LIST OF EXHIBITS

Exhibit 1: Senator Diane Feinstein summary of proposed legislation http://www.feinstein.senate.gov/public/index.cfm/files/serve/?File_id=10993387-5d4d-4680-a872-ac8ca4359119

Exhibit 2: FICG Letter to ATF dated Oct. 3, 2013 (and materials referenced therein)

A -- FICG letter to ATF dated Sept. 1, 2013
B -- ATF e-Mail Response to FICG dated Sept. 4, 2013
C -- Rep. David M. Maloney, Sr. letter to ATF dated Sept. 6, 2013
D -- FICG letter to ATF dated Sept. 9, 2013
E -- FICG letter to ATF dated Sept. 10, 2013
F -- FICG letter to ATF dated Sept. 11, 2013

Exhibit 3: Memorandum from Polly Trottenburg & Robert S. Rivkin to Secretarial Officers & Modal Administrators, "Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses" (Feb. 28, 2013)

Exhibit 4: Comment of Thomas J. Braddock, Jr. (and materials referenced therein)

A -- Letter to Luzerne County District Attorney,
Stephanie Salavantis (Apr. 22, 2013)
B -- Letter to Pennsylvania Attorney General,
Kathleen G. Kane (May 22, 2013)
C -- Letter from Chief Deputy Attorney General
(Office of Civil Law),
Robert A. Mulle (July 1, 2013)

Exhibit 5: St. Johns County Sheriff Facebook Posting (July 11, 2012)

Exhibit 6: "Silencers Loophole Targeted for Closure," *Wall Street Journal,* Oct. 3, 2013

Exhibit 7: Silencer Legality & Ownership Map, http://americansilencerassociation.com/education/

Exhibit 8: Gregory A. Flamme, et. al., "Auditory Risk to Unprotected Bystanders Exposed to Firearm Noise, " 22 *J. Am. Acad. Audiology* 93 (2011).

Exhibit 9: Michael Stewart, et. al., "Risks Faced by Recreational Firearm Users," *Audiology Today* 38, 40 (Mar.-Apr. 2011).

Exhibit 10: Article by Matthew Parker Branch, M.D.

Exhibit

1

Summary of 2013 Feinstein Assault Weapons Legislation

Bans the sale, transfer, importation, or manufacturing of:

- 120 specifically-named firearms
- Certain other semiautomatic rifles, handguns, shotguns that can accept a **detachable magazine** and have **one military characteristic**
- Semiautomatic rifles and handguns with a **fixed magazine** that can accept **more than 10 rounds**

Strengthens the 1994 *Assault Weapons Ban* and various state bans by:

- Moving from a 2-characteristic test to a **1-characteristic** test
- Eliminating the easy-to-remove bayonet mounts and flash suppressors from the characteristics test
- Banning firearms with "**thumbhole stocks**" and "**bullet buttons**" to address attempts to "work around" prior bans

Bans large-capacity ammunition feeding devices capable of accepting more than 10 rounds.

Protects legitimate hunters and the rights of existing gun owners by:

- **Grandfathering** weapons legally possessed on the date of enactment
- **Exempting** over 900 specifically-named weapons used for hunting or sporting purposes and
- **Exempting** antique, manually-operated, and permanently disabled weapons

Requires that grandfathered weapons be **registered** under the **National Firearms Act**, to include:

- **Background check** of owner and any transferee;
- **Type and serial number** of the firearm;
- **Positive identification**, including photograph and fingerprint;
- Certification from **local law enforcement** of identity and that possession would not violate State or local law; and
- Dedicated funding for ATF to **implement registration**

Exhibit

2

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October 03, 2013

Ms. Stephanie M. Boucher
Disclosure Division
Bureau of Alcohol, Tobacco, Firearms and Explosives
99 New York Avenue, NE
Washington, DC 20226

Brenda Raffath Friend, Esquire
Bureau of Alcohol, Tobacco, Firearms, and Explosives
Office of Regulatory Affairs, Enforcement Programs and Services
Mailstop 6N-602
99 New York Avenue, NE,
Washington, DC 20226

RE: **Re: ATF 41P -- Notice of Proposed Rulemaking**

Dear Ms. Boucher and Attorney Friend,

The Bureau of Alcohol, Tobacco, Firearms, and Explosives ("ATF") is in the midst of the public comment phase in rulemaking ATF 41P. On September 27, 2013, I made arrangements through the Disclosure Division to visit the public reading room on Monday, September 30, for the express purpose of reviewing the entire docket in ATF 41P. I spoke with Team Leader Peter J. Chisholm in coordinating that visit. I made clear and he acknowledged understanding that I wanted to review everything that had been filed in the docket, not just public comments.

When I arrived at ATF at the appointed time on September 30, all that was made available to me were the public comments. I asked Team Leader Chisholm to confirm that that was the case. He did. I asked again for anything and everything that ATF had placed into the docket. Team Leader Chisholm confirmed that I had everything. I pointed out that the Federal Register notice was not even provided and I asked Team Leader Chisholm to sign an acknowledgment that I had

requested the entire docket and been provided only the public comments. After consulting with Chief Boucher, he declined saying that he agreed with everything in the tendered statement but had been directed not to sign because ATF was not required to do so.

I had made perfectly clear to Team Leader Chisholm when I first spoke to him that I was driving two-and-a-half hours each way to inspect the docket. Despite my diligent efforts, it appears that one or both of you are ignoring your obligations to the public and transforming the public comment period into some form of bad performance art.

First, the comments I did receive were consecutively numbered starting with 2, mirroring the numbers assigned to those comments when posted on www.regulations.gov. On www.regulations.gov, the obvious reason for starting with 2 was that the first entry recorded into the docket was the Notice of Proposed Rulemaking itself ("NPR"). Yet, not even the NPR was made available in response to my request to see the entire docket. The federal Freedom of Information Act, 5 U.S. Code § 552 (hereinafter "FOIA"), applies not only to written requests for documents; it also mandates that agencies make documents available for inspection, *id.* § 552(a)(2), as well as requiring the publication of others, *id.* § 552(a)(1). I do not see how either of you could conclude that you made a good faith effort to comply with your obligations under FOIA. The failure to include the NPR in the documents provided me leaves me still wondering what else was excluded. The failure to sign a factually correct statement compounds the problem. Not only have I been denied access to materials to which FOIA entitles me, I have been denied a written determination of that fact.

Second, upon review of the materials that were provided to me, it was evident that written communications (what FOIA calls "documents") to and from Attorney Friend concerning rulemaking ATF 41P and so captioned had been omitted. I know of some of these documents and can identify them in detail. I know they were sent and received. What I do not know is on what possible basis they were excluded from the docket and what other similar documents may exist of which I have no direct knowledge. Among this class of documents, I know of the following:

- Letter to Ms. Friend from Joshua Prince requesting documents referenced in the NPR (Sept. 1, 2013)
- E-mail from Ms. Friend to Joshua Prince responding to his letter requesting those documents (Sept. 4, 2013)
- Letter to Ms. Friend from David M. Maloney, Sr., of the Pennsylvania House of Representatives (Sept. 6, 2013)
- Letter to Ms. Friend from Joshua Prince renewing his request for the documents referenced in the NPR (Sept. 9, 2013)

- Letter to Ms. Friend from Joshua Prince regarding misleading information posted by ATF on www.regulations.gov (Sept. 10, 2013)

- Letter to Ms. Friend from Joshua Prince regarding delays in the posting of comments to www.regulations.gov (Sept. 11, 2013)

I have reason to believe that there are more such written communications to and from Ms. Friend, the designated contact person for ATF 41P. The public has a right to know of the issues raised in *all* such documents, not just those ATF arbitrarily decides place in the docket.

I respectfully request that you promptly (1) place this letter in the docket for ATF 41P, (2) ensure the specific documents referenced above are placed in the docket for ATF 41P, (3) locate and place all similar documents in the docket for ATF 41P, and (4) locate and place the pertinent ATF-generated documents in the docket for ATF 41P.

Yours truly,
Prince Law Offices, P.C.,

Tom Odom

Tom Odom
todom@princelaw.com

to/web
Matter No. 31821
By email: Ms. Stephanie M. Boucher
By fax: Brenda Raffath Friend, Esquire

Exhibit

A

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September 01, 2013

Ms. Brenda Raffath Friend
Bureau of Alcohol, Tobacco, Firearms, and Explosives
Office of Regulatory Affairs, Enforcement Programs and Services
Mailstop 6N-602
99 New York Avenue, NE,
Washington, DC 20226

RE: **ATF Proposal to Further Restrict Access to Firearms Under the National Firearms Act, Docket Number ATF 41P RIN 1140-AA43**

Dear Ms. Friend,

I am writing in connection with the above-referenced draft proposed rule posted on the Department of Justice Website last week that identifies you as the contact person. The draft makes reference to numerous sources purportedly considered by the Bureau of Alcohol, Tobacco, Firearms, and Explosives ("ATF") in formulating the proposal.

I have examined the Federal e-Rulemaking portal, www.regulations.gov, but do not find any docket entries for either ATF 41P or RIN 1140-AA43. In order to ensure an adequate opportunity to comment on the ATF proposal, I respectfully request that you immediately make available the following documents together with any others upon which ATF relied in preparing the proposal:

1. The National Firearms Act Trade and Collectors Association ("NFATCA") petition for rulemaking dated December 3, 2009, together with other documents exchanged with NFATCA or disclosing consultations with NFATCA on the subjects on the petition.

2. The "numerous statements" that ATF has received from Chief Law Enforcement Officers ("CLEOs") regarding purported reasons CLEOs decline to sign applications.

3. Documents regarding the denial of an unidentified person's application for transfer of a silencer and that individual's subsequent effort to procure transfer of the same silencer to a trust as to which the individual was the settlor.

4. Documents regarding the situation in Texas in which ATF became aware that "a member of a LLC was an illegal alien, living in the United States under an assumed name, and had a felony warrant outstanding" at the time "the LLC had 19 firearms registered to it".

5. Documents regarding the situation in Tennessee in which "ATF became aware of applications submitted to transfer two NFA firearms to a trust in which one of the trustees was a convicted felon."

6. Documents demonstrating the basis for ATF's "estimate" that, on average, legal entities have only two responsible persons, including the methodology for the survey of thirty-nine applications.

7. Documents reflecting the methodology for the selection of the sample upon which ATF based the estimate of an average of only 15 pages per submission for the proof of the existence and validity of a legal entity (e.g., partnership agreements, articles of incorporation and corporate registration, declarations of trust with any trust schedules, attachments, exhibits, and enclosures).

Please send the documents to me or advise me where I may access them now. All communications should be sent to:

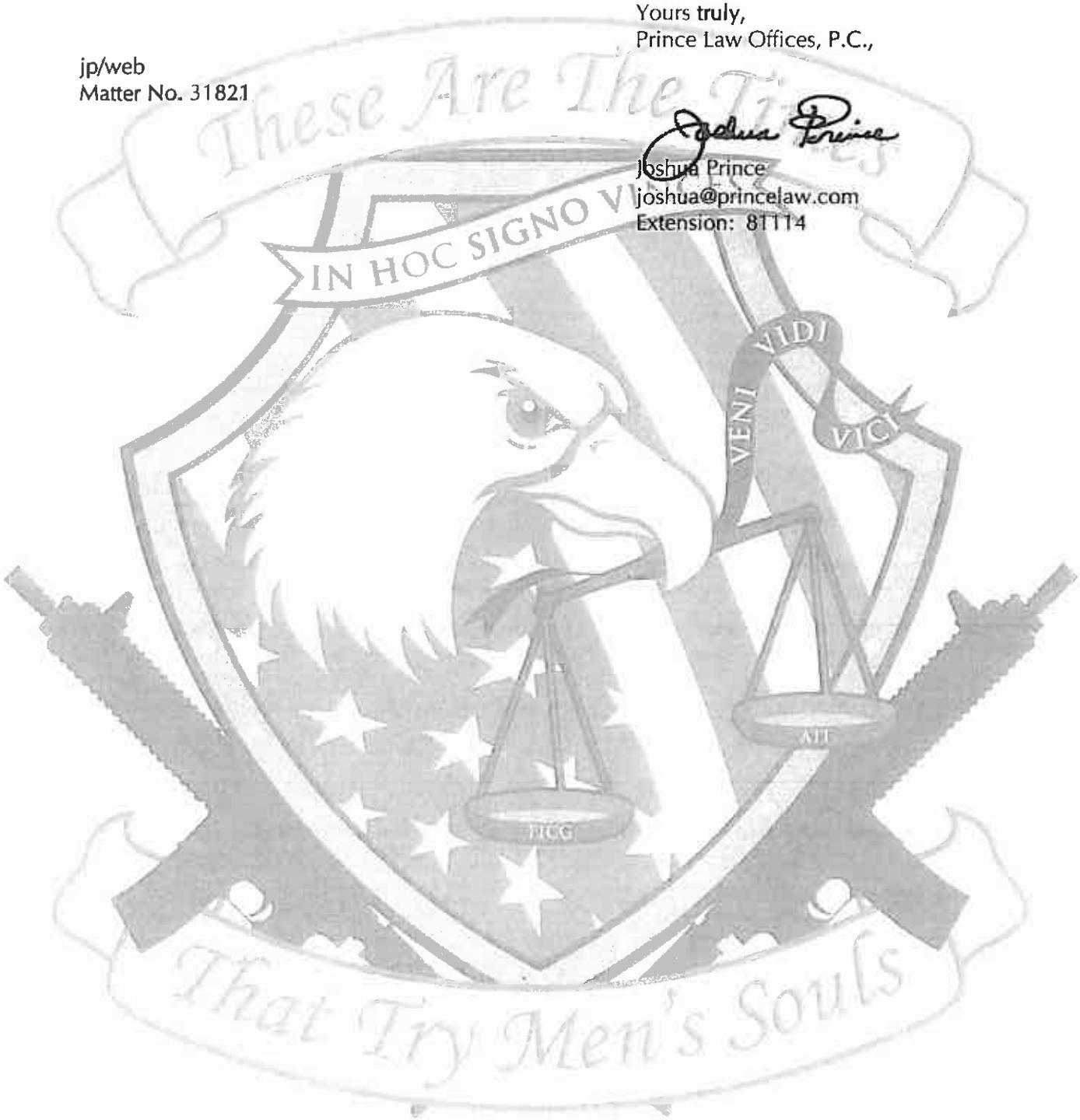
Joshua Prince, Esq.
Firearms Industry Consulting Group
646 Lenape Rd
Bechtelsville, PA 19505
610-845-3803
Joshua@PrinceLaw.com

Thank you for your attention to this matter.

Yours truly,
Prince Law Offices, P.C.,

jp/web
Matter No. 31821

Joshua Prince
joshua@princelaw.com
Extension: 81114



Exhibit

B

31821
CEA

Josh

<Brenda.R.Friend@usdoj.gov> September 4, 2013 5:06 PM
To: Joshua Prince
Your Faxes Dated September 1 and 2, 2013

Mr. Prince,

I am in receipt of your two facsimile transmissions dated September 1 and 2, 2013. I have given the one dated September 1, 2013 to ATF's Freedom of Information Act Disclosure Division. The September 2, 2013 fax will be treated as a public comment to the proposed rule and, as such, will be addressed to the extent appropriate, as part of the rulemaking process. You are welcome to submit other public comments. The proposed rule is expected to publish this week in the Federal Register.

Thank you,

Brenda Friend

Exhibit

C

Josh

DAVID M. MALONEY, SR.
MEMBER
130TH LEGISLATIVE DISTRICT

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31821 CEI

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Fax: (610) 385-1176

COMMITTEES:
Local Government,
Subcommittee Chairman on Counties
Children and Youth
Commerce
Game and Fisheries
State Government

September 6, 2013

Brenda Raffath Friend
Office of Regulatory Affairs
Enforcement Programs and Services
Bureau of Alcohol, Tobacco, Firearms and Explosives

Dear Brenda,

I have had the chance to briefly review the notice of proposed rulemaking to 27 C.F.R. Part 479, dated Aug. 29, 2013, Docket No. ATF 41P, obtained from the library at www.atf.gov. As a preliminary matter, while I strongly support the right of citizens to keep and bear arms under the Second Amendment to the United States Constitution as well as Article I, § 21 of the Pennsylvania Constitution, I also understand the desire to prevent firearms from falling into the hands of criminals.

At this point, without focusing on the specific changes suggested in the notice of proposed rulemaking, I wanted to raise concerns about the process thus far. I believe that changes of this magnitude, which have the potential to affect local law enforcement agencies, small businesses and other individuals and entities throughout the Commonwealth of Pennsylvania, deserve a thorough review. I am somewhat troubled by the cavalier disregard of the review requirements and attendant provisions of the Regulatory Flexibility Act, the Small Business Regulatory Enforcement Fairness Act of 1996 and the Unfunded Mandates Reform Act of 1995. These important analytical tools provide information needed for a complete and thorough consideration of the impact of federal regulations. I believe it would be inappropriate to proceed without taking the time, and working through the steps, to come up with a fair, balanced and reasonable regulatory change.

I appreciate your time and attention to my communication and look forward to a response.

Thank you for your time and consideration.

David M. Maloney Sr.
State Representative
130th Legislative District

Exhibit

D

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September 09, 2013

Brenda Raffath Friend, Esquire
Bureau of Alcohol, Tobacco, Firearms, and Explosives
Office of Regulatory Affairs, Enforcement Programs and Services
Mailstop 6N-602
99 New York Avenue, NE,
Washington, DC 20226

RE: **ATF Proposal to Further Restrict Access to Firearms Under the National Firearms Act, Docket Number ATF 41P RIN 1140-AA43**

Dear Attorney Friend,

To the extent your previous e-mail response to my requests of September 1, 2013 and September 2, 2013, were premised on them being premature because the Notice of Proposed Rulemaking had not yet been published in the *Federal Register*, I hereby renew the requests. In the alternative, to the extent you deem both the earlier requests and this renewal to be noting more than requests under the Freedom of Information Act ("FOIA"), I respectfully request the FOIA reference number assigned to my September 1, 2013 request. For your convenience, I am enclosing a copy of my original requests of September 1, 2013 and September 2, 2013.

Thank you for your time and consideration in this request.

Yours truly,
Prince Law Offices, P.C.,

jp/web
Matter No. 31821

Enclosure
By fax: Brenda Raffath Friend, Esquire

Joshua Prince
joshua@princelaw.com
Extension: 81114

Exhibit

E

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September 10, 2013

Brenda Raffath Friend, Esquire
Bureau of Alcohol, Tobacco, Firearms, and Explosives
Office of Regulatory Affairs, Enforcement Programs and Services
Mailstop 6N-602
99 New York Avenue, NE,
Washington, DC 20226

RE: **ATF Proposal to Further Restrict Access to Firearms Under the National Firearms Act, Docket Number ATF 41P RIN 1140-AA43**

Dear Attorney Friend,

With the publication of the Notice of Proposed Rulemaking ("NPR") in ATF 41P yesterday, the electronic portal at www.regulations.gov was opened. I was struck by the fact that the only item placed in the docket at the same time as the NPR was a final rule entitled Importation of Defense Articles and Defense Services: U.S. Munitions Import List, codified in 27 C.F.R. Part 447. As the NPR addresses 27 C.F.R. Part 449, it is not immediately apparent what relationship the final rule has to the newly-proposed rule. The NPR in ATF 41P contains no reference either to Part 447 or the U.S. Munitions Import List.

If the final rule was added to this docket by mistake, I respectfully request that it be removed as it would seem very likely to confuse interested persons who care to comment on ATF 41P. Such confusion would seem to be compounded by the fact that the "Primary Documents" page for ATF 41P contains the text "Comment Period Closed" which could lead some interested persons to believe that it was too late to submit comments with respect to ATF 41P.

Thank you for your attention to this matter.

Yours truly,
Prince Law Offices, P.C.,

jp/web
Matter No. 31821
By fax: Brenda Raffath Friend, Esquire

Joshua Prince
joshua@princelaw.com
Extension: 81114

Exhibit

F

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September 11, 2013

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Bureau of Alcohol, Tobacco, Firearms, and Explosives
Office of Regulatory Affairs, Enforcement Programs and Services
Mailstop 6N-602
99 New York Avenue, NE,
Washington, DC 20226

RE: **ATF Proposal to Further Restrict Access to Firearms Under the National Firearms Act, Docket Number ATF 41P RIN 1140-AA43**

Dear Attorney Friend,

With the publication of the Notice of Proposed Rulemaking ("NPR") in ATF 41P on Monday, the electronic portal at www.regulations.gov was opened. The Docket Folder Summary page for the rulemaking reflects that as of midnight last night 102 comments had been "received." Yet, no comments are "posted" so as to permit public access to them.

The Docket Folder does state: "This count refers to the total comments received on this docket, as of 11:59 PM yesterday, from Regulations.gov and alternate means. All comments including the bulk submissions received for this docket may not be posted at this time; therefore, the counts may differ between: total comments received and posted, as well as the counts shown on the Docket Folder Summary page."

As I am sure you are aware, one of the benefits that Regulations.gov is designed to provide is a means for persons who have submitted comments to confirm that they have properly been posted to the docket. Rather than provide a substantive response to at least one of my prior

letters to you, you indicated by e-mail that you would post the inquiry to the docket as a comment. In the absence of posting the comments, I have no way to verify whether such filing has been completed. Moreover, even if I had your assurance that filing has been completed, the issues that I raised are of general concern to interested persons who may be filing their own comments and, as a consequence, such persons should be able to view the comments.

Another benefit that Regulations.gov is designed to provide is that we, as interested persons preparing our own comments, would have access to the comments that other interested persons have already filed so as to evaluate whether particular issues have been adequately raised and supported, as well as to evaluate and respond to any alternative proposals raised in the comments of other interested persons. That purpose is not served if public comments are not posted to the Docket Folder on a timely basis.

As a consequence, I respectfully request that you immediately investigate the source of delays in the posting of comments received to the Docket Folder. If it is a simple matter of recoding something on the site to open comments to public inspection, please do so immediately. I understand that the Docket Folder only opened this week but if these delays are going to continue, due to some sort of processing issues, please provide information regarding the anticipated length of delay from receipt to posting. Also, if physical copies of comments received and the entire docket will be available for inspection with any shorter lag time, please let me know so that I can make arrangements for daily in-person inspection.

Thank you for your attention to this matter.

Yours truly,
Prince Law Offices, P.C.,

jp/web
Matter No. 31821
By fax: Brenda Raffath Friend, Esquire

Joshua Prince
joshua@princelaw.com
Extension: 81114

Exhibit

3

U.S. Department of Transportation

Office of the Secretary of Transportation

February 28, 2013

1200 New Jersey Avenue, SE
Washington, DC 20590

MEMORANDUM TO: **SECRETARIAL OFFICERS**
MODAL ADMINISTRATORS

From: Polly Trottenberg
Under Secretary for Policy
X6-4540

Robert S. Rivkin
General Counsel
x6-4702

Subject: Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses

---

Departmental guidance on valuing reduction of fatalities and injuries by regulations or investments has been published periodically by this office since 1993. We issued a thorough revision of our guidance in 2008 and have issued annual updates to adjust for changes in prices and real incomes since then. Our most recent update, dated July 29, 2011, stated that a new review of the technical literature would be conducted to inform the next publication. The conclusions of that review are incorporated in this guidance.

Empirical studies published in recent years indicate a VSL of $9.1 million in current dollars for analyses using a base year of 2012. We also find that an income elasticity of 1.0 should be used to project VSL to future years. Based on wage forecasts from the Congressional Budget Office, we estimate that there will be an expected 1.07 percent annual growth rate in median real wages over the next 30 years (2013-2043). These estimates imply that VSL in future years should be estimated to grow by 1.07 percent per year before discounting to present value.

This guidance also includes a table of the relative values of preventing injuries of varied severity, unchanged since the 2011 guidance. We also prescribe a sensitivity analysis of the effects of using alternative VSL values. Instead of treating alternative values in terms of a probability distribution, analysts should apply only a test of low and high alternative values of $5.2 million and $12.9 million.

This guidance and other relevant documents will be posted on the Reports page of the Office of Transportation Policy website, http://www.dot.gov/policy, and on the General Counsel's regulatory information website, http://www.dot.gov/regulations. Questions should be addressed to Jack Wells, (202) 366-9224 or jack.wells@dot.gov.

cc: Regulations officers and liaison officers

Revised Departmental Guidance 2013:

Treatment of the Value of Preventing Fatalities and Injuries in Preparing Economic Analyses

On the basis of the best available evidence, this guidance identifies $9.1 million as the value of a statistical life to be used for Department of Transportation analyses assessing the benefits of preventing fatalities and using a base year of 2012. It also establishes policies for projecting future values and for assigning comparable values to prevention of injuries.

Background

Prevention of injury, illness, and loss of life is a significant factor in many private economic decisions, including job choices and consumer product purchases. When government makes direct investments or controls external market impacts by regulation, it also pursues these benefits, often while also imposing costs on society. The Office of the Secretary of Transportation and other DOT administrations are required by Executive Order 13563, Executive Order 12866, Executive Order 12893, OMB Circular A-4, and DOT Order 2100.5 to evaluate in monetary terms the costs and benefits of their regulations, investments, and administrative actions, in order to demonstrate the faithful execution of their responsibilities to the public. Since 1993, the Office of the Secretary of Transportation has periodically reviewed the published research on the value of safety and updated guidance for all administrations. Our previous guidance, issued on July 29, 2011, stated that a new review of the literature (our first since 2008) would be conducted to inform the next publication. The conclusions of that review are incorporated in this guidance.

The benefit of preventing a fatality is measured by what is conventionally called the Value of a Statistical Life (VSL), defined as the additional cost that individuals would be willing to bear for improvements in safety (that is, reductions in risks) that, in the aggregate, reduce the expected number of fatalities by one. This conventional terminology has often provoked misunderstanding on the part of both the public and decision-makers. What is involved is not the valuation of life as such, but the valuation of reductions in risks. While new terms have been proposed to avoid misunderstanding, we will maintain the common usage of the research literature and OMB Circular A-4 in referring to VSL.

Most regulatory actions involve the reduction of risks of low probability (as in, for example, a one-in-10,000 annual chance of dying in an automobile crash). For these low-probability risks, we shall assume that the willingness to pay to avoid the risk of a fatal injury increases proportionately with growing risk. That is, when an individual is willing to pay $1,000 to reduce the annual risk of death by one in 10,000, she is said to have a VSL of $10 million. The assumption of a linear relationship between risk and willingness to pay therefore implies that she would be willing to pay $2,000 to reduce risk by two in 10,000 or $5,000 to reduce risk by five in 10,000. The assumption of a linear relationship between risk and willingness to pay (WTP) breaks down when the annual WTP becomes a substantial portion of annual income, so the assumption of a constant VSL is not appropriate for substantially larger risks.

When first applied to benefit-cost analysis in the 1960s and 1970s, the value of saving a life was measured by the potential victim's expected earnings, measuring the additional product society might have lost. These lost earnings were widely believed to understate the real costs of loss of life, because the value that we place on the continued life of our family and friends is not based entirely, or even principally, on their earning capacity. In recent decades, studies based on estimates of individuals' willingness to pay for improved safety have become widespread, and offer a way of measuring the value of reduced risk in a more comprehensive way. These estimates of the individual's value of safety are then treated as the ratio of the individual marginal utility of safety to the marginal utility of wealth. These estimates of the individual values of changes in safety can then

be aggregated to produce estimates of social benefits of changes in safety, which can then be compared with the costs of these changes.

Studies estimating the willingness to pay for safety fall into two categories. Some analyze subjects' responses in real markets, and are referred to as revealed preference (RP) studies, while others analyze subjects' responses in hypothetical markets, and are described as stated preference (SP) studies. Revealed preference studies in turn can be divided into studies based on consumer purchase decisions and studies based on employment decisions (usually referred to as hedonic wage studies). Even in revealed preference studies, safety is not purchased directly, so the value that consumers place upon it cannot be measured directly. Instead, the value of safety can be inferred from market decisions that people make in which safety is one factor in their decisions. In the case of consumer purchase decisions, since goods and services usually display multiple attributes, and are purchased for a variety of reasons, there is no guarantee that safety will be the conclusive factor in any purchasing decision (even products like bicycle helmets, which are purchased primarily for safety, also vary in style, comfort, and durability). Similarly, in employment decisions, safety is one of many considerations in the decision of which job offer to accept. Statistical techniques must therefore be used to identify the relative influence of price (or wage), safety, and other qualitative characteristics of the product or job on the consumer's or worker's decision on which product to buy or which job to accept.

An additional complication in RP studies is that, even if the real risks confronted by individuals can be estimated accurately by the analyst, the consumer or employee may not estimate these risks accurately. It is possible for individuals, through lack of relevant information or limited ability to analyze risks, to assign an excessively low or high probability to fatal risks. Alternatively, detailed familiarity with the hazards they face and their own skills may allow individuals to form more accurate estimates of risk at, for example, a particular job-site than those derived by researchers, which inevitably are based on more aggregate data.

In the SP approach, market alternatives incorporating hypothetical risks are presented to test subjects, who respond with what they believe would be their choices. Answers to hypothetical questions may provide helpful information, but they remain hypothetical. Although great pains are usually taken to communicate probabilities and measure the subjects' understanding, there is no assurance that individuals' predictions of their own behavior would be observed in practice. Against this weakness, the SP method can evaluate many more alternatives than those for which market data are available, and it can guarantee that risks are described objectively to subjects. With indefinitely large potential variations in cost and risk and no uncontrolled variation in any other dimension, some of the objections to RP models are obviated. Despite procedural safeguards, however, SP studies have not proven consistently successful in estimating measures of WTP that increase proportionally with greater risks.

RP studies involving decisions to buy and/or use various consumer products have focused on decisions such as buying cars with better safety equipment, wearing seat belts or helmets, or buying and installing smoke detectors. These studies often lack a continuum of price-risk opportunities, so that the price paid for a safety feature (such as a bicycle helmet) does not necessarily represent the value that the consumer places on the improvement in safety that the helmet provides. In the case of decisions to use a product (like a seatbelt) rather than to buy the product, the "price" paid by the consumer must be inferred from the amount of time and degree of inconvenience involved in using the product, rather than the directly observable price of buying the product. The necessity of making these inferences introduces possible sources of error. Studies of purchases of automobiles probably are less subject to these problems than studies of other consumer decisions, because the price of the safety equipment is directly observable, and there are usually a variety of more or less expensive safety features that provide more of a range of price-risk trade-offs for consumers to make.

While there are many examples of SP studies and RP studies involving consumer product purchases, the most widely cited body of research comprises hedonic wage studies, which estimate the wage differential that

employers must pay workers to accept riskier jobs, taking other factors into account. Besides the problem of identifying and quantifying these factors, researchers must have a reliable source of data on fatality and injury risks and also assume that workers' psychological risk assessment conforms to the objective data. The accuracy of hedonic wage studies has improved over the last decade with the availability of more complete data from the Bureau of Labor Statistics' (BLS) Census of Fatal Occupational Injuries (CFOI), supported by advances in econometric modeling, including the use of panel data from the Panel Study of Income Dynamics (PSID). The CFOI data are, first of all, a complete census of occupational fatalities, rather than a sample, so they allow more robust statistical estimation. Second, they classify occupational fatalities by both industry and occupation, allowing variations in fatalities across both dimensions to be compared with corresponding variations in wage rates. Some of the new studies use panel data to analyze the behavior of workers who switch from one job to another, where the analysis can safely assume that any trade-off between wage levels and risk reflects the preferences of a single individual, and not differences in preferences among individuals.

VSL estimates are based on studies of groups of individuals that are covered by the study, but those VSL estimates are then applied to other groups of individuals who were not the subjects of the original studies. This process is called benefit transfer. One issue that has arisen in studies of VSL is whether this benefit transfer process should take place broadly over the general population of people that are affected by a rulemaking, or whether VSL should be estimated for particular subgroups, such as workers in particular industries, and people of particular ages, races, and genders. Advances in data and econometric techniques have allowed specialized estimates of VSL for these population subgroups. Safety regulations issued by the Department of Transportation typically affect a broad cross-section of people, rather than more narrowly defined subgroups. Partly because of that, and partly for policy reasons, we do not consider variations in VSL among different population groups (except to take into account the effect on VSL of rising real income over time).

Principles and policies of DOT guidance

This guidance for the conduct of Department of Transportation analyses is a synthesis of empirical estimates, practical adaptations, and social policies. We continue to explore new empirical literature as it appears and to give further consideration to the policy resolutions embodied in this guidance. Although our approach is unchanged from previous guidance, the numbers and their sources are new, consistent with OMB guidance in Circular A-4 and other sources, and with the use of the best available evidence. The methods we adopt are:

1. Prevention of an expected fatality is assigned a single, nationwide value in each year, regardless of the age, income, or other distinct characteristics of the affected population, the mode of travel, or the nature of the risk. When Departmental actions have distinct impacts on infants, disabled passengers, or the elderly, no adjustment to VSL should be made, but analysts should call the attention of decision-makers to the special character of the beneficiaries.

2. In preparing this guidance, we have adjusted the VSL from the year of the source data to the year before the guidance is issued, based on two factors: growth in median real income and monetary inflation, both measured to the last full year before the date of the guidance.

3. The value to be used by all DOT administrations will be published annually by the Office of the Secretary of Transportation.

4. Analysts should project VSL from the base year to each future year based on expected growth in real income, according to the formula prescribed on page 8 of this guidance. Analysts should not project future changes in VSL based on expected changes in price levels.

5. Alternative high and low benefit estimates should be prepared, using a range of VSLs prescribed on page 10 of this guidance.

In Circular A-4 (2003), the Office of Management and Budget endorsed VSL values between $1 million and $10 million, drawing on two recently completed VSL meta-analyses.[1] In 2012 dollars, these values would be between $1.24 million and $12.4 million. The basis for the previous DOT guidance, adopted on February 5, 2008, comprised five studies, four of which were meta-analyses that synthesized many primary studies, identifying their sources of variation and estimating the most likely common parameters. These studies were written by Ted R. Miller;[2] Ikuho Kochi, Bryan Hubbell, and Randall Kramer;[3] W. Kip Viscusi;[4] Janusz R. Mrozek and Laura O. Taylor;[5] and W. Kip Viscusi and Joseph Aldy.[6] They narrowed VSL estimates to the $2 million to $7 million range in dollar values of the original data, between 1995 and 2000 (about $3 million to $9 million at current prices). Miller and Viscusi and Aldy also estimated income elasticities for VSL (the percent increase in VSL per one percent increase in income). Miller's estimates were close to 1.0, while Viscusi and Aldy estimated the elasticity to be between 0.5 and 0.6. DOT used the Viscusi and Aldy elasticity estimate (averaged to 0.55), along with the Wages and Salaries component of the Employer Cost for Employee Compensation, as well as price levels represented by the Consumer Price Index, to project these estimates to a 2007 VSL estimate of $5.8 million.

Since these studies were published, the credibility of these meta-analyses has been qualified by recognition of weaknesses in the data used by the earlier primary studies whose results are synthesized in the meta-analyses. We now believe that the most recent primary research, using improved data (particularly the CFOI data discussed above) and specifications, provides more reliable results. This conclusion is based in part on the advice of a panel of expert economists that we convened to advise us on this issue. The panel consisted of Maureen Cropper (University of Maryland), Alan Krupnick (Resources for the Future), Al McGartland (Environmental Protection Agency), Lisa Robinson (independent consultant), and W. Kip Viscusi (Vanderbilt University). The Panel unanimously concluded that we should base our guidance only on hedonic wage studies completed within the past 10 years that made use of the CFOI database and used appropriate econometric techniques.

A White Paper prepared for the U.S. Environmental Protection Agency (EPA) in 2010 identifies eight hedonic wage studies using the CFOI data;[7] we have also identified seven additional studies, including five published since the EPA White Paper was issued (see Table 1). Some of these studies focus on estimating VSL values for narrowly defined economic, demographic, or occupational categories, or use inappropriate econometric techniques, resulting in implausibly high VSL estimates. We have therefore focused on nine studies that we

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[1] Viscusi, W. K. and J.E. Aldy (2003). "The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World." *Journal of Risk and Uncertainty*, 27(1): 5-76; and Mrozek, J.R. and L. O. Taylor (2002). "What Determines the Value of a Life? A Meta-Analysis." *Journal of Policy Analysis and Management*. 21(2).

[2] Miller, T. R. (2000). "Variations between Countries in Values of Statistical Life." *Journal of Transport Economics and Policy*. 34(2): 169-188. http://www.bath.ac.uk/e-journals/jtep/pdf/Volume_34_Part_2_169-188.pdf

[3] Kochi, I., B. Hubbell, and R. Kramer (2006). "An Empirical Bayes Approach to Combining and Comparing Estimates of the Value of a Statistical Life for Environmental Policy Analysis." *Environmental and Resource Economics*. 34(3): 385-406.

[4] Viscusi, W. K. (2004). "The Value of Life: Estimates with Risks by Occupation and Industry." *Economic Inquiry*. 42(1): 29-48.

[5] Mrozek, J. R., and L. O. Taylor (2002). "What Determines the Value of Life? A Meta-Analysis." *Journal of Policy Analysis and Management*. 21(2).

[6] Viscusi, W. K. and J. E. Aldy (2003). "The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World." *Journal of Risk and Uncertainty*. 27(1): 5-76.

[7] U.S. Environmental Protection Agency (2010), *Valuing Mortality Risk Reductions for Environmental Policy: A White Paper (Review Draft)*. Prepared by the National Center for Environmental Economics for consultation with the Science Advisory Board – Environmental Economics Advisory Committee.

think are useful for informing an appropriate estimate of VSL. There is broad agreement among researchers that these newer hedonic wage studies provide an improved basis for policy-making.[8]

The 15 hedonic wage studies we have identified that make use of the CFOI database to estimate VSL are listed in Table 1. Several of these studies focus on estimating how VSL varies for different categories of people, such as males and females,[9] older workers and younger workers,[10] blacks and whites,[11] immigrants and non-immigrants,[12] and smokers and non-smokers,[13] as well as for different types of fatality risks.[14] Some of these studies do not estimate an overall ("full-sample") VSL, instead estimating VSL values only for specific categories of people. Some of the studies, as the authors themselves sometimes acknowledge, arrive at implausibly high values of VSL, because of econometric specifications which appear to bias the results, or because of a focus on a narrowly-defined occupational group. Moreover, these papers generally offer multiple model specifications, and it is often not clear (even to the authors) which specification most accurately represents the actual VSL. We have generally chosen the specification that the author seems to believe is best. In cases where the author does not express a clear preference, we have had to average estimates based on alternative models within the paper to get a representative estimate for the paper as a whole.

Table 1: VSL Studies Using CFOI Database

(VSLs in millions of dollars)

	Study	Year of Study $	VSL in Study-Year $	VSL in 2012$	Comments
1.	Viscusi (2003) *	1997	$14.185M	$21.65M	Implausibly high; industry-only risk measure
2.	Leeth and Ruser (2003) *	2002	$7.04M	$8.90M	Occupation-only risk measure
3.	Viscusi (2004)	1997	$4.7M	$7.17M	Industry/occupation risk measure
4.	Kniesner and Viscusi (2005)	1997	$4.74M	$7.23M	Industry/occupation risk measure
5.	Kniesner *et al.* (2006) *	1997	$23.70M	$36.17M	Implausibly high; industry/occupation risk measure

[8] A current survey of theoretical and empirical research on VSL may be found in: Cropper, M., J.K. Hammitt, and L.A. Robinson (2011). "Valuing Mortality Risk Reductions: Progress and Challenges." *Annual Review of Resource Economics.* 3: 313-336. http://www.annualreviews.org/doi/abs/10.1146/annurev.resource.012809.103949

[9] Leeth, J.D. and J. Ruser (2003). "Compensating Wage Differentials for Fatal and Nonfatal Injury Risks by Gender and Race." *Journal of Risk and Uncertainty*, 27(3): 257-277.

[10] Kniesner, T.J., W.K. Viscusi, and J.P. Ziliak (2006). "Life-Cycle Consumption and the Age-Adjusted Value of Life." *Contributions to Economic Analysis and Policy.* 5(1): 1-34; Viscusi, W.K. and J.E. Aldy (2007). "Labor Market Estimates of the Senior Discount for the Value of Statistical Life." *Journal of Environmental Economics and Management.* 53: 377-392; Aldy, J.E. and W.K. Viscusi (2008). "Adjusting the Value of a Statistical Life for Age and Cohort Effects." *Review of Economics and Statistics.* 90(3): 573-581; and Evans, M.F. and G. Schaur (2010). "A Quantile Estimation Approach to Identify Income and Age Variation in the Value of a Statistical Life." *Journal of Environmental Economics and Management.* 59: 260-270.

[11] Viscusi, W.K. (2003). "Racial Differences in Labor Market Values of a Statistical Life." *Journal of Risk and Uncertainty.* 27(3): 239-256, and Leeth, J.D. and J. Ruser (2003), *op. cit.*

[12] Hersch, J. and W.K. Viscusi (2010). "Immigrant Status and the Value of Statistical Life." *Journal of Human Resources.* 45(3): 749-771.

[13] Viscusi, W.K. and J. Hersch (2008). "The Mortality Cost to Smokers." *Journal of Health Economics.* 27: 943-958.

[14] Scotton, C.R. and L.O. Taylor. "Valuing Risk Reductions: Incorporating Risk Heterogrneity into a Revealed Preference Framework." *Resource and Energy Economics.* 33 and Kochi, I and L.O. Taylor (2011). "Risk Heterogeneity and the Value of Reducing Fatal Risks: Further Market-Based Evidence." *Journal of Benefit-Cost Analysis.* 2(3): 381-397.

6.	Viscusi and Aldy (2007) *	2000			Industry-only risk measure; no full-sample VSL estimate
7.	Aldy and Viscusi (2008) *	2000			Industry-only risk measure, no full-sample VSL estimate
8.	Evans and Smith (2008)	2000	$9.6M	$12.84M	Industry-only risk measure
9.	Viscusi and Hersch (2008)	2000	$7.37M	$9.86M	Industry-only risk measure
10.	Evans and Schaur (2010)	1998	$6.7M	$9.85M	Industry-only risk measure
11.	Hersch and Viscusi (2010)	2003	$6.8M	$8.43M	Industry/occupation risk measure
12.	Kniesner *et al.* (2010)	2001	$7.55M	$9.76M	Industry/occupation risk measure
13.	Kochi and Taylor (2011)*	2004			VSL estimated only for occupational drivers
14.	Scotton and Taylor (2011)	1997	$5.27M	$8.04M	Industry/occupation risk measure; VSL is mean of estimates from three preferred specifications
15.	Kniesner *et al.* (2012)	2001	$4M - $10M	$5.17M - $12.93M	Industry/occupation risk measure; mean VSL estimate is $9.05M

* Studies shown in grayed-out rows were not used in determining the VSL Guidance value.

We found that nine of these studies provided usable estimates of VSL for a broad cross-section of the population.[15] We excluded Viscusi (2003) and Kniesner *et al.* (2006) on the grounds that their estimates of VSL were implausibly high (Viscusi acknowledges that the estimated VSLs in his study are very high). We excluded Leeth and Ruser (2003) because it used only variations in occupation for estimating variation in risk (the occupational classifications are generally regarded as less accurate than the industry classifications). We excluded Viscusi and Aldy (2007) and Aldy and Viscusi (2008) because they did not estimate overall "full-sample" VSLs (they focused instead on estimating VSLs for various subgroups). We excluded Kochi and Taylor (2011) because it estimated VSL only for a narrow occupational group (occupational drivers). For Scotton and Taylor (2011) and Kniesner *et al.* (2012) we calculated average values for VSL from what appeared to be the preferred model specifications. For this guidance, we adopt the average of the VSLs estimated in the remaining nine studies, updated to 2012 dollars (based both on changes in the price level and changes in real incomes from the year for which the VSL was originally estimated). This average is $9.14 million, which we round to $9.1 million for purposes of this guidance.

Our current guidance specifies that our VSL guidance will be updated each year, to take into account both the increase in the price level and the increase in real incomes. The VSL literature is generally in agreement that VSL increases with real incomes, but the exact rate at which it does so is subject to some debate. In our

[15] In addition to Viscusi (2004) [cited in footnote 4], Viscusi and Hersch (2008) [cited in footnote 13], Evans and Schaur (2010) [cited in footnote 10], Hersch and Viscusi (2010) [cited in footnote 12], and Scotton and Taylor (2011) [cited in footnote 14], these include Kniesner, T.J. and W.K. Viscusi (2005). "Value of a Statistical Life: Relative Position vs. Relative Age." *AEA Papers and Proceedings*. 95(2): 142-146; Evans, M.F. and V.K. Smith (2008). "Complementarity and the Measurement of Individual Risk Tradeoffs: Accounting for Quantity and Quality of Life Effects." National Bureau of Economic Research Working Paper 13722; Kniesner, T.J., W.K. Viscusi, and J.P. Ziliak (2010). "Policy Relevant Heterogeneity in the Value of Statistical Life: New Evidence from Panel Data Quantile Regressions." *Journal of Risk and Uncertainty*. 40: 15-31; and Kniesner, T.J., W.K. Viscusi, C. Woock, and J.P. Ziliak (2012). "The Value of a Statistical; Life: Evidence from Panel Data." *Review of Economics and Statistics*. 94(1): 74-87.

current guidance, we cite research by Viscusi and Aldy (2003) that estimated the elasticity of VSL with respect to increases in real income as being between 0.5 and 0.6 (i.e., a one-percent increase in real income results in an increase in VSL of 0.5 to 0.6 percent). We accordingly have increased VSL by 0.55 percent for every one-percent increase in real income. More recent research by Kniesner, Viscusi, and Ziliak (2010) has derived more refined income elasticity estimates ranging from 2.24 at low incomes to 1.23 at high incomes, with an overall figure of 1.44.[16] An alternative specification yielded an overall elasticity of 1.32. Similarly, Costa and Kahn (2004) estimated the income-elasticity of VSL to be between 1.5 and 1.6.[17] These empirical results are consistent with theoretical arguments suggesting that the income-elasticity of VSL should be greater than 1.0.[18]

In view of the large increase in the income elasticity of VSL that would be suggested by these empirical results, and because the literature seems somewhat unsettled, we will increase our suggested income-elasticity figure only to 1.0. While this figure is lower than the elasticity estimates of Kniesner *et al.* and Costa and Kahn, it is higher than that of Viscusi and Aldy, the basis for our previous guidance. It is difficult to state with confidence whether a cross-sectional income elasticity (such as those estimated in these empirical analyses), representing the difference in sensitivity to fatality risks between low-income and high-income workers in a given population, corresponds to a longitudinal elasticity, representing the way in which VSL is affected by growth in income over time for an overall population. Consequently, we adopt this more moderate figure, pending more comprehensive documentation.

The index we use to measure real income growth as it affects VSL is the Median Usual Weekly Earnings (MUWE), in constant (1982-84) dollars, derived by BLS from the Current Population Survey (Series LEU0252881600 – not seasonally adjusted). This series is more appropriate than the Wages and Salaries component of the Employment Cost Index (ECI), which we used previously, because the ECI applies fixed weights to employment categories, while the weekly earnings series uses a median employment cost for wage and salary workers over the age of 16. A median value is preferred because it should better reflect the factors influencing a typical traveler affected by DOT actions (very high incomes would cause an increase in the mean, but not affect the median). In contrast to a median, an average value over all income levels might be unduly sensitive to factors that are less prevalent among actual travelers. Similarly, we do not take into account changes in non-wage income, on the grounds that this non-wage income is not likely to be significant for the average person affected by our rules. The MUWE has been virtually unchanged for the past decade, so this has very little effect on the VSL adjustment over the past ten years. However, it is likely to be more significant in the future.

We have chosen the Consumer Price Index (CPI-U) as a price index that similarly is representative of changes in the value of money that would be considered by a typical worker making decisions corresponding to his income level. This index grew from 2002 to 2012 by 27.62 percent, raising estimates of VSL in 2002 dollars by over 27 percent over ten years.

In 2011, we adopted a procedure for estimating VSL in each future year as it would respond to expected growth in real income levels. Logical consistency required that higher incomes in the future would influence projected VSLs, just as they affect the current year's baseline. The procedure we now specify uses the projected rate of

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[16] Kniesner, T.J., W.K. Viscusi, and J.P. Ziliak (2010). "Policy Relevant Heterogeneity in the Value of Statistical Life: New Evidence from Panel Data Quantile Regressions." *Journal of Risk and Uncertainty.* 40(1):15–31.

[17] Costa, D.L. and M.E. Kahn (2004). "Changes in the Value of Life, 1940-1980." *Journal of Risk and Uncertainty.* 29(2): 159-180.

[18] Eeckhoudt, L.R. and J.K. Hammitt (2001). "Background Risks and the Value of a Statistical Life." *Journal of Risk and Uncertainty.* 23(3): 261-279; Kaplow, L. (2005). "The Value of a Statistical Life and the Coefficient of Relative Risk Aversion." *Journal of Risk and Uncertainty,* 31(1); Murphy, K.M. and R.H. Topel (2006). "The Value of Health and Longevity." *Journal of Political Economy.* 114(5): 871-904; and Hammitt, J.K. and L.A. Robinson (2011). "The Income Elasticity of the Value per Statistical Life: Transferring Estimates between High and Low Income Populations." *Journal of Benefit-Cost Analysis.* 2(1): 1-27.

growth of the Real Median Wage for Workers Covered by Social Security, estimated by the Congressional Budget Office (CBO).[19] While the growth rate forecast fluctuates significantly over the next decade in response to incentives in the Affordable Care Act to receive wage compensation versus health insurance benefits, we believe that it is reasonable to use a long-term average growth rate to estimate changes in future VSL. We have calculated the average projected growth rate in the real median wage, based on the CBO data over the next 30 years, to be 1.07 percent per year. With an income elasticity of 1.0, the base-year VSL should thus be increased by 1.07 percent per year to estimate VSL for any future year (in base-year dollars), before discounting to present value.[20]

For future years, the formula for calculating future values of VSL is therefore:

$VSL_{2012+N} = VSL_{2012} \times 1.0107^{N}$

where VSL_{2012+N} is the VSL value N years after 2012

and VSL_{2012} is the VSL value in 2012 (i.e., $9.1 million).

When conducting sensitivity analyses using alternative VSL values (see page 10), analysts should use those alternative VSL values in place of the $9.1 million value used here. We emphasize that future VSL values should be adjusted only for changes in real wages, not for changes in price levels. For analysts using base years prior to 2012, the new VSL for 2011 (adjusted for changes in real income and prices) is $8.98 million in 2011 dollars. For 2010, this value is $8.86 million in 2010 dollars.

Value of Preventing Injuries

Nonfatal injuries are far more common than fatalities and vary widely in severity, as well as probability. In principle, the resulting losses in quality of life, including both pain and suffering and reduced income, should be estimated by potential victims' WTP for personal safety. While estimates of WTP to avoid injury are available, often as part of a broader analysis of factors influencing VSL, these estimates are generally only available for an average injury resulting in a lost workday, and not for a range of injuries varying in severity. Because detailed WTP estimates covering the entire range of potential disabilities are unobtainable, we use an alternative standardized method to interpolate values of expected outcomes, scaled in proportion to VSL. Each type of accidental injury is rated (in terms of severity and duration) on a scale of quality-adjusted life years (QALYs), in comparison with the alternative of perfect health. These scores are grouped, according to the Abbreviated Injury Scale (AIS), yielding coefficients that can be applied to VSL to assign each injury class a value corresponding to a fraction of a fatality.

In our previous guidance, the values of preventing injuries were updated by new estimates from a study by Spicer and Miller.[21] The measure adopted was the quality-adjusted percentage of remaining life lost for median

[19] The projected growth of the mean real wage is reported by CBO in its 2012 Long-Term Budget Outlook (p. 34, p. 65, fn. 5). CBO has provided us with unpublished forecasts of median real wages, which we believe are more relevant to estimating the VSL of the average person affected by transportation-related safety risks. We use these projected median real wage forecasts in our guidance for adjustments of future VSLs.
http://www.cbo.gov/sites/default/files/cbofiles/attachments/06-05-Long-Term_Budget_Outlook.pdf
http://www.cbo.gov/sites/default/files/cbofiles/attachments/43288-LTBOSuppTables.xls

[20] 1.0107^1.0 = 1.0107 (annual income growth factor of 1.0107, raised to the power of the income elasticity, 1.0, yields annual real VSL growth of 1.0107).

[21] Rebecca S. Spicer and Ted R. Miller. "Final Report to the National Highway Traffic Safety Administration: Uncertainty Analysis of Quality Adjusted Life Years Lost." Pacific Institute for Research and Evaluation. February 5, 2010.
http://ostpxweb.dot.gov/policy/reports/QALY Injury Revision_PDF Final Report 02-05-10.pdf

utility weights, based on QALY research considered "best," as presented in Table 9 of the cited study. The rate at which disability is discounted over a victim's lifespan causes these percentages to vary slightly, and the study shows estimates for 0, 3, 4, 7, and 10 percent discount rates. These differences are minor in comparison with other sources of variation and uncertainty, which we recognize by sensitivity analysis. Since OMB recommends the use of alternative discount rates of 3 and 7 percent, we present the scale corresponding to an intermediate rate of 4 percent for use in all analyses. The fractions shown should be multiplied by the current VSL to obtain the values of preventing injuries of the types affected by the government action being analyzed.

Table 2: Relative Disutility Factors by Injury Severity Level (AIS)
For Use with 3% or 7% Discount Rate

AIS Level	Severity	Fraction of VSL
AIS 1	Minor	0.003
AIS 2	Moderate	0.047
AIS 3	Serious	0.105
AIS 4	Severe	0.266
AIS 5	Critical	0.593
AIS 6	Unsurvivable	1.000

For example, if the analyst were seeking to estimate the value of a "serious" injury (AIS 3), he or she would multiply the Fraction of VSL for a serious injury (0.105) by the VSL ($9.1 million) to calculate the value of the serious injury ($955,000). Values for injuries in the future would be calculated by multiplying these Fractions of VSL by the future values of VSL (calculated using the formula on page 8).

These factors have two direct applications in analyses. The first application is as a basis for establishing the value of preventing nonfatal injuries in benefit-cost analysis. The total value of preventing injuries and fatalities can be combined with the value of other economic benefits not measured by VSLs, and then compared to costs to determine either a benefit/cost ratio or an estimate of net benefits.

The second application stems from the requirement in OMB Circular A-4 that evaluations of major regulations for which safety is the primary outcome include cost-effectiveness analysis, in which the cost of a government action is compared with a non-monetary measure of benefit. The values in the above table may be used to translate nonfatal injuries into fatality equivalents which, when added to fatalities, can be divided into costs to determine the cost per equivalent fatality. This ratio may also be seen as a "break-even" VSL, the value that would have to be assumed if benefits of a proposed action were to equal its costs. It would illustrate whether the costs of the action can be justified by a VSL that is well within the accepted range or, instead, would require a VSL approaching the upper limit of plausibility. Because the values assigned to prevention of injuries and fatalities are derived in part by using different methodologies, it is useful to understand their relative importance in drawing conclusions. Consequently, in analyses where benefits from reducing both injuries and fatalities are present, the estimated values of injuries and fatalities prevented should be stated separately, as well as in the aggregate.

While these injury disutility factors have not been revised in this update of our VSL guidance, the peer review process for this guidance raised the question as to whether their accuracy could be further improved. We therefore believe that a more thorough review of the value of preventing injuries is warranted. While the results of that review are not incorporated in this guidance, we plan to incorporate the results of that review in future guidance as soon as it is completed.

Recognizing Uncertainty

Regulatory and investment decisions must be made by officials informed of the limitations of their information. The values we adopt here do not establish a threshold dividing justifiable from unjustifiable actions; they only suggest a region where officials making these decisions can have relatively greater or lesser confidence that their decisions will generate positive net benefits. To convey the sensitivity of this confidence to changes in assumptions, OMB Circular A-4 and Departmental policy require analysts to prepare estimates using alternative values. We have previously encouraged the use of probabilistic methods such as Monte Carlo analysis to synthesize the many uncertain quantities determining net benefits.

While the individual estimates of VSL reported in the studies cited above are often accompanied by estimates of confidence intervals, we do not, at this time, have any reliable method for estimating the overall probability distribution of the average VSL that we have calculated from these various studies. Consequently, alternative VSL values can only illustrate the conclusions that would result if the true VSL actually equaled the higher or lower alternative values. Analysts should not imply a known probability that the true VSL would exceed or fall short of either the primary VSL figure or the alternative values used for sensitivity analysis. Kniesner et al. (2012) suggest that a reasonable range of values for VSL is between $4 million and $10 million (in 2001 dollars), or $5.2 million to $12.9 million in 2012 dollars. This range of values includes all the estimates from the eight other studies on which this guidance is based. For illustrative purposes, analysts should calculate high and low alternative estimates of the values of fatalities and injuries by using alternative VSLs of $5.2 million and $12.9 million, with appropriate adjustments for future VSL values and for values of injuries calculated using the VSL.

Because the relative costs and benefits of different provisions of a rule can vary greatly, it is important to disaggregate the provisions of a rule, displaying the expected costs and benefits of each provision, together with estimates of costs and benefits of reasonable alternatives to each provision.

This guidance and other relevant documents will be posted on the Reports page of the Office of Transportation Policy website, http://www.dot.gov/policy. Questions should be addressed to Jack Wells, (202) 366-9224, or jack.wells@dot.gov.

Exhibit

4

Thomas F. Braddock Jr.
12 Detweiler Lane
White Haven, Pa. 18661

September 24, 2013

Brenda Raffath Friend
Mailstop 6N–602
Office of Regulatory Affairs
Enforcement Programs and Services
Bureau of Alcohol, Tobacco, Firearms, and Explosives
U.S. Department of Justice
99 New York Avenue NE.
Washington, DC 20226;
ATTN: ATF 41P

Re: *ATF 41P – Notice of Proposed Rulemaking*

My name is Thomas F. Braddock, Jr., and I am writing in opposition to certain provisions in the proposed rule of the Bureau of Alcohol, Tobacco, Firearms, and Explosives ("ATF") published in the September 9, 2013 Federal Register, volume 78, at pages 55014 through 55029.

After almost twenty-seven years, I retired from the Pennsylvania National Guard as a Major. I also worked for thirteen years as a federal law enforcement employee in federal correctional institutions. I have had a secret-level security clearance for twenty-five years and the Federal Bureau of Prisons did a background check on me every five years. I am certainly not a criminal.

I have lived in the same rural community since 1992. We have no local law enforcement officers and response times from the Pennsylvania State Police can take an hour to ninety minutes. In light of those circumstances, I have concerns about self- and home-defense.

I also purchase some firearms regulated under the National Firearms Act ("NFA"). Earlier this year I found a buying opportunity with a class III Federal Firearms Licensee ("FFL") and made a commitment to purchase the item. The FFL sent me the necessary paperwork for me to complete including a Form 4. When I sought to obtain the required signature from a Chief Law Enforcement Officer ("CLEO") on my Form 4, I was surprised by the problems I encountered. As we have no local police force, on April 19, 2013, I went to the office of the county sheriff. I had my passport photos in hand and was prepared to be fingerprinted.

When I spoke with Sheriff Jack Robshaw directly he refused to sign without even hearing me out. He said he was not required to sign the Form 4 and so he was not going to sign. I asked him to identify the law that purportedly gave him discretion to refuse his signature. He never did identify any source for his authority or identify any supervisor to whom I could take the issue.

The situation became a matter of local controversy with reporters writing new stories about the affair. They interviewed Sheriff Robshaw as well as me. The articles they produced confirmed the situation as I have described it. Sheriff Robshaw did not retreat into some pretext about having any concerns with me specifically nor did he claim any concern with respect to what he was asked to certify on the Form 4 nor did he offer up some sort of explanation like he was protecting himself or his office from civil liability. Rather, he made it clear that his position was based exclusively on his personal and political views regarding whether citizens should be permitted to own firearms that both Congress and the Pennsylvania General Assembly had determined were appropriate for such ownership.

As reported by Jennifer Learn-Andes of the Times Leader, Sheriff Robshaw "said the state gives sheriffs discretion to refuse Class III permit requests, and he has rejected them all since he became interim sheriff in February 2012 because he disagrees with allowing civilians to acquire automatic guns. He receives several requests each month, he said." Learn-Andes quotes Sheriff Robshaw as stating: "My belief is civilians don't need them, and if it costs me my job, I don't care."

As reported by Michael P. Buffer of Citizens Voice, Sheriff Robshaw "said he has never signed a form for an NFA weapon and is asked to sign the form a couple times a month."

On April 22, 2013, I wrote the Luzerne County District Attorney, Stefanie Salavantis, about the situation. I am attaching a redacted copy of that letter as Exhibit A. She neither offered to sign in lieu of Sheriff Robshaw or replied in any other way.

On May 22, 2013, I wrote Pennsylvania Attorney General Kathleen G. Kane about the situation. I am attaching a redacted copy of that letter as Exhibit B. A copy of the July 1 reply which offered no assistance and failed to indicate that the Attorney General would sign my Form 4 is attached as Exhibit C.

Contrary to Sheriff Robshaw's position, it would seem fairly clear that Pennsylvania law does not give sheriffs or any other local law enforcement the authority to establish policy with respect to a citizen's acquisition of any legal firearm. State statutory law provides:

> No county, municipality or township may in any manner regulate the lawful ownership, possession, transfer or transportation of firearms, ammunition or ammunition components when carried or transported for purposes not prohibited by the laws of this Commonwealth.

18 Pa. C.S. § 1620(a). To underscore the legislature's preemption of all local regulation of such matters, it also made violation of section 1620 a misdemeanor of the first degree. 18 Pa. C.S. § 1619. It does not matter whether or not the county or municipality has a home rule charter under State law. 53 Pa. C.S. § 2962; 16 P.S. § 6107-C(k). The highest court of the State has confirmed that "[b]ecause the ownership of firearms is constitutionally protected, its regulation is a matter of statewide concern. . . . [T]he General Assembly, not city councils, is the proper forum for the imposition of such regulation." *Ortiz v. Commonwealth,* 681 A.2d 152, 156 (Pa. 1996) The

Pennsylvania Supreme Court has been "crystal clear" that only the General Assembly may establish policy with respect to the ownership, possession, and transfer of firearms, as the entire field is preempted. *See Nat'l Rifle Ass'n v. City of Philadelphia,* 977 A.2d 78, 82 (Pa. Cmwlth. 2009).

ATF's CLEO certification requirement essentially invests individual local officials with *de facto* arbitrary power to establish policies directly contrary to State law, undermining the role of the State in our federal system. I cannot see how such interference is consistent with the U.S. Constitution.

The entire system of CLEO certification is outdated and needs to be abandoned. As is evidenced by my own experience, even in a small rural county, it is no longer the case – as it may have been when the CLEO certification requirement was first imposed -- that the sheriff is likely to know even long-time residents. With the development of the National Instant Check System ("NICS") and other resources that ATF and the Federal Bureau of Investigation already access for other background checks, the requirement that individuals get CLEO signatures on a Form 4 is not only antiquated, it unnecessarily invests arbitrary power in one man to disregard the policy judgments of Congress and the State legislatures as to which firearms are appropriate for citizens to own.

In light of my own experience, I am shocked to see that not only does ATF plan to abandon the CLEO certification requirement, it now proposes to expand that requirement to responsible persons associated with gun trusts and other legal entities. That course will only exacerbate the problem of interference in State law and subject more law-abiding citizens to CLEO decisions rooted in personal political views and disagreements with the policy judgments of elected legislators at both the Federal and State level.

Changing the wording of the CLEO certification will do nothing to solve the problem. ATF is operating on a false premise as to why CLEOs will not sign forms. As Sheriff Robshaw's statements to me and to the press evidence, as long as a form requires *any* CLEO signature for *any* reason, that empowers individual CLEOs to effectively maintain a *de facto* ban of legal firearms.

Like many others, I established a gun trust precisely because ATF continued to empower CLEOs to maintain such *de facto* bans on the acquisition of NFA firearms by individuals long after alternative and superior means of background checks became available. I should not have been required to pay for legal services in order to exercise my lawful rights but at least that option was available. Extending the CLEO certification to cover gun trusts and other legal entities removes that option altogether.

If ATF is concerned about the increasing number of applications submitted on behalf of trusts and other legal entities, the single most effective measure ATF could take would be to eliminate the CLEO certification requirement *for individuals,* recognizing that NICS has rendered such certification obsolete. Or, at least ATF should mandate that CLEOs provide a statement of reason if they refuse to sign and provide some sort of appeal mechanism, and ATF should expand the list of officers who may sign as CLEOs in each jurisdiction so as to provide

law-abiding citizens additional alternatives when confronted with obstinate officers who place themselves above the Federal and State legislatures.

One other thing that should be clear from my experience, ATF is way off-base in its estimate that "the time needed for a responsible person to procure the CLEO certificate is 100 minutes (70 minutes travel time and 30 minutes review time with the CLEO)." 78 Fed. Reg. at 55,021. Completely absent from that estimate is the time needed to persuade a CLEO even to engage in review of the background of the individual seeking certification or the time needed to identify a second (or third) CLEO for the jurisdiction who will entertain the request after the first CLEO refuses to make any individualized determination. In light of the number of individuals who established gun trusts or other legal entities precisely because of the difficulty in obtaining CLEO certification -- as ATF seems to acknowledge -- it would seem likely that those additional costs would be present in quite a large number of instances. Moreover, to the extent that responsible persons associated with a legal entity may reside in States that do not permit NFA firearms, it would seem that if it were even possible to get CLEO certification it would require an extensive period of education and interaction with the official.

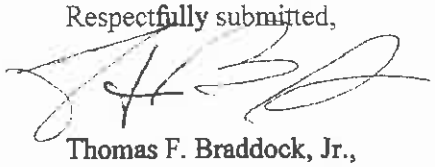
More fundamentally, it seems to me that ATF's entire approach is misguided. It is already a violation of federal criminal law for a trustee (or any other "responsible person" associated with a legal entity) to permit a prohibited person to possess a firearm if he has even "reasonable cause" to believe the person is prohibited, 18 U.S.C. § 922(d), and it is already illegal for the prohibited person to possess a firearm, 18 U.S.C. § 922(g). The use of a trust or other legal entity creates no "loop-hole" to those provisions. Rather, those same criminal prohibitions upon which ATF relies to deter an individual from transferring a NFA firearm to a complete stranger are equally applicable here.

Just about the only part of the proposed rule that makes any sense is § 479.90. I welcome ATF stating in a regulation what had long been its practice of treating inheritances as involuntary transfers handled on a Form 5 without imposition of transfer tax. What is telling, however, is that ATF imposes on the executor (or administrator or personal representative or the like) no obligation to submit photographs, fingerprints, CLEO certification, or even a bare Form 4 to receive any NFA firearm from the decedent. Of course, it would be absurd to impose such a requirement. But one might ask: Is ATF not concerned that a convicted felon might be the executor and thereby gain possession of a machine gun? No, I expect ATF realizes that such an executor would either decline to serve or would make other arrangements to ensure never coming into contact with the machine gun so as to avoid the criminal penalties of 18 U.S.C. § 922(g). What is unclear, however, is why that reasoning is not equally applicable to each "responsible person" of each of the forms of legal entities addressed by the remainder of the proposed rule. The treatment of executors reveals a fundamental internal inconsistency in ATF's approach to the issue.

Due to the delays attributable to my CLEO's arbitrary refusal to sign my Form 4, the need to take time to set up a trust, and the enormous backlog of applications the NFA Branch has to process, it could require in excess of a year before I finally receive permission to take possession of my firearm. It may even be that ATF completes its formulation of new regulations before taking final action on my application. Consequently, I am concerned about ATF's plan to

transition from current law to any new regulation. ATF would be entirely unjustified in returning pending forms to applicants for resubmission in conformance with any new regulation. The fact that ATF has refused to adopt regulations that would streamline the process (such as abandoning the CLEO certification requirement altogether) and has devoted insufficient resources to processing applications should not serve as justification for effective retroactive application of any new rule. I urge ATF to publish a notice making absolutely clear that it has no intent to take such an approach.

Respectfully submitted,



Thomas F. Braddock, Jr.,

Enclosures

Exhibit A: Letter to Luzerne County District Attorney, Stefanie Salavantis (Apr. 22, 2013)

Exhibit B: Letter to Pennsylvania Attorney General, Kathleen G. Kane (May 22, 2013)

Exhibit C: Letter from Chief Deputy Attorney General (Office of Civil Law), Robert A. Mulle (July 1, 2013)

Exhibit

A

Thomas F. Braddock Jr.
12 Detweiler Lane
White Haven, Pa. 18661
[redacted]
September 19, 2013

Stefanie J. Salavantis, Esquire
Luzerne County District Attorney
200 North River St.
Wilkes-Barre, PA 18711
Phone: (570) 825-1674

Dear Stefanie J. Salavantis, Esquire,

I am writing to relay the results of a disappointing meeting I had with Sheriff Jack Robshaw last week for refusing to sign ATF F4 (5320-4). Please allow me to provide you background information on government services I have rendered. I am a retired Army National Guard Major, (secret clearance) 27 years service and an OIF veteran. Additionally, I worked for the Federal Bureau of Prisons for 13 years and 20 years total with the Federal Government. I'm willing to bet I had more background checks then most folks.

Sheriff Jack stated in front of multiple Sheriff Staff, due to his "personal beliefs," he and previous Sheriffs have not signed these forms. Jack further stated his beliefs included no individual, other then Military or Law Enforcement, should own these Class III items. Now I know for a fact, this is a flat out lie, as I have family members who have purchased Class III items with no issues through previous Sheriffs. An obvious liar in public office is not in the best interest of Luzerne County law abiding citizens and furthermore, personal beliefs are unconstitutional with respect to the 2nd amendment and Pa. State Law concerning Class III items. Luzerne County has had its share of corruption and illegal activities; why open the door to more?

Furthermore, I will own a Class III weapon, bypassing Jack, although it will cost me a few extra bucks. Jack essentially put an additional financial burden on me, handing money to a Lawyer and delaying the Federal Government from getting much needed tax revenue.

I can assure you; I've already contacted the ACLU and the NRA on this matter and will further pursue this matter through social media, election support, and any other legal means.

In closing, I sincerely hope you do the right thing abiding by the Constitution and set "personal belief" aside and get rid of liars in public office!

Thank you for your support.

Sincerely,

Thomas F. Braddock Jr.

Exhibit

B

Thomas F. Braddock Jr.
12 Detweiler Lane
White Haven, Pa. 18661
September 19, 2013

Attorney General Kathleen G. Kane
Pennsylvania Office of Attorney General
16th Floor, Strawberry Square
Harrisburg, PA 17120

Subject: Interim Luzerne County Sheriff John (Jack) Robshaw

Dear: Kathleen G. Kane

I am reluctantly writing to you as I feel I have nowhere else to turn. I trust no elected or appointed official in Luzerne County, based on "Kids for Cash" and numerous other questionable activities in Luzerne County.

I was recently refused Jack Robshaw's signature on an ATF document required for the Class III transfer of weapon in Luzerne County. Jack refused to sign based on his personal beliefs stating he believes no one other then the Military or Law Enforcement should own these types weapons. This lack of action appears to be a direct violation of the new Luzerne County Home Rule Charter, the Constitution of the United States and of Pennsylvania. Furthermore, the appointment as interim sheriff longer than six months is another direct violation of the Luzerne County Home Rule Charter.

What has become even more disturbing is, I did a "Right to Know Request" (all documents enclosed) and discovered Jack Robshaw has never taken a Loyalty Oath for Sheriff and the enclosed Loyalty Oath for Chief of Security has no date, Notary stamp or seal. As I understand, Chief of Security and Sheriff are two entirely different assignments. Please make note, I see no completion of PCCD Sheriff Training.

Should you find these actions disturbing, I encourage you to pursue further action or point me in the right direction to get answers. Luzerne County residents deserve better.

Thank you in advance for your support.

Kindest regards,

Thomas F. Braddock Jr.

Exhibit

C

COMMONWEALTH OF PENNSYLVANIA
OFFICE OF ATTORNEY GENERAL

KATHLEEN G. KANE
ATTORNEY GENERAL

July 1, 2013

15th Floor, Strawberry Square
Harrisburg, PA 17120
(717) 783-1111

Thomas Braddock
12 Detweiler Lane
White Haven, PA 18661

Dear Mr. Braddock:

Your letter to the Attorney General has been referred to this office for reply.

Please know that our office receives a large number of letters from people who have legal matters or other problems they are trying to resolve. The authority of the Office of Attorney General is defined by state laws and, unfortunately, the matter you raise in your letter does not come under our jurisdiction.

If you want to pursue legal action, we recommend that you consult your own attorney about the matter presented in your letter. If you do not have an attorney, we recommend that you consult the bar association referral service in your county or the Pennsylvania Bar Association in Harrisburg at 1-800-932-0311 or 717-238-6715. If you are not able to afford an attorney, you may want to ask your local Legal Services office if you are eligible for their assistance. The phone number for the Legal Services office may be found in the blue pages of your telephone directory.

Finally, if you are represented by counsel, you may have your lawyer call or write me directly if he or she believes this office can be of assistance within our authority.

Sincerely yours,

Robert A. Mulle
Chief Deputy Attorney General
Office of Civil Law

RAM:mlm
SR-48213-QF39

Exhibit

5

Scott David Barrish shared **St. Johns County Sheriff's Office**'s post.

JSF

The Sheriff of St. John's County is now in violation of the Statewide Preemption Law (790.33) for his executive order that he has enacted in not certifying the NFA applications for Short Barrel Rifles and Shotguns.

St. Johns County Sheriff's Office
July 11, 2012

The National Firearms Act (NFA) of 1936 has been the primary source of federal regulation for "class 3" weapons such as automatic firearms, silencers, short-barreled shotguns and explosives. While owning a firearm is a fundamental right for a United States citizen and is recognized by the 2nd Amendment of the United States Constitution, the Sheriff will only participate in the application process when a St. Johns County resident is applying for ownership of an automatic weapon. While the Sheriff has participated in this process in the past, he will no longer consider an application for silencers, short-barreled shotguns, explosives, etc.

Alternatively, a citizen may create what is commonly referred to as a "NFA Gun Trust" where the possession of prohibited NFA weapons (class 3) may be obtained. Although this is a legal instrument which must be properly drafted to be valid, there is no requirement for the Sheriff to participate in the application process. While the Sheriff's Office cannot offer or provide any advice on creating such a trust, I would invite you to utilize the many associations and/or lawyers that specialize in 2nd Amendment issues.

July 12, 2012

Share

1 Share

Exhibit

6

U.S. NEWS | Updated October 3 2013 7:36 p.m. ET

Silencers Loophole Targeted for Closure

ATF Seeks Background Checks for All Members of Weapon-Buying Trusts

By JOE PALAZZOLO CONNECT

Enlarge Image

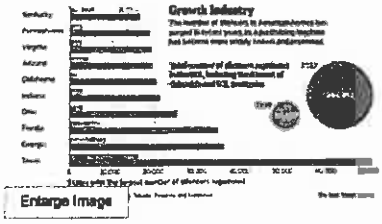
Erin Trieb for The Wall Street Journal

Paul Bonelli, an employee at Silencer Shop in Austin, Texas, demonstrates a silencer assembly. Proprietor Dave Matheny says a proposal that could curb silencer sales would 'destroy the market.'

Dave Matheny started selling gun silencers about three years ago as a hobby and took in about $19,000 in his first month. He now sells close to $1 million of the sound-suppressing devices each month from his Austin, Texas-based Silencer Shop.

But a recently proposed federal regulation that would close a loophole in current law could stifle sales of silencers—one of the fastest-growing segments of the gun industry—and, thereby, Mr. Matheny's business.

The loophole involves a legal construct known as a trust, which has allowed many gun buyers to sidestep a requirement of the National Firearms Act of 1934 that local sheriffs or chiefs of police approve purchases of silencers and highly regulated firearms, such as machine guns. The trusts used to purchase many of the silencers range in sophistication and scale, but generally they allow a group of people to purchase weapons or accessories and transfer them among themselves.



Under the new rule, proposed Sept. 9 by the Bureau of Alcohol, Tobacco, Firearms and Explosives, people linked to the trusts also would have to obtain a sign-off from local law enforcement and undergo criminal background checks. The proposal is open to public comment until December.

The proposed rule is galvanizing gun-control supporters, who say silencers inherently make a weapon more dangerous, and gun-rights advocates, who say the popular portrayal of silencers as the tools of criminals is off base and that silencers protect owners' hearing.

Mr. Matheny, who said about 80% of his clients use gun trusts to buy their silencers, is worried that the sign-off requirement would crush sales of silencers, which range in price from about $200 to more than $2,000.

"It's going to absolutely destroy this market," said Mr. Matheny, who employs eight people at his shop. "If sheriffs won't sign, they've essentially made them illegal."

The number of such trusts jumped from 840 in 2000 to 40,700 in 2012, according to the ATF, as the trust loophole became more widely known and promoted. As of April 2013, there were 494,452 silencers in American homes, according to the ATF, a figure that is up 73% since 2011.

The ATF's move comes as part of President Barack Obama's push to expand federal gun regulations through legislative and executive means after 20 children and six adults were shot to death at an elementary school in Newtown, Conn., last year. The rule doesn't need congressional approval.

While federal law permits ownership of silencers, they are banned in 11 states, according to the American Silencer Association, a group of dealers and manufacturers that has focused its efforts in recent years on improving the device's image in popular culture. The group promotes silencers as a guard against hearing loss and an aid for young and inexperienced shooters who are jarred by the sound of gunfire.

The efforts of the ASA and the National Rifle Association, which endorsed the use of silencers to prevent hearing loss in 2011, have led to a number of state legislatures easing restrictions on the devices. For instance, North Carolina and North Dakota approved silencers for hunting this year. Arizona, Texas and Oklahoma passed silencer-related bills or regulations in 2012.

"Requiring background checks for corporations and trusts does not keep firearms out of the hands of criminals," Andrew Arulanandam, an NRA spokesman, said of

the proposed regulation. ASA President Knox Williams declined to comment.

Gun-control advocates say the proposed change would close a dangerous loophole that has been exploited thousands of times in recent years.

Ladd Everitt, spokesman for the Coalition to Stop Gun Violence, said guns' loud sound serves as a warning to stay away, a function undermined by silencers. "You want to alert someone to your presence when you are firing a weapon," he said.

The ATF's proposal says "responsible persons" of a trust seeking to purchase a silencer or other weapons covered by the National Firearms Act would have to submit fingerprints and a photo to the federal government, pass a criminal-background check and get local law-enforcement approval. Even absent background checks and the law-enforcement sign-off, dealers say it takes the ATF from two to nine months to process the paperwork.

Gun dealers said signatures are hard to get in many jurisdictions. The ATF acknowledged as much, disclosing in its proposal that several sheriffs and police chiefs had privately expressed their discomfort at signing off on applications for items regulated under the National Firearms Act. A spokeswoman for the ATF declined to comment.

Sheriff David B. Shoar in St. Johns County, Fla., said last year that he would no longer sign off on the paperwork for those seeking weapons covered by the National Firearms Act, including silencers. Commander Chuck Mulligan, a spokesman for the office, said the sheriff's decision was driven by a lack of resources to conduct the necessary checks.

Federal courts have upheld the sign-off requirement, most recently in 2002. The U.S. Court of Appeals for the D.C. Circuit rejected complaints that the rule allowed law-enforcement officials in Virginia and Alaska to arbitrarily wall off access to weapons and accessories that are otherwise legal.

Mr. Matheny said silencers don't live up to their name or their portrayal in movies as reducing the noise of a gunshot to a deadly whisper. An AR-15, the most popular semiautomatic rifle by sales, fitted with a top-of-the-line silencer still registers 129 decibels when it is fired, he said. According to the American Speech-Language-Hearing Association, that's about as loud as a jackhammer.

Attached to some smaller-bore weapons, however, a silencer comes closer to its stereotype. A silenced .22-caliber gun loaded with special ammunition makes a noise that is "quieter than an air gun," said Mark Attanasio, owner of Virginia-based gun store Immortal Arms.

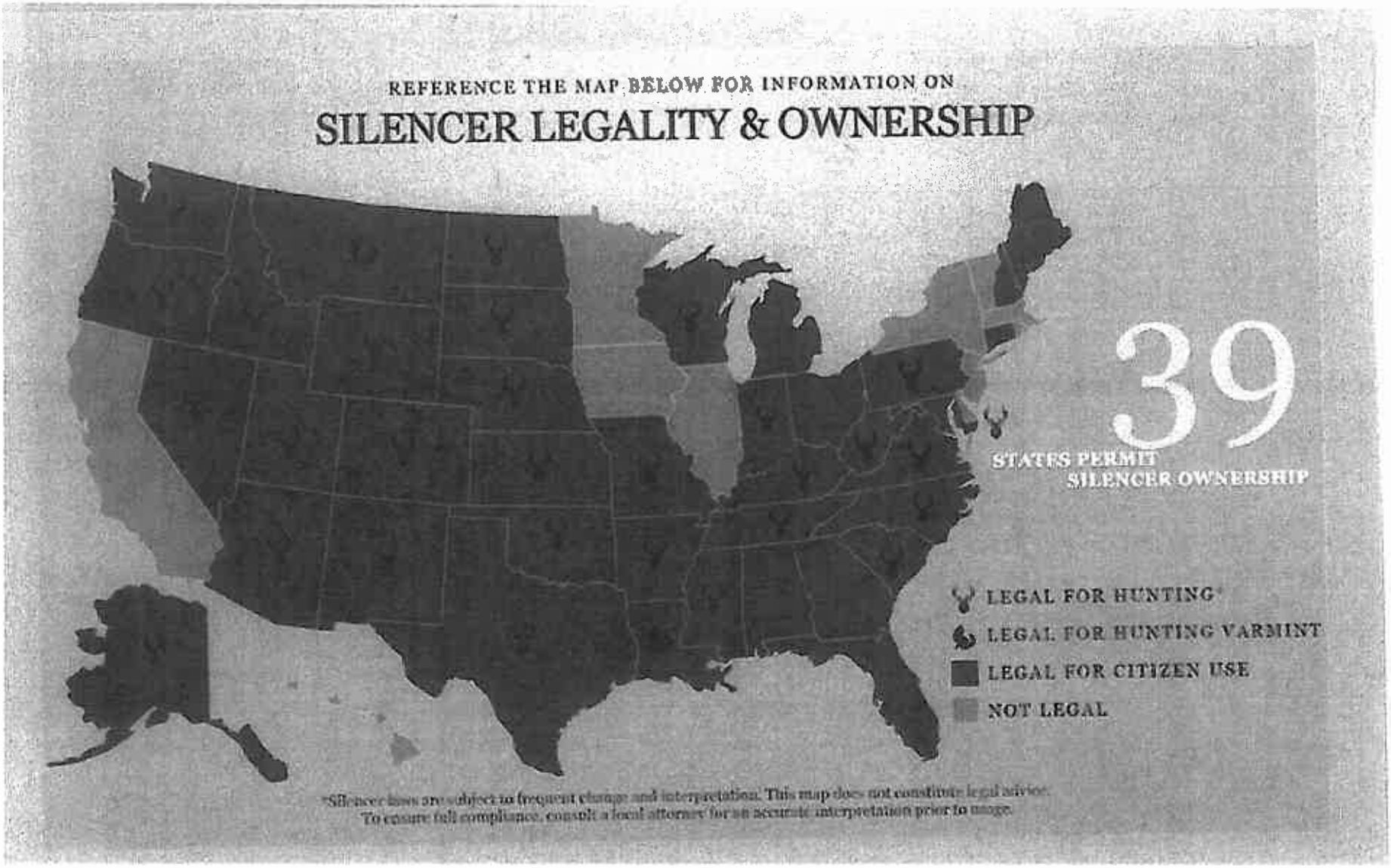
Silencers are good for taking care of pests without scaring neighbors or livestock, or damaging hearing, he said. "If you get around a lot of old hunters, they are all deaf," said Mr. Attanasio.

Write to Joe Palazzolo at joe.palazzolo@wsj.com

A version of this article appeared October 4, 2013, on page A3 in the U.S. edition of The Wall Street Journal, with the headline: Rule Seeks to Close Silencer Loophole.

Exhibit

7


REFERENCE THE MAP BELOW FOR INFORMATION ON
SILENCER LEGALITY & OWNERSHIP
39
STATES PERMIT
SILENCER OWNERSHIP
LEGAL FOR HUNTING*
LEGAL FOR HUNTING VARMINT
LEGAL FOR CITIZEN USE
NOT LEGAL
*Silencer laws are subject to frequent change and interpretation. This map does not constitute legal advice.
To ensure full compliance, consult a local attorney for an accurate interpretation prior to usage.

Exhibit

8

J Am Acad Audiol 22:93–103 (2011)

Auditory Risk to Unprotected Bystanders Exposed to Firearm Noise

DOI: 10.3766/jaaa.22.2.4

Gregory A. Flamme*
Michael Stewart†
Deanna Meinke‡
James Lankford§
Per Rasmussen**

Abstract

Background: What is the risk of hearing loss for someone standing next to a shooter? Friends, spouses, children, and other shooters are often present during hunting and recreational shooting activities, and these bystanders seem likely to underestimate the hazard posed by noise from someone else's firearm. Hunters use hearing protection inconsistently, and there is little reason to expect higher use rates among bystanders. Acoustic characteristics and estimates of auditory risk from gunfire noise next to the shooter were assessed in this study.

Research Design: This was a descriptive study of auditory risk at the position of a bystander near a recreational firearm shooter.

Data Collection and Analysis: Recordings of impulses from 15 recreational firearms were obtained 1 m to the left of the shooter outdoors away from reflective surfaces. Recordings were made using a pressure-calibrated 1/4 inch measurement microphone and digitally sampled at 195 kHz (24 bit depth). The acoustic characteristics of these impulses were examined, and auditory risk estimates were obtained using three contemporary damage-risk criteria (DRCs) for unprotected listeners.

Results: Instantaneous peak levels at the bystander location ranged between 149 and 167 dB SPL, and 8 hr equivalent continuous levels (L_{eqA8}) ranged between 64 and 83 dB SPL. Poor agreement was obtained across the three DRCs, and the DRC that was most conservative varied with the firearm. The most conservative DRC for each firearm permitted no unprotected exposures to most rifle impulses and fewer than 10 exposures to impulses from most shotguns and the single handgun included in this study. More unprotected exposures were permitted for the guns with smaller cartridges and longer barrel length.

Conclusions: None of the recreational firearms included in this study produced sound levels that would be considered safe for all unprotected listeners. The DRCs revealed that only a few of the small-caliber rifles and the smaller-gauge shotguns permitted more than a few shots for the average unprotected listener. This finding is important for professionals involved in hearing health care and the shooting sports because laypersons are likely to consider the bystander location to be inherently less risky because it is farther from the gun than the shooter.

Key Words: Auditory risk, firearms, impulse noise, noise exposure, prevention—hearing loss

Abbreviations: AHAAH = Auditory Hazard Assessment Algorithm for Humans; ACP = automatic Colt pistol; BOSS® = Ballistic Optimizing Shooting System; DRC = damage-risk criterion; HPD = hearing protection device; MPE = maximum permissible exposure; SEL = sound exposure level

The use of firearms and participation in recreational hunting vary as a function of geographical location and culture. In the United States, 18.6 million individuals over the age of 16 yr hunted an average of 18 days a year during the 5 yr period from 2002 to 2006. Youth hunters 6 to 15 yr of age are estimated to number 1.6 million (U.S. Fish and Wildlife Service, 2006). The National Shooting Sports Foundation (2009)

*Western Michigan University, Kalamazoo; †Central Michigan University, Mount Pleasant; ‡University of Northern Colorado, Greeley; §Northern Illinois University, DeKalb; **G.R.A.S. Sound and Vibration A/S, Holte, Denmark

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reports that there are 30 million active sports shooters (hunters, cowboy shooters, etc.) over age seven in the United States. In addition, there are an estimated 20.3 million active target shooters (skeet, trap, and sporting clays) in the United States (National Shooting Sports Foundation, 2009). These statistics do not include the "occasional shooter" who may fire a weapon at gun shows, guest resort activities, rural farms/ranches, or outdoor fundraising/sporting events. Friends, family members, spectators, and instructors may accompany these "shooters" and be indirectly exposed to firearm impulses that potentially put them at risk of acoustic trauma.

Impulses from firearms are commonly referenced in terms of instantaneous peak sound pressure levels. Peak sound pressure levels typically exceed the U.S. Occupational Safety and Health Administration (1983), the National Institute of Occupational Safety and Health (NIOSH), the U.S. MIL-STD-1474D (U.S. Department of Defense, 1997), and the World Health Organization (1999) limit of 140 dB SPL (Odess, 1972; Ylikoski et al, 1995; Kardous et al, 2003; Murphy and Tubbs, 2007) and can potentially lead to noise-induced hearing loss (Patterson and Hamernik, 1992; Chan et al, 2001). However, the potential damage to the auditory system is not fully represented by peak SPL values. Sound exposure characteristics such as the total energy contained in the impulse, frequency spectrum, and pressure wave (i.e., *A*) and pressure envelope (i.e., *B*) durations of the time waveform are important considerations in terms of describing auditory risk from firearms (see Flamme et al, 2009a, for a review; Committee on Hearing, Bioacoustics, and Biomechanics [CHABA], 1992). Briefly, the A-duration is the time interval between the initial pressure rise of the impulse and the moment the pressure passes through ambient. The B-duration is the time interval during which the envelope of the signal resides within 20 dB of the peak pressure.

Firearm impulse sound exposure contributes to the poorer hearing ability and hearing handicap evident in sports hunters when compared to nonhunters (Taylor and Williams, 1966; Stewart et al, 2002). Nondahl et al (2000) calculated a 7% increase in the likelihood of having a marked high-frequency hearing loss for every 5 yr of hunting. In addition, hunters consistently used hearing protection less than 5% of the time during their hunting activities (Wagner et al, 2006). Hunters are more likely (62–80%) to wear hearing protection when target shooting than when hunting (Wagner et al, 2006), and the use of hearing protection tends to be higher among target shooters (Nondahl et al, 2000). This tendency was also noted in police officers, who were also more likely to consistently wear hearing protection devices (HPDs) during job-related firearms-qualification activities (95%) as opposed to nonoccupational shooting activities (0% [Hughes and Lankford, 1992]). In workers exposed to occupational noise, the additional exposure to firearm noise can be expected to lead to a greater degree of hearing loss than for peers without exposure to firearm noise (Prosser et al, 1988; Clark, 1991; Kryter, 1991; Pekkarinen et al, 1993; Stewart et al, 2001; Neitzel et al, 2004).

Exposure to firearm noise is encountered in both occupational and nonoccupational settings. Law enforcement, security, military, wildlife officers, hunting guides, firearm and ballistics/accessory manufacturers, gunsmiths, and firearm range personnel are occupationally exposed to firearm noise. Recreational firearm use encompasses the traditional hunter and target shooters and also extends to cowboy action shooting, travel resort shooting galleys, dog training, .50 caliber shooting associations, gun shows, Boy/Girl Scouts, and 4-H activities. In most if not all of these situations, a bystander may be participating in the training and/or observing the event.

Bystander firearm noise exposure has primarily been assessed in the occupational shooting range environment. Recently, Kardous et al (2003) recorded a time-weighted average noise exposure of 108 dBA (19,282% daily dose) for an observer in an indoor shooting range using the NIOSH (1998) noise sampling criteria. While these authors recognize the limitations of noise dosimeter instrumentation in terms of capturing the impulse noise source, the results are valid in terms of documenting overexposure for the bystander.

While there are few data concerning the auditory risk to those near the shooter, there is evidence to suggest that the noise exposure is dependent upon the location of the listener (or bystander). Plomp (1967) showed that the Fusil Automatique Léger assault rifle produced lower peak levels 180 degrees from the line of fire than at other locations. Similar results were obtained recently with a bolt-action rifle chambered for the .22 Hornet cartridge (Rasmussen et al, 2009). The current study was designed to measure the impulse sound levels and estimate the auditory risk for persons standing approximately 1 m to the left of a right-handed shooter. The auditory risk for a bystander will be estimated by using the waveform parameter–based damage-risk criterion (DRC) developed by Coles et al (1967) and modified by the National Academy of Sciences Committee on Hearing, Bioacoustics, and Biomechanics (1968); the energy-based approach advocated by Smoorenburg (2003); and the Auditory Hazard Assessment Algorithm for Humans (AHAAH) developed by Price and Kalb (1991) and described further by Price (2007).

METHOD

Firearms and Ammunition

The 15 firearms used in this study were selected to represent a variety of those used for recreational shooting activities such as hunting and target practice.

Details concerning each firearm are presented in Table 1. Photographs of the guns and ammunition are available as supplementary data accompanying the electronic version of this article on the publisher's Web site (www.audiology.org/resources/journal). The .410 gauge and 20 gauge shotguns are typically used when hunting smaller game such as rabbits, squirrels, and some game birds; while the 12 and 10 gauge shotguns are favorites for hunting waterfowl (Stewart et al, 2009), pheasant, quail, and turkeys. The .30-06 rifle, 7 mm Remington Magnum rifle, .45-70 rifle, and the .50 caliber muzzle-loader are commonly used for large game such as deer, elk, and bear. According to Wagner et al (2006), the .30-06 rifles and 12 gauge shotguns are the most frequently used firearms for large and small game, respectively. For target shooters, the firearm preferences are rifles (67.4%), handguns (62.5%), muzzle-loaders (24.5%), and shotguns (20.4% [Southwick Associates, 2009]). The AR-15, the M14, and the Auto-Ordnance (Thompson) 1927-A1 Model T1 "Tommy gun" rifles are civilian versions of military models and can be used for hunting but are typically used for target practice. The .22 caliber handgun is also used primarily for target practice. Three rifles had commercial barrel modifications (muzzle brake, compensator, or flash suppressor), and measurements were obtained with these in place. These devices are designed to improve shooting accuracy and reduce recoil; however, installing a muzzle brake on a firearm will increase peak sound pressure levels when the gun is fired. The ammunition used in the firearms in this study included a wide variety of commercially available cartridges typically used for hunting and target practice activities.

Instrumentation

Impulse recordings were made using a 1/4 inch prepolarized pressure-calibrated microphone (G.R.A.S. Type 40BD) having an essentially flat frequency response through 70 kHz, oriented at grazing incidence to the sound source. Microphone output was conditioned by a G.R.A.S. Type 26AC preamplifier and a G.R.A.S. Type 12AA power supply and routed to a Tucker-Davis Technologies real-time processor (RP2.1). The real-time processor was configured to perform 24 bit analog-to-digital conversion at a 195 kHz sample rate prior to storage in a memory buffer and subsequent transfer and scaling into Pascal units in MATLAB.

Data Analyses

After recordings were transferred to the analysis computer, impulse baseline corrections were made by

Table 1. Description of Recreational Firearms and Ammunition Used in the Measurement of Impulse Noise

Manufacturer	Model	Gauge/Caliber	Cartridge/Bullet	Action	Barrel Length (inches)
Rifles					
Winchester	Model 70	7 mm Remington Magnum	140 grain	bolt action	26 with BOSS
Remington	742 Woodsman	.30-06	165 grain	semiautomatic	18
Remington	742 Woodsman	.30-06	165 grain	semiautomatic	22
Ruger	Model 1S	.45-70	300 grain	single shot, lever	22
Thompson/Center	Encore Pro Hunter	.50	250 grain with 150 grain powder	muzzle-loader	22
Rock River Arms	M14	7.62 × 51 mm (.308)	150 grain	semiautomatic	24 with flash suppressor
Colt	AR-15	5.56 × 45 mm (.223)	60 grain	semiautomatic	20
Auto-Ordnance (Tommy Gun)	1927-A1 Model T1	.45 ACP	230 grain	semiautomatic	16.5 with compensator
Shotguns					
Remington	SP10	10 gauge	3.5 inch	semiautomatic	28
Remington	11-87 slug gun	12 gauge	3 inch copper solid	semiautomatic	21
Remington	11-87 turkey gun	12 gauge	3 inch turkey load	semiautomatic	21
Remington[a]	11-87 standard	12 gauge	3 inch duck load	semiautomatic	26
Remington[a]	11-87 standard	12 gauge	2.75 inch field load	semiautomatic	26
Mossberg	—	20 gauge	2.75 inch	pump	26
Mossberg[b]	—	.410 caliber	3 inch	bolt	24
Mossberg[b]	—	.410 caliber	2.5 inch	bolt	24
Handgun					
Ruger	Bearcat	.22 Long Rifle	40 grain	revolver	4

[a]Same gun.

[b]Same gun, with and without external choke.

subtracting the mean value during a silent period in the waveform from all points on the recording. Each impulse was then analyzed independently using MATLAB software routines developed in the NIOSH Taft Laboratories (Cincinnati, Ohio). Risk estimates were calculated in terms of maximum permissible exposure (MPE) via the three DRCs for a listening condition in which the adult bystander was directly facing the sound source (i.e., grazing incidence to the ear). The MPE metric represents the highest number of exposures allowable without exceeding the exposure limits defined within the DRCs. We judged the median to be the best indicator of MPE for each firing condition, while ranges are also reported in the results that follow.

The DRCs included the Coles/CHABA (Coles et al, 1967; CHABA, 1968) approach based on waveform parameters, the Smoorenburg (2003) approach based on A-weighted energy in the impulse, and the AHAAH, developed by Price and Kalb (1991), using a physiological model of the ear (Price, 2007). A detailed review of these DRCs has been presented elsewhere (Flamme et al, 2009a), but prior comparisons of these DRCs (Flamme et al, 2009a; Flamme et al, 2009b) have revealed that there are substantial differences in MPE determined by these DRCs. The Coles/CHABA criterion is most conservative for high-level impulses and least conservative for low-level impulses, the Price/Kalb DRC is the least conservative for high-level impulses and most conservative for low-level impulses, and the Smoorenburg DRC lies somewhere in the middle for impulses less than 116 dBA sound exposure level (SEL). The SEL represents the integrated sound level over an averaging period of 1 sec (see Earshen, 2000, p. 72). In this sense, SEL is similar to the 8 hr equivalent continuous level, but instead of dividing the sound energy over a time frame of 8 hr, the amount of sound energy is divided over a 1 sec period when computing SEL. The Smoorenburg DRC is discontinuous for impulses with 8 hr equivalent A-weighted sound pressure levels greater than 80 dB. In this range, MPE is 0 for impulses with peak levels above 116 dBA SEL but increases to a fixed value of 50 for impulses below 116 dBA SEL and above 80 dBA 8 hr equivalent continuous level (dBL_{eqA8}). As suggested by Smoorenburg (2003), a +4 dB correction was applied to the SEL limit (i.e., 120 dB SEL) to retain consistency with the other DRCs, which presumed that the impulse source was oriented at grazing incidence to the ear. The Price/Kalb DRC permits separate assessments of auditory risk for listeners who are unwarned or warned that firing is imminent. The difference between these conditions follows a hypothesis that human listeners who know an impulse is imminent (i.e., warned listeners) will contract their middle-ear muscles in anticipation and therefore gain some additional protection from the high-pass filtering provided when the middle-ear muscles are contracted. On the other hand, the middle-ear muscle contractions for unwarned listeners will be reflexive and follow the latency characteristics of a reflex, resulting in a contraction long after the impulse has passed. MPEs via the Price/Kalb DRC were calculated using a maximum of 500 auditory risk units under unwarned listening conditions (i.e., no anticipatory middle-ear muscle contraction). We elected to use the unwarned condition based on the results of Bates et al (1970), which found that anticipatory middle-ear muscle contractions cannot be conditioned in the majority of human listeners.

Procedure

A minimum of five shots (range = 5–24) were fired from each firearm. The firearms were fired on a horizontal plane in a nonreverberant open field with the shooter in a typical standing shooting position. The microphone was positioned with a grazing incidence 1 m immediately to the left of the right-handed shooter to simulate a typical bystander location for civilian shooting conditions.

RESULTS

Acoustic Characteristics of Firearm Impulse Noise

Examples of noise impulses from each type of firearm are presented in Figure 1. For each gun, a secondary peak caused by ground reflection lagged the primary peak by approximately 6 msec. Standard deviations of impulse levels were 1 dB or less for all guns except the A-weighted peak level produced by the Remington SP10 Magnum, 10 gauge (Table 2). Unweighted peak levels produced at the bystander location ranged between 149.1 dB SPL for the Mossberg .410 shotgun and 166.5 dB SPL for the Winchester Model 70 with the Ballistic Optimizing Shooting System® (BOSS) muzzle brake. A-weighted levels were 1.7 to 3.7 dB lower than unweighted levels. Peak levels of shotguns and the handgun were more affected by A-weighting than those of rifles. A-weighted 8 hr equivalent continuous levels (L_{eqA8}) varied between 64.0 and 82.9 dB SPL and corresponding sound exposure levels ranged between 108.6 and 127.5 dB SPL.

Rifles tended to produce the highest peak levels at the bystander location, followed by shotguns and the .22 handgun. Exceptions were the Remington SP10 Magnum 10 gauge and Remington 11-87 12 gauge slug shotguns, which produced greater peak levels than most rifles (see Table 2). The Remington SP10 Magnum and the Remington 11-87 slug gun also produced higher peaks than all other shotguns. This may be related to the type of ammunition used in these particular shotguns. The Remington SP10 Magnum 10 gauge shotgun fired a 3.5

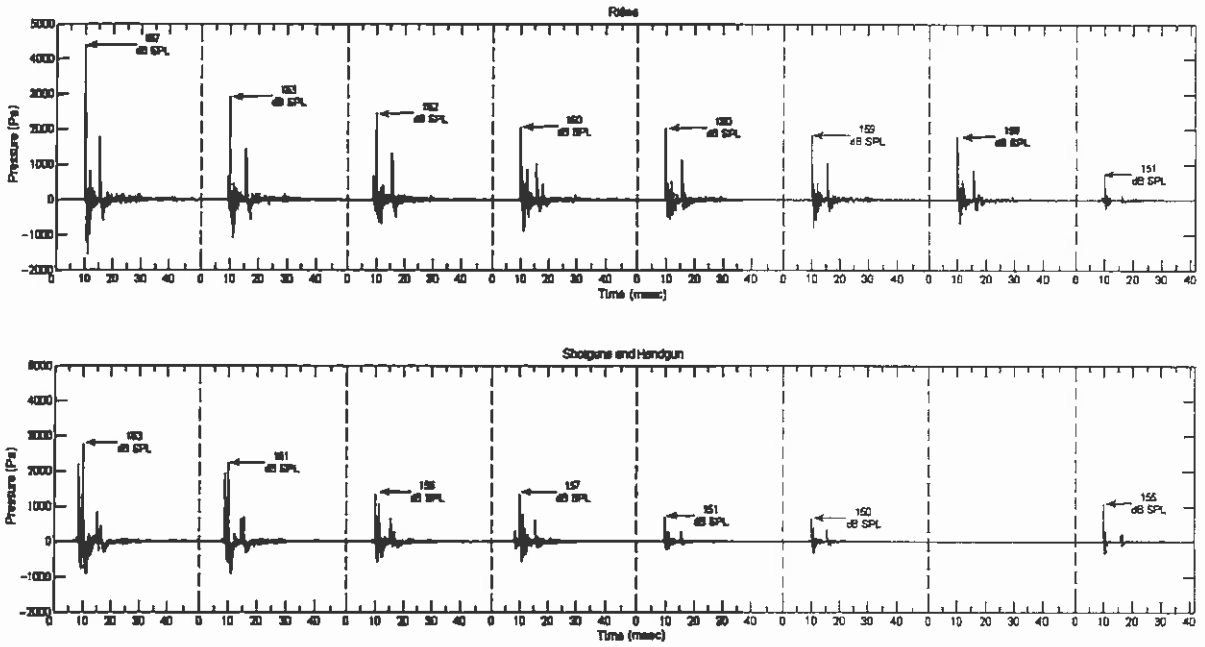

Figure 1. Examples of individual impulses from each gun. The upper panel includes sample impulses for each rifle; examples from the shotguns and the handgun are in the lower panel. Upper panel impulses are from the Winchester Model 70 (7 mm Magnum), Remington #742 carbine (.30-06), Remington #742 with a 22 inch barrel (.30-06), Ruger Model 1 (.45-70), Thompson/Center Encore muzzle-loader (.50), M14 (7.62 × 51 mm), Colt AR-15 (5.56 × 45 mm), and Auto-Ordnance Tommy gun (.45 ACP), respectively. Lower panel sample impulses are from the Remington SP10 Magnum (10 gauge), Remington 11-87 slug gun (12 gauge), Remington 11-87 turkey gun (12 gauge), Remington 11-87 standard gun firing a 3 inch cartridge (12 gauge), Mossberg 20 gauge, Mossberg .410 caliber firing a 3 inch cartridge, and Ruger Bearcat .22 caliber, respectively. Differences between individual examples and summary values (Table 1) are due to rounding and the specific example selected for display.

inch cartridge as opposed to a 3 or 2.75 inch cartridge, while the Remington 11-87 12 gauge slug shotgun fired a cartridge with a single large (1 oz) projectile (i.e., slug) rather than multiple smaller projectiles (i.e., shot). The .22 caliber revolver also produced higher bystander peak levels than the 20 gauge and .410 caliber shotguns and the Auto-Ordnance Tommy gun, which fires .45 caliber handgun ammunition. The higher bystander peak levels produced by the .22 handgun, which fires the smallest cartridge of all the firearms in this study, may be related to the significantly shorter barrel length and action of this firearm, which resulted in the bystander being positioned closer to the sound source.

A comparison of the acoustic characteristics of impulses generated by the same firearm but with different-size cartridges is also shown in Table 2. Three-inch cartridges fired in the Remington 11-87 12 gauge shotgun (turkey or duck loads) generated impulses with higher peak levels and longer durations compared to 2.75 inch cartridges fired by the same firearm. Three-inch and 2.5 inch cartridges fired in the same .410 shotgun produced essentially equivalent peak levels, and B-durations, but the smaller cartridge had shorter A-durations.

Table 2 also displays the mean durations for firearm impulses measured in this study. Pressure wave A-durations were generally less than 500 msec, particularly for smaller cartridges. Pressure envelope B-durations for impulses ranged from 6.8 to 9.3 msec. In general, the 10 and 12 gauge shotguns produced the longest B-duration values (approximately 9 msec), while the Winchester Model 70 (7 mm Remington Magnum) rifle and the .22 Ruger Bearcat revolver produced the shortest and nearly identical mean B-durations of 6.868 and 6.896 msec, respectively.

Risk Estimates

Maximum permissible exposures, assuming no hearing protection, differed across DRCs. The Coles/CHABA DRC showed the greatest range of median unprotected MPEs across firearms, ranging from 0.18 MPE (i.e., no allowable unprotected exposure) for the Winchester Model 70, 7 mm Remington Magnum, equipped with a muzzle brake to 217 MPE for the .45 Tommy gun. The Price/Kalb DRC produced the smallest range of unprotected median MPEs, with values ranging from 4 MPE for the Winchester Model 70, 7 mm Remington Magnum, to 26 MPE for the .45 Tommy gun. The Smoorenburg DRC generated median MPEs of either 0 MPE (big-bore rifles and the M14) or 50 MPE (all other firearms).

Table 2. Acoustic Characteristics of Firearm Impulses at the Bystander Location

Firearm and Ammunition	*N*	Variable	Peak (dB SPL)	A-Weighted Peak (dB SPL)	L_{eqA8} (dB SPL)	SEL_A (dB SPL)	A-Duration (μsec)	B-Duration (msec)
Rifles								
Winchester Model 70, 7 mm Magnum	5	Mean	166.5	164.8	82.9	127.5	519	6.868
		SD	0.3	0.5	0.3	0.3	32	0.061
Remington 742 carbine, .30-06	13	Mean	162.9	160.6	78.9	123.5	378	7.907
		SD	0.4	0.2	0.2	0.2	85	0.173
Remington 742 22 inch barrel, .30-06	24	Mean	161.6	159.4	77.7	122.3	353	8.044
		SD	0.5	0.4	0.3	0.3	57	0.287
Ruger Model 1, .45-70	5	Mean	160.1	157.6	77.4	122.0	442	8.354
		SD	0.2	0.1	0.7	0.7	77	0.450
Thompson/Center Encore, .50	5	Mean	159.7	157.2	75.3	119.9	427	7.396
		SD	0.2	0.3	0.2	0.2	32	0.670
M14, 7.62 × 51 mm	5	Mean	159.0	156.4	75.6	120.2	403	7.126
		SD	0.2	0.2	0.1	0.1	11	0.139
Colt AR-15, 5.56 × 45 mm	5	Mean	158.9	156.4	74.5	119.1	382	7.305
		SD	0.1	0.2	0.6	0.6	155	0.441
Auto-Ordnance Tommy Gun, .45 ACP	5	Mean	151.0	148.5	64.0	108.6	238	7.080
		SD	0.4	0.2	0.2	0.2	25	0.609
Shotguns								
Remington SP10 Magnum, 10 gauge	5	Mean	161.4	157.7	79.8	124.4	518	9.228
		SD	1.0	1.2	0.4	0.4	184	2.199
Remington 11-87 12 gauge slug	5	Mean	160.1	157.1	78.2	122.8	461	6.792
		SD	0.8	0.3	0.5	0.5	139	2.113
Remington 11-87 12 gauge turkey load, 3 inch ammunition	5	Mean	156.0	153.3	73.9	118.5	300	9.205
		SD	0.3	0.3	0.3	0.3	26	2.375
Remington 11-87 12 gauge duck load, 3 inch ammunition	5	Mean	156.1	153.2	72.6	117.2	382	9.090
		SD	0.4	0.6	0.3	0.3	114	0.054
Remington 11-87 12 gauge, 2.75 inch ammunition	5	Mean	152.7	149.7	68.2	112.8	230	7.904
		SD	0.6	0.7	0.7	0.7	32	0.527
Mossberg 20 gauge	5	Mean	150.1	147.1	66.2	110.8	208	7.438
		SD	0.4	0.4	0.3	0.3	38	0.221
Mossberg .410, 3 inch ammunition	5	Mean	149.1	145.8	64.5	109.1	382	7.750
		SD	0.3	0.5	0.6	0.6	114	0.750
Mossberg .410, 2.5 inch ammunition	5	Mean	150.0	146.6	65.8	110.4	248	7.358
		SD	0.4	0.6	0.7	0.7	23	0.554
Handgun								
Ruger Bearcat .22	6	Mean	154.0	150.6	67.1	111.7	134	6.896
		SD	0.6	0.8	0.7	0.7	10	0.098

Rifles

The preponderance of DRCs recommended no more than 10 unprotected exposures to impulses produced by the rifles in this study (Fig. 2). For large conventional hunting rifles (e.g., those firing 7 mm Magnum, .30-06, and .45-70 cartridges), median MPEs ranged between 0 (Smoorenburg DRC) and 5 (Price/Kalb DRC). The median MPEs for the Thompson/Center Encore .50 caliber muzzle-loader and the M14 and AR-15 rifles ranged between 0 (M14 rifle, Smoorenburg DRC) and 50 (Thompson/Center Encore and AR-15 rifles, Smoorenburg DRC). Median MPEs for the .45 Tommy gun ranged between 26 (Price/Kalb DRC) and 217 (Coles/CHABA DRC).

Shotguns

Most of the shotguns included in this study (i.e., all but the 10 gauge shotgun and the 12 gauge slug gun) produced noise impulses with unprotected median MPEs greater than 1 as estimated by all three damage-risk criteria (Fig. 3). The Smoorenburg DRC generated median MPE values of either 50 or 0 across all shotguns, while the Price/Kalb produced median MPE values ranging from 1 to 26 across all shotguns. The Coles/CHABA DRC tended to produce similar MPE values as the other two DRCs for the large-bore shotguns (10 and 12 gauge) but calculated much larger median MPEs (300–500) for the smaller-bore shotguns (20 and .410 gauge). In general,

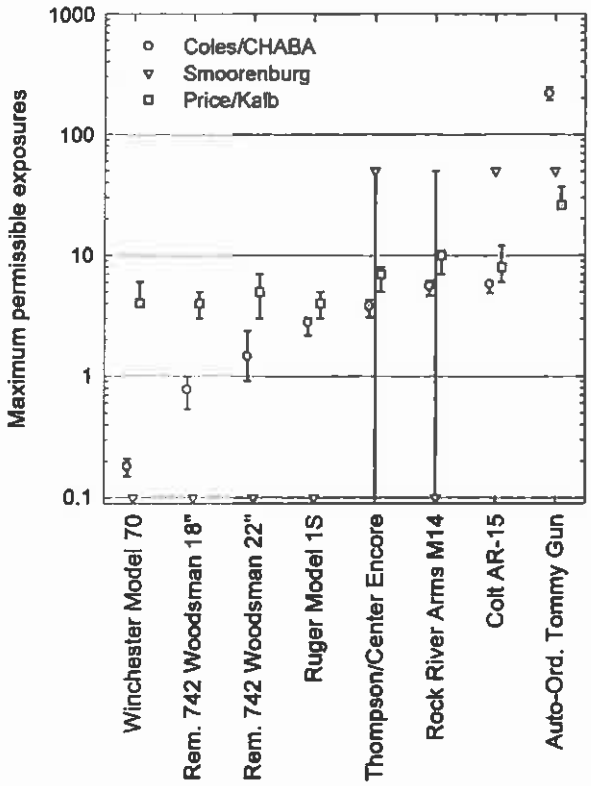

Figure 2. Median maximum permissible unprotected exposures for each rifle, by damage-risk criterion. Error bars represent the range of maximum permissible unprotected exposures across shots. Permissible exposures of 0 returned by the Smoorenburg criterion were entered as 0.1 to permit plotting.

greater numbers of permissible exposures were observed for shotguns firing smaller-diameter cartridges. The 10 gauge shotgun and 12 gauge slug gun had the fewest permissible exposures (unprotected), while the .410 caliber shotgun had the most by all three DRCs. The two types of ammunition used in the standard 12 gauge firearm had a substantial effect on MPE estimated by the Coles/CHABA risk criterion, increasing from 16 MPE with a 3 inch cartridge to 69 MPE with a 2.75 inch cartridge. However, small differences (<1 dB) in the opposite direction were observed with the .410 gauge shotgun. Fewer exposures were permissible with the shorter cartridge (2.5 inch) than with the longer cartridge (3 inch) for the Coles/CHABA and the Price/Kalb DRCs. Medians for the Smoorenburg DRC were 50 MPE regardless of .410 gauge shell length.

Handgun

Unprotected MPEs for the Ruger Bearcat .22 Long Rifle caliber handgun exhibited similar trends to those observed with the other types of recreational firearms. A minimum of 40 MPE and maximum of 86 MPE (median 55) were estimated via the Coles/CHABA DRC (Fig. 3). The Smoorenburg DRC resulted in an estimate of 50 MPE for all impulses from this gun. The Price/Kalb DRC estimated a range of 9 to 15 MPE (median 10).

DISCUSSION

Auditory Risk to Bystanders

The focus of this investigation was to describe auditory risks for bystanders exposed to civilian firearm noise. This study reports the acoustic characteristics and risk estimates for firearm noise across several rifles ($N = 8$), several shotguns ($N = 6$), and a handgun at a single position where a bystander might typically be located. That location was 1 m to the left of the individual firing each of the guns listed in Table 1. Although numerous other locations could and should be assessed, this location was chosen as a likely position for a hunting guide, firearms instructor, hunting partner, observer, or additional shooter who might or might not be an active part of a shooting event. It should also be mentioned that these data were collected outdoors in a nonreverberant open field without walls, barriers, trees, or other obstructions. The magnitude of each impulse was evaluated using unweighted instantaneous peak levels and A-weighted instantaneous peak levels, 8 hr equivalent continuous levels (L_{eqA8}), and sound exposure levels (SEL_A). In addition, the pressure wave durations (i.e., A-durations) and the pressure envelope durations (i.e., B-durations) of the impulse waveforms were evaluated (Table 2).

Several different approaches to determining auditory damage risk from exposure to impulse noise can be applied (Coles et al, 1967; CHABA, 1968; Smoorenburg, 2003; Price, 2007), and the results of each can be transformed into maximum permissible unprotected exposures, which is simply the number of gunshot exposures allowed for a given firearm. These can be seen in Figures 2 and 3 for the firearms used in this study. It is noted that the Price/Kalb model appears to compress the range of MPEs across firearms compared to the other two models. This makes it atypically liberal relative to the other DRCs that would allow few shots (e.g., large game rifles) and also atypically conservative in cases where the other DRCs would tend to allow many unprotected shots (e.g., the 20 gauge and .410 shotguns). It is apparent for the rifles tested (Fig. 2) that most MPE values ranged from 0 to 10, whereas for shotguns tested (Fig. 3) most ranged from 0 to 50 MPE. As expected, the higher the peak sound pressure levels, the lower the MPE for both the rifles and shotguns. The one rifle that produced the highest peak SPL (166.3 dB) was a bolt-action rifle with a 26 inch barrel and a BOSS muzzle brake. This particular firearm configuration used a belted 7 mm Remington

Magnum cartridge (high velocity and high powder capacity).

The higher peak SPLs for rifles may relate to the larger powder charge and/or the higher bullet velocity when all other variables are considered. The exception to this generalization is the addition of porting or brakes to the barrel of the firearm. The brake allows the muzzle gases to escape from openings in the brake, permitting the noise to travel more directly toward the bystander and shooter. Ports (holes) and slits in the barrel of firearms and muzzle brakes (used to reduce recoil, barrel elevation, and vibration) are potentially more hazardous to hearing than firearms without such alterations.

There is also a trend for the unprotected MPEs to be lower for more powerful hunting rifles than for the military-style rifles (AR-15, M14, and Tommy gun), particularly when those rifles were evaluated using the Coles/CHABA and Smoorenburg DRCs (Fig. 2). The rationale for this outcome may be that the military-style firearms have smaller powder capacities (.223, .308, and .45) than the typical hunting rifles (7 mm Remington Magnum, .30-06, and .45-70), regardless of the caliber of the cartridge.

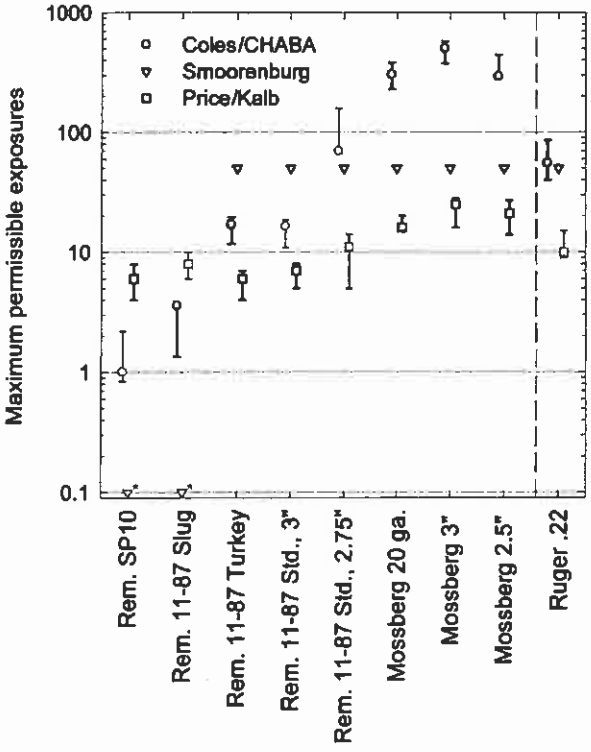

Figure 3. Maximum permissible unprotected exposures for each shotgun and the Ruger .22 caliber handgun, by damage-risk criterion. Error bars represent the range of maximum permissible unprotected exposures across shots. Separate estimates of maximum permissible unprotected exposures were obtained for each cartridge fired in the 12 gauge standard and the .410 caliber shotguns. Permissible exposures of 0 returned by the Smoorenburg criterion were entered as 0.1 to permit plotting.

The highest peak noise level from a shotgun at the bystander location (161.4 dB SPL) was produced by the largest-gauge shotgun sampled, a 10 gauge firing a 3.5 inch cartridge. On the other end of the shotgun noise level range was the .410 gauge shotgun firing a 3 inch cartridge and producing a peak level of 149.1 dB SPL. When the same 12 gauge shotgun is fired with two different cartridges (2.75 vs. 3 inch), the longer cartridge yields a higher peak SPL (150.0 dB), assuming barrel length and distance to the bystander are held constant. It is also apparent that the larger cartridge diameters (gauge) yield higher peak SPLs.

The impulse noise from the handgun assessed in this study should also be mentioned. This small revolver fired one of the smallest cartridges commercially available: the .22 Long Rifle. However, the peak was 154.0 dB SPL, which exceeded the peak levels of five of the other firearms. This may be explained in two ways. First, the shorter 4 inch barrel length places the noise source closer to the bystander. Second, since this firearm is a revolver, there is a significant blast of gases and noise emitted between the exit chamber from the cylinder and the rear opening of the barrel, further reducing the distance between the noise source and the ears of the bystander. These two factors probably account for the high SPL for such a small cartridge.

When the Auto-Ordnance .45 Tommy gun and the .22 Ruger revolver noise levels are compared, another seemingly counterintuitive finding was observed. The Tommy gun shoots a rather substantial (larger) handgun cartridge (.45 automatic Colt pistol [ACP]) that produced a peak level of 151.0 dB SPL, while the .22 caliber Ruger revolver produced a higher peak level (154.0 dB SPL). This probably again reflects the short barrel length of the handgun and the opening between the cylinder and barrel when compared to the longer barrel and closed interface of the chamber with the barrel of the Tommy gun.

It could be concluded that firing a handgun with a short barrel length (especially one with a large bore), compared to long-barreled rifles and shotguns, may increase the auditory risk factor for the bystander. And when the handgun is a revolver, the bystander's risk for hearing loss may be greater than for semiautomatics or single-shot handguns.

Estimates of MPEs were based on the assumption that the shooter or bystander is unprotected (not wearing earplugs and/or earmuffs). Hearing protectors can be expected to generally decrease the auditory risks to the wearer in direct proportion to the reduction in the peak sound level (W. Murphy, personal communication, March 4, 2010). Therefore, the unprotected MPEs from the current study could be adjusted by the proportional effect of a given ear protector. For example, with

the Winchester Model 70 (7 mm Remington Magnum) rifle with the BOSS muzzle brake producing an unprotected MPE of 0.2 (Coles/CHABA DRC) or 4 (Price/Kalb DRC), an ear protector that reduces the DRCs by a factor of 100 would increase the MPE to 20 or 400, respectively. Unfortunately, this approach would not be suitable for the Smoorenburg DRC, because many guns have an MPE of either 0 or 50 and increases in MPEs due to the hearing protector would need to be determined by the effect of the hearing protector on the A-weighted 8 hr equivalent level and the SEL, after transformation of the recordings under the protector to equivalent levels in the undisturbed sound field.

None of the guns included in this study should be considered safe for unprotected bystanders, but the sound produced by some guns (e.g., Mossberg bolt-action .410) is less risky than others, and the longer gun barrels and lower-powered guns and ammunition carry less risk to the unprotected auditory system. We assumed a grazing incidence for the risk estimates in this study, and this situation may not always reflect the angle of incidence to the bystander's ear in the field. The relative risk of auditory damage may be higher for normal incidence where the acoustic effects of the head and pinna lead to greater gain in the high frequencies (Shaw, 1974).

The presumed location of the bystander in this study was 1 m to the left of a right-handed shooter. However, the sound field surrounding the firearm and shooter is not uniform (Rasmussen et al, 2009). The results of the current study can be expected to provide underestimates of sound levels and auditory risk for bystanders nearer the muzzle (e.g., closer to the shooter or forward) and could overestimate the risk for those farther away. Companion hunters, shooting instructors, and long-range precision shooting teams are examples where bystanders might be closer than the conditions evaluated in this study. In the case of companion hunters, particularly waterfowl hunters in a blind, it is possible to have a group of three or more shooters firing at flying waterfowl simultaneously from inside an enclosure (e.g., a duck blind [Stewart et al, 2009]). In such conditions, each person is both a bystander and a shooter, and each listener's distance to the muzzle is determined by the flight path of the bird. Shooting instructors will occasionally help the student shooter use the gunsight from a position directly behind the student shooter. In these conditions, it would be most appropriate to apply auditory risk estimates obtained at the shooter's location. Long-range precision shooting teams employ a person in the role of spotter who assists in identifying the location and range to the target, and competitions of this sort could lead to the spotter occupying a location forward of the shooter, particularly when shooting from inside an enclosure or in close quarters.

Clinical Implications

People involved in hearing health care are acutely aware of the general risk of unprotected firearm noise exposure for shooters, and this research highlights the need to extend this clinical awareness to bystanders. The specific auditory risk to any particular bystander is contingent upon the shooter's behavior, the firearm in use, the number of shots fired, the ammunition used, and the shooting environment. Bystanders accompanying hunters may not recognize that their relative risk would be expected to increase when accompanying bird hunters who may have higher daily limits on quail (10) and are successful on every third shot versus pheasant hunters with a lower daily limit (two–five) or deer hunters who may fire only one or two limited opportunity shots. Bird hunts are often group hunts, and bystander exposure is common. Persons functioning as hunting guides or instructors may find themselves routinely in the bystander position regardless of the type of hunting. Many hunters assist other hunters once they have gained the skills or harvested their personal game, thus increasing their personal risk of hearing loss.

Hearing protection is advisable for anyone observing in close proximity to a shooter, whether a family member accompanying a hunter to a waterfowl blind or an observer at a target shooting event. Firearm users who take turns shooting and become temporary bystanders may not realize that they could be positioned in a more hazardous situation than the shooter. These situations may necessitate the utilization of hearing protection. Bystanders cannot predict the frequency and acoustic conditions of impulse noise exposure, and consequently a conservative approach to universally recommending HPDs is justified. Shooters themselves may be the most likely person to advise a bystander of the need to wear hearing protection, since shooters are often aware of other safety considerations before firing a shot. Electronic or nonlinear hearing protection may be especially useful for bystanders who wish to maintain speech communication and environmental awareness while participating in the shooting activity.

It may be advantageous to relocate bystanders or fellow shooters to a less hazardous observation point when feasible and practical. If close observation is not warranted or desired, then increasing the distance between the bystander and the muzzle blast would be preferable. In the case of formal shooting events and supervised target practice, spectators can be required to observe from a substantial distance. In many sports, video cameras are used to bring the "action" closer to the spectator, and these strategies might be useful in terms of hearing loss prevention for bystanders at shooting events.

Special consideration for children who are bystanders may be warranted, since the World Health Organization (1999) suggests that children should not be

exposed to impulse peak sound levels greater than 120 dB SPL. In this case, hearing protection that fits well and provides adequate attenuation is necessary when bystander exposure cannot be avoided. The American culture of passing on hunting traditions from parents and grandparents to young children can be respected by counseling adults on the importance of eliminating unnecessary and unprotected firearm exposure to children and modeling appropriate protective behaviors.

Audiologists are encouraged to expand their clinical inquiry beyond asking, "Do you shoot firearms?" to address any history of firearm noise exposure as a bystander and/or shooter, e.g., "Are you exposed to *any* firearm noise?" Follow-up questions would then focus on the use of hearing protection, the description of bystander situations, and the types of firearms (if known). Any specific occurrences of unprotected firearm noise exposure should receive special attention. Extensive counseling focusing on higher-risk situations—using high-powered rifles, large shotguns, handguns, and firearms with muzzle brakes—should emphasize the need to wear effective HPDs in these instances. Routine audiologic monitoring should also be encouraged for bystanders exposed to firearm noise in order to monitor hearing protector effectiveness.

CONCLUSION

Bystanders are at risk of auditory damage from unprotected civilian firearm noise exposure, and HPD use is warranted. Civilian firearm impulse noise peak levels ranged from 149 to 166.5 dB SPL when measured from a bystander location 1 m to the left of the shooter. These results illustrate that maximum permissible exposures (unprotected) vary across firearms, ammunition, and DRCs. MPEs ranged from 0 to 217 dependent upon the DRC applied and firearm used. In general, firearms with longer barrels and lower-power ammunition are less hazardous to hearing. The risk of auditory damage is influenced by a variety of acoustic, firearm, ammunition, environmental, and circumstantial conditions that cannot always be predicted in advance of the exposure. Damage-risk criteria can be used to quantify the relative auditory damage risk between various firearms and shooting conditions. Audiologists are advised to consider unprotected bystander firearm noise exposure in the clinical evaluation of hearing loss and when implementing hearing loss prevention programs for recreational firearm users and bystanders/spectators.

Acknowledgments. The authors thank William Murphy and Edward Zechmann (Centers for Disease Control and Prevention/NIOSH Taft Laboratories) for the MATLAB software routines used for data analyses and Ed Terrell (G.R.A.S. Sound and Vibration) for his assistance with this study.

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Exhibit

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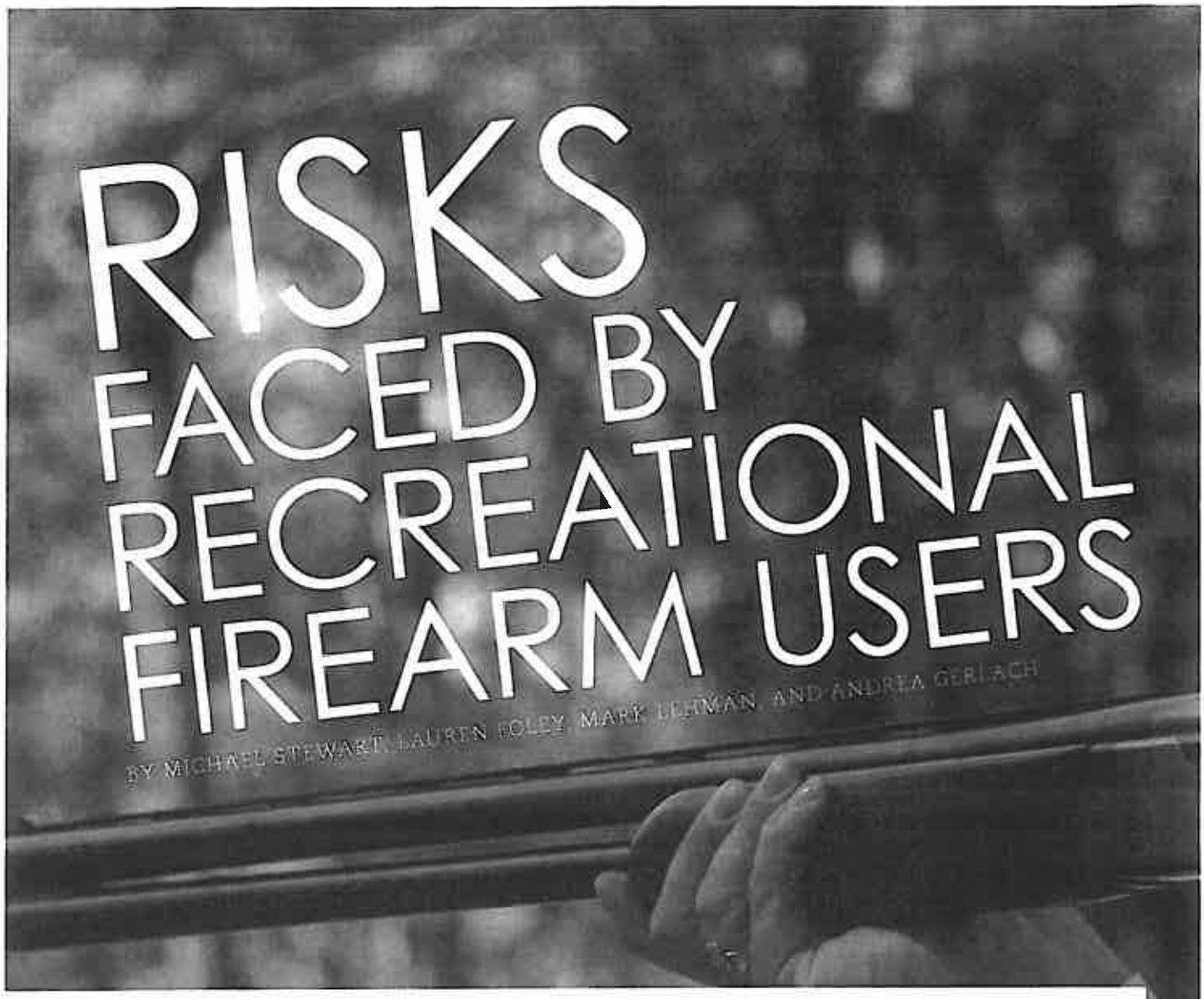
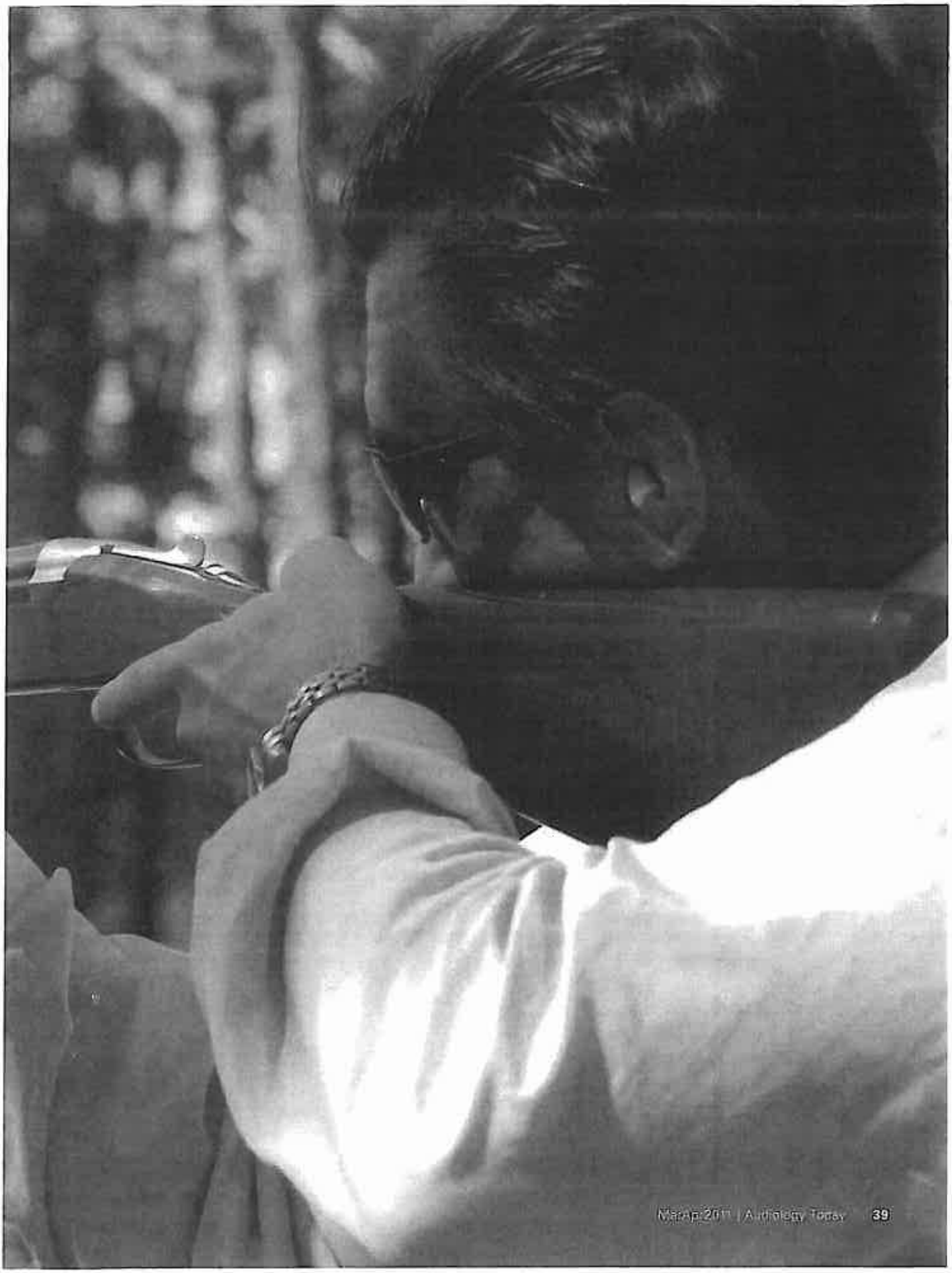


RISKS FACED BY RECREATIONAL FIREARM USERS

BY MICHAEL STEWART, LAUREN FOLEY, MARK LEHMAN, AND ANDREA GERLACH

The level of impulse noise generated by almost all firearms exceeds the 140 dB peak SPL limit recommended by OSHA and NIOSH. Studies of the shooting habits of recreational firearm users indicate that many of these shooters are at risk to acquire NIHL. The present study provides information about the shooting habits of recreational firearm users that will help audiologists provide better hearing conservation services to this population.

The civilian use of firearms for hunting and other sport activities is widespread in the United States today. According to the Small Arms Survey, Geneva (2007), the number of firearms owned by Americans is estimated to be 270 million, more than any other country in the world. According to the U.S. Department of the Interior Fish and Wildlife Service (2006), over 12.5 million Americans use firearms for hunting purposes. The National Shooting Sports Foundation (2009) reports over 30 million U.S. citizens are actively involved in the shooting sports (hunting, target shooting, etc.). In many communities, especially those in rural areas, the tradition of recreational firearm use passes from older generations to younger generations within the family structure. Several states have hunting laws that allow children as young as 10 years of age (17 of those states have virtually no age requirement) to share a limited hunting experience



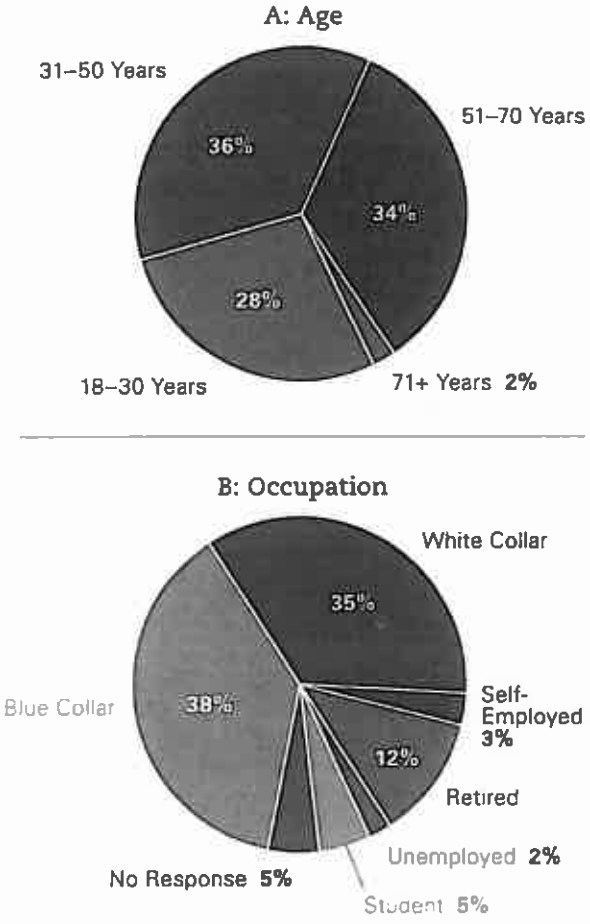


FIGURE 1. Demographic data of subjects: age (A), occupation (B), and occupational loud noise exposure (C).

when mentored by an adult family member (National Shooting Sports Foundation, 2010).

Although recreational firearm activities can provide individuals and families with leisure-time opportunities, participation in those activities can also be hazardous to hearing. The level of impulse noise generated by almost all firearms exceeds the 140 dB peak SPL limit recommended by the Occupational Health and Safety Administration (OSHA) and the National Institute of Safety and Health (NIOSH) (Coles et al, 1967; Odess, 1972; Ylikoski, 1989; Ylikoski and Ylikoski, 1994; Kardous et al, 2003; Murphy and Tubbs, 2007; Flamme et al, 2009). Exposure to impulse noise levels in excess of 140 dB SPL can lead to noise-induced hearing loss (NIHL) (Patterson and Hamernick, 1992; Chan et al, 2001). Increasing the duration of firearm noise by shooting in an enclosed, reverberant environment increases auditory risk (CHABA, 1968; Weissler and Kobal, 1974; Smoorenburg, 2003).

Because of the widespread use of firearms for recreational pursuits and the dangerously high peak SPLs generated by most firearms, it is not surprising that recreational firearm noise exposure is one of the leading causes of NIHL in America today (Clark, 1991). Several studies have found recreational firearm use can result in high frequency NIHL (Prosser et al, 1988; Dancer et al, 1991; Kryter, 1991; Cox and Ford, 1995; Stewart et al, 2001; Stewart et al, 2002). Nondahl et al (2000) estimated an increase of seven percent incidence of high frequency hearing loss for every five years of hunting activity. Audiometric configurations of NIHL caused by firearm noise exposure are often characterized by normal or near normal hearing in the lower frequencies, with a precipitous drop-off in the higher frequencies for both ears. Individuals with this type of hearing loss often minimize the communication difficulties and may not always receive adequate benefit from hearing aids.

An important factor in the incidence rate of NIHL secondary to firearm noise exposure may be the shooting habits of many recreational firearm users. Wagner et al (2006) surveyed 297 recreational firearm users and found more than 80 percent of the subjects reported never using hearing protective devices (HPDs) while engaging in hunting activities. Only 39 percent of the subjects reported consistently using HPDs during target practice. The majority of subjects in the Wagner et al study were males. However, Nakayama et al (2008) found a similar trend of sporadic HPD use in a survey of 153 female shooters. A study by Stewart et al (2009) found waterfowl hunters reported inconsistent use of HPDs during both hunting (only five percent reported 100 percent use) and

target practice (only 40 percent reported 100 percent use) while many hunters reported being exposed to over 100 unprotected shots in a single hunting season. Approximately 90 percent of the waterfowl hunters reported using the 12 gauge shotgun (which is one of the loudest shotguns available), and over half of subjects in this study reported routinely shooting in a reverberant environment (hunting blind) when hunting waterfowl. Collectively, these studies of the shooting habits of recreational firearm users indicate many of these shooters are at risk to acquire NIHL.

The purpose of the present study was to collect more information about the shooting habits of recreational firearm users including their use of conventional HPDs, their use and knowledge of commercially available HPDs designed specifically for the shooting sports, the types of commonly used firearms, use of enclosed hunting blinds, the estimated number of unprotected exposures, and their self-assessed auditory status. This information is necessary to increase understanding about how and under what conditions firearms are being used in recreational shooting activities so that better hearing conservation services can be provided to this population.

Methods

Subjects

The subjects in this study were 573 recreational firearm users and were solicited while they shopped at a central Michigan sporting goods store during the first week of deer season (November 2009).

Materials

A 25-item survey was used to collect information from participants regarding demographic information and their recreational firearm use (see Appendix A). Five items requested demographic information, including age, sex, county of residence, occupation, and exposure to occupational noise; five items requested information regarding use of HPDs during target practice and while hunting; ten questions focused on shooting habits during target practice and while hunting; and five items inquired about self-perceived hearing ability, hearing aid use, and tinnitus.

Procedures

A proposal of this project was submitted and approved by the institutional review board of Central Michigan University. It was concluded no risk would exist to participants of this project.

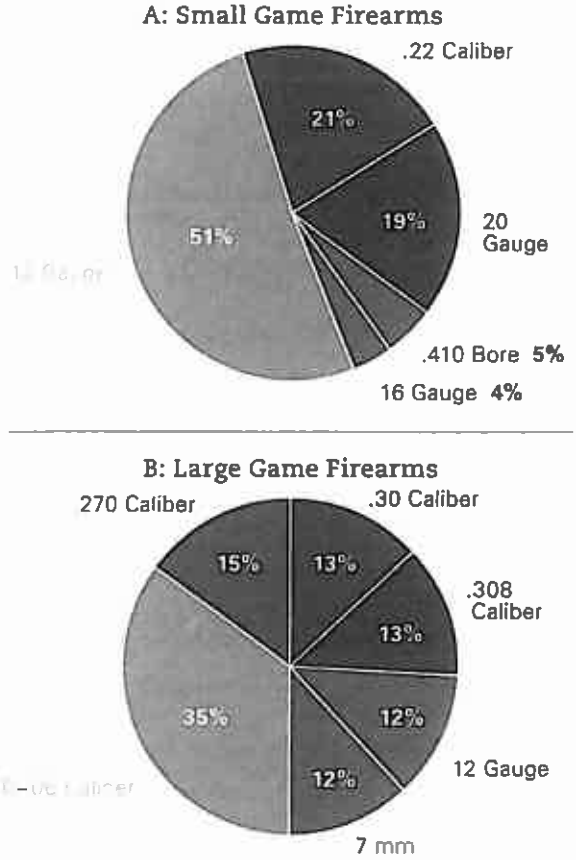


FIGURE 2. Firearms typically used by subjects in this study to hunt small game (A, N = 533) and large game (B, N = 549) as a function of reported usage.

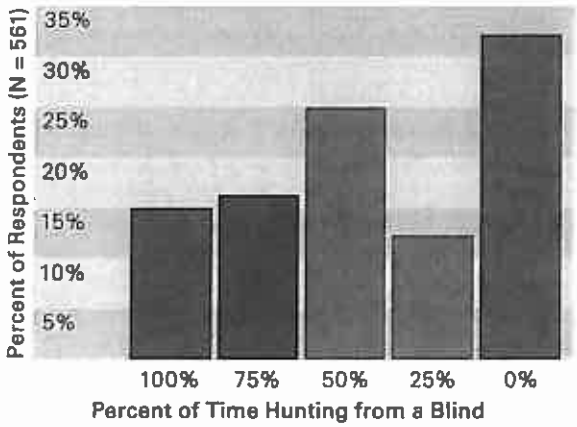


FIGURE 3. Number of subjects who reported hunting large game from a blind (N = 561).

A display was set up in the lobby of the central Michigan sporting goods store, and customers were invited to complete the survey to assist in data collection for the project. The survey took approximately 10 minutes to complete, and subjects were given a pair of hearing protection devices for participating. Data analysis was completed using Microsoft Excel, and descriptive statistics were derived from the raw data.

Results

Demographics

Of the 573 participants—90 percent were male and 10 percent female. Participants ranged in age from 18 to 82 years with a mean age of 42.6 years. See FIGURE 1 for additional data regarding age, occupation, and loud noise exposure.

Shooting Habits

Shooting habits of participants were assessed through multiple questions on the survey, including years of firearm use, types of firearms used (size of bore and type of action), hunting environments, and estimated shots taken both during target practice and hunting.

The majority of recreational firearm users in this study (62 percent) reported shooting firearms for more than 21 years. Approximately 17 percent reported shooting 10 years or less, while 21 percent reported shooting for 11 to 20 years. The average age of subjects in this study, in addition to the average number of years of reported recreational firearm use, would likely increase the risk of acquiring an NIHL for many of these subjects.

The firearms most commonly used for large and small game hunting by these subjects are shown in FIGURE 2. A majority (70 percent) of small game hunters reported that their guns were equipped with either semiautomatic (36 percent) or pump (34 percent) actions, which allow several shots to be fired in a short period of time. The most commonly used actions reported by the large game hunters were either a bolt (54 percent) or semiautomatic (17 percent). Both of these actions allow the hunter to fire several shots in a short period of time. Thus, both large and small game hunters reported using large-bore guns that are loud and can be fired in a rapid manner. Both the 30.06 rifle and 12 gauge shotgun are capable of generating peak impulses over 160 dB SPL (Flamme et al, 2009). Noise levels of this intensity may physically damage the inner ear resulting in temporary or permanent hearing loss (Ylikoski et al, 1987; Patterson and Hamernick, 1992; Chan et al, 2001).

Another important variable in the analysis of risk for NIHL is acoustic environment in which shots are fired.

Peak SPL and duration values can be significantly higher if the shots are fired in a small enclosure like a hunting blind. Higher peaks and longer durations of firearm noise impulses increase auditory risk (CHABA, 1968; Weissler and Kobal, 1974; Smoorenburg, 2003). FIGURE 3 shows the majority (70 percent) of respondents reportedly hunt large game from an enclosed blind at least part of the time. The use of an enclosed blind, especially in cold weather climates during later hunting seasons, is a common hunting practice that serves to protect the hunter

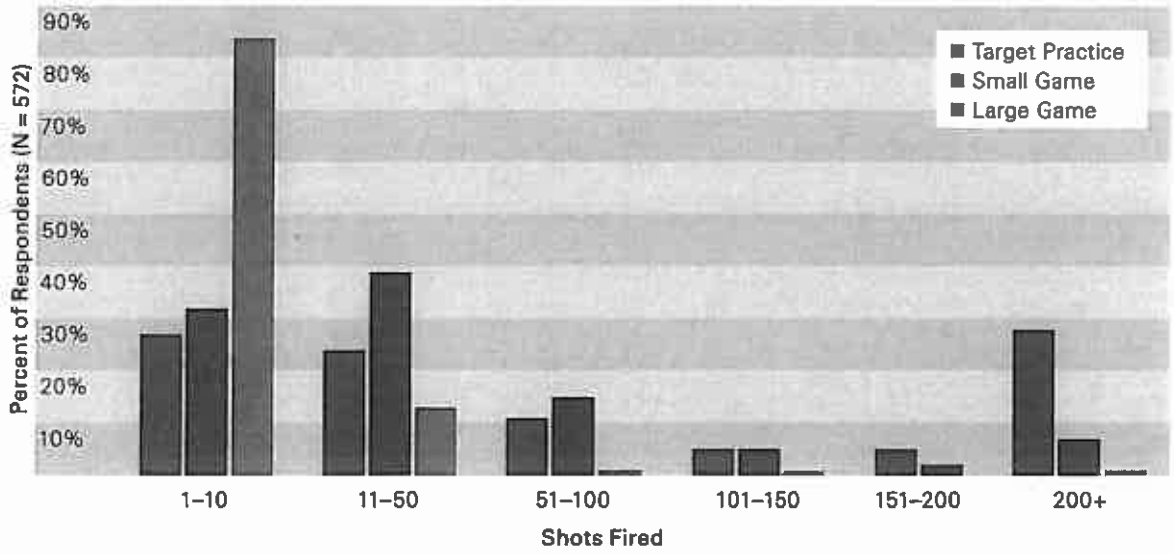


FIGURE 4. Number of shots fired during target practice and during hunting (N = 572).

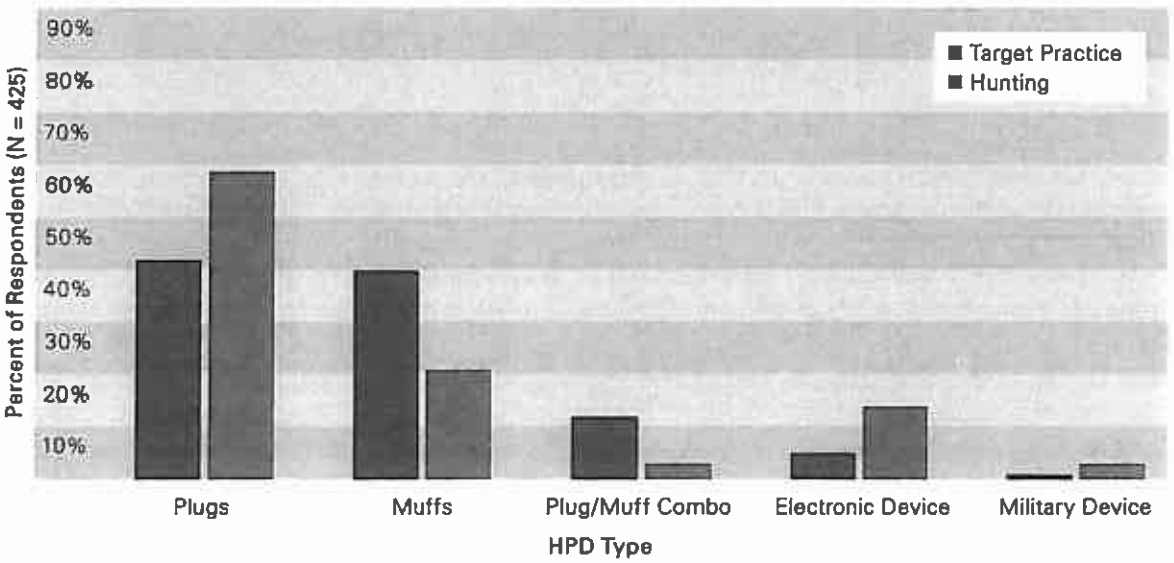


FIGURE 5. Types of HPDs used during target practice and hunting (N = 425).

from the elements while concealing him or her from approaching game.

Probably the most important aspect of shooting habits, as they relate to NIHL, is the total number of shots taken during various shooting activities in a year's time. Increasing the number of exposures, especially if unprotected, logically serves to increase the risk of hearing loss. The comparison of the number of shots reportedly taken during target practice and during small and large game hunting in the past year can be seen in FIGURE 4.

Hearing Protection Devices

A major goal of this study was to assess the use of HPDs by recreational firearm users during firearm use. Several questions on the survey focused on this issue, including the percentage of time HPDs were worn and which types were worn during target practice versus hunting. Over 70 percent of the subjects reported never wearing HPDs during hunting activities, and only 54 percent reported consistent use of HPDs during target practice. These results are consistent with those of prior studies (Wagner et al, 2006; Stewart et al, 2009) and suggest many recreational firearm users are putting themselves at risk for NIHL, especially while hunting with large-bore (loud) firearms. FIGURE 5 shows that the most common types of HPDs used by subjects for both target practice and hunting were nonelectronic plugs or muffs. Approximately 15 percent of the subjects reported using electronic hearing protective devices (EHPDs) when hunting. This is a significant increase in EHPD use, compared to a previous study by Wagner et al in 2006, and indicates hunters are becoming more aware of this type of protective device. Although over 50 percent of the subjects reported that they were aware of the nonlinear (military) type of HPDs, few reported utilizing these devices during target practice or hunting.

Large numbers of shots and lack of HPD use increase auditory risk. FIGURE 6 shows the reported number of shots taken by subjects in the past year without HPDs as a function of firearm type. The types of firearms were categorized as small, medium, and large rifles, small and large pistols, and shotguns. Rifles categorized as small included the .17 and .22 caliber rimfire guns. Rifles categorized as medium included .22–250, .223, .243, .25–06, and .257 caliber. Rifles categorized as large included .30 caliber and larger. Any pistol larger than a .22 caliber was classified as large. Shotguns were placed in the same category regardless of gauge. Most subjects reported being exposed to either 1–10 or 11–50 unprotected shots in the past year across firearm types. However, many

individuals reported much higher numbers of unprotected shots for various firearm types. For example, over 15, 18, and 10 percent reported being exposed to over 200 unprotected shots in the past year from large pistols, medium rifles, and shotguns, respectively. Individuals exposed to a high number of unprotected shots in a year's time from firearms capable of generating high impulse noise levels may be at considerable risk for NIHL.

Subjective Hearing Status

Self-perceived hearing ability was assessed for both right and left ears. Subjects were asked to categorize their right and left ear hearing ability as being excellent, very good, good, fair, or poor. Although over 75 percent of the subjects assessed right and left hearing ability to be good to excellent, approximately 20 percent reported right and left hearing to be either fair or poor. In the personal clinical experience of the authors, it has been observed that most patients presenting with a hearing loss underestimate the severity of their hearing loss when asked to make a self-assessment.

In addition to self-assessment of their hearing ability, subjects were asked if they experience temporary or constant tinnitus, or if they noticed an increase in tinnitus, a major symptom of sensorineural hearing loss (Axelsson and Barrenas, 1992; Eggermont and Roberts, 2004; Moller, 2007; Bauer and Brozoski, 2008; Dawes and Welch, 2010; Mazurek et al, 2010), following firearm use. Twenty-two percent of the subjects reported constant tinnitus (81 percent bilateral, 11 percent left ear only, eight percent right ear only) while approximately 44 percent reported temporary tinnitus or an increase in constant tinnitus after shooting a firearm in the past year. The reported incidence of constant tinnitus by firearm users in this study is significantly higher than the national average of 10–15 percent (Henry et al, 2005; American Speech-Language-Hearing Association [ASHA]) and suggests many of these individuals may have NIHL secondary to firearm noise exposure. Individuals reporting temporary tinnitus after shooting a firearm may have been exposed to SPLs high enough to cause NIHL.

Discussion

Results of this study reveal that the shooting habits and inconsistent use of HPDs reported by many recreational firearm users may put them at risk of acquiring an NIHL. The majority of subjects reported using firearms for over 20 years. The most frequently used firearms reported by

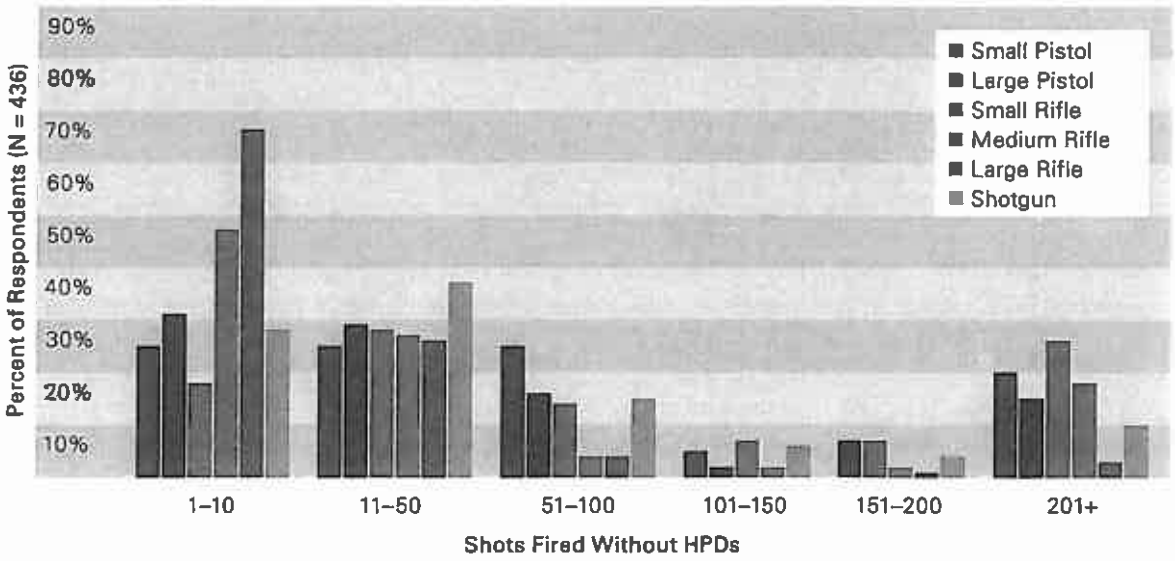


FIGURE 6. Number of shots fired without HPDs as a function of firearm type (N = 436).

shooters in this study for hunting small and large game were the 12 gauge shotgun and 30.06 rifle, respectively. Most shooters reported using either the semiautomatic or pump actions for small game hunting, while the most common action for large game was a bolt. The most commonly used firearms for both small and large game are not only loud (over 160 dB peak SPL) but are equipped with actions that allow up to five shots to be fired in a few seconds. Also, small game hunters often hunt in groups, which could serve to increase the number of exposures to high-level firearm noise during a single hunting excursion. The majority of large game hunters in this study reported frequently, if not always, hunting from an enclosure (hunting blind), which can increase peak SPL and duration of the impulse noise generated by their firearms via reverberation and lead to an increase in auditory risk.

Many subjects reported inconsistent use of HPDs, especially during hunting activities. Over 70 percent of the hunters reported never using HPDs while hunting, while only slightly more than one-half reported consistent use of HPDs during target practice. Ironically, using HPDs during target practice would not only protect hearing but also has the potential side benefit of increasing accuracy by reducing physical flinching by the shooter caused by anticipation of hearing the loud shot. Over half of the shooters reported they were aware of non-electronic, level-dependent (i.e., military style) HPDs specifically designed for the shooting sports, yet fewer than five percent reported using them during hunting activities. Approximately 12 percent of the shooters did report using electronic HPDs when hunting. Overall, the finding that approximately 17 percent of the hunters in this study used either active or level-dependent HPDs for hunting purposes is encouraging and indicates a significant increase in both awareness and use of these devices compared to previous studies (Wagner et al, 2006; Stewart et al, 2009). Both of these devices are especially applicable for hunting game since they allow hearing of softer environmental and animal sounds while protecting hearing from loud firearm noise.

Although an overwhelming majority (88 percent) of recreational firearm users in this study acknowledged that firearm noise can cause hearing loss, many reported a large number of unprotected firearm noise exposures within the past year. This finding suggests that recreational firearm users in this study may be recklessly putting themselves at risk for NIHL. Audiologists and other hearing health professionals should be aware of this behavior and effectively counsel recreational firearm

Approximately 20 percent of the subjects reported right and left hearing to be either fair or poor.

users about the importance of protecting their hearing during target practice and especially while hunting.

The reported incidence of subjective hearing problems and tinnitus by recreational firearm users in this study should be of concern to audiologists and hearing conservationists, as approximately 20 percent of the subjects rated their hearing to be only fair or poor, 22 percent reported constant tinnitus, and 44 percent reported tinnitus or an increase in their constant tinnitus after firing a gun in the past year. Many of these subjects may be hearing aid candidates (although only four percent reported wearing hearing aids), and the incidence of constant tinnitus is significantly higher than the estimated rate in the general adult population of 10–15 percent (Henry et al, 2005; ASHA). The percentage of subjects with tinnitus who reported their tinnitus as being severely annoying (nine percent) is similar to findings by Axelsson and Barrenas (1992). These subjects may be considered candidates for a tinnitus therapy program.

Results of this study support the need for hearing conservation educational programs for recreational firearm users. A major focus of the educational training should stress the hazardous effects of firearm noise on hearing so shooters fully understand the auditory consequences of excessive exposure. Appropriate selection and proper use of HPDs should be a major component of any educational program. Students enrolled in these programs should be advised on the effectiveness of various types of HPDs and when double protection (muff and plug) may be needed to attenuate firearm noise to nonhazardous levels. They also need to be knowledgeable about and able to select appropriate active (electronic) and level-dependent HPDs that are specially designed for the shooting sports. Demonstrations of simulated hearing loss (NIOSH, 2004) and simulated tinnitus (Martin, 2009) should also be used to allow the students to actually hear the consequences of excessive firearm noise exposure. Students should also receive a basic hearing test by a qualified hearing health professional to identify possible hearing loss and establish a baseline audiogram. The educational programs could be offered through hunter safety courses, hunting clubs, or during shooting instructions. A special firearm noise section in industrial hearing conservation program educational programs could be included for workers who use firearms. Finally, clinical audiologists should educate their patients who use firearms with regard to the hazards and types of hearing protection to prevent NIHL.

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Appendix A

Shooter Survey

Department of Communication Disorders
Central Michigan University

Age: _____ County of Residence: _____ Sex: M ☐ F ☐
Occupation: _____ Do you work in loud noise? Yes ☐ No ☐

1. Do you feel that noise from shooting a gun may cause hearing loss?
   ☐ Yes ☐ No

2. Do you shoot:
   ☐ Right-handed ☐ Left-handed

3. How many years have you been shooting guns?
   _____ years

4. Which type of gun do you use the most for small game hunting?
   Caliber/gauge _____
   ☐ Auto ☐ Single/double barrel ☐ Bolt ☐ Pump
   ☐ Lever

5. Which type of gun do you use the most for large game hunting?
   Caliber/gauge _____
   ☐ Auto ☐ Single/double barrel ☐ Bolt ☐ Pump
   ☐ Lever

6. How many shots do you typically fire per year during target practice?
   ☐ 1–10 ☐ 11–50 ☐ 51–100 ☐ 101–150 ☐ 151–200
   ☐ 201+

7. What percentage of time do you use ear protection during target practice?
   ☐ 100% ☐ 75% ☐ 50% ☐ 25% ☐ 0%

8. Are you aware of the non-electronic type of hearing protection device used by the military to reduce loud sounds while allowing softer sounds to be heard?
   ☐ Yes ☐ No

9. If you use ear protection during target practice, which type do you use?
   ☐ Plugs ☐ Muffs ☐ Plug/muff combo
   ☐ Electronic device ☐ Military device

10. How many shots do you typically fire per year while hunting small game?
    ☐ 1–10 ☐ 11–50 ☐ 51–100 ☐ 101–150 ☐ 151–200
    ☐ 201+

11. How many shots do you typically fire per year while hunting large game?
    ☐ 1–10 ☐ 11–50 ☐ 51–100 ☐ 101–150 ☐ 151–200
    ☐ 201+

12. What percentage of time do you use ear protection while hunting?
    ☐ 100% ☐ 75% ☐ 50% ☐ 25% ☐ 0%

13. If you used ear protection while hunting, which type did you use?
    ☐ Plugs ☐ Muffs ☐ Plug/muff combo
    ☐ Electronic device ☐ Military device

14. When hunting large game, what percentage of time do you shoot from an enclosed blind?
    ☐ 100% ☐ 75% ☐ 50% ☐ 25% ☐ 0%

15. How would you rate your hearing ability?

Right Ear	Left Ear
☐ Excellent	☐ Excellent
☐ Very good	☐ Very good
☐ Good	☐ Good
☐ Fair	☐ Fair
☐ Poor	☐ Poor

16. Do you wear hearing aids?
    ☐ Yes ☐ No

    If yes, which ear?
    ☐ Right ☐ Left ☐ Both

17. Do you notice constant or almost constant ringing in your ears?
    ☐ Yes ☐ No

    If yes, which ear?
    ☐ Right ☐ Left ☐ Both

18. If you experience ringing in your ears, at which level of annoyance do you find it:
☐ Severely ☐ Moderately ☐ Mildly

19. Do you ever notice ringing or an increase of ringing in your ears after shooting?
☐ Yes ☐ No

If yes, how many times in the past year?
_____ times

20. List all guns you've shot in the past year *without* wearing hearing protection. List the bore size and whether the gun is a rifle, shotgun, carbine, or pistol. Check the number of shots that you take per year with each gun.

Gun #1: _____
Number of shots per year without protection:
☐ 1–10 ☐ 11–50 ☐ 51–100 ☐ 101–150 ☐ 151–200 ☐ 201+

Gun #2: _____
Number of shots per year without protection:
☐ 1–10 ☐ 11–50 ☐ 51–100 ☐ 101–150 ☐ 151–200 ☐ 201+

Gun #3: _____
Number of shots per year without protection:
☐ 1–10 ☐ 11–50 ☐ 51–100 ☐ 101–150 ☐ 151–200 ☐ 201+

Exhibit

10

AMERICAN ACADEMY OF OTOLARYNGOLOGY–HEAD AND NECK SURGERY FOUNDATION

Otolaryngology–Head and Neck Surgery 144(6) 950–953

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Comparison of Muzzle Suppression and Ear-Level Hearing Protection in Firearm Use

Matthew Parker Branch, MD[1]

No sponsorships or competing interests have been disclosed for this article.

Abstract

Objective. To compare noise reduction of commercially available ear-level hearing protection (muffs/inserts) to that of firearm muzzle suppressors.

Setting. Experimental sound measurements under consistent environmental conditions.

Subjects. None.

Study Design and Methods. Muzzle suppressors for 2 pistol and 2 rifle calibers were tested using the Bruel & Kjaer 2209 sound meter and Bruel & Kjaer 4136 microphone calibrated with the Bruel & Kjaer Pistonphone using Military-Standard 1474D placement protocol. Five shots were recorded unsuppressed and 10 shots suppressed under consistent environmental conditions. Sound reduction was then compared with the real-world noise reduction rate of the best available ear-level protectors.

Results. All suppressors offered significantly greater noise reduction than ear-level protection, usually greater than 50% better. Noise reduction of all ear-level protectors is unable to reduce the impulse pressure below 140 dB for certain common firearms, an international standard for prevention of sensorineural hearing loss.

Conclusion. Modern muzzle-level suppression is vastly superior to ear-level protection and the only available form of suppression capable of making certain sporting arms safe for hearing. The inadequacy of standard hearing protectors with certain common firearms is not recognized by most hearing professionals or their patients and should affect the way hearing professionals counsel patients and the public.

Keywords

tinnitus, sensorineural hearing loss, noise-induced hearing loss, firearm suppression, hearing protection

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Noise-induced inner ear injury is a substantial cause of preventable disability in the United States. Approximately 15% of Americans between the ages of 20 and 69 years—or 26 million Americans—have hearing loss that may have been caused in part by exposure to loud sounds or noise at work or in leisure activities.[1] Subjective tinnitus affects approximately 50 million Americans (12%-15% of the adult population)[2-4] and often accompanies sensorineural hearing loss in patients with a history of loud noise exposure.[5-9]

Recreational use of firearms is a significant cause of noise and related ear injury in America.[10] There are approximately more than 250 million privately owned firearms in the United States,[11,12] and the number increases about 4.5 million per year.[13] This rate of increase rose by 14% for 2007-2008.[14] Unlike industrial exposure, hearing protection during recreational firearm use is not regulated or enforced. This represents one of the largest neglected areas of advocacy for prevention of ear injury.

Ear-level hearing protection is poorly understood by patients and hearing specialists alike. Far from being a panacea, ear-level protection rarely, if ever, confers the level of protection or noise reduction ratio (NRR) advertised. NRRs are determined using laboratory tests in continuous noise (not impulse sounds such as gunfire) and are not useful for determining the actual level of protection achieved by a given individual in a particular environment.[15]

How much protection is afforded by ear-level protection? The National Institute of Occupational Safety and Health (NIOSH) recommends that earmuffs be considered to have 25% less NRR than stated and formable earplugs 50% less.[16] The most common commercially available ear protection has an advertised NRR of 19 to 25 dB. The highest rated NRR are 31 dB and are less common. The Occupational Safety and Health Administration sets 140 dB

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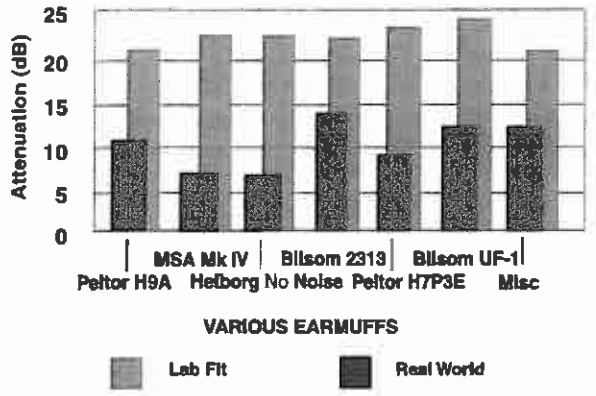

Figure 1. Noise reduction ratio (NRR) hearing protection provides in the real world: earmuffs.

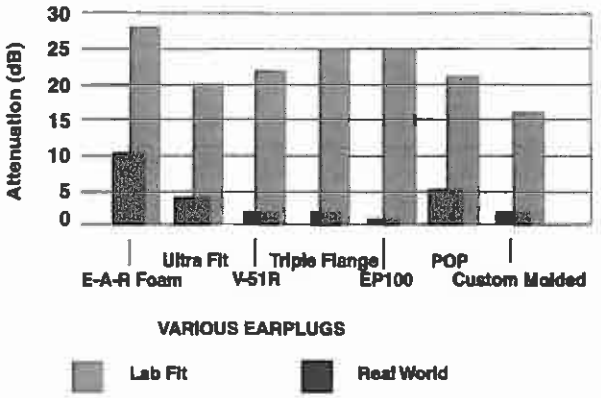

Figure 2. Noise reduction ratio (NRR) hearing protection provides in the real world: earplugs.

as the safe threshold for single-impulse sound exposure. Using the adjusted NRR levels, most hearing protection (NRR 19-25 dB) is unable to make hearing safe a firearm producing an impulse sound louder than 149.5 to 154 dB. The best available ear-level protection (earmuffs, NRR 31 dB) is unable to make hearing safe any firearm louder than 163 dB under the best of conditions. According to Berger et al,[16] even these adjusted figures are likely unrealistic. This review of 20 published studies demonstrated far worse performance than the corrected NRR suggests: the laboratory NRRs consistently overestimated the real-world NRRs by 140% to 2000% (**Figures 1** and **2**).[16] It is unlikely, however, that most consumers of hearing protection have any idea what the NRR is of the products they purchase or what level of protection is necessary to make their particular firearm safe for hearing.

Hiram Maxim first introduced and marketed muzzle suppressors in the 1920s in the United States. These devices either attach to the muzzle (by way of threading the barrel or by proprietary quick attachment mechanisms) or are integrated into the barrel. Muzzle suppressors allow the heated gases from the barrel to expand into a series of chambers or baffles, cooling and slowing the gas's exit from the barrel. The result is a shorter, quieter sound signature. The basic design of suppressors has changed little over the years, but modern design and manufacturing have improved their sound reduction effectiveness. Unlike ear-level protection, muzzle suppressors are relatively easy to use in a consistent, repeatable fashion. They confer protection for the shooter and bystanders alike and allow interpersonal conversation and situational awareness of sounds not afforded by ear-level devices. They are also legal in most states, although their ownership and transfer are regulated by the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF&E) and requires a $200 tax and somewhat lengthy process for registration, delaying use of the device for weeks or months from the time of purchase. Importantly, it is relatively simple to demonstrate their actual noise reduction capability compared with ear-level devices.

Study Design

We hypothesized that modern muzzle suppression has a demonstrable superiority to ear-level protection due to the unpredictable protection of ear devices and improbability of one-size-fits-all products. We tested common pistol and rifle calibers with and without muzzle suppression using strict military/industrial standard sound measurement for impulse noise. We recorded the impulse noise in decibels and compared the sound levels with and without suppression. We then compared the average noise reduction of the suppressors to likely NRR levels of ear-level products.

Methods

The tests were conducted using the Bruel & Kjaer (B&K) 2209 sound meter with a B&K 4136 microphone calibrated with the B&K 4220 Pistonphone. Calibration was checked after the tests to verify there were no shifts in calibration during the tests. All equipment has been certified and tested so that it can be traced back to the National Institute of Standards and Technology's standards. The meter and weapon are also placed in accordance with Military-Standard 1474D protocol. Five shots were fired to establish the unsuppressed level, and then 10 shots were fired with the suppressor attached.[17]

For the pistol tests, we used 9 mm and 45 ACP semiautomatic pistols (**Table 1**). These are very popular sporting rounds as well as common military standard calibers. The rifle tests were performed with a semiautomatic 5.56 mm/223 caliber round, as is used in the AR-15 style civilian rifle and the NATO military M16/M4 carbine rifle, and a bolt-action 7.62 × 51 mm/308 caliber rifle, also a common sporting round and NATO military standard round.

The suppressors used are commercially available and legally obtained by way of the standard BATF&E registration process for civilian ownership. No institutional review or ethics committee approval was deemed necessary or sought for this study.

Table 1. Firearms (Caliber, Manufacturer), Ammunition, and Suppressors Used

	Caliber	Manufacturer	Ammunition	Suppressor
Pistol	9 mm	Sig Sauer P226, Exeter, NH	Remington UMC 147 gr ball, Lonoke, AK	Advanced Armament Ti-Rant, Norcross, GA
	45 ACP	Glock 21, Smyrna, GA	Remington UMC 230 gr ball, Lonoke, AK	HTG Cycle-2, Boise, ID
Rifle	5.56 mm/223	Colt M4 16 inch barrel, Hartford, CT	M855 NATO 62 gr steel core penetrator, Independence, MO	Gemtech G5, Eagle, ID
	7.62 × 51 mm/308	Remington Model 700, Madison, NC	Remington 168 gr BTHP MK, Lonoke, AK	HTG M-30, Boise, ID

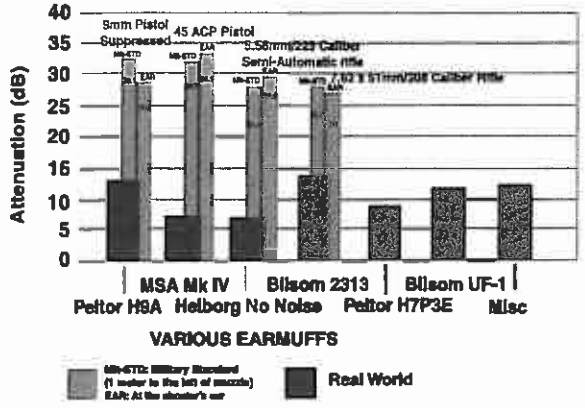

Figure 3. Firearm/suppressor attenuation compared with real-world earmuff attenuation. EAR indicates at the shooter's ear; MLT-STD, military-standard.

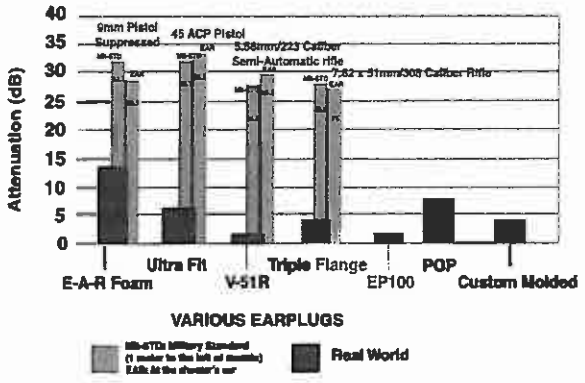

Figure 4. Firearm/suppressor attenuation compared with real-world earplug attenuation. EAR indicates at the shooter's ear; MLT-STD, military-standard.

Results

The average unsuppressed sound levels for the 9 mm pistol at military standard recording distance (1 m to the left of the muzzle) was 160.5 dB and 157.7 dB at the ear of the shooter. The average suppressed levels were 127.4 dB and 129.6 dB, respectively (difference of 33.1 dB and 28.1 dB).

The average unsuppressed sound levels for the 45 ACP pistol at military standard recording distance and the shooter's ear was 162.5 dB. The average suppressed levels were 131.8 dB and 128.5 dB, respectively (difference of 30.7 dB and 33.9 dB, respectively). The suppressor for the 45 ACP is also designed to function wet (filled with 10 mL of water for additional noise reduction). The average wet suppressed level was 121 dB (difference of 41.5 dB).

The average unsuppressed sound levels for the 5.56 mm/223 caliber semiautomatic rifle at the military standard recording distance was 164 dB and 155 dB at the shooter's ear. The average suppressed levels were 137.4 dB and 134.2 dB, respectively (difference of 26.6 dB and 29.8 dB, respectively).

The average unsuppressed sound levels for the bolt-action 7.62 × 51 mm/308 caliber rifle at the military standard recording distance was 165.7 dB and 157.2 dB at the ear. The average suppressed sound levels were 138.9 dB and 131.2 dB, respectively (difference of 26.8 dB and 26 dB, respectively). See **Figures 3** and **4**.

Discussion

The consistency of hearing protection use with recreational firearms is dismal.[18] We know that hearing compliance programs in industry rely on routine, supervised use of ear-level devices and periodic audiometric screening to assess effectiveness. No such programs exist for the recreational shooter. As the NIOSH Web site explains, the best hearing protection is the one the worker will wear.[16] But how do we motivate shooters to be compliant, especially in light of the data regarding the poor effectiveness of ear-level devices? Even compliant use of dual ear protection (plugs and muffs) over time leads to degradation of hearing.[19] Practical limitations of ear-level devices are myriad. Poor fit, migration of device due to activity or sweat, incorrect use, pain, heat, and loss of communication top the list.

Because of their use at the source of noise production, muzzle suppressors are much more effective at reducing noise. This facilitates communication and situational awareness, which can improve safety when operating firearms. Suppressors can easily and reliably be removed and transferred between multiple weapons of like caliber and reattached in a way that ensures proper fit and function. With suppression levels from 26 dB to 41 dB that are reliable and reduce impulse noise below 140 dB, all of the devices in

our study are "hearing safe." However, weapon-suppressor combinations producing sound levels 130 dB or less (9 mm and 45 ACP wet) are much more comfortable to shoot without any hearing protection at all. In fact, the sound level of the 9 mm pistol's slide closing without any shot fired measured 124 dB. To our knowledge, this is the first time the efficiency of muzzle suppressors has been properly tested and compared with ear-level protection in any medical journal.

Conclusion

The muzzle-level suppressors studied on these weapons and calibers reduced sound levels well below the likely noise reduction of either earplugs or earmuffs.

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Author Contributions

Matthew Parker Branch, original concept, experimental design and execution, research, writing, editing entire text, final approval.

Disclosures

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