

A snapshot of young adults' noise exposure reveals evidence of 'Binge Listening'

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ABSTRACT

There have been several previous studies into daily noise exposure levels in modern urban communities, which typically report mean noise exposure levels (L_{Aeq}) for adults between 73 and 79 dB. In this study, rather than focus on group mean exposures across a wide age range, individual patterns of noise exposure over 4- and 5-day periods were examined in a group of 45 young adults aged 18 to 35 years. The main objective of the study was to determine the extent to which young adults exhibit a 'binge listening' pattern of noise exposure, i.e., high weekend leisure noise vs. low weekday work noise exposure. A secondary objective was to identify the types of activities that generate the highest noise exposures. The results showed that although most participants (60%) were exposed to low daily noise levels, 33% of participants exhibited a 'binge listening' exposure pattern characterised by one or two high-noise days, usually a Friday, Saturday or Sunday, preceded or followed by much quieter days. The most notable high-noise activities were playing an instrument solo or in a band; attending a nightclub; and attending a pop concert, each of which recorded average noise levels greater than 100 dB. Future research is needed to determine whether 'binge listening' is more or less harmful than the chronic exposure presupposed in traditional risk models, however, under the equal-energy principle, repeated 'binge' noise exposures from weekend visits to nightclubs, live music events and other high-noise events represent a significant risk to long-term hearing health.

Keywords noise exposure, young adults, binge listening, noise-induced hearing loss

1. Introduction

The daily noise exposure of individuals in the community has been measured by researchers since the late 1970s. The aim of these studies has been to determine typical noise exposure levels of individuals in modern urban environments, and whether such noise levels pose a risk to hearing health. The studies have also been used to identify which activities emit the highest noise levels, and which members of society (in terms of age, gender, and occupation) are exposed to excessive noise and are therefore at risk of noise-induced hearing loss (NIHL) and other noise-related effects.

In Johnson and Farina's [1] epic study, a male medical technician wore a noise dosimeter for 31 days. His daily A-weighted noise exposures ($L_{Aeq,24h}$) were quite low, ranging from 59 dB to 83 dB per day, with a daily average of 76 dB. Seventy percent of the total noise exposure was from events that occupied less than 7% of the wearer's time. The noisy activities were parties, nightclubs, outings to a bowling alley, and a 'car hobby shop'. Although this case study was not intended to provide representative data for the community, it established personal noise dosimetry as a reliable methodology which has been adopted by researchers in the field ever since.

Since then, a number of dosimetry studies have examined daily noise exposure in children and adults in the US, Japan, China, and Spain [2-11]. Most of these studies have reported average noise exposure results ($L_{Aeq,24hr}$ or $L_{Aeq,8hr}$) that were often higher than the recommended daily EPA limit of 70 dB $L_{Aeq,24hr}$ /75 dB $L_{Aeq,8hr}$ [12] but usually less than the most widely used occupational standard of 85 dB $L_{Aeq,8hr}$ [e.g., 11, 13].

The broader scope of these studies has also allowed investigation of the exposure patterns of different groups. Where gender differences have been examined, males have tended to have higher noise exposures than females [9, 10, 13]. The few studies which found a relationship between age and noise levels, found more noise exposure amongst

younger than older participants [2, 6, 11], and those studies that focussed on children [8, 10] reported higher average daily noise levels than all of the adult studies.

No clear pattern emerges as to the relative contribution of occupational versus non-occupational (or leisure) noise. Although occupational noise was found to be more significant than leisure noise for a group of (mostly male) US construction workers [4, 14], the opposite was true for Spanish adults with a mix of occupations who experienced most of their noise (64.6%) during the 4.5% of the time spent participating in leisure activities [2]. In contrast, occupational noise accounted for 61% of daily noise experienced by Chinese adults with a mix of occupations [3]. These varying results suggest that the relativities between leisure and occupational noise are not straightforward and are highly dependent on the particular occupational and leisure activities of individuals.

In those studies where noise exposure was measured over several days, researchers have been able to examine whether certain days of the week were more or less noisy than others. Two studies compared the average daily noise exposures of their entire samples and found no significant differences between average noise levels on different days of the week [11, 13]. However, Diaz and Pedrero [2] examined this question as a function of age and found a striking pattern. In their young adult group (17-25 years), there was a large peak in noise exposure on weekends (Fridays, Saturdays and Sundays), such that 76% of their weekly noise exposure was received during weekend leisure activities, such as attending nightclubs and discotheques. This contrasted with adults aged between 25 and 73 whose noise exposure was more evenly distributed throughout the week.

The aim of the current study was to examine individuals' patterns of daily noise exposure in a similar sample of young Australian adults aged 18-35 years. It was hypothesised that noise exposure in this group would reveal a similar pattern to that found for under-25s in the Diaz and Pedrero [2] study. Because young adults are more likely to engage in high-noise leisure activities such as nightclubs and live music events [15, 16],

which tend to occur at the end of the week, higher weekend than weekday noise exposures were anticipated. Moreover, in a pilot study of nine young adults, six showed this pattern of high weekend leisure noise vs. low weekday work noise exposure – a pattern which came to be called ‘binge listening’ [see 17]. This pattern of exposure is of particular interest because it is unknown whether ‘binge’ episodes of high noise exposure are more or less harmful than the lower, but more constant, levels of noise exposure assumed in occupational noise exposure risk modelling [e.g., 18]. The equal-energy principle implies that higher noise exposures of shorter duration are equivalent to lower noise exposures of longer duration, but it may be that recovery time between exposures ameliorates some of the risk associated with episodic high-noise exposures.

In the current study, 45 young adults wore dosimeters to obtain a snapshot of their noise exposure. Noise exposure was measured over a 4- or 5-day period, and participants kept a written diary of events and activities during this period. The objectives of the study were to i) determine the extent to which ‘binge listening’ occurs amongst 18-35-year-olds; and ii) identify the types of activities that generate the highest noise exposures for this group.

2. Material and Methods

Ethics approval for this project was obtained through the Australian Hearing Human Research Ethics Committee. Daily noise measurements were gathered using CEL-350 dBadge Personal Sound Exposure meters from Casella-CEL (Bedford, UK), which were calibrated prior to use with a CEL-110 Acoustic Calibrator. The dosimeters have a frequency range of 30 to 12000 Hz and log L_{Aeq} between 65 and 140 dBA in one-minute intervals. Dosimeters were worn continuously by participants for 4- or 5-day periods. The measurement periods were chosen to represent exposures that individuals may receive during a typical week from both occupational and leisure activities. The measurement periods included Friday, Saturday and Sunday in order to gather information on the full range of leisure activities that may be experienced during participants’ typical non-work

hours. Prior to commencing the study, participants were shown how to use the dosimeters. They were instructed to attach the dosimeter to their clothing, usually the lapel, for all waking hours, except for water sports or body contact sports where participants were advised to place them as close by as possible. During sleep periods, the devices were attached to a battery charger for recharging and thus noise measurements were not carried out during this time.

Participants were asked to complete a daily diary record of activities and events experienced at the end of each day. They were provided with several blank diary pages with a grid for entering details under the following headings: date, time period, brief description of activity, location, sources of noise, number of people in immediate area, location of dosimeter if not on lapel, and a subjective loudness rating. The data pertaining to the loudness ratings have been reported in an earlier paper and will not be discussed further here [see 19]. Participants were required to account for the entire day, and they were asked to start a new entry whenever their environment changed, e.g. a day during which several different activities occurred was to be entered as a series of separate events/activities, e.g. (1) lunch, (2) bushwalk, (3) cafe etc; and a single evening may have been recorded as: (1) dinner, (2) pub with mates, (3) same pub with live music.

2.1 Participants

Participants were volunteers recruited through social-network internet sites, individuals known to researchers, and work colleagues using a 'snowball' recruitment method. In total there were 45 participants aged between 18 and 35 years with most participants living in Sydney (n = 42), and three from rural areas. All participants received a department store gift voucher valued at \$100 for their participation. Data from three participants were discarded because either the diary (n=1) or the noise recordings (n=2) were incomplete.

The education levels of the final sample of participants were high: 62% held a university degree, (which is more than double the 28% of 20 – 34-year-olds in Australia who currently hold a degree [20]; 14 had obtained a vocational qualification; and the remaining 24% held a school qualification only. Eleven participants were students, three of whom were studying music. The remainder were employed as business and information professionals (n = 8), health professionals (n = 7), education professionals (n = 7), in trades and related roles (n = 5), administration (n = 2), or home duties (n = 2). In addition to the three music students, two of who were employed part-time in the music industry, a fourth participant was an amateur musician, who played in a band.

2.2 Data Analysis

A total of 39 participants (93%) recorded data for 5 full days, while the remaining participants completed four days. At the conclusion of each participant's measurement period, dosimeter results were downloaded using supplied software with International Organization for Standardization (ISO) protocols and definitions. Each participant's dosimeter output and diary were compared and any incomplete or ambiguous diary entries were identified. Individual post-test interviews were held with all participants and where necessary, participants were asked to provide additional details to ensure that each diary entry was as complete and accurate as possible. All L_{Aeq} peaks (n=23) that were a result of interference such as 'accidentally knocking the dosimeter' or were 20 dB or greater than the adjacent peaks were excised before any noise calculations were performed.

Each participant's average daily noise exposure was calculated in Pa^2h [21, 22]. This method of quantifying noise exposure is particularly useful because Pa^2h is a linear measure and straightforward comparisons can be made between occupational limits and actual exposures. In particular, an exposure of 85 dBA over 8 hours (i.e. the recommended workplace noise exposure standard) is equivalent to 1.01 Pa^2h . Thus, any person with an

average daily noise exposure greater than 1.01 Pa²h can be immediately identified as receiving excessive and potentially harmful noise exposure.

3. Results

3.1 Noise exposure

Just over a quarter of participants (29%) had an average daily dose greater than 1.01 Pa²h (see Figure 1). Even though the majority of participants' average noise exposure was less than 1.01 Pa²h, and the median daily exposure was 0.3 Pa²h, the average daily noise exposure per person was greater than the allowable workplace limit, $M = 1.3 \text{ Pa}^2\text{h}$, $SD = 2.4$. One participant, a music student and part-time musician, received an exceptionally high noise dose, averaging 13.35 Pa²h per day. Four of this participant's five test days were over 1.01 Pa²h and on Saturday night, exposure reached 51 Pa²h from playing in a live band. Even when this participant was removed from the sample, the average was still greater than the workplace limit at 1.1 Pa²h. The majority of the total noise exposure was from leisure activities (69%) versus work- and education-related activities (31%).

*****Insert Figure 1 about here*****

3.2 High-noise days and activities

Of the 207 days on which noise was measured across all participants, the noise exposure was greater than 1.01 Pa²h on 27 days (13%), most of which were weekend days (20 out of 27). The loudest day of the week was Saturday with an average noise exposure level of 2.9 Pa²h, almost 15 times louder than the quietest day, Thursday: 0.2 Pa²h. Seventeen participants experienced at least one high-noise day (>1.01 Pa²h) and their diaries were examined to identify the activities that contributed most to the noise exposure on these days (as shown in Table 1). Six activities were particularly notable because the L_{Aeq} s were

measured at over 100 dB: playing an instrument solo or in a band (105.7 dB, 103.2, 100.4); attending a nightclub (102.7 dB, 100.5 dB); and attending a pop concert (101.1 dB).

*****Insert Table 1 about here*****

3.3 Evidence of Binge Listening Pattern

Each individual's pattern of noise exposure over the 4- or 5-day period was assessed to see whether it showed evidence of 'binge listening'. An individual was deemed to exhibit a 'binge listening' pattern if their noise exposure was greater than 1.01 Pa²h on one or two days and less than 1.01 Pa²h on the remaining days. Of the 42 participants, a binge listening pattern was identified in 14 participants (33%). Most of the remaining participants (25/42 or 60%) exhibited either a 'flat' pattern, where all days were under 1.01 Pa²h, and the remaining 3 participants (7%) exhibited a 'noisy' pattern with noise exposures greater than 1.01 Pa²h on three or more days. An example of each noise exposure pattern is shown in Figure 2. The group of binge listeners comprised both men ($n = 8$), and women ($n = 6$). Of the 14 binge listeners, five were aged under 25 and the remaining nine were aged 26-35. Their mean age was 27.4 years, similar to the group average of 26.8.

*****Insert Figure 2 about here*****

4. Discussion

This study's main finding was that 'binge listening' was apparent in the noise exposure of one-third of young adult participants. This pattern of noise exposure is characterised by one or two high-noise days, usually on a Friday, Saturday or Sunday, preceded or followed by much quieter days. This noise exposure pattern reflects the findings of Diaz and Pedrero [2] who showed that young adults aged 17-25 in Madrid received the vast majority of their weekly noise exposure from weekend leisure activities. In addition to the 'binge listeners' in

this study, a further three participants were characterised as having a 'noisy' pattern of exposure. These participants were either music students or regularly rode a motorbike, which explains their consistently high noise levels.

Perhaps not surprisingly, the three activities which generated the highest noise levels in this study – playing an instrument solo or in a band, attending a nightclub, and attending a pop concert – were similar to the three loudest activities reported by Diaz (2006) – attending a nightclub, band rehearsal, and discotheque. Earlier dosimetry studies report a wider range of particularly loud activities, such as, use of power tools, car radio, attendance at church, animal noises, driving a moped, flying in aircraft, and attending a sports event [7, 11]. Although some of these high-noise activities were also observed by Diaz and Pedro [2] and in the current study, the evidence from these two studies suggests that in recent years, young adults' participation in music-related events has become a more prominent contributor to overall noise exposures. It would be of great interest to examine the specific noise exposure of participants in Flamme et al [13]'s study to see the extent to which music-related events feature in a larger contemporary US sample of young urban adults.

The overall average daily noise exposure for this group of young adults was 1.3 Pa²h. This equates to an L_{Aeq,8hr} of 86.1 dB, which is higher than the allowable workplace limit and higher than any of the previous adult dosimetry studies described earlier [2-7, 9, 11]. It is of particular concern that this is the average exposure level for a sample of participants who are either students or employed in mostly quiet occupations because most of the noise (69%) is coming from voluntary leisure activities, where hearing protection and other noise control measures are unlikely to be observed. Further, their occupation or study background means that it would be unlikely that many would have had explicit education about noise or hearing health, and may be unaware of the implications of their exposure levels. Further research is needed to determine whether young adults employed in noisy work environments are also receiving high leisure noise exposures and therefore even higher overall noise exposures overall.

Previous studies into the noise exposure of adults have tended to focus mainly on reporting the overall average noise exposure levels for their respective samples. A different approach has been taken in this study whereby the focus has been on individuals' *patterns* of noise exposure. We believe this approach can reveal trends in noise exposure patterns which are not apparent from sample-wide averages alone. If one of the aims of noise exposure research is to identify those most at risk of NIHL and other hearing-related problems, we need research methods that allow identification of groups of individuals whose particular behaviours are putting them at risk. Once identified, at-risk groups can be targeted in noise reduction campaigns and awareness-raising efforts to ensure the message is reaching those most in need.

It could be suggested that the noise snapshots presented here may not be indicative of the group's usual noise exposure because participants may have been tempted to experience higher than usual noise exposures during the test period. However, two measures were undertaken to examine whether this had occurred. Firstly, at the post-test interview, participants were asked whether the test period was 'typical' for them. The majority (26 of the 42 participants) agreed that it was typical; 11 said it was quieter than usual, and only four said it was louder than usual. Secondly, prior to commencing the test period, we asked participants to rate the noisiness of their overall lifestyle on a 10-point scale. Responses to this question, which are presented in Beach et al [19] show good agreement between self-rating of lifestyle noise and the objectively measured noise from the dosimeters (*Spearman's* $r = 0.71$, $p < 0.001$), which again suggests that the noise exposures presented here are reasonably representative of participants' typical daily noise exposures.

Having shown evidence of 'binge listening' in around one-third of young adults' noise exposure, the next question which needs investigation is whether or not this exposure pattern is more or less damaging than constant exposure to daily noise levels of 85 $L_{Aeq,8hr}$. Animal models suggest that recovery time between noise exposures is beneficial and possibly protective for the hearing system; however, it is unknown whether the same is true

for humans [23, 24]. On the other hand, it may be that recovery time and the opportunity it provides for the diminution of temporary symptoms of hearing damage lulls 'binge listeners' into the mistaken belief that any noise damage sustained has been resolved, thus encouraging continued exposure. A further question relates to the age of exposure. We found evidence of binge listening across the age range 18-35 years. Additional research is needed to examine whether binge listening becomes less common in older age groups. If it is the case that 'binge listeners' tend to be younger adults, they may be more vulnerable to episodic high-noise doses and suffer greater long-term damage than older listeners, as suggested in some animal models [25, 26]. Clearly, further research into long-term hearing outcomes of 'binge listeners' is required to fully understand the implications of this pattern of noise exposure.

4.1 Conclusions

The noise exposure snapshots presented here reveal evidence of 'binge listening' amongst young adults. Further research is needed to determine whether this 'binge' pattern of exposure is more or less harmful than the chronic exposure presupposed in traditional risk models. In the meantime, 'binge listeners' should be aware that under the equal-energy principle, high noise levels from weekend visits to nightclubs, live music events and other high-noise events has the potential to significantly damage long-term hearing health.

5. References

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Figure Captions

Figure 1: Average daily noise exposure for all participants. The columns representing the four participants who were musicians are shaded in grey. The dotted line represents the daily acceptable workplace limit of $1.01 \text{ Pa}^2\text{h}$.

Figure 2: Noise exposure pattern of three different participants, each exhibiting either a 'noisy', 'flat' or 'binge' pattern.

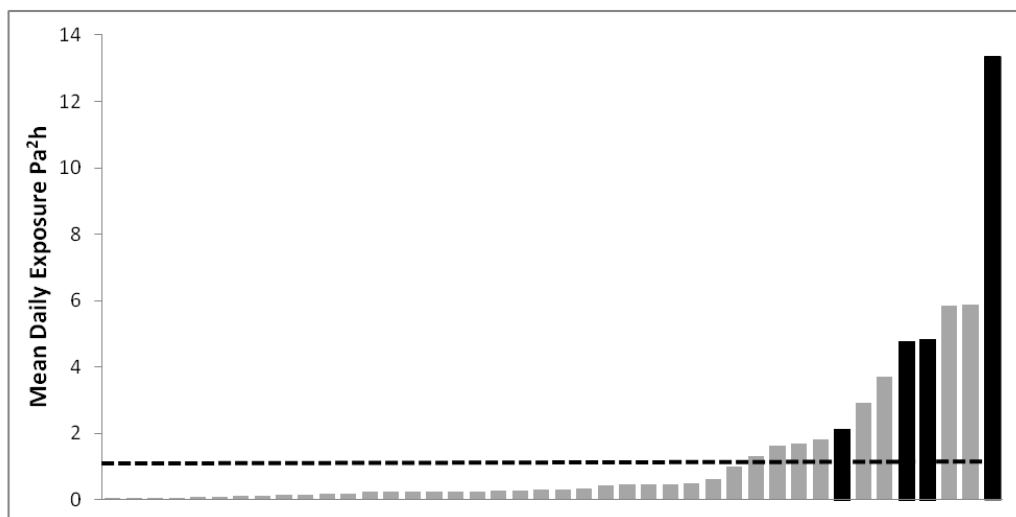


FIGURE 1

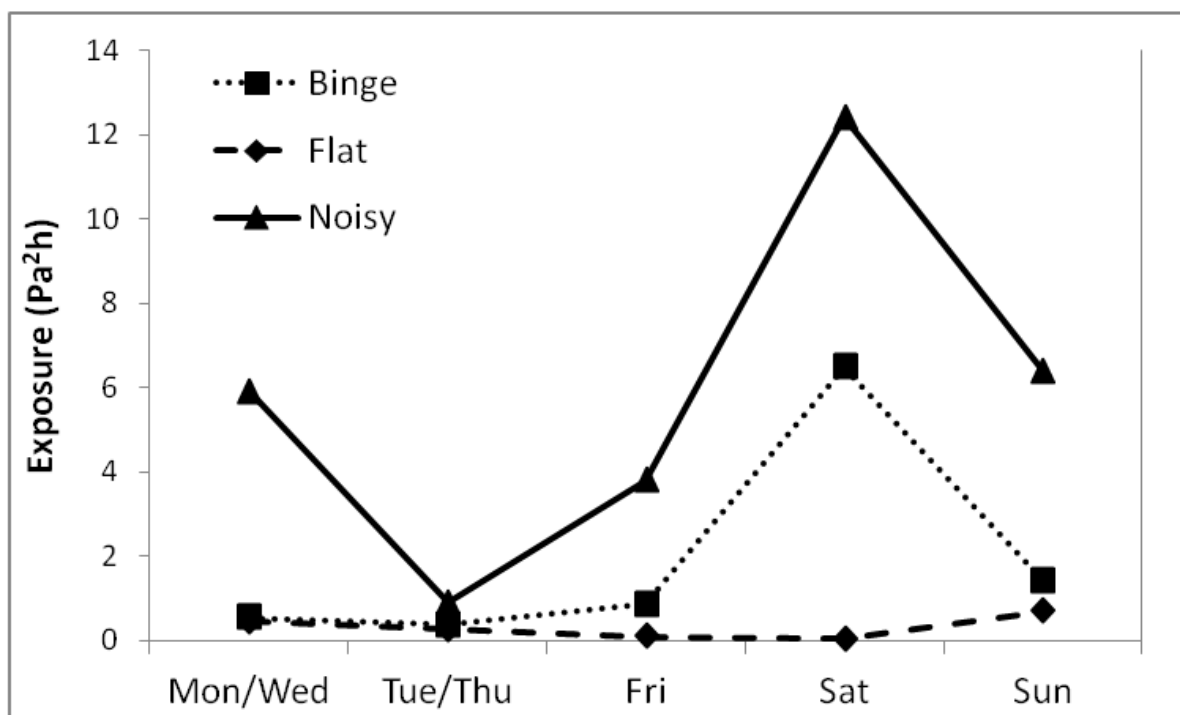


FIGURE 2