Postdeployment Hearing Loss in U.S. Army Soldiers Seen at Audiology Clinics From April 1, 2003, Through March 31, 2004

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Purpose: U.S. Army soldiers face unique noise exposures in the current deployed setting. The effects of these deployment-related exposures have not previously been documented.
Method: In an attempt to initiate this process, medical evaluations performed at military audiology clinics from April 2003 through March 2004 were reviewed to compare noise-induced hearing loss injury (NIHLI) outcomes among soldiers whose diagnoses were classified as postdeployment-related versus non-postdeployment-related. Sentinel NIHLI outcomes of interest included acoustic trauma, permanent threshold shift, eardrum perforation, tinnitus, and military-specific H-3 and H-4 hearing loss profiles.
Results: Significantly higher rates of NIHLI and associated outcomes were observed among soldiers whose diagnoses were postdeployment-related.
Conclusions: Based on the findings from this evaluation, recommendations are provided for enhancing the force health protection posture for prevention of hearing loss in future deployments.

Key Words: noise-induced hearing loss injury, surveillance, postdeployment, evidence-based practice

The U.S. Army is evolving into an expeditionary force with periods of deployment interspersed with periods of home garrison training. The majority of recent deployments have been in relation to Operation Iraqi Freedom (OIF) and have involved battlefield scenarios and potentially volatile peacekeeping missions. Given the current military operations, the Army represents a unique noise-exposed and medically evaluated population of soldiers who may be at increased risk for noise-related health outcomes.

The objective of this study was to establish a noise-induced hearing loss injury (NIHLI) prevalence baseline for a period of time including major unit deployments and units returning from deployments (redeploying) with noise exposures consistent with heavy combat operations from April 1, 2003, through March 31, 2004. This baseline is intended to help military preventive medicine better assess deployment health risks and improve monitoring effectiveness of risk reduction intervention efforts in current and future deployments; it is also designed to be compliant with federal law regarding current deployment health surveillance (Medical Tracking System for Members Deployed Overseas, 1997, 2003). To our knowledge, no such evaluation of noise-related postdeployment health outcomes has been reported to date.

The Department of Defense Military Health System (MHS) has, however, established procedures that enable such an evaluation. Every soldier returning from theaters of operations is required to complete a standard post-deployment health assessment form (DD Form 2796; U.S. Department of Defense, 2003) and is interviewed by a health care provider predicated on the soldier's responses to the standard questionnaire. Included in the standard health assessment form are questions about changes in health status, noise exposure, and experiencing "ringing in the ears." In a random sample of 3,000 DD2796 records for OIF (for the time frame June 1, 2003, through May 31, 2004), Geckle and Lee (2004) observed that 71.0% of the soldiers reported exposures to loud noises and 15.6% reported ringing in the ears. They also reported that exposure to loud noises was the third most common exposure, preceded by sand/dust exposure and vehicle exhaust fumes exposure.

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The interviewers who review the DD2796 surveys and make referrals to specialty clinics include physicians, physician's assistants, nurse practitioners, and senior medics. Based on the results of the interviews, soldiers are referred for medical evaluation at different clinics (General Accounting Office, 2003). Positive answers to these questions about noise exposure and ringing in the ears should generate referrals to the audiology clinic for evaluation.

Outcomes data from audiology generally exist in three separate formats: (a) the objective audiometric data recorded on a paper form, (b) the audiologist's documented interpretation of the data (usually expressed in a Subjective, Objective, Assessment, Plan [SOAP] note; Miller & Groher, 1990; Paul-Brown, 1994; see the Appendix for details), and (c) the Composite Healthcare System/Ambulatory Data Module or Composite Healthcare System II electronic patient record health care database, which translates the SOAP note into *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes (U.S. Department of Health and Human Services, 2003), Current Procedural Terminology (CPT) codes (American Medical Association, 2003), and specific clinic codes. The ICD-9-CM and CPT codes are stored in a standard ambulatory data record (SADR) database in compliance with the Health Insurance Portability and Accountability Act of 1996 and the federal regulations on electronic health care data transaction standards (Health Insurance Reform, 2000). These SADR database codes are mainly used for MHS health care administration purposes (reimbursement) but are also used for public health surveillance including deployment health surveillance.

Helfer, Shields, and Gates (2000) published standardized ICD-9-CM/CPT coding guidelines for audiology clinic visits associated with NIHLI with a goal of establishing outcomes data standards that support an evidence-based practice approach to occupational hearing loss prevention, force health protection, and deployment health surveillance. Their intention was to use these data to apply public health surveillance methods in evaluating the effectiveness of hearing loss prevention and intervention. This process would include monitoring population health outcomes (standardized ICD-9-CM) data through active and passive surveillance for sentinel events associated with NIHLI.

This hearing loss surveillance would be performed by applying the public health performance evaluation processes and deployment health surveillance strategies outlined by the Institute of Medicine of the National Academy of Sciences (1996, 1997, 1999a, 1999b). These approaches include involving experts in clinical practice, epidemiology, biostatistics, and clinical data management to analyze health outcomes data for increasing the effectiveness of interventions with noise-exposed populations, including deployed U.S. armed forces (Adera, Amir, & Anderson, 2000a, 2000b; Adera, Donahue, Malit, & Gaydos, 1993a, 1993b; Adera & Gaydos, 1997; Adera, Gullickson, Helfer, Wang, & Gardner, 1995; Brownson, Baker, Leet, & Gillespie, 2003; Dever, 1997).

The present study was based on the premise that clinical coding quality at Army Medical Department medical treatment facilities had improved hearing loss surveillance data quality substantially since these coding guidelines were initially developed and updated routinely. The latest MHS Audiology/Hearing Conservation coding guidelines are available at http://www.tricare.osd.mil/org/pae/ubu/default.htm (U.S. Department of Defense, 2005).

Method

MHS health care administration data (ICD-9-CM codes from the SADR) accessed through the Medical Metrics (M2) database of the MHS Executive Information/Decision Support system were used in this analysis. The M2 database was queried for Army soldier (Active Duty, Reserves, and Guard) visits to audiology clinics from April 2003 through March 2004.

The relevant ICD-9-CM code with an extension related to postdeployment and other NIHLI ICD-9-CM codes of analytic interest are presented in Table 1. Two of the NIHLI categories noted (H-3 and H-4 hearing profiles) are specific to the military population and are considered duty-limiting. H-3 hearing profiles constitute moderate to severe hearing loss with speech reception thresholds less than 30 dB HL (can be aided), thus precluding soldiers from performing certain normal military duties; H-4 hearing profiles comprise severe to profound hearing loss with aided speech reception thresholds greater than 30 dB HL, thereby potentially disqualifying a soldier from continued service (U.S. Department of the Army, 2005). Of note, a diagnosis of permanent threshold shift within the MHS is taken to mean that in the audiologist's documented

Table 1. ICD-9-CM codes for passive surveillance of targeted sentinel events (deployment, noise exposure, and hearing outcomes).

ICD-9-CM[a]	Condition diagnosed
V70.56[b]	Postdeployment-related
388.11	Acoustic trauma
388.12	Permanent threshold shift
388.30–388.32	Tinnitus
384.20–384.9	Eardrum perforation
389.8[b]	H-3 hearing profile
389.9[b]	H-4 hearing profile
E923.8	Exposure to other explosive materials—explosions not a result of war operations
E928.1	Exposure to noise—usually steady noise not impulse
E993	Exposure to enemy explosives and own—injury due to war operations by explosion
E995	Exposure due to unspecified forms of conventional war operations—injury due to war operations (not including blast injury, E993)

Note. ICD-9-CM = *International Classification of Diseases, Ninth Revision, Clinical Modification* (U.S. Department of Health and Human Services, 2003).

[a]In coding into Military Health System (MHS) data systems, the V code comes first, then the applicable diagnostic numeric codes, and lastly the E code.

[b]MHS unique code usage for data collection; not applicable to civilian providers.

clinical judgment, the hearing loss is sensory, caused by noise exposure, and permanent.

Quarterly NIHLI visit rates and annual NIHLI prevalence rates among audiology clinic patients whose diagnoses were classified as postdeployment-related were compared with rates observed among the remaining audiology clinic patients within the same time frame whose visits were considered non-postdeployment-related. Quarterly rates were based on the number of visits recorded during the time frame examined, while the prevalence rates were based on the clinic patient population seen during this period.

Statistical analysis was performed using SPSS Version 13.0. Basic descriptive statistics to include odds ratio estimates and 95% confidence intervals were generated. Estimates were adjusted for various demographics using binary logistic regression. Interactions between variables included in the model were also evaluated. Because of the large sample size, all statistical tests of significance were two-tailed at the $\alpha = .01$ level. Fisher's exact tests were used as needed; chi-square tests were used otherwise.

Results

Within the time frame examined, a total of 141,856 Army Active Duty, Reserve, and Guard members were seen through the MHS audiology clinics. Multiple visits were noted among 21,680 (15.3%) of this patient population, resulting in a total of 171,261 audiology clinic visits over the course of the year.

Audiology patients evaluated were 29.3 years old on average (F9.2 years). Patients were predominately active duty (82.3%), male (87.1%), enlisted (83.9%) soldiers. Population demographics are summarized in Table 2.

Table 2. Demographics of Army audiology patient population seen from April 1, 2003, through March 31, 2004 (N = 141,856).

	Frequency	
Demographics	*n*	%
Age[a]		
<25	56,970	40.2
25–34	45,410	32.0
35–44	29,136	20.6
45–54	8,380	5.9
55+	1,834	1.3
Gender		
Male	123,595	87.1
Female	18,254	12.9
Service		
Army Active Duty	116,749	82.3
Army National Guard/Reserves	25,107	17.7
Officer status		
Enlisted	116,718	83.9
Officer	22,465	16.1

Note. Missing responses noted; therefore, totals do not add up to the *N* provided.

[a]M = 29.3, SD = 9.2.

As can be seen in Table 3, annual prevalence rates of NIHLI during the period April 2003 through March 2004 were significantly higher among audiology clinic patients whose diagnoses were classified as deployment-related for all NIHLI categories (68.6% compared with 4.0%, respectively; $p < .001$). Postdeployment status remained a highly significant predictor ($p < .001$) of NIHLI for all categories when adjusted for various demographics. Additional predictors of risk included increased age and active duty status. Results of this analysis are presented in Table 4.

Figure 1 shows the quarterly visit rates of NIHLI occurring from April 2003 through March 2004 (April–June 2003, July–September 2003, October–December 2003, and January–March, 2004) for postdeployment and non-postdeployment visits.

Visits classified as deployment-related during the time period investigated showed significantly higher rates of NIHLI. A surge of postdeployment visits for acoustic trauma and permanent threshold shift was observed during the second and third quarters. Rates observed during non-postdeployment visits were relatively stable and low.

An elevated visit rate for eardrum perforations occurred in the first quarter, and a decline in that rate occurred in the following quarters among soldiers with documented postdeployment-related visits as compared with the low and stable rates observed during non-postdeployment visits. Pearce (2004) has shown a similar pattern for combat fatality rates during this time frame; the majority of deaths and wounded in action during the first quarter were due to blast injuries, a major cause of eardrum perforations. This first period coincided with the heaviest combat operations during OIF.

Quarterly visit rates for tinnitus steadily increased during postdeployment visits occurring in the first three quarters, with a sharp increase in the fourth, while a steady decrease occurred during non-postdeployment visits. In regard to the MHS-specific H-3 and H-4 hearing profiles, rates were also considerably higher among soldiers whose diagnosis was classified as postdeployment-related, with rates decreasing each quarter after an initial high in the first quarter. The opposite trend was observed among non-postdeployment-related visits.

The ICD-9-CM E codes shown in Table 1 for external cause of injury based on noise exposure could not be evaluated due to apparent lack of use. In total, only 3 of the 171,261 audiology clinic visits included such a code.

Limitations

As is the case with many studies that rely on passive surveillance, the analysis presented here is limited by its dependence on clinical coding practices. The accuracy of the ICD-9-CM codes related to postdeployment is unknown. It is also likely that in focusing on the audiology clinic population that some NIHLI outcomes were missed. Future analyses should address this issue by linking the MHS health care data from all clinics with the postdeployment data

Table 3. Comparison of annual noise-induced hearing loss injury (NIHLI) prevalence rates among Army audiology patients by postdeployment visit ICD-9-CM classification (*N* = 141,856).

	Postdeployment-related diagnosis (*n* = 806)		Non-postdeployment-related diagnosis (*n* = 141,050)		Post:non-post[a]	
Condition diagnosed	*n*	%	*n*	%	OR	95% CI
Acoustic trauma	45	5.6	78	0.1	122.8	83.6–180.6
Permanent threshold shift	236	29.3	639	0.5	76.1	63.7–90.9
Tinnitus	248	30.8	2,101	1.5	25.1	21.3–29.7
Eardrum perforation	13	1.6	88	0.1	30.0	16.5–54.5
H-3 or H-4 hearing profile	127	15.8	3,140	2.2	7.2	5.9–8.8
Any of the above[b]	553	68.6	5,668	4.0	52.5	44.8–61.4

Note. Rates are per 100 Army soldiers seen at audiology clinics from April 2003 through March 2004. OR = odds ratio; CI = confidence interval.

[a]ORs were adjusted for gender, age, and service (active duty vs. guard); officer status was excluded from the regression model due to significant interaction with the age variable.

[b]Of the patients with NIHLI outcomes, 7.7% had multiple diagnoses; counts and percentages provided are per person—therefore, patients with more than one diagnosis are counted only once.

captured on the DD2796 postdeployment screening forms and soldier personnel data that include arrival and departure dates by theaters of operation. This would capture all MHS-reported NIHLI regardless of clinic type and enhance determination of soldiers' deployment status, time deployed, and deployment exposures encountered as potential risk factors. Additionally, M2 data are captured at a higher MHS echelon of care, whereas outpatient data in theater during this period are sparse, not systematically collected, and unavailable for analysis.

Table 4. NIHLI risk factor analysis (all NIHLI categories included).

Risk factor	Crude OR	95% CI	Adjusted OR	95% CI[a]
Age				
<25	1.0		1.0	
25–34	1.9	1.7–2.0	1.8	1.7–1.9
35–44	3.3	3.1–3.6	3.3	3.1–3.6
45–54	6.4	5.9–7.0	6.6	6.1–7.3
55+	8.3	7.2–9.5	9.2	7.9–10.6
Gender				
Female	1.0		1.0	
Male	1.2	1.1–1.3	1.1	1.0–1.2
Service				
Army National Guard/Reserves	1.0		1.0	
Army Active Duty	1.1	1.0–1.1	1.4	1.3–1.6
Officer status				
Enlisted	1.0		NA	
Officer	1.5	1.4–1.5	NA	
Postdeployment-related				
No	1.0		1.0	
Yes	52.2	44.9–60.7	52.5	44.8–61.4

[a]ORs and CIs are adjusted for all factors listed; however, officer status was omitted from the regression model due to a significant interaction with the age variable.

Lastly, the Army Reserve and Guard population evaluated is believed to be underrepresented. This is because Reservists and Guard members are subject to limited medical coverage as compared with active duty members; therefore, they are more likely to seek care through civilian providers rather than through the MHS providers queried in this particular analysis. Despite the limitations of the analysis, the clear increase in NIHLI rates observed for soldiers whose visits were reported to be postdeployment-related warrants further investigation.

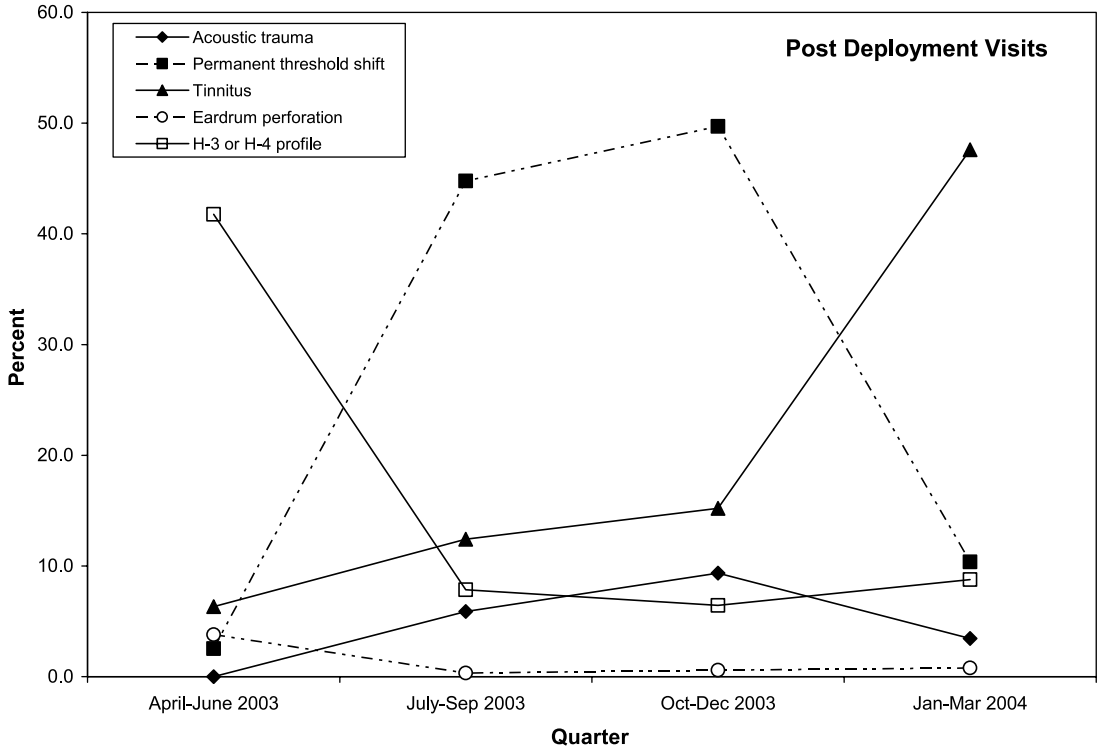
Discussion

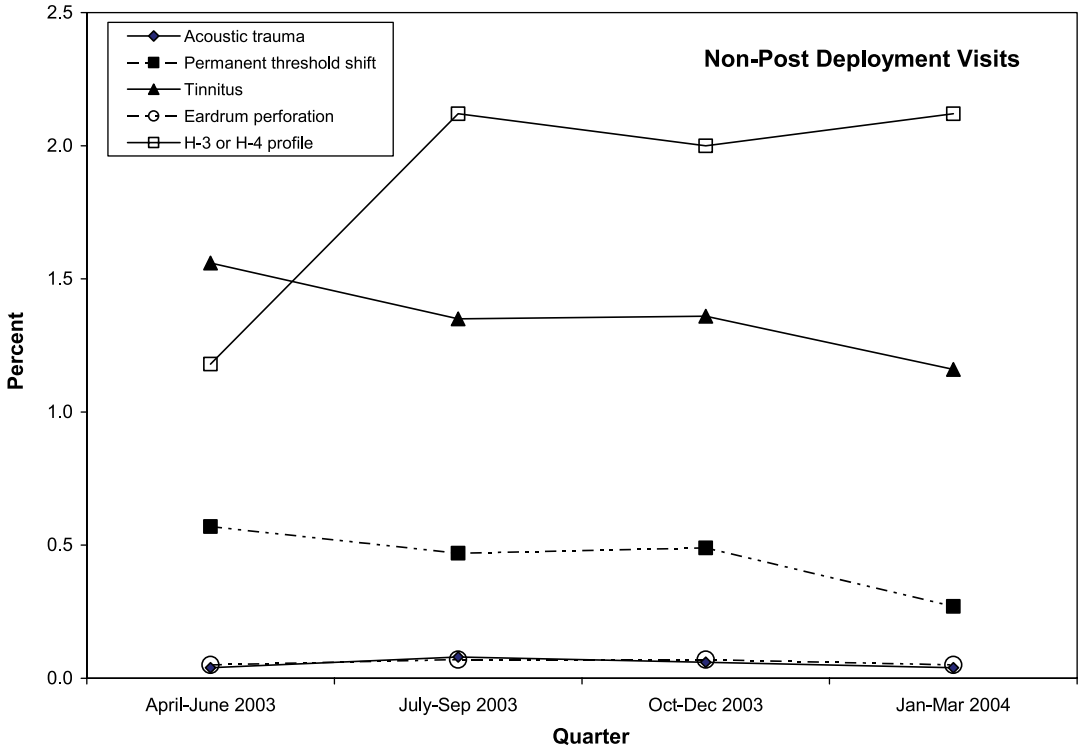
Part of the postdeployment soldiers' higher risk for hearing loss may be attributed to failure of force health protection and surveillance measures (General Accounting Office, 2003). The hearing loss prevention measures include providing adequate hearing protection and health education to soldiers before deployment, including the standard earplugs in the military's inventory (U.S. Department of the Army, 1998) and the new combat arms earplug (Sienda, 2004; U.S. Army Center for Health Promotion and Preventive Medicine, 2005). During the months preceding OIF, reports from force projection (deployment) sites to the Army hearing conservation program at the U.S. Army Center for Health Promotion and Preventive Medicine indicated that there were not adequate supplies of earplugs to fit all deploying soldiers.

There was also failure of an Army medical readiness automation system, the Medical Protection System (MEDPROS), to provide unit commanders with information regarding troops having adequate hearing protection and predeployment baseline audiograms, as well as ensuring that all troops had hearing profiles not limiting their duties, or waivers if appropriate. The only hearing information in MEDPROS consisted of whether soldiers wore hearing aids and, if so, whether the soldier had a 6-month supply of batteries.

Finally, there is evidence (from data acquired through the Transportation Command Regulating and Command

Figure 1. Comparison of noise-induced hearing loss injury rates between postdeployment and non-postdeployment visits.





& Control Evacuation System [TRAC^{2}ES]) that soldiers having blast injuries may not have been referred to audiology for adequate evaluation and treatment. We believe that there is a high probability of underreporting of eardrum perforations. These suppositions were developed after comparison with data from another source. TRAC^{2}ES data from other clinics' treatments of soldiers wounded in action show evidence of 600 to 800 OIF soldiers with potential blast injuries who may not have been referred to audiology for evaluation. This supposition is under investigation based on available data.

It is important to note that some NIHLI is unavoidable despite the availability/use of hearing protection and other preventive measures. This is because some exposures, particularly those experienced in the operational setting, are so extreme that they will exceed the protective capability of hearing protective devices. In addition, skull transmission of intense noise, the element of surprise, and the coeffects of inhaled toxins such as carbon monoxide in conjunction with noise can affect hearing loss outcomes.

In summary, we recommend the following: (a) fixing the hearing protection supply chain so that troops receive hearing protection and health education before deployment; (b) improving MEDPROS to ensure that unit commanders have correct information about troops having hearing protection, predeployment baseline audiometry, and suitable hearing profiles for deployment, including waivers; (c) referring all blast injuries to audiology for evaluation, including referrals to civilian audiologists outside the MHS (see the Appendix for preferred documentation format); (d) making routine use of external cause of injury (ICD-9-CM E) codes by health care providers to capture soldier deployment and nondeployment noise exposure data from their clinical records; and (e) targeting future research and development efforts at useful treatments for acute acoustic trauma, a condition that is currently not treatable.

Since the time of the initial postdeployment analyses reported in this study (Helfer, Jordan, & Lee, 2004), corrective actions consistent with our recommendations have taken place. Supplies of earplugs are becoming more available to deploying soldiers, and MEDPROS is being updated to reflect more pertinent deployment readiness information for commanders. Also, since January 2004, Army audiologists have been deployed to a hospital in Baghdad, Iraq, to provide audiology care in the OIF theater of operations. Intradeployment audiology clinic outcomes data are currently being collected from this site for analysis.

Future planned analyses will also expand on the baseline data provided to incorporate more detailed analysis of NIHLI outcomes and potential risk factors acquired through additional data sources. The current Army hearing health surveillance plan is to continue to monitor and report the Army deployment and nondeployment hearing loss outcomes data, examining NIHLI risk behaviors for proof of performance from preventive measures intervention.

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Appendix

Documentation and Coding Recommendation

Civilian audiologists may be called upon to evaluate soldiers redeploying from theaters of operations. It will be important to capture and document key variables in the case history and reporting of the postdeployment evaluation (“SOAP note”) along with associated ICD-9-CM codes (Miller & Groher, 1990; Paul-Brown, 1994).

Subjective:

1. Was the soldier deployed? (V70.56 is an MHS unique code for postdeployment-related diagnoses; “E” codes below signal an exam of a uniformed armed forces member in a civilian clinic).
2. Were they exposed to noise? What type?
   - Operations of war, weapons firing, wheeled/tracked vehicles (E995)
   - Enemy explosive devices (E993)
   - Exposure to other explosive materials—explosions not a result of war operations (E923.8)
   - Exposure to noise—steady noise and/or impulse (E928.1) (E995 and/or E993 should be used by a civilian audiologist to indicate a postdeployment exam. E923.8 and/or E928.1 should be used by a civilian audiologist to indicate a non-postdeployment exam.)
3. Did they have hearing protection and use it?
4. Do they experience ringing in the ears? (388.30–388.32)
   How does it sound?
   How disruptive is it?

Objective:

1. Otoscopic exam shows eardrum perforation or evidence of perforation? (384.20–384.9)
2. Audiometric results.

Assessment:

1. Acoustic trauma? (388.11-blast/impulse noise injury)
2. Noise-induced hearing loss? (388.12-noise-induced, sensory, permanent)
3. Tinnitus? (388.30–388.32)
4. Eardrum perforation or indication? (384.20–384.9)
5. Moderate to severe hearing loss? (389.8-MHS unique, civilians would not use)
6. Severe to profound hearing loss? (389.9-MHS unique, civilians would not use)

Plan:

Refer copy of records to appropriate Army Medical Department authority for further disposition regarding soldier’s health status.