The Leisure-Noise Dilemma: Hearing Loss or Hearsay?

What Does the Literature Tell Us?

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Introduction

- Noise exposure hearing effect
- Workplace noise control for occupation noise exposure, well documented
- Leisure-noise exposure may cause damage to auditory system, to date, inconclusive
- Increasing users of personal stereo players (PSPs) draw attention of media and scientific publication

Noise cause - effect

Audiometric results:

- Temporary threshold shift (TTS)
- Acoustic notch and/or high frequency loss
- Permanent threshold shift (PTS)---resulting noiseinduced hearing loss (NIHL)
- Reduced speech processing ability(Kumar et al. 2012),
 with HTLs better than 25 dBHL from 250 to 8kHz

Biological and physiological effects

- Tinnitus
- Temporal and Frequency resolution(Carter et al. 1978; West and Evans, 1990)
- Loudness difference limen (Bienvenue et al. 1976)
- Okamoto et al. (2011) reported a study of magnetoenphaolographic (MEG) responses of long-term users and nonusers of PSPs, found significantly broadened frequency tuning in a group of long-term users

Occupational noise exposure

- Occupational Noise induced hearing loss in people of various ages had been well documented by International Organization for Standardization, in 1975----ISO 1999
- Noise (or working hours) controls at workplaces where the excessive noise may cause NIHL have been mandatorily implemented

Leisure noise

- With technological advances, the users of PSP have led to dramatically increased leisure-noise exposure (Zhao et al.2010; Levey et al. 2011)
- With concomitant increase in risk for young people
- A large body of literature concerned with the possible relationship between leisure-noise exposure and hearing threshold shift has since amassed(accumulated)

Will Leisure noise damage hearing?

Definition of "Leisure noise": loud sound encountered during everyday leisure activities; other noted as "social noise" (Smith et al. 2000) "sociacusis" (Ward 1976; Yaremchuk et al. 1997)

- The leisure-noise issue raised a critical attitude discernible in media as tending toward alarmist headlines
- One scientific publication(Maassen et al. 2001 p
 4) commented that: "a techno freak" subjecting
 himself to loud music via a PCP(Personal Cassette
 Player) endangers his ears in the same way as a
 worker in a steel factory suing no ear protection

Purposes

 Authors (NAL, Australia) has conducted a range of studies, to quantify leisure-noise sources, patterns of exposure, estimate community risk of noise injury from everyday nonwork activities and determine the prevalence of hearing threshld impairment in the younger Australia population

Purposes

- It is not possible to conduct a long-term study applying loud noise on human ears for several years, and to observe the effects of noise on hearing
- Through an extensive literature review, authors aim to provide an objective frame of reference for disseminating recent NAL findings and for considering methodological "best practice" for ongoing research

Materials and Methods

- Titles search included: hearing threshold levels, leisure noise, music and hearing, recreational noise, prevalence of hearing loss, and personal stereo players
- About 737 titles of interest (including peer-reviewed publications, referenced conference abstracts, and postgraduate theses)
- A total of 265 articles relevant to the topic were reviewed in full

Publication by decade Morata 2007; Zocoli et al. 2009

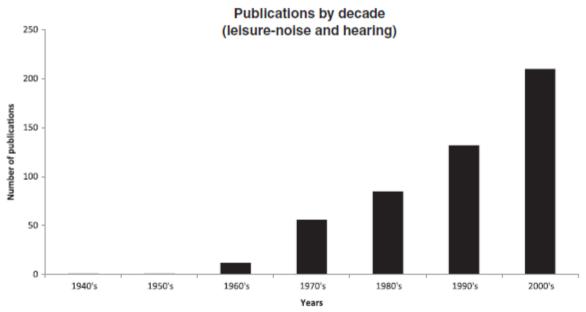


Fig. 1. Publications by decade (leisure-noise and hearing).

Results

- The difficulty in directly comparing the findings of different studies, which have used a variety of specific methods and metrics
 - Articles were categorized in six types of study:
 - 1. Exploring the relationship between leisure-noise exposure and HTL
 - 2. Retrospective Cohort Studies
- 3. Cross-sectional studies (n< 500) that include comment on leisure-noise exposure
- 4. Cross-sectional studies (n> 500) that include comment on leisure-noise exposure

Results

- Articles were categorized in six types of study: (continued)
 - 5. longitudinal studies
- 6. cross-sectional surveys using audiometric configuration (notch) as indicator

Results of study Type I

- **Table 1**, . Exploring the relationship between leisure-noise exposure and HTL, described the effects of leisure-noise exposure, pre- and post-exposure audiometry data, and other measures, such as OAEs, to look for evidence of post-exposure shift, then recovery of HTLs (i.e., TTS)
- Conducted from the late 1960s to date
- 19 out of 20 showed TTS
- However, the relationship between TTS and PTS is still debated

TABLE 1. Studies of TTS

Authors	Participants	Method/Noise Source	Conclusion
Rintelmann and Borus (1968)	N = 52 United States (U.S.) 18–20 yrs	PTA (pre/post live rock music)	Concern seems unwarranted
Reddell and Lebo (1972)	N = 43 U.S. rock musicians Mean age 22 yrs	PTA (pre/post hard rock music)	TTS observed in musicians and some listeners
Axelsson and Lindgren (1978)	N = 83 Swedish pop musicians and listeners	PTA (pre/post pop music)	Less TTS in musicians than listeners
Lindgren and Axelsson (1983)	N = 10 Swedish teenagers	PTA (pre/post 10 min laboratory stimuli)	Noted differences in TTS with musical vs. nonmusical stimuli
Lee et al. (1985)	N = 16 U.S.	PTA (pre/post 3 hr PCP exposure)	6/16 showed TTS. All recovered after 24 hr
Clark and Bohne (1986)	N = 6 U.S. rock concert attendees	PTA (pre/post rock concert)	5/6 showed TTS
Swanson et al. (1987)	N = 20 U.S. undergraduate students	PTA, tympanometry, acoustic reflex thresholds (pre/post laboratory noise and music)	Relationship found between TTS and music preference (greater for disliked music)
Hellström et al. (1998)	N = 21 Swedish PCP/speaker listeners	Bekesy (pre/post 1 hr of PCP use)	Most had only "discrete" TTS, despite levels of 91–97 dB
Drake-Lee (1992)	N = 5 United Kingdom (U.K.) heavy metal players 25–37 yrs	PTA (pre/post rock concert)	TTS noted in all but one musician (who used PHP)
Yassi et al. (1993)	N = 22 Canadian 18–40 yrs	PTA (pre/post rock concert)	81% showed TTS of 10 dB or more
Vittitow et al. (1994)	N = 12 U.S.	PTA (pre/post music and cycling)	Greater TTS for noise and exercise condition than noise alone
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McCombe et al. (1995)	N = 18 U.K. motorcyclists	PTA (pre/post 1 hr motorcycle ride)	Significant TTS found at 0.25-2 kHz
Strasser et al. (1999)	N = 10 German 18-30 yrs	PTA (pre/post laboratory music vs. industrial and white noise)	Demonstrated TTS with all sources. Least effect with classical music. Industrial noise and heavy metal music showed similar effect
Mazelova et al. (2001)	N = 12 Czech 18–25 yrs	PTA, Bekesy high resolution, OAE (pre/post laboratory amplified music)	Demonstrated changes in all measures except gap detection
Nassar (2001)	N = 28 U.K. Mean age 21 yrs	PTA (pre/post aerobics class)	Exposed group showed TTS, control group slightly improved HTLs (practice effect?)
Sadhra et al. (2002)	N = 14 U.K. university student bar employees 20–40 yrs	PTA (pre/post bar/ discotheque music)	13/14 showed TTS
Emmerich et al. (2002)	N = 34 German 18–24 yrs	PTA and AEF (pre/post discotheque music)	TTS found in all subjects and AEF latency shifts
Opperman et al. (2006)	N = 29 U.S. 17–59 yrs	PTA (pre/post concert- amplified music)	64% of unprotected listeners showed TTS, 27% of those using earplugs
Keppler et al. (2010)	N = 21 Belgian 19–28 yrs	PTA and OAE (pre/post high- level MP3 pop/rock music)	Changes in PTA and TEOAE in exposed group. No significant changes in DPOAE
Tam et al. (2013)	N = 12 Australian 19–28 yrs	PTA and OAE (pre/post MP3 music)	Significant increase in 6kHz HTL and significant reduction in some DPOAE and TEOAE amplitudes post exposure

AEF, auditory evoked magnetic field; DP, distortion product; CAE, otoacoustic emission; PCP, personal cassette player, PHP, personal hearing protector; PTA, pure-tone auditometry; TE, transient evoked; TTS, temporary threshold shift.

Results of study type 2

- **Table 2**, . Retrospective Cohort Studies with a total of 7 investigations, HTLs and other indicators (i.e. OAEs) have been examined in voluntarily exposed to specific leisure-noise sources vs. non-exposed (control) groups
- 5 out of 7 showed differences

TABLE 2. Retrospective cohort studies

Authors	Participants	Exposure Source	Findings
Hanson and Feam (1975)	N = 505 U.K. students	Pop music	PTA: Small but statistically significant difference between case and controls
Fearn (1981)	N = 367 U.K. school children	Amplified pop music	PTA: statistical analysis not presented (differences in order of a few decibels)
West and Evans (1990)	N = 60 U.K. 15–23 yrs	Amplified music	Bekesy audiometry and frequency resolution: "Trend" toward wider bandwidths in the exposed
Jorge Junior (1993) (cited by Zocoli et al. 2009)	N = 958 Brazilian teenagers	PSPs	PTA: no significant differences
Schmidt et al. (1994)	N = 133 Dutch Music students and controls	Classical music	PTA: no significant difference
Meyer-Bisch (1996)	N = 1364 French -15-25 yrs	Discotheques, PSPs, and rock concerts	PTA: no significant differences for discotheque exposure. Small (-2-4 dB) but significantly significant differences comparing controls and the "intensively" exposed for PSP and rock concert exposure
Mostafapour et al. (1998)	N = 50 U.S. college students	PSPs	PTA: no significant differences
Peng et al. (2007)	N = 120 Chinese University students	PSPs	PTA: statistically significant differences (-3-5 dB) reported

Results of study type 3

- Table 3, Cross-sectional studies (n< 500) that include comment on leisure-noise exposure, relatively small sample sizes and use of convenience samples in smaller cross-sectional and experimental studies may affect generalizability of results. It seems possible that this type could be subject to publication bias, that is, studies with positive results are more likely to be accepted for publication than those with null or negative results.
- 4 out of 7 demonstrated positive relationship between HTLs and leisure-noise

TABLE 3. Cross-sectional studies (n < 500) that include comment on leisure-noise exposure

Authors	Participants	Assessment Method	Effect of Leisure-Noise?
Carter et al. (1978)	N = 231 Australian university students	PTA; survey—occupational and recreational exposure	No
Lees et al. (1985)	N = 60 Canadian 16-25 yrs	PTA; survey—occupational and recreational exposure	Yes. 40% prevalence rate of hearing loss (but insufficient to cause hearing disability)
Ahmed et al. (2007)	N = 24 Canadian university students	PTA (PSP users only); survey	No evidence of early hearing loss
Kim et al. (2009)	N = 490 Korean adolescents 13-18 yrs	PTA Interview (PSP use)	No relation between HTL and daily use; however, 4000 Hz "elevated" in 24 participants with highest exposure
Martinez-Wbaldo et al. (2009)	N = 214 Mexican teenagers	PTA; survey—noisy activities at school and leisure	"Moderate" association between leisure noise and hearing loss. 20% prevalence rate of loss
Zocoli et al. (2009)	N = 245 Brazilian 14-18 yrs	PTA; survey—noisy leisure activities	No
Le Prell et al. (2011)	N = 56 U.S. college students	PTA; survey—risk factors	"Statistically reliable relationship" between HTL and PSP use in males only

PSP, personal stereo player, PTA, pure-tone audiometry.

Results of study type 4

• **Table 4**, Cross-sectional studies (n> 500) that include comment on leisure-noise exposure, only 2 of these studies (2/10) suggest an association between HTLs and leisure-noise exposure

TABLE 4. Cross-sectional studies (n ≥ 500) that include comment on leisure-noise exposure

Authors	Participants	Assessment Method	Effect of Leisure-Noise?
Strauss et al. (1977)	N = 1300	PTA?	No
	German	(German article)	
Axelsson et al. (1981)	N = 538	PTA	No
	Swedish		
	17–20 yrs		
Carter et al. (1982)	N = 944	PTA; ENT exam	No
	Australian		
	16–20 yrs		
Buffe et al. (1986)	N = 51,726	PTA; medical exam;	No real correlation between
Article in French, cited	French	noise history	music exposure and HTL.
by Petrescu (2008)	18–25 yrs		(Noted professional DJs had higher HTLs).
Costa et al. (1988)	N = 2264	PTA screen (no exposure	Yes, on the basis that HF loss is
	Swedish	data or tympanometry)	more common, and males more
	7, 10, and 13 yrs		affected than females
Axelsson et al. (1994)	N = 500	PTA	No
	Swedish		
	18 yrs		
Haapaniemi (1995)	N = 687	PTA; ENT exam; survey	No
	Finnish		
	6–15 yrs		
Cone et al. (2010)	N = 6591	PTA screening	Reported PSP use as a risk factor,
	Australian		but most significant factor = NICU
	school children		admission
	yrs 1 and 5		
Twardella et al. (2011) (German)	N = 2240	PTA; medical exam;	Nonoccupational risk factors
	German	questionnaire	identified: firearms, chain saws,
	students grade 9		and power tools
Carter (2011)	N = -1400	PTA; interview; questionnaire	No (preliminary analysis)
Carter (2011)	Australian	FIA, litterview, questionilatie	140 (preliminary analysis)
	11–35 yrs		

DJ, disc jockey; ENT, ear, nose and throat specialist; HF, high frequency; NICU, neonatal intensive care unit; PSP, personal stereo player; PTA, pure-tone audiometry.

Results of study type 5

• **Table 5,** longitudinal studies, only one study showed significant downward shift in HTLs for frequencies above 8kHz, others reported no significant HTL shifts

TABLE 5. Longitudinal studies

Authors	Participants	Assessment Method	Effect of Leisure-Noise?	
Roche et al. (1977, 1979, 1982)	N = 1100	PTA over 5 yrs; survey;	No significant associations between	
	United States	dosimetry	HTL and noise exposure scores	
	Main sample 6-18 yrs			
Carter et al. (1984)	N = 141	PTA x 2 (retest 6-8 yrs	No significant HTL shifts	
	Australian 10-12 yrs	after baseline)	-	
	(at first assessment)	*		
Biassoni et al. (2005);	N = 173	PTA annually for 4 yrs	Significant downward shift in HTLs	
Serra et al. (2005)	Argentine		for frequencies above 8000 Hz	
, ,	14-17 yrs			
Jin et al. (2013)	N = 698	PTA; OAE; survey (retest	No significant bilateral HTL shifts	
	U.S. university band members	3-4 mo after baseline)	reported	
	≤25 yrs		·-F	

OAE, otoecoustic emission; PTA, pure-tone audiometry.

Results of study type 6

• Table 6, cross-sectional surveys using audiometric configuration (notch) as indicator, showed study results from population surveys of HTLs, 11 reported positive findings with total of 17 articles

TABLE 6. Cross-sectional surveys using audiometric configuration (notch) as indicator

U.S.

18-30 yrs

Authors	Participants	Assessment Method	Findings
Guild (1950)	Unknown United Kingdom (U.K.)		"Abrupt" audiometric configurations not always associated with impulse noise exposure
linchcliffe (1959)	N = 100	PTA; ENT exam;	Poorer mid-high frequency HTLs in
	U.K.	questionnaire; risk factors	males-associated with small arms use
ozad (1974)	N = 18,600 U.S. school students	PTA (no exposure data)	Cite audiometric configuration (hearing loss above 3000 Hz) as possible evidence of NIHL
lsson et al. (1981)	N = 538 Swedish 17–20 yrs	PTA	15% showed some hearing loss. Refers to "dip" at 6 kHz—but no correlation with leisure-time activities
zner and Rytzner (1981)	N = 14,391 Swedish 7, 10, and 13 yrs	PTA screen; ENT follow-up	Small occurrence (4kHz "dip") associated with exposure in approximately 200 cases
vaer et al. (1983)	N = 1474 Norwegian 20–80 yrs	PTA; ENT exam; questionnaire	6kHz "dip" noted, even in youngest participants. Assumed noise related
paniemi (1995)	N = 687 Finnish 6–15 yrs	PTA; ENT exam; questionnaire	8.3% occurrence. Cites several possible factors
olmes et al. (1997)	N = 342 U.S. 10–20 yrs	PTA screen; six-item questionnaire	6kHz "dip" associated with firearms use
ostafapour et al. (1998)	N = 50	PTA; speech	Found only one case of "notch" at 6 kHz

discrimination test

Niskai et al. (2001)	U.S. 6–19 yrs	(no exposure data)	12.5% estimated to have a noticin (NITS)
McBride and Williams (2001)	N = 357 U.K.	Bekesy audiometry; questionnaire	49% determined to have a "notch"—no association with NIHL risk factors
Rabinowitz et al. (2006a)	electricity employees N = 2526 U.S. 15–25 yrs	PTA (limited exposure data)	Almost 20% had "notch"— rate constant over 20 yr interval. Likely related "at least in part" to noise exposure
Nondahl et al. (2009)	N = 2395 U.S. 43–84 yrs	Compared algorithms using previous data (Beaver Dam study)	"Notches" noted in the absence of noise exposure history. Poor agreement among four different algorithms
Osei-Lah and Yeoh (2010)	N = 149 U.K. outpatients 19–91 yrs	ENT outpatient assessment	39.6% exhibited "notches" not attributable to noise or other risk factors
Schlauch and Carney (2011)	N = 5089 U.S. 6 to 19 yrs	PTA (NHANES III data) compared test and retest data and computer-simulated audiograms	Similar prevalence of "notches" in actual and simulated audiograms
Jin et al. (2013)	N = 698 U.S. marching band members and controls ≤25 yrs	PTA; OAE	Noted transitory behavior of "notches" on multiple retests
Twardella et al. (2013)	N = 1843 German adolescents	PTA	2.4% prevalence of "notches"

PTA (NHANES III data)

12.5% estimated to have a "notch (NITS)"

N = 5249

-15 to 16 yrs

Niskar et al. (2001)

ENT, ear, nose, and throat specialist; NHANES, National Health and Nutrition Examination Survey; NHL, noise-induced hearing loss; NITS, noise-induced threshold shift; OAE, otoacoustic emission; PTA, pure-tone audiometry.

Discussions

- Six factors identified by authors which attributed to interpretation of results and
- The extent to which the results of different studies can be meaningfully synthesized

- 1. Inherent imprecision of PTA
 - Calibration issues, test protocol, test-retest reliability, test environment, tester, and participant factors (motivation)
- 2. Influence of "Pass-Fail" criterion
 - The cutoff criterion between "normal hearing" and "hearing loss" has not been standardized
- 3. Reference HTL data
 - "audiometric zero" established in ISO 7092, is not an absolute but must be inferred statistically from specific and adequate population data

- 4. Basline PTA
 - Lack of basline PTA in majority of hearing surveys
- 5. Audiometric Configuration
 - Noise notch at frequency range been identified revealed different criteria among studies
- 6. Confounding Variables
 - Such as, middle ear dysfunction, prenatal exposure to disease, ototoxic drug exposure, family history, and head/ear trauma; other agents such as tobacco and solvents are also risk factors for hearing loss

Conclusions

- The commentary in this field of research to date is arguably more speculative than evidence based and scientifically defensible
- Scientists should be prepared to challenge overstated public information
- The freedom of individuals of make personal choices about their recreational pursuits, based on accurate scientific information

Conclusions

- The difficulty in directly comparing the findings of different studies, which have used a variety of specific methods and metrics, is noteworthy
- Damaging effects of noise depend not only on intensity but also on the duration and pattern of exposure, and possibly on other individual susceptibility factors