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The Benefits of Reducing Gun Violence: Evidence from Contingent-Valuation Survey Data*

JENS LUDWIG† ludwigj@gunet.georgetown.edu
Georgetown University and National Consortium on Violence Research

PHILIP J. COOK cook@pps.duke.edu
Duke University, National Consortium on Violence Research, and National Bureau of Economic Research

Abstract

This article presents an estimate of the benefits of reducing crime using the contingent-valuation (CV) method. We focus on gun violence, a crime of growing policy concern in America. Our data come from a national survey in which we ask respondents referendum-type questions that elicit their willingness-to-pay (WTP) to reduce gun violence by 30%. We estimate that the public's WTP to reduce gun assaults by 30% equals $24.5 billion, or around $1.2 million per injury. Our estimate implies a statistical value of life that is quite consistent with those derived from other methods.

Keywords: costs of crime, gun violence, contingent valuation

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1. Introduction

Since the early 1970s, the United States have averaged nearly 14,500 gun homicides and perhaps another 70,000 non-fatal injuries from gun assaults.[1] Concern about gun

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†Corresponding author: Jens Ludwig, Georgetown Public Policy Institute, 3600 N Street, NW, Suite 200, Washington, DC 20007.

violence has prompted a substantial policy response. For example, in New York City, the elite Street Crimes Unit has employed aggressive stop-and-search tactics to reduce illegal gun carrying in high-crime neighborhoods (Bratton and Kobler, 1998). In St. Louis the police sought parental consent to search homes and seize illegal firearms kept by teens (Rosenfeld and Decker, 1996), while the Boston Gun Project targeted illegal gun trafficking and gang shootings (Kennedy, Piehl, and Braga, 1996; Piehl, Kennedy, and Braga, 1998). Richmond, Virginia's Project Exile threatens felons who use guns with prosecution and sentencing in federal court (Cook and Ludwig, 2000). And at the national level, policies ranging from background checks for gun-show sales to an outright ban on handguns are being actively considered.[2]

While some of these programs may be effective in reducing the risk of assault-related gunshot injuries to citizens (Blumstein and Rosenfeld, 1998; Blumstein and Wallman, 2000; Cook and Ludwig, 2000), each imposes some cost on society in the form of additional government expenditures and inconvenience to citizens. One of the central insights from the economics of crime is that information about the benefits and costs of crime reduction may be useful in deciding how to make these tradeoffs (Becker, 1968; Stigler, 1970; Rottenberg, 1970). Yet applying this insight to the case of gun violence requires some estimate for the benefits of reducing gun injuries.

The present article represents the first attempt to estimate the benefits of reducing crime using the contingent-valuation (CV) method. Our focus on gun violence in particular is motivated by the growing policy concern about this issue. We adopt the standard approach of public economics and define the benefit of a public good as what society is willing to pay (WTP) to achieve some change in the level of the good (Viscusi, 1992). The public good in question here is freedom from the *ex ante* risk of victimization. This *ex ante* approach is appropriate for the decision problem facing policymakers, who must decide whether to fund crime-control programs that will prevent injuries to victims whose identity is not yet known.

The estimates presented in the current article are obtained from a nationally representative CV survey of 1,204 adults conducted in 1998. The survey elicits respondents' WTP to finance a 30% reduction in gun violence through programs that target gun thefts and illegal gun dealers. Since such interventions should have little effect on the ability of most adults to own guns, the public good of interest is a marginal decrease in assault-related gunshot injury (hereafter "gun crime" or "gun violence") holding constant whatever benefits may be associated with widespread gun ownership. Responses to this CV question should in principle yield comprehensive estimates for the benefits of reductions in the risk of gunshot injury. Our results suggest that a 30% reduction in gun violence is worth $24.5 billion to the American public. Dividing this figure by the number of gunshot injuries in 1998 implies a WTP per injury equal to around $1.2 million.

Despite some limitations of the CV data used to derive our estimates, these findings are consistent with a number of reasonable benchmarks. First, we find that WTP is positively correlated with household income. Controlling for other background characteristics, WTP also increases with household size; since the reduction in risk the household experiences is related to the number of members, this finding suggests that the responses are driven at least in part by the demand for specified reductions in the risk of gunshot injury. Second, Anderson (1999) finds that the average household currently spends around $1,800 per year in taxes and consumption expenditures to fund the criminal justice system and private protection measures. Thus, it does not seem implausible that the average household will spend an additional $240 per year to reduce the threat of gunshot injury by 30%, particularly since the fear of crime in America appears to be driven largely by the threat of *violent* crime (Zimring and Hawkins, 1997; Hamermesh, 1998; Cullen and Levitt, 1999).[3] Third, our estimates imply a value for one statistical life that is quite consistent with those derived in other contexts (Viscusi, 1992, 1993).

Compared with earlier research, our estimates provide a very different picture of both the magnitude and distribution of the costs of gun violence. Previous studies of the benefits of reducing gun violence have adopted an *ex post* approach that begins with a count of the annual number of gunshot injuries and then multiples this figure by some estimate of the cost per injury.[4] The primary limitation with this *ex post* method is that it does not fit the decision problem that faces policymakers, and ignores averting behaviors and other costs imposed even on those who are not victimized. Much of this research has been conducted within the public health "cost-of-illness" (COI) tradition, which is likely to understate the cost per injury by focusing only on medical treatment for gunshot injuries and other direct costs plus a measure of lost productivity (Max and Rice, 1993).[5] And in fact the leading COI study reports a cost per injury (equal to about $80,000 in 1998 dollars) that is far lower than our own estimate (Max and Rice, 1993).

More recent studies improve on the COI approach by adding measures for the value of life and health obtained from the workplace-risk or jury-award literatures (Miller and Cohen, 1996, 1997; Miller, Cohen, and Wiersema, 1996; Anderson, 1999), and generate estimates that are closer in magnitude to our own. But these studies like the COI literature adopt an *ex post* approach.

Our CV evidence suggests instead that the costs of gun violence are far more evenly distributed across the population than victimization statistics would suggest. Although gunshot injuries are concentrated disproportionately among low-income young men (Cook and Ludwig, 2000), as noted above the WTP to reduce gun violence is highest among middle-class parents. Although these households are at low personal risk of injury, their stake in reducing gun violence comes in part from the costly averting behaviors that they undertake in response to the threat of gunshot injury. For example, economists have found that decisions about whether to live in the city or suburb (Cullen and Levitt, 1999) and whether to work in the evening (Hamermesh, 1998) are affected by the risk of homicide victimization, most of which is accounted for by the risk of gun homicide. Cook and Ludwig (2000) show that the cost of administering the criminal justice system are increased by $2 billion or more each year because guns increase the likelihood that a robbery or fistfight results in a homicide. Gunshot injuries increase the net medical expenditures of public and private health insurance programs. And schools and other government agencies divert scarce resources to metal detectors and other security precautions designed largely to reduce the risk of gunshot injury.

The rest of the article is organized as follows. The second section reviews the willingness-to-pay (WTP) approach and discusses the application of this method to the case of gunshot injuries. The third section describes our data and the fourth presents the empirical results. The fifth section discusses the implications of these findings.

2. The WTP approach

In this section we discuss the WTP approach within the context of gun violence, and then discuss different methods for estimating WTP.

Defining WTP

Under the traditional benefit-cost framework of public economics, the benefits of a violence-reduction program consists of the sum of the values that citizens are WTP to fund some program or policy that reduces the risk of injury victimization. Previous research suggests that individual WTP to support a program to reduce gun violence may be motivated by four factors (Schelling, 1968):

- First, the individual may attach some value to the reduction in risk of being shot.
- Second, she may value the reduction in risk to other members of her household. Because we assume that individuals value the well-being of others in the household and because households pool income, we follow Manning et al. (1991) and treat households as the economic unit of interest.
- Third, she may derive some value from reducing the risk of others outside her household for whom she feels altruistic (Viscusi, Magat, and Forrest, 1998).
- Fourth, a reduction in the population risk of gunshot injury may have secondary benefits by improving her material quality of life. Part of this benefit comes from reductions in her own preventive expenditures (Berger, Blomquist, Kenkel and Tolley, 1994), while reductions in preventive behaviors by others may produce additional benefits. (For example, the overall quality of life in the community may improve from a reduction in gun violence, as a reduced threat of being caught in the cross fire engenders more socializing). Further, she may also receive some financial gain from reductions in the number of gunshot injuries to strangers through reductions in taxes or insurance premiums (Cook et al., 1999, Cook and Ludwig, 2000).

Total societal WTP is then defined as the sum of what each individual household is willing to pay.

Measuring WTP

One way to measure societal WTP for programs that reduce health risks is to examine marketplace behavior. For example, a widely used approach is to examine the extra wage compensation that workers require in order to take risky jobs; these wage premiums reflect the price of some health risk in the labor market (see, for example, Moore, and Viscusi, 1988a,b, 1990a,b; Viscusi and Moore, 1989). Another possibility is to examine variations in the prices of housing (Gayer, Hamilton, and Viscusi, 2000) or other consumer goods (Viscusi, 1993) related to health risks to estimate the value that people attach to risk reduction. In practice, identifying the independent effects of health risks on wages and prices is complicated by the possibility of other job or product attributes that may be correlated with these risks. Another complication stems from the choice of the appropriate risk measure that should be used. Most studies rely on some objective measure of the health risk facing consumers or workers, under the assumption that perceived and actual risks are closely related. This assumption is usually justified by noting that individuals have tangible incentives to gather information about the risks associated with particular consumer products or jobs.

When market behavior cannot be directly examined to estimate societal WTP for a public good, the preferred method, known as "contingent-valuation (CV)," is to survey a representative group of respondents about how much they would be willing to pay. A 1992 panel sponsored by the National Oceanic and Atmospheric Administration (NOAA) outlined the key components of a CV study that would maximize the likelihood of producing reliable results (Arrow et al., 1993), which include the use of referendum formats that ask respondents to vote on a hypothetical government program. The referendum format is deemed preferable to open-ended questions because citizens have experience in casting such votes, and because the referendum format minimizes incentives to free ride (Mitchell and Carson, 1989).

Whether even high-quality CV studies produce reliable estimates of WTP remains the topic of ongoing debate. One concern is that individuals will have limited information about the nature of the risk that is being asked about. This issue should not pose a major problem for our CV study because individuals already make decisions about where to live and when to work in response to the threat of gun violence (Hamermesh, 1998; Cullen and Levitt, 1999), decisions that provide people with incentives to gather information about these risks on their own.

Another concern stems from the tendency of survey respondents to present themselves favorably to interviewers (Sudman and Bradburn, 1974), which produces social desirability bias or yea-saying. A related concern is the possibility that CV responses are motivated more by the respondent's desire to "purchase moral satisfaction" rather than support the provision of a defined quantity of some public good (Kahneman and Knetsch, 1992). Both problems may manifest themselves in what is known as the "embedding effect," where the respondent's WTP is independent of the quantity of the public good that is being provided.

Perhaps the primary concern that most economists have about CV research is that respondents have no incentive to take the questions seriously since they relate to hypothetical rather than actual market behavior, what Kenkel, Berger, and Blomquist (1994) call "hypothetical bias." The use of referendum-type CV questions is one attempt to address this concern by increasing the realism of the survey exercise.

The empirical evidence on the existence of embedding effects is somewhat mixed (see, for example, Desvousges et al., 1993; Balson et al., 1990; Beattie et al., 1998; Hammitt and Graham, 1999). Some evidence against hypothetical bias comes from experimental designs that compare reported with actual WTP, and from comparisons of CV responses with estimated travel times to use parks and other public goods or to wage premiums associated with health risks (Brookshire et al., 1982; Viscusi and O'Conner, 1984; Brookshire and Coursey, 1987; Smith, 1992; Hanemann, 1994), though several studies do find some discrepancies between hypothetical and actual behavior (Hausman, 1993; Diamond and Hausman, 1994; Johannesson et al., 1999). More generally, CV responses are typically consistent (at least broadly) with economic theory, in the sense that WTP increases with income and decreases with the availability of substitute goods (Tolley and Fabian, 1988; Kenkel, Berger, and Blomquist, 1994).

In sum, while most economists agree that WTP is the conceptually appropriate measure for valuing improvements to health and safety, most also agree that none of the available methods for measuring WTP are entirely satisfactory. Wage-risk tradeoffs cannot be used to value the benefits of reducing gun violence in part because of limited data on the risks of gunshot injury across occupations. Wage-risk tradeoffs will also fail to capture the value that workers place on reductions in the averting behaviors that they undertake in their private lives, or the value of reductions in risks to family, friends, and others in the community. In contrast the contingent-valuation method will produce WTP measures that are (at least in principle) complete. Despite the ongoing debates about contingent valuation there are, as Hammitt and Graham (1999, p. 58) note, "few good alternatives."

3. CV survey data

The 1998 National Gun Policy Survey (NGPS) is a nationally representative telephone survey of 1,204 American adults conducted during the Fall of 1998 by the National Opinion Research Center (NORC) at the University of Chicago. Interviews were conducted with one adult per sampled household, with the adult chosen randomly via the most-recent-birthday method. The response rate for the NGPS was 61% (see Kuby, Imhof, and Shin, 1999).

After a series of questions asking about their attitudes towards government and various current or proposed gun regulations, respondents are asked the following questions: "Suppose that you were asked to vote for or against a new program in your state to reduce gun thefts and illegal gun dealers. This program would make it more difficult for criminals and delinquents to obtain guns. It would reduce gun injuries by about 30%, but taxes would have to be increased to pay for it. If it would cost you an extra [$50/$100/$200] in annual taxes would you vote for or against this new program?" The amount of the tax increase that the respondent is asked about, either $50, $100 or $200, is randomly determined by the survey software. Respondents are then asked a follow-up where the dollar amount asked about in the initial referendum question is either doubled or halved, depending on whether the respondent's initial answer was positive or negative, respectively.

The intervention specified in the CV scenario should have no effect on hunting or defensive gun uses, and previous research suggests that gun availability within an area increases the lethality but not the volume of violent crime (Cook, 1979, 1981, 1983). Thus the implicit counterfactual scenario that respondents are asked to “buy” in the NORC survey is a 30% reduction in gun crime, an equivalent increase in the number of non-gun crimes, and no change in the number if defensive gun uses. It is possible that respondents ignore the possibility of a countervailing increase in non-gun crimes when formulating their WTP responses, which will lead them to overstate the value of moving from the *status quo* to the counterfactual that we have in mind. Yet the degree of bias is likely to be modest, given the evidence cited above that Americans appear to be far more worried about serious injuries than other criminal victimizations.

As noted earlier, we assume that respondents are reporting on the total dollar value that their *household* would be willing to pay to fund this program, rather than reporting strictly on the value that they themselves would pay. Our assumption is conservative in that if respondents are in fact reporting on personal rather than household WTP, our estimates will understate total societal WTP to fund the hypothetical reduction in gun crime.[6]

4. Empirical results

We begin by presenting a non-parametric estimate for WTP to reduce gun violence by 30%. This estimate does not impose any assumptions on the population distribution of WTP, and suggests a WTP equal to $21.8 billion. We then present a more elaborate set of maximum-likelihood estimates that are derived under alternative assumptions about the distribution of WTP. Our preferred estimates suggest a societal WTP of $24.5 billion, equal to around $1.2 million per gunshot injury avoided.

Non-parametric estimates

Table 1 presents the descriptive statistics from the NGPS data. The proportion of respondents who vote to support the violence-reduction program decreases as the amount required to fund the program increases, ranging from 76% at a cost of $50 more in annual taxes to 38% at a cost of $400. Figure 1 provides a graphical representation of the cumulative distribution function implied by these descriptive statistics.

If we integrate under the area shown in Figure 1 and multiply by the total number of households in the US—equal to 102.5 million in 1998 (US Bureau of the Census, 1999a)—we obtain an estimated total WTP of $21.8 billion to reduce assault-related gunshot injuries by 30% (Table 2). In these calculations we assign a WTP of $0 to those respondents who answer no to both the first and follow-up CV questions, under the assumption that each individual’s WTP to reduce gunshot injuries must be non-negative.[7] Although some people may object to the specific *mechanism* used to reduce gun injuries, presumably few people would be willing to pay to see more Americans shot, and in any case it is not clear that such preference should be given standing in benefit-cost analysis. In order to convert this estimate into WTP per gunshot injury avoided,

Table 1. Descriptive statistics from the 1998 NGPS

	How vote on program to reduce gunshot injuries by 30% but cost \$50 more per year in income taxes?	How vote on program to reduce gunshot injuries by 30% but cost \$100 more per year in income taxes?	How vote on program to reduce gunshot injuries by 30% but cost \$200 more per year in income taxes?
% Vote in favor of program (N)	75.8 (400)	68.5 (400)	63.6 (404)
% Vote in favor of program on follow-up Q (N)			
Amount asked about on follow-up Q			
\$25	23.3 (95)		
\$50		24.2 (112)	
\$100	67.2 (290)		27.9 (133)
\$200		59.4 (268)	
\$400			59.4 (253)

Source: Authors' calculations from 1998 NGPS; descriptive statistics are calculated using the 1998 NGPS sampling weights. Figures are in 1998 dollars.

we can divide total WTP by the estimated annual incidence of assault-related gunshot woundings—around 68,900 in 1998[8]—multiplied by 30%. This suggests WTP per injury equal to around \$1.1 million.

Parametric estimates

The non-parametric estimate understates societal WTP because it does not interpolate the underlying distribution between the CV bid values or extrapolate beyond the highest value used in the survey. The non-parametric approach is also limited in that it only uses a fraction of the information available with the CV data. In this section we develop refined estimates that use maximum-likelihood methods to estimate societal WTP under a number of different assumptions.

Our empirical strategy is based on the framework outlined by Cameron and James (1987) and Cameron (1988). Let Y_i equal the (unobserved) WTP value that respondent (i) has in mind when answering the first and second referendum questions in the NGPS. The respondent will answer in the affirmative to the first referendum question ($I_{1i} = 1$) if the "price" of the program in the form of higher taxes (t_{1i}) is not greater than the respondent's WTP ($Y_i \geq t_{1i}$). Similarly, the respondent will support the program in the follow-up CV question ($I_{2i} = 1$) if the new price t_{2i} is less than WTP ($Y_i \geq t_{2i}$), where t_{2i} is equal to double t_{1i} if $I_{1i} = 1$ and half of t_{1i} if $I_{1i} = 0$. We initially assume that Y_i is log-normally distributed (equation 1), which constrains WTP to be positive.

$$\log Y_i = \beta + u_i, \quad u_i \sim N(0, \sigma^2) \tag{1}$$

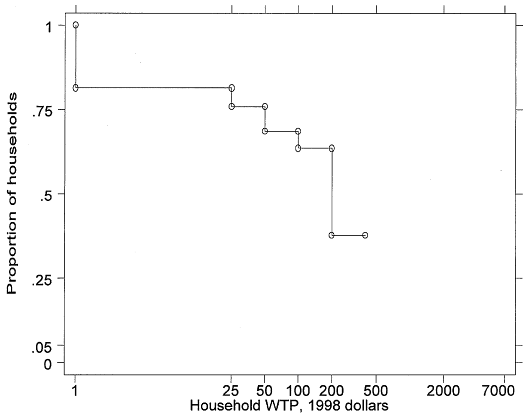

Figure 1. Demand for 30% reduction in gun violence.

From this setup we can estimate household WTP using the "interval-data" or "double-bounded" model from Hanemann, Loomis, and Kanninen (1991). The probabilities for the four possible joint outcomes for the first (I_{1i}) and second (I_{2i}) referendum questions are given in equations (2)–(5) (recall that $t_{2i} = 2t_{1i}$ if $I_{1i} = 1$, and $t_{2i} = 0.5t_{1i}$ if $I_{1i} = 0$).

$$\begin{aligned} P[I_{1i} = 1, I_{2i} = 1] &= P[Y_i \geq t_{2i} > t_{1i}] = P[Y_i \geq t_{2i}] \\ &= P[u_{1i}/\sigma \geq (\log t_{2i} - \beta)/\sigma] \\ &= 1 - F[(\log t_{2i} - \beta)/\sigma] \end{aligned} \tag{2}$$

Table 2. Nonparametric estimates for mean WTP from NGPS

Frequency distribution of maximum WTP to reduce gun assaults by 30% implied by descriptive statistics in Table 1	(% households)
$ 0	18.6
25	5.6
50	7.3
100	4.9
200	25.8
400	37.8
Implied mean WTP per household	$212.7
Implied aggregate WTP[a]	$21.8 billion

Notes: Estimates calculated from (weighted) descriptive statistics for NGPS shown in Table 1. Results reported in 1998 dollars.
[a]Obtained by multiplying mean WTP per household by number of households in the United States in 1998, which is equal to 102.5 million (US Bureau of the Census, 1999a,b).

$$
\begin{aligned}
P[I_{1i} = 0, I_{2i} = 0] &= P[Y_i < t_{2i} < t_{1i}] = P[Y_i < t_{2i}] \\
&= P[u_{1i}/\sigma < (\log t_{2i} - \beta)/\sigma] \\
&= F[(\log t_{2i} - \beta)/\sigma] \qquad (3) \\
P[I_{1i} = 1, I_{2i} = 0] &= P[t_{1i} \leq Y_i < t_{2i}] = P[Y_i < t_{2i}] - P[Y_i < t_{1i}] \\
&= F[(\log t_{2i} - \beta)/\sigma] - F[(\log t_{1i} - \beta)/\sigma] \qquad (4) \\
P[I_{1i} = 0, I_{2i} = 1] &= P[t_{2i} \leq Y_i < t_{1i}] = P[Y_i < t_{1i}] - P[Y_i < t_{2i}] \\
&= F[(\log t_{1i} - \beta)/\sigma] - F[(\log t_{2i} - \beta)/\sigma] \qquad (5)
\end{aligned}
$$

We obtain estimates for the parameters of this model by applying maximum-likelihood estimation (MLE) to the log-likelihood function in equation (6).

$$
\begin{aligned}
\ln L = \sum_i &(I_{1i})(I_{2i})\{1 - F[(\log t_{2i} - \beta)/\sigma]\} \\
&+ (1 - I_{1i})(1 - I_{2i})\{F[(\log t_{2i} - \beta)/\sigma]\} \\
&+ (I_{1i})(1 - I_{2i})\{F[(\log t_{2i} - \beta)/\sigma] - F[(\log t_{1i} - \beta)/\sigma]\} \\
&+ (1 - I_{1i})(I_{2i})\{F[(\log t_{1i} - \beta)/\sigma] - F[(\log t_{2i} - \beta)/\sigma]\} \qquad (6)
\end{aligned}
$$

The coefficient estimate for the variables t_{1i} and t_{2i} is an estimate for $1/\sigma$, which in turn allows us to identify an estimate b for the parameter β. Calculating the standard errors for mean and median household WTP is complicated by the fact that our estimate for b is really the ratio of two estimates—the estimated value for β/σ divided by an estimate for $1/\sigma$. Our method for calculating standard errors is provided in the technical appendix. If w_i represents the NGPS sampling weight for household (i), which equals the number of households in the population that each sampled household represents, then estimated societal WTP is given by equation (7). While b provides an unbiased estimate for the expected value of log WTP, for a log-normal variable the mean of WTP itself will be given by $\exp(b) \times \exp(0.5\sigma^2)$ as in equation (7) (Manning, 1998).

$$
\text{Societal WTP } = \sum_i w_i \times \exp(b) \times \exp(0.5\sigma^2) \qquad (7)
$$

In Figure 2, we compare the cumulative distribution function for WTP implied by the parametric estimates presented in Table 3 with the non-parametric function from Figure 1. The MLE estimates imply mean and median household WTP equal to \$203 and aggregate WTP equal to \$20.8 billion, or around \$1 million per injury (Table 4). The parametric estimate does not exceed the non-parametric figure as might be expected because the former uses data from both the first and second CV questions, while the latter is based largely on responses to the first CV question.

We further refine our parametric estimates by calculating mean household WTP conditional on a vector of household characteristics $\mathbf{X}_i$ that may affect the risk of gunshot

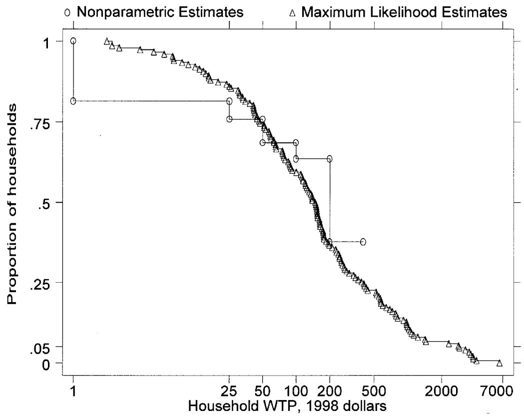

Figure 2. Demand for 30% reduction in gun violence.

Table 3. Coefficient estimates from MLE estimates, from NGPS contingent valuation referendum data

Variable	Without household covariates	With household covariates
Intercept	3.078 (0.155)**	3.096 (0.220)**
Bid value $(1/\sigma)$	0.600 (0.030)**	0.634 (0.033)**
Race		
African-American		−0.046 (0.131)
Hispanic		−0.129 (0.155)
Other Race		−0.213 (0.213)
Region		
Northeast		0.057 (0.119)
Midwest		−0.156 (0.100)
West		−0.155 (0.116)
HH composition		
# Children < 6 in HH		0.229 (0.064)**
# Children 6–17 in HH		0.115 (0.041)**
# Adults in HH		−0.027 (0.057)
Family income		
$20–39,999		0.214 (0.121)*
$40–59,999		0.438 (0.135)**
$60,000 plus		0.449 (0.133)**
Income missing		0.081 (0.141)
Gun in home		−0.201 (0.088)**
N	1,145	1,110
Log likelihood	−804.57	−759.3

Notes: Author calculations from applying maximum likelihood estimation to equation (3) for the 1997 gun survey data and equation (11) for the 1998 gun survey data, under the assumption that WTP is normally distributed. Figures are in 1998 dollars.

*Statistically significant at the 10% level.

**Statistically significant at the 5% level.

injury, attitudes towards risk, or ability to pay. In our empirical analysis the vector of household variables includes income, household composition (the number of children under 6 or 6–17, and the number of adults), household gun ownership, and race.[9]

As seen in Table 3, income has a strong positive effect on support for the violence program. We also find that households with guns have lower WTP than other households to support gun-violence reduction, consistent with previous findings that gun owners are less supportive of gun control than non-owners (Teret et al., 1998). Table 3 also provides some support for the assumption that respondents are reporting on household (rather than individual) WTP, since WTP has a strong correlation with the number of children in the home.

Including the household covariates serves to increase our estimated mean WTP per household from $203 to $239 (Table 4). Total WTP to reduce gun violence by 30% equals $24.5 billion, or around $1.2 million per injury. We use household-level covariates because we interpret the CV responses as reflections of household (rather than individual) WTP. If different individuals within the home would report different WTP values, then our estimates should still be unbiased (since adults are randomly selected from households) but may be inefficient.[10]

Sensitivity analyses

We find that our estimates are fairly robust to assumptions about the distribution of WTP. Re-estimating equation (7) with covariates under the assumption that WTP has a log-logistic (rather than log-normal) distribution produces an estimated mean WTP of $206. Using a normal distribution, which allows WTP to be negative, produces an estimate of $213.

One concern with these CV data is the possibility that responses to the follow-up CV question are influenced by the initial question. As Cameron and Quiggin (1994) note,

Table 4. Maximum likelihood estimates for WTP to reduce gun assaults by 30%, from NGPS data

	Without covariates	With covariates[a]
Estimated WTP to reduce GSW by 30%		
Mean	$203	$239
(95% confidence interval)	(185–220)	(103–375)
Median	$203	$204
(95% confidence interval)	(185–220)	(68–340)
Estimated societal WTP for program to reduce gun assaults by 30%[b]	$20.8 billion	$24.5 billion
Estimated societal WTP for each gun assault avoided	$1.0 million	$1.2 million

Notes: Figures are in 1998 dollars.
[a]Covariates included in model are household income, household composition (the number of children under 6 or 6–17, and the number of adults), household gun ownership status, and race
[b]Obtained by multiplying mean WTP per household by number of households in the United States in 1998, which is equal to 102.5 million (U.S. Bureau of the Census, 1999a,b).

respondents may become more certain about their response to the second rather than first question because they have had more time to reflect on the public good in question. Alternatively, respondents may believe that the first question provides information about the actual average cost of the public good, and may then react negatively to the second question that asks the respondent to pay "more than it costs." The descriptive statistics presented in Table 1 provides some evidence to support this second effect. For example, Table 1 shows that 69% of respondents who are asked about a $100 tax increase in the first question will pay this much to support the program, though only 51% of those who are asked about a $50 increase in the first question will support a $100 tax increase (76% × 67%).

To address the possibility that the respondent is sensitized by the first CV question, and thus that the first and second questions produce draws from slightly different WTP distributions, we follow Cameron and Quiggin (1994) and re-estimate WTP using a bivariate probit model. The bivariate probit model allows for different means for the first and second WTP values ($\beta_1 \neq \beta_2$), as well as separate error processes that have different variances ($\sigma_1^2 \neq \sigma_2^2$) and are only imperfectly correlated ($\mathrm{Corr}[u_{1i}, u_{2i}] = \rho < 1$). Although the bivariate probit model affords greater flexibility than the MLE model given by equation (6), this strategy comes at the cost of less precise estimates (Alberini, 1995) and makes interpretation of the results somewhat complicated. Relative to our preferred WTP estimate of $239 in Table 4, the bivariate-probit estimate for the first referendum response is 30% higher and for the second response is 13% lower. Both of these are within the 95% confidence interval for the estimate in Table 4.

Another concern that commonly arises with CV studies is that of "protest zeroes," defined as cases in which the respondent rejects the hypothetical market scenario even though her true WTP exceeds the stated "price" of the referendum (Mitchell and Carson, 1989). The proper definition of protest zeroes is complicted in our application. Fairly uncontroversial is the case of tax protestors—those respondents who object to financing the program out of tax revenues, but who would be willing to pay the stated amount to achieve a 30% reduction in gun violence if the program were financed by some other means. One possibility is to identify as tax protesters the 24% of respondents who "strongly agree" with the survey question that "taxes are too high." When we re-estimate our model without these respondents in the sample—which is the preferred method for dealing with protesters (Freeman, 1993)—our estimate is only 13% higher than the $239 figure reported in Table 4.

More complicated are cases where the respondent objects to the mechanism for reducing gun violence, rather than the mechanism for financing the program. The NGPS asks about programs that target the illegal use or transmission of firearms, which in turn should reduce gun violence holding the overall crime rate constant. Respondents who object to these interventions should *only* be counted as protest zeroes if alternative interventions exist that could plausibly reduce gun crime without reducing the overall crime rate.

In any case, when we exclude "intervention-protesters," defined as those who "strongly disagree" that "the government should do everything it can to keep handguns out of the hands of criminals, even if it means that it will be harder for law-abiding citizens to purchase handguns," the result is only a 7% increase in WTP compared with Table 4. Another way to assess the problem of "intervention-protestors" is to estimate WTP for those households that own guns, which turns out to be only slightly lower than the estimate for all households ($211 versus $239 per household).

5. Discussion

This article estimates the demand for reductions in crime using CV methods. Our estimates suggest that a 30% reduction in gun violence is worth $24.5 billion to the American public in 1998 dollars, around $1.2 million per injury. These findings are generally quite robust to our decisions about the estimation procedure—even the descriptive statistics imply a societal WTP of $21.8 billion.

The most fundamental issue is whether NGPS respondents take the CV questions seriously and provide thoughtful answers, and, if so, whether these responses reflect underlying preferences about a given quantity of violence reduction rather than social desirability bias, moral satisfaction or some other motivation. CV responses that are motivated by something other than the public's demand for a public good may be insensitive to the quantity of the public good that is offered (the embedding effect), and thus not useful for benefit-cost analysis.

Some evidence that respondents devote at least some thought to answering the CV questions comes from the positive correlation of WTP with family income, consistent with economic theory, and negative correlation with household gun ownership, consistent with previous research that gun owners are less supportive of government efforts to reduce gun violence (Teret et al., 1998).

Our crude test for an embedding effect with the NGPS data suggests that WTP is in fact sensitive to the amount of risk reduction provided. Table 4 shows that WTP increases with the number of children in the home, which in turn is related to the total amount of risk reduction that the households gains from a violence-reduction program. Since these findings could be explained by taste or other differences between households with and without children, we re-estimated our models using only those households with children. We find that each additional child in the home under the age of 6 increases the respondent's WTP by 50%, and each additional child between 6 and 17 increases WTP by 25%. Although these findings provide some evidence against an embedding effect, for some reason additional adults within the home do not appear to increase household WTP.

Our estimates are based on CV questions that are limited in length and level of detail by the constraints of telephone survey methods, and are thus necessarily imperfect. The CV questions used in the gun survey described here can be criticized for excluding important information about the hypothetical interventions that respondents are asked to support, a problem that plagues all CV studies to some degree. In particular, the NGPS questions do not specify the baseline risk to the respondent, although there is substantial heterogeneity in the risk of gunshot injury within the population. This problem may be mitigated somewhat if, as we have suggested earlier, individuals already have incentives to obtain information about their risk of gunshot injury as part of their decisions about where to work and live.

A related concern is that respondents to these CV questions may overstate the baseline risk of gunshot injury as a result of the rash of school shootings that have occurred during the past several years. Although we have no way to directly assess this problem, it is useful to note that the CV survey was conducted during the Fall of 1998, several months before the most heavily publicized school shooting in Littleton, Colorado. Prior to the survey, the most recent school shooting that received substantial national attention occurred in March, 1998 in Jonesboro, Arkansas.

Despite the limitations of these CV survey data, some support for the credibility of our findings comes from their consistency with other benchmarks. As noted above, our estimates for what households are willing to pay to reduce gun crime by 30% seems reasonable compared to what households currently pay in taxes and private expenditures to protect themselves against crime. Our estimates for society's WTP to reduce gun violence are also remarkably consistent with previous estimates from wage-risk tradeoffs. Deriving a value of statistical life from our CV results is complicated somewhat by the fact that our question reflects WTP for both fatal and nonfatal gunshot injuries. If we start with the extreme assumption that WTP is driven entirely by concern about fatal gunshot injuries, then our preferred estimate of $1.2 million per gunshot injury avoided implies a value per statistical life equal to around $6.8 million. But presumably part of WTP to reduce gun injuries is motivated by concern about non-fatal gunshot injuries. If we assume that non-fatal gunshot injuries are twice as undesirable as the average workplace injury, our estimates imply a value per statistical life of around $5.4 million.[11] By way of comparison, studies of wage-risk tradeoffs produce estimates for the value of life (also in 1998 dollars) between $3.7 and $8.6 million (Viscusi, 1993).

We would expect societal WTP to be far smaller if citizens were concerned only about reducing the risk of gun injury to themselves and members of their families. The reason is that gunshot injuries in the United States are highly concentrated among a group of people who on average are far less risk averse than are members of the general population. Two-thirds of all firearm homicides in 1996 were to males between the ages of 15 and 39 (CDC, 1999), and three-quarters of gun homicide victims under 21 in Boston in 1990–94 had criminal records (Kennedy, Piehl, and Braga, 1996). Levitt and Venkatesh (2000) studied the records documenting the opportunities and violence-victimization risks for members of a crack-dealing street gang: Comparing the risk to the reward suggests that they placed a value on a statistical life of just $55,000 on average. Our WTP estimates thus suggest that the benefits from reducing gun violence in America are substantial, and accrue primarily to citizens at low personal risk of injury through reductions in risk to friends, family and others for whom they feel altruistic, lower tax bills, or improvements to the overall quality of community life.

Finally, it is important to note that our CV estimates are for *marginal* reductions in the prevalence of gun violence, and can provide only limited information about the benefits of eliminating gun violence altogether. Simply multiplying our estimates for the value of a 30% reduction in gun violence by 3.33 may either understate or overstate the value of a 100% reduction. This simple extrapolation may produce a number that is too low if some forms of averting behavior only respond to the complete elimination of gunshot injuries. On the other hand, this extrapolation could produce a number that is too high if the technology of reducing gunshot injuries is different from that of complete elimination. Although marginal reductions in gun violence are possible without much affecting hunting or defensive gun use, the complete elimination of gun violence is unlikely to be attainable without at least some effect on whatever benefits arise from guns. Of course, with more than 200 million guns already in circulation (Cook and Ludwig, 1996), ending gun violence altogether in America is an unrealistic objective for public policy in any case.

Appendix

A. Calculating standard errors for mean and median WTP

The usual standard error formula for a linear predictor evaluated at some value of the regressors $\mathbf{x}_0$ is given by equation (A1)

$$SE(\mathbf{x}_0{}'\mathbf{b}) = (\mathbf{x}_0\mathbf{V}\mathbf{x}_0')^{1/2} \tag{A1}$$

Estimation of the log likelihood given in equation (7) is simplified somewhat because b is a scalar rather than a vector, so V is also a scalar equal to the variance of b, $x_0 = 1$, and equation (A1) simplifies to (A2)

$$\mathrm{SE}(b) = (V)^{1/2} \tag{A2}$$

The complication in our case comes from the fact that b is actually the ratio of two estimates b'/s', where b' is an estimate for (β/σ) and s' is an estimate for $(1/\sigma)$. In this case the variance for $b = b'/s'$ can be approximated by the formula given in equation (A3) (Yates, 1981, p. 190)

$$V = \mathrm{Var}(b) = \mathrm{Var}(b'/s') \approx (b'/s')^2\left[(\mathrm{Var}(b'))/(b')^2 + (\mathrm{Var}(s'))/(s')^2\right] \tag{A3}$$

The final complication is that (A3) gives us the variance for the estimated mean of the natural log of Y (WTP), while ultimately we are interested in the variance of predicted mean of the untransformed WTP. With $E[\ln Y] = b$ and $\mathrm{Var}(E[\ln Y]) = V$ then the variance of $E[Y]$ is given by equation (A4) (Maddala, 1977, p. 33).

$$\mathrm{Var}(E[Y]) = \exp(2b + V) * (e^V - 1) \tag{A4}$$

Notes

1. Unpublished figures from the Vital Statistics for fatal gun homicides from 1972 onward were provided to us by James Mercy of the Centers for Disease Control and Prevention. Estimates for the number of non-fatal assault-related gunshot injuries come from applying the case-fatality ratios reported in Cook and Ludwig (2000).
2. See for example Fox Butterfield, "Small-Print Provisions of Gun Bill Please Federal Officials Best," *New York Times*, May 22, 1999, and "Handguns: Who Will Stand Up?" Editorial, *Washington Post*, April 28, 1999.
3. Unpublished calculations kindly provided to us by Julie Cullen and Steve Levitt show that each additional homicide reduces a city's population by 70 residents, far larger than the 1-resident reduction caused by each additional non-fatal violent or property crime.
4. Only a handful of studies have adopted an *ex ante* approach to evaluating the benefits of reducing crime. All of these studies rely on hedonic-pricing methods to relate crime rates and housing prices (Thaler, 1978; Hellman and Naroff, 1978; Rizzo, 1979). These estimates rely on data from a single city, may confound the price effects of crime with other factors, and are incomplete. None of these studies focuses on gun violence specifically.
5. The COI approach defines lost productivity as foregone earnings plus the lost value of household work; all other forms of non-market production are excluded. See Kenkel (1994) for a detailed review of the COI approach.
6. One implication of this assumption is that our analysis should convert the NGPS sampling weights from person weights into household weights. The NGPS respondent weights calculated by NORC equal one divided by the probability of the household's selection into the sample. The weights are then divided by the adult's probability of selection from within the household, equal to (1/A) where A is the number of adults in the home. To convert these into household weights we multiply by (1/A).
7. The estimate in Table 2 for the proportion of households who would pay $400 per year is derived by multiplying the proportion of household who say they would pay $200 to fund the program in the first CV question (63.6% from the last column of Table 1) by the proportion who answer yes to the follow-up CV question. To derive the share of households whose WTP is $200 we multiply those who say yes to an initial bid value of $100 by the fraction who say no to the follow-up question. The estimates in Table 2 for WTP of $0 and $25 are derived using an analogous procedure for those who say no to an initial bid value of $50. The estimated proportion of households whose WTP is $50 in Table 2 comes from subtracting the share of households whose WTP is $0 or $25 (Table 2) from the proportion of households who say no to an initial bid value of $100 (Table 1). The figure for the $100 WTP level in Table 2 comes from subtracting the share of household whose WTP is $200 or $400 from the share who say yes to an initial bid value of $100.
8. Data from the Vital Statistics census of deaths suggest that there were 12,102 firearm homicides in 1998 (NCHS, 2000). To calculate the total number of assault-related firearm injuries we multiply the number of gun homicides by the estimated ratio of total to fatal assault-related gun injuries for 1997 (5.69) from Cook and Ludwig (2000).
9. Since only 2.2% of all marriages were inter-racial in 1992, the last year for which such data are available (US Bureau of the Census, 1999b), we infer "household race" from the respondent's race. The household gun ownership measure will slightly understate the true prevalence of gun ownership across households because some married women either do not know about or are unwilling to report on guns owned by their spouses (Ludwig, Cook, and Smith, 1998).
10. To explore this possibility, we re-estimated our preferred MLE model after restricting the sample to married respondents and including an indicator for the respondent's gender. While the coefficient estimate for an indicator variable for husbands is negative and statistically significant, inclusion of this variable serves to reduce estimated mean WTP by less than 7% compared with the results obtained when the variable is excluded.
11. This comes from multiplying twice the highest estimate for workplace injuries reported in Viscusi (1993), around $300,000 in 1998 dollars, by the number of nonfatal gun injuries for every fatality (4.69), and subtracting this figure ($1.4 million) from the estimated value of 5.69 gunshot injuries ($6.8 million).

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