Hearing health of New South Wales prison inmates

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Abstract

Objective: To assess the hearing health of New South Wales prison inmates.

Methods: The method of testing hearing chosen was the rapid click-evoked otoacoustic emissions technique, from which two key variables were evaluated for early status of ear damage. Hearing variables, including hearing history and self-reported symptoms, were incorporated in a multivariate analysis of other health and demographic variables in the prison sample.

Results: The analysis shows that the hearing acuity of prisoners is poor compared with the general Australian population. Variables significantly related to the hearing scores were history of hearing problems or having arthritis or diabetes. In this sample hearing did not interact with alcohol or drugs. Those testing positive for Hepatitis B Core-Antibody were also found to have poorer hearing than those without.

Conclusions and Implications: Prisoners in general have poorer hearing than a normative Australian population. Some conditions have a significant impact on hearing, which may be due to associated medications. A previous history of ear problems was found to be significantly related to hearing acuity as was a history of exposure to noise. Health screening programs within the correctional system may need to include hearing loss prevention programs and medical follow-ups in relation to hearing health

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As part of a wide-ranging physical and mental health survey of prison inmates conducted by the New South Wales Corrections Health Service (CHS) in 1996,[1,2] hearing assessments were carried out employing an objective measure of cochlea function, click-evoked otoacoustic emissions. Previous to this study reported evaluations elsewhere of the hearing of prisoners was by subjective pure tone audiometric testing. Between 1970 and 1989 studies of hearing loss in United States prison inmates in general found that the prevalence was higher than in the general population, where the prevalence was shown to be around 8%.[3] Melnick[4] found that 40% of prisoners in his study failed initial pure-tone screening, while Belenchia and Crowe[5] estimated that the incidence of hearing impairment in prisoners exceeded 30%. Bountress and Richards[6] screened inmates in an adult penal institution and found 17% with a significant hearing loss, 7% of whom had a high-frequency hearing loss and 5% with middle ear problems significant enough to warrant medical attention. McRandle and Goldstein[7] identified 36% of inmates with a hearing loss; 65% of these had some form of head trauma while 50% reported regular use of alcohol and all had extensive histories of illegal substance abuse. They found that it was impossible to isolate the influence of any one drug since all prisoners were poly-drug users. Jacobson et al.,[3] while finding 29% of their prisoner population presenting with some type of hearing impairment, showed only temporary effects of cocaine and marijuana on the auditory system. They speculated as to whether street drugs either in isolation or in combination with noise had influenced hearing loss in the prisoners. Indeed, they believed that it could be the synergistic effects of these factors, other unknown variables and an individual's sensitivity to each that probably contributed to the high prevalence of sensorineural hearing loss in this group and in other institutionalised prisoners.

In a New Zealand study, Bowers[8] found that in testing hearing using pure tone audiometry, 83% of Maori prisoners had at least one ear with a hearing loss of 15 dB or greater compared with 54% of the European prisoners. A combined total of 69% of prisoners had at least one ear with a hearing loss of 15 dB or greater. A Canadian study of 144 prison inmates published in 1994,[9] also using pure tone audiometry, found similar levels of hearing impairment to the New Zealand study.

This paper reports on the use of the click-evoked otoacoustic emission test instead of pure tone audiometry as a hearing assessment. Normative data is from the largest otoacoustic emissions database assembled in Australia.[10] This is the only prison study to have used otoacoustic emissions.

Methods

Sampling

Several days prior to the screening, the

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NSW Department of Corrective Services (DCS) provided a list of all male and female prisoners in the State. There was a total of 7,220 adults aged 18 years or over in the 29 (27 male and two female) correctional centres in NSW.[11] The population of each prison ranged from 58 to 856. A fixed sampling fraction was obtained proportional to the numbers in each prison.

The sample size was calculated to ensure that prevalence estimates could be generated for a range of health conditions of interest.[12,13] A minimum sample size of 241 was found to be sufficient to give an adequately precise prevalence for low prevalence conditions such as diabetes (prevalence assumed to be approximately 6%, with 3% error). Since age-specific prevalence estimates were required, age was categorised into three groups: 18-24, 25-40, and over 40. A total of 914 inmates (representing approximately 10% of all men and 34% of all women in full-time custody) were invited to participate in the study. Data were collected from 789 male and female inmates from 26 correctional centres.

Procedures

Inmates selected for the survey were called for interview and retrieved by custodial officers from within the jail. Potential participants received a full explanation of the project and were required to give written consent. A reserve list was drawn to replace those who were either unavailable at the time of the survey or declined to participate. Interviewers were recruited from nursing staff within CHS and, as a rule, did not screen prisoners at the facilities at which they were routinely employed. As many of the prisons are working jails, participants received $10 compensation to cover possible loss of income. The methods have been described elsewhere.[14]

Those who consented to participate were interviewed in private. Screening involved a face-to-face interview covering chronic health complaints diagnosed by a doctor, recent health symptoms, use of medications, disability, health service utilisation, dental health, diet and nutrition, exercise, sun protection, and injury. The survey included screening for blood-borne viruses and sexually transmitted infections and risk behaviours (e.g. injecting drug use, alcohol consumption and tattooing). Overall physical and mental well-being and the individual's perception of their own health status were assessed using the 36-item Short-Form Health Survey (SF-36).[13] Medication was coded using the Society of Hospital Pharmacists of Australia Structured Drug Codes.

Questions were included regarding past hearing health issues such as ear troubles, tinnitus, exposure to noise (both occupational and personal stereo listening), exposure to chemicals or solvents, and head trauma. Six hundred and forty one (641) prisoners (530 males, 110 females) participated in the otoacoustic emission hearing assessment and related questionnaire. Of these, 203 were Aborigines. All subjects were aged between 20 and 60 years. Subjects were excluded if there were results for only one ear. Final analyses were carried out on 497 prisoners (413 males, 84 females); of these, 171 were Aboriginal.

Click-evoked otoacoustic emissions (CEOAE) is a rapid, objective measure of the functionality of the outer hair cells in the cochlea and as such has been found to be a worthwhile screening tool as well as a useful early warning indicator of potential hearing loss.[15] It is not a hearing test that requires subjects to push a button. It is a physical, objective measurement of ear performance. Ears with little damage give strong responses indicating high performance, while ears with a lot of damage give weak responses or none at all. It is far more sensitive to early ear damage from noise exposure than the conventional hearing test.[16] CEOAEs were measured by CHS nurses trained by one of the authors (NM) in using an Otodynamics™ ILO88 click-evoked ototacoustic emissions analyser. A probe, containing a microphone and earphone, was inserted into the canal of each ear tested. The test stimulus was a train of clicks at a peak stimulus level of 80 (±1.5)dB SPL, designed to extract nonlinear response of the outer hair cells. Two hundred and sixty repetitions of response were averaged to produce the record for each ear, taking about one minute. The two time waveforms of the emission record and a Fast Fourier Transform depicting the amplitude of the emission from 0 to 6 kHz were displayed on a computer screen. Testing was carried out in the quietest background noise level available at each facility, usually less than 45 dBA, which is a level that would not overall adversely affect the CEOAE test results.[17]

Ethics

Ethics approval was obtained from the CHS Human Research and Ethics Committee and the DCS Research Committee.

Data analysis

Since the National Acoustic Laboratories' Australian normative population has been assessed in decade age ranges,[10] the comparisons between prisoners and this population are shown in the comparable decade age ranges (see Figures 1a and 1b).

The otoacoustic emission parameter Waverepro% (also designated as OAE1) was analysed in relation to health and demographic variables included in the survey such as age (as a continuous variable), sex, Aboriginality, history of ear troubles, noisy jobs and tinnitus. Most categorical variables were simplified into binary form. For example, hearing and health-related conditions, No=condition absent, Yes=condition present; substance and drug use, No=none and Yes=Regular use (regular use being defined as >once per week). The parameter Waverepro% is the correlation of the two time waveforms of the emission and represents the reproducibility of the emission, which is computed for each CEOAE record as an essential measure. The issue of test-retest reproducibility from record to record is discussed separately.[18]

An analysis of variance of the demographic variables, sex and Aboriginality each with age as the covariate, and OAE1 as the dependent variable, was undertaken first. As there was no significant association with sex this was excluded from further analyses. Similarly, from an analysis of variance it was determined that there was no significant difference between ears; therefore results for both ears were averaged for all further analysis. For the remainder of the independent variables, multiple linear regression analyses were undertaken.

Results

Figures 1a and 1b show the variations between the Australian normative population[10] for decade age ranges compared with Aboriginal and non-Aboriginal prisoners in the same age groups. For both males and females, OAE1 values for non-Aboriginal prisoners are lower in all age groups than the normative population. OAE1 for Aboriginal prisoners was lower again ($p<0.01$).

Demographic variables

It can be seen from Table 1 that the mean values for OAE1 for Aboriginal prisoners are lower than non-Aboriginal prisoners ($p=0.03$), while sex is not significant with or without adjustment for age.

Hearing variables. Hearing variables (history of ear troubles, tinnitus and noisy jobs) were grouped and a multiple linear regression analysis carried out, adjusting for age.

Ear troubles. As expected, on average those subjects who acknowledged having had an ear problem, such as otitis media, had significantly poorer otoacoustic emission results ($p<0.01$) and hence poorer hearing, than those who had never had ear problems. Those with ear troubles had significantly poorer emissions than those who had been employed in a noisy job and/or had tinnitus.

Results of a separate one-way ANOVA show those with tinnitus ($p<0.01$) had significantly poorer emissions than those who did not have tinnitus.

It was also found from the results of a one-way ANOVA that those who had been engaged in noisy jobs had poorer emissions than those who had not had a noisy job ($p=0.12$).

Health conditions. Table 1 presents the results of separate multiple linear regressions for health conditions I and health conditions II (separate regressions), and substance use variables (depressant and stimulant non-injected drugs) again, both separate regressions, all adjusted for age.

Those with arthritis or diabetes have significantly poorer emissions than those without the condition and, although no statistically significant differences were found for any of the other conditions, those prisoners testing positive for having hepatitis B core antibody, hepatitis C antibody, cholesterol levels ^{3}5.5 mM/L, and taking blood pressure medication all had poorer emissions than those prisoners without the condition.

Surprisingly, users of any drug show higher emission levels than non-users (see Table 1). However, differences in the means between users and non-users were not statistically significant when age is taken into consideration.

Discussion

Overall, the hearing of both male and female prisoners is degraded in relation to that of the Australian normative population. The results are consistent with a study of hearing loss in United States prison inmates.[3,4] Within our study population of prisoners the hearing of males is poorer compared with females, although not significantly so. This is consistent with the Australian normative population.[10] The hearing of both male and female Aboriginal prisoners is poorer than that of non-Aboriginal prisoners.

The otoacoustic emission outcome parameter (Wavepro%, OAE1) has been used in the analysis of the hearing acuity of a sample of prisoners. In an earlier study,[15] it was established that there is a critical level in Wavepro% values of approximately 20% below which there is a steep increase in the probability of a mild hearing loss.

Figures 1a and 1b reveal important properties of click-evoked otoacoustic emissions in that they decline only very slowly with age. When comparing the two populations, it is seen that the ears

Figure 1a: Comparisons of the means and 95% CI for OAE1 (Wavepro%) between (NAL) predetermined Australian male normative population[10] (solid line) for age ranges comparable with those in the NSW male prisoner population (Aboriginal – dotted line) and non-Aboriginal (dashed-dotted line).

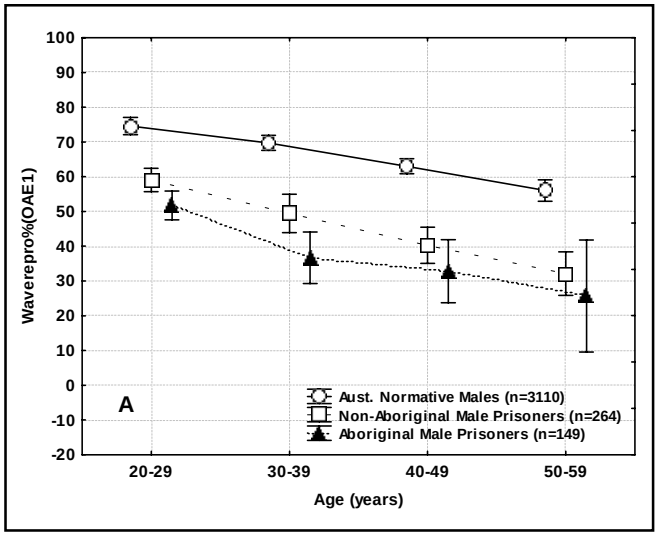

Figure 1b: Comparisons of the means and 95% CI for OAE1 (Wavepro%) between (NAL) predetermined Australian female normative population[10] (solid line) for age ranges comparable with those in the NSW female prisoner population Aboriginal (light dotted line) and non-Aboriginal (heavy dotted line).

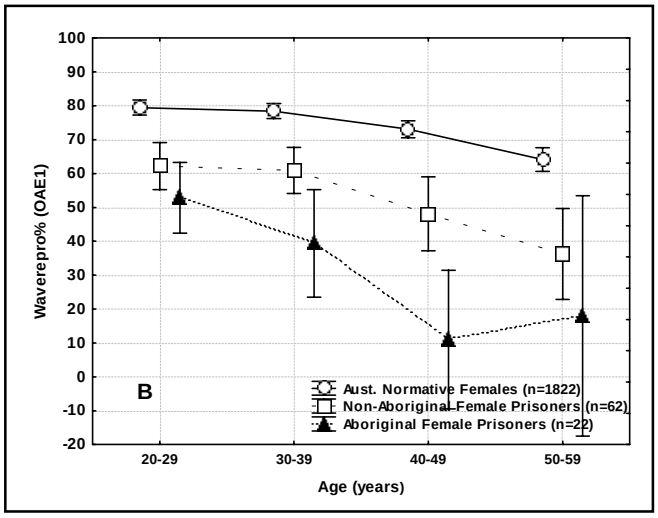

Table 1: Means, standard deviations and n for each subgroup with multiple linear regression summary for dependent variable OAE1 (see text) – both ears averaged. Total sample size=789. Age has been used as a continuous variable.

	Subgroup	n	Means	SD	Without age: Est. of differences between means	Without age: 95% CI	Without age: *p*-value *sig.	Adjusted analyses with age: Est. of differences between means	Adjusted analyses with age: 95% CI	Adjusted analyses with age: *p*-value *sig.
Demographic variables										
Age								-1.01	-0.44	<0.01*
Aboriginal	Non-Aboriginal	326	67.5	28.9						
	Aboriginal	171	44.7	35.5	-6.15		0.03*	-11.99	-10.66	<0.01*
Age								-0.90	-0.43	<0.01*
Sex	Female prisoners	84	53.5	35.9						
	Males	413	48.0	11.3	-1.71		0.64	3.23	-13.39	0.34
Hearing-related conditions										
Age								-0.76	-0.43	<0.01*
Ear problems	No	374	51.8	28.2						
	Yes (≥1 trouble)	85	30.0	28.7	-21.5	-14.2	0.00*	-17.73	-13.69	<0.01*
Tinnitus	No tinnitus	320	49.9	29.1						
	Tinnitus	139	42.3	29.6	-1.45	-11.9	0.63	-3.78	-11.40	0.26
Noisy job	No	208	51.4	27.9						
	Yes	253	44.8	30.4	-4.11	-10.5	0.12	-4.93	-10.00	0.08
Health conditions I										
Age								-0.71	-0.47	<0.01*
Arthritis	No	390	49.9	29.3						
	Yes	73	36.7	28.4	-11.88	-14.8	0.001*	-6.73	-14.64	0.03*
Diabetes	No	427	48.5	29.4						
	Yes	19	25.7	24.7	-20.56	-26.73	0.003*	-13.96	-26.10	0.02*
Hep B core antib.	No	290	48.3	30.0						
	Yes	178	47.1	30.8	-4.47	-8.33	0.03*	-3.89	-8.06	0.06
Hep C	No	279	44.3	30.8						
	Yes	186	53.3	28.9	3.56	-8.32	0.08	3.41	-8.01	0.10
Health conditions II										
Age								-0.76	-0.54	<0.01*
BP medication	No	442	48.0	29.6						
	Yes	16	30.0	26.1	-16.39	-3.03	0.03*	-2.22	-30.99	0.78
Cholesterol ≥5.5	No	282	51.8	28.8						
	Yes	186	42.1	31.8	-8.82	-11.33	0.002*	-2.77	-11.77	0.36
Substance use[a]										
Age								-0.86	-0.44	<0.01*
Heroin	No	350	44.8	30.4						
	Yes	147	53.7	29.1	8.06	-12.75	0.01*	2.59	-12.40	0.12
Morphine	No	478	47.3	30.3						
	Yes	19	49.9	29.5	-6.11	-29.43	0.42	-4.77	-27.88	0.87
Methadone	No	422	46.9	30.4						
	Yes	75	50.3	29.6	7.89	-21.87	0.16	7.78	-20.71	0.84
Non-injected drugs (depressant type)[a]										
Age								-1.00	-0.48	<0.01*
Alcohol	No	248	47.2	30.7						
	Yes	249	47.6	29.9	-0.52	-10.80	0.85	-3.57	-10.24	0.22
Cannabis	No	226	44.8	30.9						
	Yes	271	49.6	29.5	3.6	-11.48	0.22	-5.53	-11.62	0.33
Tranquilisers	No	405	46.2	30.2						
	Yes	92	52.8	30.3	5.1	-14.52	0.17	4.61	-13.63	0.24
Non-injected drugs (stimulant type)[a]										
Age								0.29	-0.44	<0.01*
Speed	No	391	45.6	30.4						
	Yes	106	54.0	28.8	8.49	-13.97	0.02*	1.03	-13.33	0.09
Cocaine	No	436	46.9	30.2						
	Yes	61	51.1	30.3	2.35	-18.27	0.61	2.68	-17.33	0.99
Ecstasy	No	469	47.0	30.3						
	Yes	28	53.8	28.4	3.94	-27.95	0.58	-6.36	-26.41	0.42
LSD	No	468	47.3	30.3						
	Yes	29	49.3	30.0	-6.03	-27.34	0.39	6.39	-25.82	0.24

Notes: (a) No=none, Yes=regular use, see text.

of prisoners are effectively much older than the ears of the normative population. The ears of prisoners appear to be approximately 30 years older than the normative population.

These results are similar to results from New Zealand[8] and Canadian[9] studies, which found that the hearing of indigenous prisoners was poorer than that of non-indigenous prisoners. It has been well known for some time that the hearing of Aboriginal children is affected by chronic otitis media leading to conductive hearing losses.[19] It has been assumed that there would be some legacy of this into adulthood and this is reflected in our findings. Our current method does not distinguish whether any hearing loss is of a sensorineural or conductive nature. Low otoacoustic emission strength can be indicative of a conductive hearing problem as well as a sensorineural hearing problem and tympanometry, which would have elucidated this, was not carried out. Hearing health care programs aimed at helping prisoners may need to be continued into adulthood; prisons may be an opportunity to initiate such programs.

As has been found in other studies, those exposed to noise exhibit poorer hearing than those who have not; this population is no exception. The OAE1 parameter is lower for those prisoners who report having had noisy jobs in the past. This may be compared with a study by Bountress and Richards,[6] who found that 7% of prisoners had a high-frequency hearing loss, presumably attributable to noise. While tinnitus is often associated with noise exposure and is a significant factor in lower otoacoustic emission results, particularly for males, it was found that it was not highly correlated with noisy jobs.

For self-reported health conditions, only arthritis and diabetes significantly affect the emission results.

Other researchers (McRandle and Goldstein, 1986,[7] and Jacobson et al.,[3] 1989) have found it impossible to isolate the influence on the auditory system of any one drug, except perhaps a temporary effect for cocaine and cannabis. This is our experience in this study, although it was found that those using drugs, on average, had higher emissions than those who did not.

In terms of prevention of hearing loss objectives, it is worthwhile to limit the rate of accelerated ageing of hearing. Several influences that bear upon prisoner health appear to include non-noise effects, such as high cholesterol levels, and these add to the general health issues of these agents. As in the general population, the main factor that individuals may influence is noise exposure. Loud noise results in extensive preclinical damage,[15] which eventually leads to hearing loss. Our methods did not allow determination of the actual levels of hearing impairment in the prison population, but on the basis of the otoacoustic emission estimations a significant percentage of those inmates tested will already have at least a mild hearing loss. From the study of Walkman use,[15] prisoners were the users who most often reported more than six hours per week of exposure, having at least equivalent rate of damage to workers in heavy industry. It is possible that hearing impairment prior to detention may have contributed to the development of behavioural problems. Conversely, others may have acquired damage while in detention. Our results cannot distinguish between these cases.

Conclusions

By way of otoacoustic emission testing an assessment was made of the auditory acuity of 640 inmates from 26 correctional centres in New South Wales. From this it was ascertained that prisoners had poorer hearing than a normative Australian population sample. Similar to the normative population, where females have better hearing than males, female prisoners had better hearing than male prisoners. Many variables, including tobacco, alcohol and other drugs, and a history of neurological or mental illness did not appear to affect hearing in this sample and were, therefore, excluded from the analysis. However, certain conditions, such as arthritis or diabetes, appear to significantly influence hearing. However, this may be due to medications associated with these illnesses, as it was also found that blood pressure medication and a high cholesterol level were linked with lower emissions.

Implications

This study has implications for correctional centre management. Inmates with hearing impairment may be unable to hear verbal requests and orders from correctional officers leading to potential misunderstandings.

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