USAARL Report No. 95-18

U.S. Army Aviation Epidemiology Data Register: Comparison of the Administrative Effect of Historical and Proposed Hearing Standards for Army Aviators

By

Kevin T. Mason

Aircrew Protection Division

March 1995

United States Army Aeromedical Research Laboratory
Fort Rucker, Alabama 36362-0577

Notice

Qualified requesters

Qualified requesters may obtain copies from the Defense Technical Information Center (DTIC), Cameron Station, Alexandria, Virginia 22314. Orders will be expedited if placed through the librarian or other person designated to request documents from DTIC.

Change of address

Organizations receiving reports from the U.S. Army Aeromedical Research Laboratory on automatic mailing lists should confirm correct address when corresponding about laboratory reports.

Disposition

Destroy this document when it is no longer needed. Do not return it to the originator.

Disclaimer

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation. Citation of trade names in this report does not constitute an official Department of the Army endorsement or approval of the use of such commercial items.

Reviewed:

Kevin T. Mason

KEVIN T. MASON
LTC, MC, MFS
Director, Aircrew Protection
Division

Released for publication:

ROGER W. WILEY, O.D., Ph.D.
Chairman, Scientific
Review Committee

Dennis F. Shanahan

DENNIS F. SHANAHAN
Colonel, MC, MFS
Commanding

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release, distribution unlimited
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) USAARL Report No. 95-18	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION U.S. Army Aeromedical Research Laboratory 6b. OFFICE SYMBOL (If applicable) MCMR-UAD	7a. NAME OF MONITORING ORGANIZATION U.S. Army Medical Research and Materiel Command
6c. ADDRESS (City, State, and ZIP Code) P.O. Box 620577 Fort Rucker, AL 36362-0577	7b. ADDRESS (City, State, and ZIP Code) Fort Detrick Frederick, MD 21702-5012
8a. NAME OF FUNDING / SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
62787A	30162787A878	HC	144

11. TITLE (Include Security Classification)
U.S. Army Aviation Epidemiology Data Register: Comparison of the administrative effect of historical and proposed hearing standards for Army aviators

12. PERSONAL AUTHOR(S)
Mason, Kevin T.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM TO	1995 March	11

16. SUPPLEMENTAL NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	aviator, hearing standards
05	09		
06	04		

19. ABSTRACT (Continue on reverse if necessary and identify by block number)
The U.S. Army Aeromedical Activity, U.S. Army Aeromedical Center, Fort Rucker, Alabama, requested a descriptive analysis of the current and proposed U.S. Army Class 2 aviator hearing standards to estimate the effect of changing to the proposed from the current standard in 1995. The background section compared one historical hearing standard from 1980 to the current (1983), and proposed (1995), hearing standards. The application of the aviator hearing standards in a hearing conservation, public health protocol was described.

A cohort of Army aviators, numbering 19,916, from calendar year 1993, were studied to determine the effect of changing the current aviator hearing standard to a standard proposed for the 1995 Army Regulation 40-501, Medical fitness standards. Six percent of the cohort (1242 of 19,916) failed the current hearing standard. An additional 5.5 percent of the cohort (1091 of 19,916) passed the current 1983 standard, but failed the proposed 1995 standard.

(Continued on next page)

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION	
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL Chief, Science Support Center	22b. TELEPHONE (Include Area Code) (334) 255-6907	22c. OFFICE SYMBOL MCMR-UAX-SS

DD Form 1473, JUN 86 *Previous editions are obsolete.*

SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

19. Abstract (Continued):

The burden of managing the increased audiology consultation workload among the 1,091 new cases will be negligible among 201 of 212 aviation medicine clinics affected by the change in standards. However, the remaining clinics can expect more than one new audiology consultation requirement per month. Fort Rucker Aviation Medicine Clinic will carry the greatest burden with a predicted 187 additional consultations in the first 1 to 2 years of standard implementation. After initial screening, the number who will have progressive hearing loss requiring follow-up audiology consultations is unknown. Among the 1,091 aviators affected by the proposed standard, 12.5 percent already have completed the baseline audiology consultation prior to standard implementation.

Table of contents

List of tables

This page was left blank intentionally

Military relevance

Army aircraft, especially rotary-wing aircraft, produce high intensity noise that will injure unprotected human hearing. Hearing loss is a common cause of medical disqualification among Army aviators, despite the occupational loss of hearing being preventable in most cases. Most aviators with hearing loss continue to fly. Hearing standards for Army aircrew members are evaluated regularly and are modified as required. A change in Army aviator hearing standards was proposed to the Aeromedical Consultant Advisory Panel in 1989, and remains under consideration today.

The U.S. Army Aeromedical Activity, U.S. Army Aeromedical Center, Fort Rucker, Alabama, requested a descriptive analysis of the current and proposed U.S. Army Class 2 aviator hearing standards to estimate the effect of changing to the proposed hearing standard in 1995 from the current one. Study findings will be presented to the Aeromedical Consultant Advisory Panel as it makes final deliberations on the hearing standards proposed for the 1995 Army regulation 40-501, Medical fitness standards (Department of the Army, 1995).

Background

The Army conducts a hearing conservation program for Army aircrew members. Program objectives include conducting hearing conservation training, providing personal and helmet mounted hearing protection devices, and by annually screening the pure tone hearing of aircrew members at 500, 1000, 2000, 3000, 4000, and 6000 Hz (Department of the Army, 1980; U.S. Army Environmental Hygiene Agency, 1988; Department of the Army, 1991).

Those with hearing threshold levels in excess of screening standards are referred for a complete audiology evaluation to include air and bone conducted pure tone testing, binaural speech discrimination at the most comfortable listening level, bilateral speech reception threshold testing, and if indicated, tympanogram, retrocochlear testing, and ear, nose and throat consultation. Aviators are returned to flying duties following evaluation, unless their binaural speech discrimination score is less than 84 percent and/or the aviator subjectively feels unsafe while flying due to hearing loss. The complete audiology evaluation is repeated only if there is a 20 dB worsening of hearing threshold level in the frequencies of 1000, 2000, 3000, or 4000 Hz, compared to the last baseline audiology consultation (Department of the Army, 1986).

In 1989, 1600 aviators were medically disqualified for flying duties. Of these, 1280 were returned to flying duties. Among those returned to flying duties, 302 had hearing loss as the cause for medical disqualification. Of the 320 aviators medically terminated from aviation service, one was terminated due to hearing loss. This aviator requested termination from aviation service because he no longer felt safe handling instrument flying rules radio communications and could not be helped by a hearing aid (Mason, 1990).

Table 1 shows a historical comparison of hearing standards for Army aviators. The current hearing standard (1983) uses the concept of the better ear and poorer ear. The regulation does not state if the relationship between the better ear and the poorer ear is an "AND" logical relationship, or an "OR" logical relationship. In practice, the "OR" logical relationship has been used by the Aeromedical Activity since at least 1983 (personal communication with former directors, U.S. Army Aeromedical Activity). It is easy for flight surgeon offices and the Aeromedical Activity staff to make an administrative error while determining hearing fitness for flying duties using the better ear and poorer ear concept. Table 2 demonstrates this method of determining hearing fitness for flying duties using an "OR" logical relationship between the better ear and poorer ear.

The proposed 1995 standard removes the confusing concept of the better ear and poorer ear by application of a single hearing threshold level standard to either ear.. The proposed standard also brings the hearing standards for Class 2 (aviators), and Classes 2S/2F/3 and 4 (other aircrew members and air traffic controllers), under one standard rather than three separate standards. These changes will reduce the confusion by the flight surgeon office and flying duty medical examination (FDME) reviewers in applying hearing standards.

In the range of 500 to 3000 Hz, the proposed standard is aligned with the current and 1980 better ear standard. In the range of 4000 to 6000 Hz, the proposed standard drops the hearing threshold level by 10 dB compared to the current standard, but is 10 to 20 dB above the previous standard of 1980.

Table 1.
Historical comparison of hearing standards for U.S. Army aviators.

Reference	Class 2 aviator hearing standard in decibels at a given frequency						
	Ear	500 Hz	1000 Hz	2000 Hz	3000 Hz	4000 Hz	6000 Hz
AR 40-501, Change 32, 1980	Better	>25*	>25	>25	>35	>35	>35
	Poorer	>25	>35	>35	>45	>45	>45
AR 40-501, Change 34, 1983, current standard	Better	>25	>25	>25	>35	>65	>75
	Poorer	>25	>35	>35	>45	>65	>75
Proposed standard, 1995	Either	>25	>25	>25	>35	>55	>65

* Each decibel standard is stated as the failing standard; example, "the aviator fails with hearing threshold levels greater than 25 dB at 500 Hz."

Table 2.
Demonstration of pass or fail the hearing standard at 1000 Hz for four example aviators.

Frequency 1000 Hz	Standard	Example aviator #1	Example aviator #2	Example aviator #3	Example aviator #4
Better ear	>25 dB	20 dB	**30 dB***	20 dB	**30 dB**
Poorer ear	>35 dB	30 dB	35 dB	**40 dB**	**40 dB**
Pass or fail standard		Pass	Fail	Fail	Fail

* Bold face type indicates the ear(s) that fails the better ear/poorer ear hearing standard.

Method

The first occurrence of a FDME for each Army aviator was extracted from the Aviation Epidemiology Data Register for the period of 1 January 1993 to 31 December 1993 by date of examination. Data elements were extracted from these FDMEs included: cohort subject social security number, age, facility of examination, pure tone audiogram findings for the right and left ear.

The hearing standards from Table 1 were applied to the hearing findings of each aviator to determined if the aviator passed or failed the standard. Appendix A shows the Visual Basic™ code applied to determine the pass or fail status for each standard (Microsoft Corporation, 1993a). The waiver and suspense file was queried for those passing the current standard, but failing the proposed standard, to determine who had already undergone a complete audiology evaluation.

Analyses of the data were conducted using the pivot wizard function (crosstabs) of Excel 5.0™ to create a descriptive comparison of the standards (Microsoft Corporation, 1993b). The effects of the proposed standard on examination facilities were tabulated.

Results

This study reviewed the audiograms of 19,916 Army aviators for calendar year 1993. Among the 1993 aviator cohort, 3,799 (19.1 percent) failed at least one of the hearing standards as shown in Table 1. Among the 3,799 aviators who failed at least one of the hearing standards, 1,242 failed all three standards. Another 1,466 failed the most stringent 1980 standard, but passed the current 1983 standard and proposed 1995 standard. This left 1,091 aviators who passed the current standard, but failed the proposed standard. These 1,091 aviators would be required to undergo a complete audiology consultation in the first year they were discovered to meet the proposed standard. Only those with progressive hearing loss would be required to undergo further audiology consultation.

The work load of the excess, first-time, audiology consultations for the 1,091 aviators will be done by 212 military facilities. Of these, 201 facilities will have 1 or less excess audiology consultations per month. The U.S. Army Aeromedical Center, which has the greatest FDME burden of all military facilities, can expect 187 audiology consultations for aviators in the first 1 to 2 years of the proposed standard implementation. Table 4 shows the distribution of burden for excess audiology consultations directed by the new hearing standard. Of the 1,091 aviators, the waiver and suspense file query showed that 136 (12.5 percent) already have completed an audiology evaluation; lessening the burden for excess audiology consultations directed by the new hearing standard.

Discussion

Army aviator hearing standards are not clinical standards, but are public health screening standards for aviators used to determine who needs a comprehensive audiology evaluation. The evaluation rules out other serious causes of hearing loss. Among the many with noise induced, high frequency hearing loss, there will be aviators with undiagnosed central nervous system, inner ear, and middle ear disorders, such as acoustic neuromas and cholesteatomas, that require further treatment or restriction from flying duties. The evaluation establishes a baseline of hearing threshold levels for reference in future screening. And hopefully, the evaluation stimulates greater attention to the aviator's hearing protection strategies at work and home.

Hearing standards for aviators should as a minimum meet the national public health standard of care for hearing screening. Unfortunately, most hearing standards in this country are exposure oriented, and not hearing threshold level oriented, thwarting comparison of Army standards to public standards.

Hearing loss is a common finding among Army aviators as seen in this study with 19 percent failing at least 1 of the 3 study hearing standards and 6.2 percent failing the current hearing standard. What significance this burden of hearing loss has on Army aviation safety, aviator performance, and mission completion is unknown. The issue is likely to be helped somewhat by the introduction of the communication ear plug (Mason and Mozo, 1995; Mozo, Murphy, and Ribera, 1995). This prototype device improves speech intelligibility in the rotary-wing environment while providing additional hearing protection to the aviator helmet earcup. But, the issue is likely to become more complex with the introduction of three dimensional acoustic cue devices to the aviator helmet as proposed in future Air Warrior aircrew member ensembles. In addition, the hearing performance effects of the aviation operational environment are not well known, including the effects of night flying and medications, and use of equipment such as spectacles, chemical protective masks, and cold weather ensembles. What other auditory factors may be as important, or more important, for aviator performance than the pure tone hearing threshold is unknown. Therefore, given the lack of performance-based aviation audiology knowledge, the aviation medicine community will in the foreseeable future, have to continue to rely on other standards development methods, such as the establishment of a "best guess" public health screening protocol.

Table 3.
Number of aviators failing combinations of three hearing standards.

1980 Standard	1983 Standard	1995 Standard	N meeting all three conditions
Pass	Pass	Pass	16117
Fail	Fail	Fail	1242
Fail	Pass	Pass	1466
Fail	Fail	Pass	0
Fail	Pass	Fail	721
Pass	Pass	Fail	370

Table 4.
Distribution of burden for audiology consultations directed by the new hearing standard.

Number of audiology consultations in excess of expected examinations	Number of flight surgeon offices carrying the burden of excess, new audiology consultations	Facility by name with >1 excess new audiology consultation per month
1	81	
2	31	
3	19	
4	22	
5	8	
6	9	
7	7	
8	4	
9	5	
10	6	
11	6	
12	3	
13	2	
14	3	
15	1	OK ARNG, Lexington, OK
16	1	Fort Belvoir
18	1	Fort Hood
29	1	EAATS, Indiantown Gap, PA
40	1	Fort Campbell
48	1	Fort Bragg
187	1	Fort Rucker
Grand Total	212	

Summary and conclusions

A cohort of Army aviators, numbering 19,916, from calendar year 1993, were studied to determine the effect of changing the current aviator hearing standard to a standard proposed for the 1995 Army regulation 40-501, Medical fitness standards. The paper compared one historical hearing standard from 1980 to the current (1983), and proposed (1995), hearing standards.

Six percent of the cohort (1,242 of 19,916) failed the current hearing standard. An additional 5.5 percent of the cohort (1,091 of 19,916) passed the current standard, but failed the proposed standard.

The burden of managing the increased audiology consultation workload among the 1,091 new cases will be negligible among 201 of 212 aviation medicine clinics affected by the change in standards. However, the remaining clinics can expect more than one new audiology consultation requirement per month. Fort Rucker Aviation Medicine Clinic will carry the greatest burden with a predicted 187 additional consultations in the first 1 to 2 years of standard implementation. After initial screening, the number who will have progressive hearing loss requiring follow up audiology consultations is unknown. Among the 1,091 aviators affected by the proposed standard, 12.5 percent have already completed the baseline audiology consultation prior to standard implementation.

For now, Army aviator hearing standards will have to be oriented to public health screening guidelines and the traditional, and perhaps arbitrary, deliberations by aviation medicine policy experts. In the future, when research projects on aviator hearing and flying performance are completed, perhaps hearing standards could be oriented to aviation performance and safety, in addition to public health screening guidelines and arbitrary deliberations. Fortunately, the Army has recently established a science and technology objective for aviator performance that includes objectives for studying aviator hearing performance.

Finally, this paper highlights the value of the Aviation Epidemiology Data Register in responding in less than 1 week to a critical question asked by aviation medicine policy makers. In this case, the issue was how would a new hearing standard affect aviation medicine clinic workload at the moment when the standard is going to press! With the study cohort established, other proposed standards could be tested and evaluated rapidly. Other questions could be addressed by the AEDR, such as what is the natural progression of hearing loss among aviators? Without the AEDR, these questions could not be answered at all, or would require an expensive, time-consuming review of records in a sampling of clinics.

References

Department of the Army. 1980. Hearing conservation. Washington, DC: Headquarters, Department of the Army. Army technical bulletin, TB MED 501.

Department of the Army. 1986. Memorandum for all flight surgeons, Subject: audiometric evaluation. Fort Rucker, AL: U.S. Army Aeromedical Center. Aeromedical policy letter 17-86.

Department of the Army. 1991. Hearing conservation. Washington, DC: Headquarters, Department of the Army. Department of the Army pamphlet 40-501.

Department of the Army. 1995. Medical fitness standards. Washington, DC: Headquarters, Department of the Army. Department of the Army regulation 40-501.

Mason, K. T. 1990. Health problems of the aging Army aviator. Presentation at the 2nd Army Safety and Standardization Conference, Savannah, GA.

Mason, K. T., and Mozo, B. T. 1995. CEP and ANR, hearing protection technologies for Air Warrior. U.S. Army aviation digest. March/April (in press).

Microsoft Corporation. 1993a. Microsoft® Visual Basic™ programming system for Windows™, version 3.0. Redmon, WA: Microsoft Corporation.

Microsoft Corporation. 1993b. Microsoft® Excel™ for Windows™, version 5.0. Redmon, WA: Microsoft Corporation.

Mozo, B. T., Murphy, B. A., and Ribera, J. E. 1995. User acceptability and comfort of the communication earplug (CEP) when used in the UH-1 helicopter. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 95-17.

U.S. Army Environmental Hygiene Agency. 1988. Hearing conservation. Aberdeen Proving Ground, MD: U.S. Army Environmental Hygiene Agency. Technical guide No. 170.

Appendix A.

Visual basic code for determining hearing fitness for Army aviator duties.

```
' *** 18 February 1995, U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL  ***
' *** This code is written in Microsoft Visual Basic 3.0 for Windows by Kevin T. Mason ***
' *** U.S. Army Aeromedical Research Laboratory places this code in the public domain ***
'
' *** Determination of PASS X=0 or FAIL X=1 for 1980 hearing standards
'
Function FAIL1980(R500, L500, R1000, L1000, R2000, L2000, R3000, L3000, R4000, L4000,_
        R6000, L6000) As Integer   ' pass the hearing test findings to the function
Dim X As Integer
X = 0   ' initialize the variable X as PASS standard  X=0, if X<>0 then X is FAIL standard
If R500 > 25 Or L500 > 25 Then
        X = 1
Elseif MIN(R1000,L1000) > 25 Or MAX(R1000,L1000) > 35 Then
        X = 1
Elseif MIN(R2000,L2000) > 25 Or MAX(R2000,L2000) > 35 Then
        X = 1
Elseif MIN(R3000,L3000) > 35 Or MAX(R3000,L3000) > 45 Then
        X = 1
Elseif MIN(R4000,L4000) > 35 Or MAX(R4000,L4000) > 45 Then
        X = 1
Elseif MIN(R6000,L6000) > 35 Or MAX(R6000,L6000) > 45 Then
        X = 1
Else
        X = 0
End If
FAIL1980 = X   ' pass variable for PASS or FAIL back to calling procedure
End Function
'
'
' *** Determination of PASS X=0 or FAIL X=1 for 1983-1994 hearing standards ***
'
Function FAIL1983(R500, L500, R1000, L1000, R2000, L2000, R3000, L3000, R4000, L4000,_
        R6000, L6000) As Integer   ' pass the hearing test findings to the function
Dim X As Integer
X = 0   ' initialize the variable X as PASS standard  X=0, if X<>0 then X is FAIL standard
If R500 > 25 Or L500 > 25 Then
        X = 1
Elseif MIN(R1000,L1000) > 25 Or MAX(R1000,L1000) > 35 Then
        X = 1
```

```
Elseif MIN(R2000,L2000) > 25 Or MAX(R2000,L2000) > 35 Then
        X = 1
Elseif MIN(R3000,L3000) > 35 Or MAX(R3000,L3000) > 45 Then
        X = 1
Elseif R4000>65 Or L4000 > 65 Then
        X = 1
Elseif R6000>75 Or L6000 > 75 Then
        X = 1
Else
        X = 0
End If
FAIL1983 = X    ' pass variable for PASS or FAIL back to calling procedure
End Function
'
'
' *** Determination of PASS X=0 or FAIL X=1 for proposed 1995 hearing standards ***
'
Function FAIL1995(R500, L500, R1000, L1000, R2000, L2000, R3000, L3000, R4000, L4000,_
        R6000, L6000) As Integer    ' pass the hearing test findings to the function
Dim X As Integer
X = 0    ' initialize the variable X as PASS standard  X=0, if X<>0 then X is FAIL standard
If R500 > 25 Or L500 > 25 Then
        X = 1
Elseif R1000 > 25 Or L1000 > 25 Then
        X = 1
Elseif R2000 > 25 Or L2000 > 25 Then
        X = 1
Elseif R3000 > 35 Or L3000 > 35 Then
        X = 1
Elseif R4000 > 65 Or L4000 > 65 Then
        X = 1
Elseif R6000 > 75 Or L6000 > 75 Then
        X = 1
Else
        X = 0
End If
FAIL1995 = X    ' pass variable for PASS or FAIL back to calling procedure
End Function
'
```