher quality were college specific, and results were not significant in all 3 studies.

Effects of drinking age on driving after drinking and traffic crashes

We located 57 published studies that assessed the effects of changes in the legal minimum drinking age on indicators of driving after drinking and traffic crashes (Table 2). In the 57 studies, a total of 102 crash outcome measures were analyzed (e.g., fatal crashes, drink-driving crashes, self-reported driving after drinking). Of the 102 analyses, 52 (51%) found a statistically significant inverse relationship between the legal drinking age and crashes; that is, as the legal age was lowered, the number of crashes increased, and as the legal age was raised, the number of crashes decreased. (From here on, we use the term *crashes* to include all traffic-related outcome measures.) An additional 12 analyses that found an inverse relationship did not report significance levels. Of the 102 analyses, only 2 found a positive relationship between the legal drinking age and traffic crashes. In short, more than half of all analyses found that a higher legal drinking age is associated with decreased rates of traffic crashes.

Of the 102 analyses of traffic crashes, 14 were the weaker cross-sectional designs, and 88 were longitudinal designs. Of the 14 cross-sectional analyses, 5 (36%) found a significant inverse relationship between legal drinking age and

crashes, whereas only 1 found a significant positive relationship. Of the 88 longitudinal analyses, 47 (53%) found a significant inverse relationship; none found a significant positive relationship. An additional 12 found an inverse relationship, and 1 found a positive relationship but did not report significance levels.

Of the 102 analyses of traffic crashes, 95 (93%) included a comparison group of some kind (for 2 analyses it was not clear whether a comparison group was used). Of the 95 analyses including comparison groups, 50 (53%) found a significant inverse relationship; only 1 found a significant positive relationship. An additional 11 analyses found an inverse relationship but no significance levels were reported. Of the 5 analyses that did not include comparison groups, 1 found a significant inverse relationship between the legal age and traffic crashes. One additional analysis without comparison groups found an inverse relationship, and 1 found a positive relationship but did not report significance levels.

Of the 102 analyses of traffic crashes, 94 (92%) included probability samples or a complete census of the relevant population, and 3 analyses clearly did not use a probability sample or census. For an additional 5 analyses it was unclear whether a probability sample or census was used. Of the 94 with a probability sample or census, 49 (52%) found a significant inverse relationship between the legal age and traffic crashes; only 1 study found a significant positive relationship. An additional 11 studies found an inverse relationship, and 1 study found a positive relationship but did not report significance levels; 34 analyses found no significant relationship. Of the 3 analyses without a probability sample or census, 2 found a significant inverse relationship, and none found a significant positive relationship. Of the 5 analyses for which it was unclear whether a probability sample or census was used, 1 found a significant inverse relationship between the legal age and traffic crashes; none found a significant positive relationship.

Finally, of the 102 analyses of traffic crashes, only 6 were specific to college student populations. Of the 6 college-specific analyses, 2 (33%) found a significant inverse relationship between the legal age and traffic crashes, 1 found a positive relationship but significance was not reported, and 3 found no significant relationship. Of the 96 analyses that were not college specific, 50 (52%) found a significant inverse relationship between the legal age and traffic crashes; only 1 found a significant positive relationship. An additional 12 analyses found an inverse relationship but did not report significance levels.

In conclusion, the preponderance of evidence indicates that higher legal drinking ages reduce rates of traffic crashes. Of all analyses that reported significant effects, 98% found higher drinking ages associated with lower rates of traffic crashes. Only 2% found the opposite. The evidence, however, is not entirely consistent: 35% of the analyses found no association between the legal age and indicators of traf-

TABLE 3.   Effects of legal minimum drinking age policies on other health and social problem outcomes

Study	Jurisdiction	Quality					Results	
		Probability sample	Design	Comp. group	College specific	Outcome measure	Dir. of relation.	Statistically significant
STUDIES ON LOWERING MINIMUM DRINKING AGE								
Smith, 1986	Australia: 2 states	Census	Pre-post	Yes		•Nontraffic emergency hospital admissions	↓	Yes
Smith and Burvill, 1986	Australia: 3 states	Census	Pre-post	Yes		•Juvenile crime (male)	↓	Yes
Howland et al., 1998	48 states	Census	Time-series	Yes		•Drownings		No
Birckmayer and Hemenway, 1999	48 states	Census	Time-series	Yes		•Suicides	↓	Yes
STUDIES ON RAISING MINIMUM DRINKING AGE								
Bessmer, 1985	Undergraduates	Not avail.	Pre-post	Not avail.	X	•Self-reported drinking-related problems		No
Hingson et al., 1985	MA	Census	Pre-post	Yes		•Nontraffic accidental fatalities		No
						•Suicide fatalities		No
						•Homicides		No
Lonnstrom, 1985	NY: Administrators at 4-year colleges	Census (90%)	Cross-sectional	Not avail.	X	Perception of students' alcohol-related problems:		
						•Vandalism	↓	Not reported
						•Academic problems	↓	Not reported
						•Social life		No
Hughes and Dodder, 1986	OK: Intro. sociology classes at 1 university	Yes	Longitudinal	No	X	Self-reported alcohol-related problems:		
						•Social problems		No
						•Legal problems		No
						•Damaging property		No
						•Fighting		No
Engs and Hanson, 1988	U.S.: Students in health/sociology/P.E classes at 56 universities	No	Longitudinal	No	X	Self-reported alcohol-related problems (all ages):		
						•Academic problems		No
						•Damaging property		No
						•Fighting	↑	Yes
						•Job problems		No
						•Social problems		No
						•Legal problems		No
Gonzalez, 1989	FL: Students in undergraduate courses at 9 colleges	Yes	Longitudinal	Yes	X	•Self-reported negative drinking consequences		No
Perkins and Berkowitz, 1989	NY: 1 university	Census (86-90%)	Pre-post	Yes	X	•Self-reported negative drinking consequences		No
Davis and Reynolds, 1990	NY: Undergraduates at 1 university	Yes	Pre-post	No	X	Self-reported alcohol-related problems (all ages):		
						•Academic problems		No
						•Damaging property		No
						•Fighting	↓	Yes
						•Legal problems		No
						•Injuries	↑	Yes
						•Social problems	↑	Yes
Gonzalez, 1990a	FL: Students in undergraduate courses at 1 university	Yes	Longitudinal	Yes	X	•Alcohol-related negative consequences		No
Hughes and Dodder, 1992	OK: Sociology classes at 1 university	Yes	Longitudinal	No	X	Self-reported alcohol-related problems:		
						•Academic problems		No
						•Damaging property		No
						•Fighting		No
						•Social problems		No
						•Legal problems		No
Jones et al., 1992	50 states and DC	Census	Longitudinal	Yes		•Pedestrian fatalities		No
						•Other injury (excl. m.v.) fatalities		No
						•Suicide fatalities	↓	Yes
						•Homicides		No
Joksch and Jones, 1993	31 states	Census	Longitudinal	Yes		•Homicides		No
						•Aggravated assaults		No

Continued

TABLE 3. *Continued*

Study	Jurisdiction	Quality				Outcome measure	Results	
		Probability sample	Design	Comp. group	College specific		Dir. of relation.	Statistically significant
						•Other assaults		No
						•Disorderly conduct	↓	Yes
						•Vandalism	↓	Yes
Parker, 1995	50 states and DC	Census	Time-series	Yes		•Acquaintance homicides (21-24 yr olds)	↓	Yes
Howland et al., 1998	48 states	Census	Time-series	Yes		•Drownings		No
Yu, 1998	NY: 16-24 year olds in 10 counties	Yes	Longitudinal	Yes		•Perceived parental approval of underage drinking	Remained low	
Birckmayer and Hemenway, 1999	48 states	Census	Time-series	Yes		•Suicides	↓	Yes

STUDIES THAT COMPARE STATES WITH HIGH AND LOW MINIMUM DRINKING AGE

Study	Jurisdiction	Probability sample	Design	Comp. group	College specific	Outcome measure	Dir. of relation.	Statistically significant
Rooney and Schwartz, 1977	5 states: Seniors from 27 high schools	No	Cross-sectional	Yes		•Self-reported drinking-related problems	↑	Not reported
Colon, 1980	50 states and DC	Not avail.	Cross-sectional	Yes		•Alcoholism (source not specified)		No
Maisto and Rachal, 1980	29 states: High schools	Yes	Cross-sectional	Yes		Self-reported alcohol-related problems:		
						•Academic problems		No
						•Social problems		No
						•Legal problems		No
Schweitzer et al., 1983	35 states	Census	Cross-sectional	Yes		•Alcoholism (cirrhosis deaths)		No
						•Alcohol-related mortality (source not specified)		No
Engs and Hanson, 1986	U.S.: Students in health/sociology/ P.E. classes at 72 colleges	No	Cross-sectional	Yes	X	Self-reported alcohol-related problems:		
						•Academic problems	↓	Yes
						•Damaging property		No
						•Fighting		No
						•Job problems		No
						•Social problems		No
Breed et al., 1990	50 college newspapers	Yes	Cross-sectional	Yes	X	•Amount of alcohol advertising		No

Notes: Comp. group = comparison group. Dir. of relation. = direction of relationship. Outcome measure and Results pertain specifically to the age group affected by law unless otherwise specified. ↓ Inverse relationship between drinking age and outcome (i.e., drinking age higher, outcome measure lower). ↑ Positive relationship between drinking age and outcome (i.e., drinking age higher, outcome measure higher). Census (X%) = full census attempted but X% participated. Not avail. = dissertation abstracts reviewed only.

fic crashes. However, focusing on the 79 studies of higher methodological quality (i.e., those that include a longitudinal design, comparison groups and probability sampling or use of a census) reveals that 46 (58%) of these 79 higher quality studies found a significant inverse relationship between the legal age and traffic crashes; none found a significant positive relationship. None of these studies of higher quality were college specific.

Effects of drinking age on other health and social problem outcomes

We identified 24 published studies that assessed the effects of changes in the legal minimum drinking age on indicators of other health and social problem outcomes (other than traffic crashes), such as suicide, homicide or vandalism (Table 3). In the 24 studies, 61 outcome measures were analyzed. Of the 61 analyses, 10 (16%) found a statistically significant inverse relationship between the legal drinking age and other outcomes; that is, as the legal

age was lowered, the number of problems increased, and as the legal age was raised, the number of problems decreased. Of the 61 analyses, 4 found a positive relationship between the legal drinking age and other outcomes; an additional 2 analyses that found an inverse relationship and 1 that found a positive relationship did not report significance levels.

Of the 61 analyses of other health and social problems, 16 were the weaker cross-sectional designs, and 45 were longitudinal designs. Of the 16 cross-sectional analyses, 1 (6%) found a significant inverse relationship between legal drinking age and other problems; none found a significant positive relationship. Of the 45 longitudinal analyses, 9 (20%) found a significant inverse relationship; 3 found a significant positive relationship.

Of the 61 analyses of other health and social problems, 36 (59%) included a comparison group of some kind (for 4 analyses it was not clear whether a comparison group was used). Of the 36 analyses including comparison groups, 9 (25%) found a significant inverse relationship; none found

TABLE 4. Studies of mediating factors related to minimum drinking age

Study	Jurisdiction	Quality Probability sample	Design	College specific	Results
McFadden and Wechsler, 1979	MA: H.S. students	?	Cross-sectional		•80% reported easy access to alcohol •Most common source of alcohol was friends/ relatives or other buyers
Hingson et al., 1985	MA: 16-19 year olds	Yes	Cross-sectional		•40% reported purchase attempts •1/3 reported that there was no request for ID •Enforcement efforts varied widely
Smart and Adlaf, 1987	Ontario: Grades 7-13	Yes	Cross-sectional		•4.6% used unauthorized age of majority cards •Positive relationship between alcohol use and unauthorized use of age of majority cards
Goldsmith, 1988	MD: 1 county	No	Cross-sectional	X	•Most common source of alcohol for underage H.S. students was older persons; for underage college students most common source was self-purchase •8% of underage college students and 10% of underage H.S. students reported use of false ID
Lotterhos et al., 1988	NC: Undergraduates in health classes at 1 university	Yes	Cross-sectional	X	•21% of students reported use of false ID
Rubington, 1990	1 university: RAs in 2 dorms	No	Cross-sectional	X	•Low levels of enforcement of drinking rules
Preusser and Williams, 1992	NY (3 counties) and DC: Licensed outlets	Yes	Cross-sectional		•44-97% of underage purchase attempts were successful
McCall, 1993	Psych. students at 1 college and store clerks	No	Cross-sectional	X	•Age estimates of underage persons were influenced by prior stimuli
Wagenaar et al., 1993	MN and WI: 18 and 19 year old college students in 15 communities	No	Cross-sectional	X	•Most common source of alcohol during high school was parties, older siblings and friends
O'Leary et al., 1994	NJ: Licensed est. in 16 cities	Yes	Cross-sectional		•59% of purchase attempts by minors were successful
Schofield et al., 1994	Australia: Licensed est. in 2 cities in S. Wales	?	Cross-sectional		•76% of purchase attempts by pseudo-underage required no proof of age
Forster et al., 1994	MN: Off-sale licensed est. in 28 communities	Census	Cross-sectional		•47% of purchase attempts by pseudo-underage were successful
Preusser et al., 1994	CO: Licensed est. in Denver	Yes	Longitudinal		•Successful purchase rates by underage reduced from 59% to 28% following enforcement intervention
Wagenaar and Wolfson, 1994	50 states	Census	Cross-sectional		•Low rates of arrests and penalties for violations of MDA •Rates varied widely among states
Forster et al., 1995	MN and WI: Licensed est. in 24 communities: •Off-sale •On-sale	 •Census •Yes	Cross-sectional		 •50% of purchase attempts by pseudo-underage at on-sale and 52% at off-sale were successful
Vaucher et al., 1995	Switzerland: Licensed est. in 1 canton	Yes	Cross-sectional		•81% of underage boys were served alcohol •17% of owners/managers knew correct MDA
Wagenaar and Wolfson, 1995	KY, MI, MT and OR	No	Cross-sectional		•Low rates of arrests and enforcement for MDA violations, especially against outlets
Wolfson et al., 1995	KY, MI, MT and OR: Law enforcement officials at 15 agencies	No	Cross-sectional		•Law enforcement officials perceived a lack of support from community to enforce MDA
Durkin et al., 1996	1 university: Undergraduate sociology courses	No	Cross- sectional	X	•46% of students reported use of false ID •Positive relationship between use of false ID and frequency of consumption
Klepp et al., 1996	Norway: 7th graders in 1 county (cohort followed)	Yes	Repeated cross-sectional		•Older friends or home were most common sources of alcohol for youth •Perceived access to alcohol at 13 was predictive of frequency of alcohol use at 15
Lewis et al., 1996	KS: 100 stores in Wichita	No	Pre-post		•Sales to minors reduced from 83% to 33% following enforcement intervention (NS)

TABLE 4. *Continued*

Study	Jurisdiction	Quality		College specific	Results
		Probability sample	Design		
Smart et al., 1996	Ontario: Grades 7-13	Yes	Cross-sectional		•66% reported easy access to alcohol •Most common sources were home or older buyers
Wagenaar et al., 1996	MN and WI: 15 communities		Cross-sectional		
	•18-20 year olds	•Yes			•Adults > 21 were most common sources of alcohol
	•9th and 12th graders	•Census (89-93%)			•Majority reported easy access to alcohol
Wolfson et al., 1996a	MN: Licensed off-sale est. in 28 communities	Census (93%)	Cross-sectional		•46% of purchase attempts by pseudo-underage were successful •Bars less likely than other types of outlets to sell to pseudo-underage
Wolfson et al., 1996b	MN and WI: Licensed est. in 15 communities		Cross-sectional		
	•Off-sale	•Census			•< 50% had policies to reduce underage sales
	•On-sale	•Yes			•Off-sale reported more aggressive age identification policies
Casswell and Zhang, 1997	New Zealand: 1 city (cohort followed ages 15-21)	?	Longitudinal		•Ease of access to alcohol at 15 positively associated with quantity of consumption and alcohol-related problems at 18
Grube, 1997	CA and SC: Off-sale outlets	Yes	Pre-post		•Sales to pseudo-underage were significantly reduced following increased enforcement efforts
Jones-Webb et al., 1997a	MN and WI: H.S. students in 2 communities	No	Cross-sectional		•Friends, siblings and co-workers >21 were most common sources of alcohol
Jones-Webb et al., 1997b	MN and WI: H.S. seniors in 15 communities	Census (93%)	Cross-sectional		•Perceived alcohol availability was positively related to consumption but not to drinking consequences among males
McCall, 1997	NY: Bartenders in 4 cities	No	Cross-sectional		•Increased attractiveness associated with less likelihood of request for proof of age
Mayer et al., 1998	MN and WI: 9th and 12th graders in 15 communities	Census (89-93%)	Cross-sectional		•Most common setting for drinking was someone else's home •Friends most common drinking partners
Schwartz et al., 1998	NY, VA, FL and GA: 16-19 year olds	No	Cross-sectional	X	•7-14% reported using false identification (14% of college students) •39% reported purchase attempts (44% of college students)
McCall, 1999	Undergraduates	No	Cross-sectional	X	•Increased attractiveness of customer and positive mood of server associated with less likelihood of request for proof of age
Fletcher et al., 2000	MN and WI: 15 communities		Cross-sectional		
	•18-20 year olds	•Yes			•7% reported using home delivery
	•12th graders	•Census (83.5%)			•10% reported using home delivery
	•Off-sale outlets	•Census (96%)			•17% reported making home deliveries

Notes: Census (X%) = full census attempted but X% participated. ? = information not clear from article.

a significant positive relationship. One additional analysis found a positive relationship but no significance levels were reported. Of the 25 analyses that did not include comparison groups, 1 found a significant inverse relationship between the legal age and other problems, and 3 found a positive relationship.

Of the 61 analyses of other problems, 47 (77%) included probability samples or a complete census of the relevant population, 12 analyses clearly did not use a probability sample or census, and for an additional 2 analyses it was unclear whether a probability sample or census was used. Of the 47 with a probability sample or census, 9 (19%) found a significant inverse relationship between the legal age and other problems; only 2 studies found a significant positive relationship. An additional 2 studies found an inverse relationship but did not report significance levels, and 33 analyses found no significant relationship. Of the 12 analyses without a probability sample or census, 1 found a significant inverse relationship, and 1 found a significant positive relationship. Of the 2 analyses for which it was

unclear whether a probability sample or census was used, neither found significant inverse or positive relationships between the legal age and other problems.

Finally, of the 61 analyses of other health and social problems, 34 were specific to college student populations. Of the 34 college-specific analyses, 2 (6%) found a significant inverse relationship between the legal age and other health and social problems, and 3 found a significant positive relationship. Two additional studies found an inverse relationship with no report on significance levels. Of the 27 analyses that were not college specific, 8 (30%) found a significant inverse relationship between the legal age and other problems; none found a significant positive relationship. One additional analysis found a positive relationship but did not report significance levels.

In conclusion, although there is clearly some evidence that higher legal drinking ages reduce rates of other health and social problems, results are not as consistent as they are for traffic crash outcome indicators. Of all analyses that reported significant effects, 75% found higher drinking ages associated with lower rates of problems. Only 25% found the opposite. The evidence, however, is not entirely consistent: 72% of the analyses found no association between the legal age and indicators of other problems. However, focusing on the 23 studies of higher methodological quality (i.e., those that include a longitudinal design, comparison groups and probability sampling or use of a census) reveals that 8 (35%) of the 23 higher quality studies found a significant inverse relationship between the legal age and other problems; none found a significant positive relationship. Two of those studies of higher quality were college specific; however, results of both were not significant.

Given the diverse types of outcomes included in this section, we also stratified the analyses of the higher methodological studies into four groups that were more homogeneous. Of the 16 analyses of nontraffic injuries (fatal and nonfatal), 4 found a significant inverse relationship between the legal drinking age and injuries; none found a positive relationship. Of the 10 analyses of "other crime" (e.g., vandalism, disorderly conduct), 3 found a significant inverse relationship between the legal drinking age and crime; none found a positive relationship. Only 1 study that analyzed the relationship between social, academic and employment problems was of higher methodological quality, and it did not find any statistically significant results. Similarly, only 3 studies that analyzed "other problems" (e.g., alcoholism, cirrhosis, general alcohol-related problems) were of higher quality, and none found significant results.

Mediating Factors

In addition to studies specifically evaluating the effects of minimum drinking age policies, there is a growing scientific literature on several closely related factors that can be deemed to mediate the relationship between drinking age law and outcomes of interest. Such factors include self-reported ease of access to alcohol and sources of alcohol, purchase success rates by underage-appearing buyers at bars and liquor stores, use of false age-identification documents, patterns of enforcement of the drinking age, effects of enforcement "crackdowns" and use of home delivery as a source of alcohol for youth. We identified 34 published articles on these factors; findings are summarized in Table 4.

Results show that more than half to more than three-quarters of teens surveyed report that alcohol is easy to obtain. Moreover, explicit tests of the propensity of alcohol retailers to sell to underage youth in purchase-attempt studies found 44-97% of outlets tested sold to underage youth with no request for age identification. Such studies show that the beneficial effects of the age-21 policy to date in terms of reduced drinking and reduced traffic crashes among youth have largely been achieved with minimal implementation of the law.

Most studies reveal that use of false age identification documents is only a modest problem. Estimates range from 5% to 21% of teens report using false age identification to obtain alcohol. One study was an outlier, finding 46% of undergraduate sociology students on one campus report use of false age identification (Durkin et al., 1996). Most studies on use of false age identification to date have not specifically focused on college students. It is possible that the accessibility and use of false identification documents is higher in college environments, but we do not know whether this is the case based on currently available data.

The limited degree to which age-21 policies have been implemented is also shown in several enforcement studies. Such studies have consistently found very low levels of enforcement of the age-21 policy. Enforcement actions against those selling or providing alcohol to minors are particularly rare (Wagenaar and Wolfson, 1994).

Studies of the effects of increased enforcement show it to be a highly effective means to reduce alcohol sales to minors. Increased enforcement, specifically compliance checks on retail alcohol outlets, typically cuts rates of sales to minors by at least half (Grube, 1997; Lewis et al., 1996; Preusser et al., 1994).

Finally, a recent study reports that 10% of high school seniors and 7% of 18- to 20-year olds use the home delivery services of alcohol retailers to obtain alcoholic beverages (Fletcher et al., 2000).

In summary, research on mediating factors between the establishment of a legal age for purchase and consumption of alcohol and actual effects on teen drinking and alcohol-related problems indicates clear means of further increasing the effectiveness of this policy. Such means include, most notably, increased rates of enforcement to prevent alcohol sales to minors. Other means to improve implementation of the age-21 policy, such as efforts to reduce use of

false age identification and tighter restrictions on home delivery of alcohol, may also help enhance effectiveness of this law.

Conclusion

Compared with a wide range of other programs and efforts to reduce drinking among teenagers, increasing the legal age for purchase and consumption of alcohol to 21 appears to have been the most successful effort to date (compare studies summarized in Table 1 with studies cited in reviews of other prevention efforts such as Moskowitz [1989] and Gorman and Speer [1996]). The magnitude of effects of the age-21 policy may appear small, particularly in studies using weak research designs and having low levels of statistical power. However, even modest effects applied to the entire population of youth result in very large societal benefits. For example, the National Highway Traffic Safety Administration, using an average estimated reduction in traffic fatalities due to the legal drinking age of 13%, calculates that the age-21 policy prevented 846 deaths in 1997 and prevented a total of 17,359 deaths since 1975 (National Highway Traffic Safety Administration, 1998).

A large proportion of studies of the MLDA found a statistically significant, *inverse* relationship between the MLDA and alcohol consumption and alcohol-related problems (48% of the higher quality studies). Only a small number of studies found a statistically significant, *positive* relationship between the MLDA and various outcomes (1% of the higher quality studies). A large number of studies found no statistically significant relationship. In addition to differences in quality of research design and analyses, several other factors may account for variability in results across studies, including size of sample and extent of change in policy. The power to detect a statistically significant effect is directly influenced by the size of the sample. In some states, the MLDA was raised only 1 year, from age 20 to age 21; in other states it was raised from age 18 to 21. Studies of policy changes that affect smaller segments of the population may be less likely to detect effects simply because of reduced statistical power when analyzing fewer data. Given potential design and analysis limitations in any single study, the large proportion of MLDA studies that found a significant inverse relationship with various outcomes gives strong support for the effectiveness of the MLDA.

It is difficult to estimate accurately the effects of the drinking age specifically on college students. Unfortunately, most studies focusing on college students have been based on weaker cross-sectional designs or limited nonprobability samples. Only 9% of the college-specific studies (6 of 64) used a higher quality research design. Of these higher quality studies, none found a statistically significant inverse relationship between the MLDA and consumption or alcohol-related problems. In addition, of these 6 analyses, 4 included a sample of students at only one university. Although it is possible that the age-21 policy has been less effective on college campuses than among the general youth population, existing research clearly does not suggest that the age-21 MLDA has increased problems among college students. However, more studies that use robust research designs would be needed to assess accurately the effect of the MLDA specifically on college campuses. In addition, studies of potential mediating factors on campuses are also needed. For example, how well are MLDA laws enforced on college campuses? How easily can underage students obtain alcohol on and around campus? If one assumes that the MLDA is less effective on college campuses, perhaps it is due to lax enforcement and particularly easy access to alcohol by underage youth in such settings.

Finally, despite progress in recent decades, most youth continue to have access to alcohol, most drink at least occasionally, and a substantial fraction regularly become intoxicated. The social costs from injuries, deaths and damage associated with underage drinking remain high. The benefits of the legal drinking age of 21 have occurred with little or no active enforcement in most areas. Simply by increasing enforcement levels and deterring adults from selling or providing alcohol to minors, even more injuries and deaths related to alcohol use among youth are likely to be prevented each year.

Policy Issues Related to the Minimum Legal Drinking Age

Despite an abundance of research demonstrating the effectiveness of the age-21 MLDA in reducing youth drinking and alcohol-related problems, three decades after states first began lowering minimum drinking ages, and two decades after states were in the midst of raising their legal drinking ages, a few states are again considering lowering their legal age limits for drinking. Many issues and arguments heard decades ago are again occasionally heard (Fell, 1985; Toomey et al., 1996). One difference this time around is that we have the benefit of hundreds of research studies summarized in the body of this article. Here we summarize 13 similar issues that are still often raised in policy debates by those opposed to a legal drinking age of 21 and provide up-to-date responses that may be useful to college administrators, public health practitioners and others.

Issue 1

Issue. "Establishing a legal drinking age of 21 is unconstitutional age discrimination."

Response. This question has been treated in detail in two court cases. The first case challenged, in federal court, the constitutionality of Michigan's increase in the drinking

age, one of the early states to raise the legal age back to 21 (Guy, 1978). The court ruled, on the basis of scientific evidence that linked lower drinking ages to increased traffic crash involvement among youth, that the drinking-age discrimination was reasonably related to the state objective of reducing highway crashes. Thus the higher drinking age withstood the constitutional challenge on three key legal issues: (1) drinking alcohol is not a "fundamental" right guaranteed by the Constitution, (2) age is not inherently a "suspect" criteria for discrimination (in contrast to race or ethnicity, for example) and (3) using the drinking age to prevent highway crashes has a "rational basis" in available scientific evidence. The court mentioned additional reasons that a higher drinking age is not unconstitutional. The higher drinking age does not cause a permanent disability, but is only a temporary postponement of a specific behavior for the young person's own protection. Furthermore, states have broad powers to regulate the distribution and use of beverage alcohol under the Twenty-first Amendment, which ended Prohibition. Therefore, the drinking age, like other alcohol-control regulations, has a "strong presumption of validity," according to the court.

More recently, the state of Louisiana's age-21 MLDA was challenged in court on the premise that it violated the state's constitutional law regarding age discrimination. Louisiana's State Supreme Court concluded, however, that "statutes establishing the minimum drinking age at a level higher than the age of majority are not arbitrary because they substantially further the appropriate governmental purpose of improving highway safety, and thus are constitutional" (Manuel vs State of Louisiana, 1996). In other words, because the age-21 MLDA was based on empirical evidence that the law saved lives, the court decided that it was not an arbitrary law and thus did not violate Louisiana's constitution.

Issue 2

Issue. "The federal government is exerting too much power over the states. The federal law encouraging states to set the legal drinking age at 21, by withholding highway funds from states that do not do so, is just one example of this."

Response. Citizens groups in a number of states began the initial movement to raise the drinking age to 21. Numerous statewide and national surveys show overwhelming public support for the drinking age of 21, both in the late 1970s and early 1980s when states were raising the age (Wagenaar, 1993), and today. The most recent national survey shows 84% of the U.S. population age 18 and over oppose lowering the age from 21 to 19 (Wagenaar et al., 2000). As several states increased the drinking age to 21, significant reductions in multiple types of injuries (including deaths related to car crashes) were observed (Jones et

al., 1992; Wagenaar, 1993). However, as some states raised their drinking age while neighboring states did not, some young people drove across state lines to get alcohol, increasing the chance of traffic crashes. Recognizing that having a uniform drinking age achieves safety, the federal government strongly encouraged, but did not mandate, the remaining states to increase their drinking ages to age 21.

Issue 3

Issue. "Europeans teens are allowed to drink from an early age, yet those countries don't have the alcohol-related problems we do. What we need are fewer restrictions, not more."

Response. The idea that Europeans do not have alcohol-related problems is a myth. European youth may be at less risk of traffic crashes because youth drive less frequently in Europe than in the United States. Compared with the United States, Europeans have higher legal driving ages, more expensive automobiles and greater access to public transportation. Looking beyond traffic crashes, however, European countries have similar or higher rates of other alcohol-related problems compared with the United States. For example, in 1990, France and Italy had higher per capita alcohol consumption and higher rates of cirrhosis deaths than did the United States. Per capita consumption in France and Italy was 12.7 and 8.7 liters of alcohol, respectively, compared with 7.5 in the United States. Cirrhosis death rates in France and Italy were 26.8 and 17.0 per 100,000, respectively, whereas the U.S. rate was 11.6 (Edwards et al., 1994). European countries are now looking to the United States for research and experience regarding the age-21 policy. Europeans are initiating the debate on the most appropriate age for legal access to alcohol.

Issue 4

Issue. "If I'm old enough to go to war, I should be old enough to drink."

Response. Many rights have different ages of initiation. A person can obtain a hunting license at age 12, driver's license at age 16, vote and serve in the military at 18, serve in the U.S. House of Representatives at age 25 and in the U.S. Senate at age 30 and run for President at age 35. Other rights we regulate include the sale and use of tobacco and legal consent for sexual intercourse and marriage. The minimum age of initiation is based on the specific behavior involved and must take into account the dangers and benefits of that behavior at a given age (Fell, 1985). The age-21 policy for alcohol takes into account the fact that underage drinking is related to numerous serious problems, including injuries and deaths resulting from car crashes, suicide, homicide, assault, drowning and recreational injuries. In fact, the leading cause of death among

teens is car crashes (National Center for Health Statistics, 1994), and alcohol is involved in approximately one-third of these deaths (National Highway Traffic Safety Administration, 1998).

Issue 5

Issue. "Nineteen- and twenty-year-olds are drinking anyway. If we legalize it, at least they'll be drinking in a controlled supervised settings, such as a bar or nightclub, rather than in cars or at unsupervised parties."

Response. Data show bars and nightclubs are not safe, controlled locations. Studies have repeatedly shown a majority of alcohol outlets regularly break the law, for example, by selling alcohol to minors (Forster et al., 1994, 1995; Preusser and Williams, 1992) or selling to intoxicated patrons (Toomey et al., 1999). When the legal age is lower than 21, teens purchase the majority of their alcohol at liquor stores because it is cheaper than getting it at bars. They then consume this alcohol in homes, cars or parks. These areas are very difficult to control (Fell, 1985).

There is also some "trickle-down" effect in that when youth get alcohol they often give it to even younger teens (Jones-Webb et al., 1997a). When the legal age is 21, 19- and 20-year olds can often obtain alcohol from their friends. When the drinking age was 18 and 19, 17- and even 16-year olds were often able to get alcohol from their friends. If the drinking age is lower, more alcohol will be available to younger high school students and perhaps even middle school students. There will always be some people who violate laws, but this does not mean we should condone the illegal behavior by modifying the law. The age-21 policy has resulted in a reduction in the amount of alcohol consumed and a substantial decrease in the number of car crashes involving underage drinkers. These results have occurred despite the fact that the law is often not strictly enforced (Wagenaar and Wolfson, 1994, 1995).

Issue 6

Issue. "Lower rates of alcohol-related crashes among 19- to 20-year olds aren't related to the age-21 policy, but rather they're related to increased drinking-driving education efforts, tougher enforcement and tougher drunk-driving penalties."

Response. After the age-21 MLDA was implemented, alcohol-involved highway crashes declined immediately (i.e., starting the next month) among the 18- to 20-year-old population. Careful research has shown declines are not due to enforcement of and tougher penalties for driving while intoxicated, but are directly a result of the legal drinking age. Studies have also shown that education alone is not effective at reducing youth drinking (Clayton et al., 1996; Ellickson et al., 1993). To achieve long-term reductions in

youth drinking problems, we have to change the environment by making alcohol less accessible to teens.

Issue 7

Issue. "Making it illegal to drink until 21 just increases the desire for the 'forbidden fruit.' Then, when teens turn 21, they'll drink even more."

Response. Actually, the opposite is true. Early legal access to alcohol is associated with higher rates of drinking as an adult. When the drinking age is 21, those under 21 drink less and continue to drink less through their early twenties. The lower rates of drinking and the reductions in injury and death before age 21 are not compensated for after reaching 21 with rates higher than they would have been (O'Malley and Wagenaar, 1991).

Issue 8

Issue. "Who will pay for enforcement of these laws? The age-21 law is too expensive."

Response. We already pay large portions of our tax dollars for problems resulting from alcohol. For example, in Minnesota, cities use approximately one-third of their police budgets to deal with alcohol-related problems (Cities Bulletin, 1989); in the United States, we pay more than $10 billion annually just for the costs associated with drunk driving (Kenkel, 1993a). Moreover, drinkers clearly do not pay their own way. They end up generating costs (in health care costs, legal fees and lost wages) of more than a dollar for every drink sold—costs we all pay in increased taxes, higher health and auto insurance premiums and higher costs for goods and services (Miller and Blincoe, 1994). The higher drinking age saves money by resulting in fewer alcohol-related health problems, fewer alcohol-related injuries and less vandalism.

Issue 9

Issue. "We have other more important problems to deal with. The truth is, underage drinking is just not a big problem."

Response. Underage drinking is a serious problem. In 1998, 52% of high school seniors in the United States drank alcohol in the last month, and more than 30% were intoxicated at least once in the last 2 weeks (Johnston et al., 1998). And these are the lower numbers under the age-21 policy. Teens would be drinking even more if the legal age were lowered. A recent national survey indicates that 96% of the public remains concerned about teen drinking (Wagenaar et al., 2000). The age-21 law clearly does not eliminate youth drinking, but it is one important component of a multifaceted effort to minimize youth drinking problems.

Issue 10

Issue. "Here come the Prohibitionists."

Response. Those supporting the age-21 policy are not Prohibitionists. They are not interested in outlawing all alcohol consumption for adults and are not interested in putting the alcohol industry out of business. They are interested in protecting youth and the safety of all citizens in our communities by supporting implementation and enforcement of the law that states that it is illegal to sell alcohol to those under the age of 21. They are interested in protecting property and reducing the costs spent on health care and crime. These are goals shared by most of the public, and research shows that if we can reduce youth access to alcohol, we can help achieve these goals.

Issue 11

Issue. "We need to punish those teens who are drinking and creating problems, not enact policies that will affect the whole community."

Response. This problem requires shared responsibility. It is adults who create the environments within communities that provide youth with easy access to alcohol. Adults own and operate the businesses that sell alcohol to underage youth. Adults permit advertising and marketing of alcohol in ways that appeal to teens. Thus it is not appropriate to blame just the teens for drinking. Surely, teens have a responsibility not to attempt to purchase or consume alcohol. But arresting after the fact and labeling as criminals teens who drink is not the most effective approach. A modest civil penalty for the teenager caught with alcohol is appropriate.

More effective in the long term are efforts to reduce the supply of alcohol to teens to prevent youth drinking and the resulting tragedies before they happen. This requires active enforcement of statutes and regulations on those who sell or provide alcohol to teens, with appropriate penalties for violations.

Issue 12

Issue. "We drank when we were young and we grew out of it. It's just a phase that all teens go through."

Response. Unfortunately, many teens will not "grow out of it." Studies indicate that youth who start drinking before they are 21 are more likely to drink heavier later in life, whereas those who do not drink until they are 21 tend to drink less as adults (Grant and Dawson, 1997). Teens who drink are also more likely to try other illegal drugs and to become victims of crime (Kandel et al., 1992). If we accept that teen drinking is just a normal phase that teens go through, youth will continue to experience car crashes, other injuries, early unprotected sex and other common problems associated with drinking.

Issue 13

Issue. "If teens can't get alcohol, they'll just switch to other, perhaps even more dangerous, drugs."

Response. Research shows that the opposite is true; teens who drink and/or smoke are more likely also to use other drugs (Fell, 1985; Kandel et al., 1992). If we can keep youth from using alcohol and tobacco, we can actually reduce the chance that they will try other illegal drugs. Moreover, when the drinking age was raised to 21, and teen drinking declined, there was no evidence of a compensatory increase in other drug use (O'Malley and Wagenaar, 1991).

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