The daily grind of cafe cacophony: noisy cafes and social exclusion

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Abstract

Introduction: Environmental noise pollution is becoming increasingly prevalent and with rising acceptance and tolerance of high noise exposure throughout society, there is some belief that such exposures are becoming increasingly normalised. The health effects of noise remains relatively unpublicised despite the fact that high noise levels are known to cause both auditory and non-auditory health effects. Wellington has been named as one of the eight great coffee cities in the world, and café-going has become an important social activity for many Wellingtonians, making noise levels in cafes an important issue. As social exclusion is detrimental to health, this study aimed to explore whether noise levels in cafes determine the demographic of patrons who attend, and if any demographic group is being socially excluded. Furthermore, we wanted to explore patron and manager attitudes to noise and whether managers would consider changing the acoustic environment of their cafe to remedy high noise levels.

Methods: Data was collected from 29 cafes in the Wellington central business district (CBD) in April 2014. Baseline sound measurements were obtained through recordings using an iPhone application. Sound levels were recorded in decibels (dB). Data was also obtained through interviews with both café management and café patrons. Observational data was also collected on the acoustic environment of each café.

Results: The average decibel reading over 3 days was 66dB (with a range of 57.33-73.47dB) and 96 patrons were interviewed form the 29 cafes. Cafe patrons interviewed had an average age of 42.3 years, 50% were female, and 70.5% lived in Wellington. Only 2.1% of patrons identified as Maori/Polynesian. Of those interviewed, 62.8% identified noise as influencing their choice of cafe (once prompted) and 29.8% self-identified as being sensitive to noise or suffering from hearing loss. There was, however, no significant difference in the patron demographics when cafes were stratified into 3 groups based on decibel readings.

Conclusion: Our study did not support the hypothesis that noise levels would influence patronage. This study provided no evidence to suggest that systematic social exclusion is occurring in cafes due to noise levels. This study also found that noise levels of a café do not play a significant role in the selection of a café and even though owners/managers were willing to adjust music volume, they were less willing to invest money into noise-reducing technologies.

Keywords: social exclusion; noise induced hearing loss; noise pollution.

1 Introduction

ENVIRONMENTAL noise pollution or 'unwanted sound' [1, 2] has become a fact of our 21st century existence. Population growth, urban crowding, technological and industrial advances all contribute to these noise levels [3]. Sound is typically represented in decibels (dB) which is a logarithmic scale, thus a 3 dB increase represents a doubling in sound intensity perceived by the human ear [4, 5]. Human perception of noise as 'unwanted sound' is subjective, which helps explain why the same decibel levels can be irritating in one context and enjoyable in another. Differing individual contexts and perceptions in addition to individual sensitivity variation are thought to contribute to why cafe noise levels can be acceptable to some but not to others. Unlike other forms of environmental pollution, such as diesel particulates, noise pollution remains relatively under-publicised despite having wide-ranging health, social and economic impacts. While noise levels created in some environments are well regulated and enforced (e.g. in the occupational setting), they are less controlled in community environments such as cafes [6]. Environmental noise exposure is becoming pervasive in urban and community environments leading to both auditory and non-auditory health effects [6].

Noise-induced auditory damage usually arises in occupational environments where sound pressure levels are high and exposure to noise is prolonged. Alarmingly, around 10% of the world's population is exposed to prolonged high sound levels; the majority of these occurring in the occupational setting [1, 7]. The New Zealand Accident Compensation Corporation (ACC) describes hearing loss as "any change in hearing acuity in quiet or in

the presence of background noise, [it] can be quantified in an audiogram as an auditory threshold of greater than 15 dB at any frequency. In New Zealand, hearing loss is categorised as slight (15–25 dB Hearing Level), mild (26–40 dBHL), moderate (41–55 dBHL), moderately severe (56–70 dBHL) severe (71–90 dBHL), or profound (91 dBHL and above)" [8, 9, 10]. Hearing loss can be temporary (temporary threshold shift) or permanent (permanent threshold shift) depending on the length and frequency of exposure to greater than 85 dbA levels [11].

Noise-induced hearing loss (NIHL) is an example of auditory damage that can result from prolonged and repeated exposure to sound pressure levels higher than 75-85 dB(A) [1, 2]. The ACC's 2008 Study, 'The Epidemiology of Noise Induced Hearing Loss,' [8] estimated a 10-13% prevalence of NIHL in the general NZ population. The study also demonstrated the 20% increase in NIHL-related claims each year from 2823 in 1995/1996 to 5580 in 2005/2006. The age distribution of claims was shown to shift towards the older age groups and males made up the majority of claimants. More recent research on NIHL in New Zealand has not been published but an extrapolation from the increasing trends seen in 2006 to the present day suggests that NIHL represents a significant cost to the New Zealand health care system and is an important public health issue [8].

Non-auditory health outcomes result from much lower levels of noise exposure and, unlike auditory impacts, cannot be attributed directly to sound energy. These outcomes include annoyance, impaired performance, sleep disturbances, and impaired cardiovascular health, for instance raised blood pressure [3, 1]. These effects begin to occur at noise levels as low as 50 dB, which can be compared to the noise level of a normal conversation between two people [12]. An individual's response to noise depends on sound characteristics such as intensity, frequency, complexity of the sound, duration and meaning of the noise to that individual and so as mentioned previously, noises some people find enjoyable may causes annoyance to others [13].

Annoyance is the most common subjective response to noise and may be expressed as fear and mild anger. Excessive noise is a stimulus which is normally perceived as an avoidable harm and interferes with everyday activities such as conversation [13]. Traffic and aircraft noise studies demonstrate an increase in annoyance with increasing noise levels [14, 15]. While some studies suggest that annoyance may lead to stress responses that manifest as symptoms such as raised blood pressure and sleep disturbance [16, 17], there may be a direct correlation between noise and health that is not mediated by annoyance. The endocrine response to noise has also been studied, and it has been shown that exposure to high intensity noise may raise levels of noradrenaline, adrenaline and cortisol in industry workers [18, 19]. However, results are inconsistent between studies, highlighting the need for further research into how noise as a stressor elicits physiological responses.

There are several groups who are particularly sensitive to noise and are more likely to encounter noise-related health effects as a result. Auditory effects are most seen in pre-school and primary-school children, while adults over the age of 40 have almost universal NIHL to varying degrees. Others who are more greatly affected by noise exposure include those with hypertension, blindness, existing hearing impairment, and those carrying out complex cognitive tasks [20, 21]. The non-auditory health effects of noise are particularly pronounced in children because "they have less cognitive capacity to understand and anticipate stressors and lack well-developed coping strategies" [17, 22, 23]. While cognitive function is not impaired uniformly, a number of studies have shown that chronic exposure to noise in primary school children manifests as deficits in language comprehension, central processing, visual attention, concentration, memory and reading ability [17, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35].

Those who are more vulnerable to hearing sensitivity and loss are more likely to be excluded from social environments. The social impact of noise is particularly relevant in Wellington where cafe-going has become an important social activity for many Wellingtonians [36]. Named as one of eight great coffee cities by CNN [37], Wellington has a strong cafe culture that is an integral part of the city's identity and tourist appeal [36]. It is hard to define what the perceived cafe experience is but contributing factors include the quality of coffee and food, location, price and noise levels. Noise levels vary considerably between cafes and in order to participate in café-going, individuals may expose themselves to noise levels above their personal safety and enjoyment threshold. Individuals with hearing sensitivity or loss may avoid the café environment because of the discomfort or isolation

they experience. Where participation in café culture is an important part of social activity this would result in social exclusion which is detrimental to health [38].

A further consideration is the "Lombard" or "cafe" effect where patrons unknowingly speak louder to be heard and understood over increasing noise around them (usually due to other conversations). For those with normal hearing, the conversation level must be at least 15dB(a) louder than the level of background noise for speech to be intelligible. Normal conversation levels generally sit around 50 dB(a) and therefore background noise level needs to be less than 35 dB(a) for the conversation to be intelligible. Due to the 'cafe effect' and the relatively low speech intelligibility thresholds, conversation in the cafe setting is likely to be disrupted by background noise and this will be particularly problematic for those with hearing sensitivity or loss who will have speech intelligibility problems at even lower dB(a) thresholds [20, 39, 21].

The 'cafe effect' demonstrates one coping mechanism that we employ to reduce the impact of high noise levels. Because we are able to cope with relatively high noise exposure, there is some belief that high levels of noise are normal [17]. The absence of social markers for denormalisation, such as social disapproval of loud noise and widespread awareness of the risk of NIHL, demonstrates this. For many individuals, the social norm dictates what behaviours they choose to engage in. Denormalisation aims to influence health-related behaviours by making those that are harmful socially unacceptable. This strategy has been used in the context of anti-smoking initiatives with great success [40, 41, 42]. It may be possible that the Wellington café experience contributes to normalisation of high levels of noise in public places, and thus people with noise sensitivity or hearing loss may be more likely to be socially excluded due to a reduced ability to normalise and compete with high levels of noise.

Social exclusion as defined by the UK Department of International Development (DFID) is "a process by which certain groups are systematically disadvantaged because they are discriminated on the basis of their ethnicity, race, religion, sexual orientation, caste, descent, gender, age, disability, HIV status, migrant status or where they live…" [43]. Exclusion takes place across four dimensions - social (I), political (II), cultural (III) and economic (IV). The social dimension encompasses any relationship which gives us a sense of belonging within a social system [38]. The inability to form and strengthen these relationships may result in a loss of social opportunities and subsequently, poor mental health outcomes. The "Te Whare Tapa Wha" model of health illustrates the interconnected nature of wairua (spiritual), whanau (family), tinana (physical) and hinengaro (mental) health - social exclusion is therefore likely to have wider health implications. As an example, social isolation has been linked to mental health issues such as depression and youth suicide. Social isolation and communication issues have been specifically implicated in Maori male suicide, as per the Lawson Te Aho paper, as part of a complex mix of contributing factors [44, 45, 46, 47].

Most research that has been carried out on the effects of noise levels has been focused on workplace and industrial exposure. The generalisability of this data to a cafe environment may be low based on the significant differences between these environments. A literature search revealed a study by Christie, Bell-Booth et. al. [48] which focused on the experience of patrons of Wellington cafes, bars and restaurants. The study focussed on objective noise measurements, the patrons' perceptions of the noise and how it contributed to their overall satisfaction with the experience. It was a small study, with less of a health focus than ours, but it was based in the same area with a similar population and related aims. Another study by Zemke et al. [49] looked at patrons expectations and preferences in regards to background noise, and whether demographic variables affected these preferences. The Zemke et. al. study perhaps had aims comparable to those in our study, but measured only one location, a Mexican themed restaurant, in the South West USA. Zemke et. al. found that customers identified the main background noise was sourced from other patrons and music, and that this overall effect resulted in an acceptable level of background noise for the patrons. A related study two years later [50], this time focussing on the link between customer perception of noise, and its influence on loyalty. This second study again only one restaurant, also in the South West USA. The results were stratified into factors of noise awareness, and hearing ability to consider the overall atmosphere in the restaurant. Raab et. al. [50] found that variations in the ability to hear, and background noise levels, were not associated with overall satisfaction with the restaurant experience. One issue with all three of these studies is that their samples may not be representative of the 'general

population', due to their small sample sizes and limited time frames. Our study hopes to examines demographics and the possibility that sections of society are being excluded. These previous studies were also performed with acoustics as a key consideration for further action, whereas our main focus was the effects of noise on health and wellbeing.

1.1 Study aims

Our study aimed to address four main aims:

1. Whether noise levels in cafes determine the demographic of patrons who attend.
2. Whether any social groups are being systematically socially excluded from the cafe experience (a 'social institution').
3. Cafe patron and owners/manager attitudes to cafe noise.
4. Whether cafe owners/managers were aware of ways to decrease cafe noise levels (other than turning the music down) and whether they would consider taking steps to temper noise levels in their cafe.

1.2 Hypothesis

We hypothesised that quieter cafes would have higher proportions of people identifying as noise sensitive/suffering from hearing loss and that CBD cafe conditions could result in these groups being socially excluded. Furthermore, we did not think noise would be a main factor for patrons when considering which cafe to visit. In addition, we predicted that cafe owners would not be willing to make acoustic changes to their premises without incentive or public pressure.

2 Methods

2.1 Literature review

We performed a literature search using Google Scholar and Medline OvidSP. The project supervisors provided additional literature and published material. Search terms included:

- 'Noise' AND 'Social Exclusion'
- 'Noise' AND 'café' OR 'restaurant'
- 'iPhone' AND 'App' AND 'Decibel'
- 'Environmental Noise' AND 'Health'
- 'Social Exclusion' AND 'Health'

2.2 Cafe identification and inclusion criteria

Fig. 1: Map of selected area within the Wellington Central Business District (CBD).

Cafes were defined as having a visible espresso machine, predominantly counter/cabinet food and the expectation that patrons would seat themselves. They were visually identified by canvassing the pre-defined area of Wellington central business district (CBD) (see Fig. 1). The area in the Wellington CBD from Kent Terrace in the south-east to Victoria Street in the north-west, and from Vivian Street and Abel Smith Street in the south-west across to Wakefield Street in the north-east was selected. This area is a mixed entertainment and business district with a wide range of cafes. To be included, the

café had to be visible from the street or through street-front advertising. Cafes that did not meet these criteria were not included in our study.

Cafes were divided into six groups, depending on geographic location in the canvassed area, to allow for simultaneous data collection by six groups of three data collectors. Cafes were randomly allocated to the groups on both days. Data was collected during a pre-specified 'lunch period' of 11am-2pm coinciding with the highest patronage, therefore likely the loudest noise.

2.3 Data collection

An initial screening set of two ten minute sound measurement samples were made at all the cafes by visiting each café twice during the lunch period and measuring the sound levels for ten minutes. To assess the differences in noise levels during a weekday compared to levels in the weekend, measurements were performed on a Friday and a Saturday [11/04/14 and 12/04/14]. For practical reasons, sound was measured in two 10–minute periods rather than the 15–minute period standardly used for environmental data collection (see NZS 6801:2008 [51]). In the case of a café having more than one room, sound recordings were obtained from the main room which was defined as having the main counter.

While taking sound measurements, iPhones were positioned with the microphone pointed at a 45° upwards angle, pointing away from the recorder. The phone was either handheld or resting on the café table on a soft object. To minimise interference with recording, the phones were kept stationary and recorders were silent. One-second time-history of short LAeq (the equivalent sound level, A-frequency weighted) values, average, maximum, minimum (A-frequency weighted, F-time weighted) levels along with their standard deviation and the overall LAeq for the 10-minute measurement period, were recorded using the application. The LAeq value is the equivalent energy value across the entire period of the data sampling, in this instance ten minutes.

In addition to these measurements, information relevant to the acoustic environment of the café was also recorded using an 'Initial Data' template (see Appendix A). Data was also collected through a number of questionnaires.

Acoustic observations questionnaire

Data was collected on a third occasion to obtain a third sound recording and detailed observations regarding the acoustic environment of the café which were recorded using the 'Acoustic Observations Template' (see Appendix **??**).

Manager/owner questionnaire

Café owners/managers were contacted via phone and/or email to obtain consent to conduct a face-to-face interview regarding the demographics of patrons and acoustic environment of their café. A letter outlining the aim and relevant details of the research was provided (see Appendix C). The owners/managers were given the 'Manager/Owner Questionnaire' (see Appendix D). Their verbal consent was obtained for interviewing of café patrons the following day.

Patron questionnaire

Data collectors conducted short (2-4 mins) surveys on patrons at selected cafes to gain demographic information and attitudes towards noise in cafes (see Appendix E). During this time, each patron was assigned a number by counting clockwise from the café door and a random number generator was used to randomly select a minimum of three patrons. Each patron was surveyed using the 'Patron Questionnaire' (see Appendix E) in an interview setting. If a patron refused to be interviewed, another was selected according to the above randomisation process.

Recording equipment

Associate Professor Wyatt Page[1] reviewed all 150 sound measurement applications (apps) at the time in the Apple AppStore for iOS devices. He reduced them to a subset of eight Apps that appeared to have the required functionality. These were installed on a 3rd generation Apple iPod Touch to enable them to be further evaluated. Key functionality required was the ability to log the sound measurements producing a time-history of short (1 second) LAeq values and the overall LAeq for the measurement

[1] Associate Professor of Acoustics and Human Health, Massey University, Wellington

period. It should be note that all eight of the Apps evaluated had the basic functionality but almost all of them measured an average sound level rather than the equivalent level. In the end, only NoiseHunter[2], had the necessary functionality and it was installed on six iPhones (model 4S and later). The iPhones were calibrated with a pure tone at a frequency of 1 Kilohertz (kHz) and a level of 75 dB. The level was measured with a Solo Class 1 sound level meter with a current calibration certificate.

Ethics approval

Category B ethical approval for this study was obtained from Richard Edwards, Public Health Department, University of Otago, Wellington on 1st May, 2014. The proposal (see Appendix F) outlined our aims, methods and discusses potential problems with data collection.

2.4 Statistical analysis

Continuous data are shown as the mean (standard deviation, SD) if normally distributed and median (interquartile, IQR) if distribution was not normal. Continuous variables were compared between groups using ANOVAs. Differences in categorical variables between groups were examined using the Pearson's chi-squared test.

cafes were divided into three groups according to dB measurements: group 1 (quiet), group 2 (medium) and group 3 (loud). We performed a two-tailed ANOVA test comparing the average dB readings from each of the three days of data recording. This showed that there is no evidence of any differences between the recording days (p = 0.74). Once it was established that all the data was from one population, the cafe's were stratified based off of the average dB levels into loud, medium and quiet. Only cafes with sound measurements for all three study days were included in the stratification process were those for which sound measurements were available on all three days. A linear regression was made between the noise levels in the cafes and the number of patrons. Strata were compared to look for any differences in the demographics of the patrons taking into account age, ethnicity and socioeconomic status (SES).

[2] Version 1.0.1, inter.net2day Gmbh, Germany

Data were analysed using SPSS Statistics[3] and Microsoft Excel[4]. P values <0.05 were considered significant and CI intervals = 95%.

3 Results

Fifty five cafes were initially identified in an area of Wellington CBD (see Figure 2). The cafes identified were consistent with the definition of 'cafe' that is described in the methods. Initial sound measurements and general observations were recorded at each cafe twice over two days. On the first day of initial data collection, 5 establishments were found to be inconsistent with our definition of a 'cafe' on closer inspection and these were excluded from the study. On the second day of initial data collection, a further 6 cafes were excluded because they were closed and we were unable to take sound measurements.

Owners/Managers of the remaining 44 cafes were contacted by phone/email to gain permission to conduct an interview with them about noise levels in their cafes. Thirty four owners/managers accepted, 10 owners/managers refused explicitly to participate in the study and the remaining owners/managers were unable to be contacted. Cafes that could not be contacted were visited at the same time as pre-arranged manager interviews were taking place. Thirty four cafes were visited for manager interviews and a further 5 managers refused to participate in the study so these cafes were excluded from the study.

On our final day of data collection, we completed noise measurements, full acoustic observation questionnaires and interviews with up to 5 randomised patrons from each of the 29 participating cafes (figure 3). In cafes where the total patronage was 5 or fewer everyone available was interviewed.

When we compared the mean decibel readings for the first two days for the cafes that dropped out against the ones we finally used there were no significant differences (p=0.468).

The mean of the average decibel reading over 3 days for the cafes was 66 dB and the cafes ranged from 57.33 to 73.47 dB. Because of the logarithmic nature of decibels this represents a 40x increase in sound energy from the lowest to the highest. A two-tailed ANOVA test to

[3] v20; IBM, USA

[4] v14.3.2; Microsoft Corporation

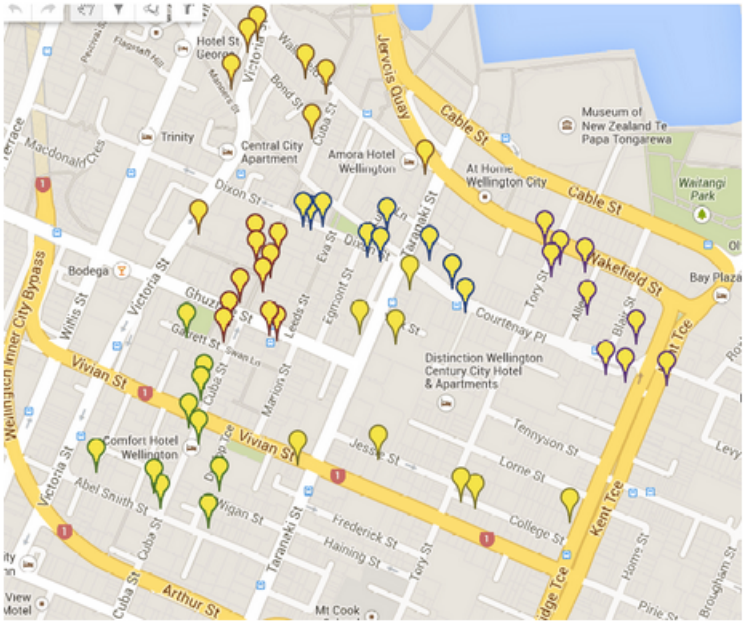

Fig. 2: Map of Wellington CBD with identified cafes marked and colour-coded by location.

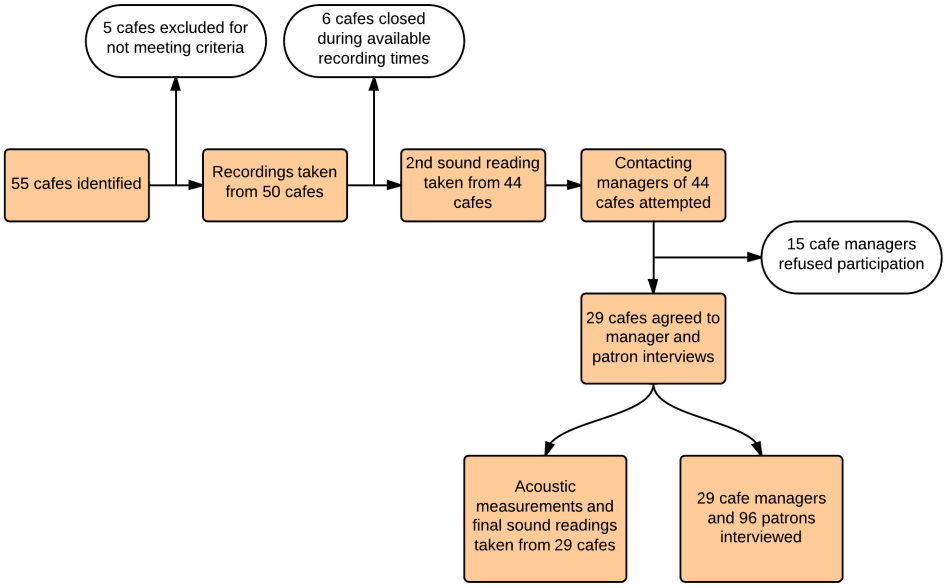

Fig. 3: Flowchart summarising the number of participating cafes/managers/patrons at each stage of the study.

compare average decibel readings from each sound measurement showed no evidence that measurements taken on different days represented different populations (p=0.713)

59.41% of the variation in average noise levels within the cafes was due to the number of patrons present (r=0.5941). However this still means that 40% of the variation is potentially modifiable through other means. The average mean room sound absorption coefficient (MRSAC) or how much noise is absorbed by building material in the surveyed cafes was 0.0931. This is due to the high prevalence of surfaces such as wood (used in 65.5% of cafes, with a noise reduction coefficient, NRC of 0-0.05), concrete (present in 55.1%, NRC=0-0.2) and gib (present in 58.6%, NRC=0.05) [52].

For the purposes of statistical analysis, participating cafes were stratified into tertiles in accordance with average dB level over the three recording periods (quiet, medium and loud).

	Group 1 'quiet' $n = 9$	Group 2 'medium' $n = 10$	Group 3 'loud' $n = 10$
Sound Measurements:			
dB(A) Ave* (σ)	59.58 (3.60)	65.985 (3.57)	70.65 (3.04)
dB(A) max*	77.14	81.11111	83.39
Acoustic Characteristics:			
Average number of chairs	36	46.5	48
Average number of tables	11.7	12.1	16.6
Total patrons (n)	117	105	270
Average number of patrons*	6.3	10.5	27
Children's area present (%)	0	10	20
Suspended ceiling present (%)	20	30	20
Doors permanently open (n)	0.8	0.7	0.7
Windows open (n)	0	0.3	0.2
Kitchen area visible (%)	0.4	0.5	0.8
Ceiling height (m)	4.7	3.6	4.45
Area (m^2)	156.1	91	163.4
Music present (%)	100	100	80
Patron Age:			
Aged 0-12 n (%)	0.2 (2.78)	0.4 (3.81)	1.7 (6.30)
Aged 13-18 n (%)	0.6 (8.33)	0.4 (3.81)	1.4 (5.19)
Aged 19-30 n (%)	2.3 (31.94)	4 (38.10)	6.9 (25.56)
Aged 31-50 n (%)	2.4 (33.33)	3.7 (35.24)	8.3 (30.74)
Aged 51+* n (%)	1.7 (23.61)	1.9 (18.10)	8.3 (30.74)

Tab. 1: Sound measurements, acoustic characteristics and patron age stratified according to cafe noise levels. dB (A) = A-weighted decibels, * indicates statistical significance at the α=0.05 level.

3.1 Acoustic observation results

When cafes were stratified into tertiles based on the average decibel levels from the 3 days of noise measurements, there were no significant difference for the patrons at cafes from the different strata in respect to gender ($p = 0.463$) ,age ($p = 0.388$) and SES ($p = 0.253$). Furthermore, there was no statistically significant difference in whether patrons said noise influenced their decision ($p = 0.159$) or whether they self-identified as being sensitive to noise or having hearing loss in each noise strata ($p = 0.269$)

When the cafes were stratified into tertiles based purely on decibel readings on the day of which the patrons were interviewed, there was a correlation between the stratified groups and the patrons ranking of the café on a 1-5 spectrum of too quiet to too loud ($p = 0.041$), indicating that patrons were correctly able to gauge the relative loudness of different cafes.

There was no significant relationship between the levels of noise in the cafes and the floor area, volume of the room or ceiling height. This was consistent both when looking at averages within tertiles or when considering each cafe individually.

3.2 Patron questionnaire results

We interviewed 96 patrons in total from the 29 cafes. The patrons had an average age of 42.3 years and were 50% male and 50% female. Only 2.1% of the entire patron population identified as Maori/Polynesian, while 87.5% identified as European (including NZ European, Pakeha, Kiwi and Caucasian). In this way the sample we interviewed in cafes differed significantly from the general Wellington population which is 12.8% Maori (2006 Census data) and differed significantly in age, where the median age for the Wellington Area is 35.3 (see Figure 4) (2006 Census data).

69.8% of patrons identified as living in the Wellington area, with all but 5 specifying particular suburbs. Through analysis of these areas via a deprivation index formed from [53] we were able to divide the associated indices into 10 groupings to serve as deprivation levels. Decile 1 was set as the least deprived, and decile 10 as the most. Of the Wellington patrons, 54.8% were then found to belong to the top 5 deprivation levels, with 45.2% being spread amongst the lowest 5 Deprivation levels. However, while

this does not appear to show too much difference, it is interesting to note that the highest frequency of patrons were from decile 1 areas, and no patrons at all were found from any decile 10 areas.

The results of our interviews showed that the single greatest influencing factor on going to cafes was the food, with 29% of our sample saying this. This was closely followed by location at 27%, and coffee at 16%. 62.8% said that noise influences their choice of cafe when prompted, though only 1.04% mentioned any form of noise without the prompt.

About two thirds (69.8%) had already been to the café they were interviewed in before. 31.9% had asked a café to turn the music down in the past.

Nearly a third (29.8%) said that they are sensitive to noise or suffer from hearing loss (95%CI 20.65%-38.95%). This is compared to an age standardised background rate of 19.41% [54] or an overall New Zealand rate of 11.6% [8].

The association between strata and whether people thought noise influenced their café choice was not significant, 45.5% of those in low noise cafes, 67.9% in medium and 68.2% in high, said noise influenced them (p=0.159), but there was a trend for those people to be in louder cafes and this may have been more significant with further research and a greater sample size.

When patrons who had asked for the noise to be turned down were compared with those who had not, there were no significant differences in gender but there was a significant difference in age, average age of 38 for those who had not and 48 for those who had (p=0.015) and SES in those from Wellington suburbs, average NZDep of 5.7 for those who had not and 3.4 for those who had (p=0.004).

3.3 Manager interviews

Managers were asked to comment on the demographic of their patrons, and evaluate the relative noise level of their cafe and suggest the main contributors to noise levels.

Managers were asked whether they would turn the music down if asked by a patron, with almost a 100% positive response. However, when asked whether they would consider making changes to the acoustic environment in order to reduce sound levels more permanently 70% said no and only 30% said yes.

When asked about their own knowledge of ways to control cafe noise levels, 47.8% of managers knew nothing, 26.1% knew of acoustic ways to alter the noise, and the final 26.1% knew of only "simple" ways to alter the noise (e.g. closing windows and doors). Cafe owners/managers in the 'loud cafes' were more willing to consider changing the acoustic environment (33%) compared to those in medium (20%). However they were no more willing than quiet cafes (33%). Finally, when asked whether they were concerned that high sound levels could affect people coming to the cafe, 56.5% of managers said no (figure 10).

Manager interviews showed that the majority of cafes were at their 'busiest' and 'noisiest' between the hours of 11am-1pm. This reinforced that we were in fact interviewing and taking noise recordings within the timeframes identified as being most commonly maximal.

4 Discussion

4.1 Results and interpretation

The results of this study showed no statistically significant variance in patron demographics (age, sex, ethnicity, SES) between the three strata of cafes (low, medium and high noise levels). Therefore, we are unable to comment on any potential correlation between noise levels and cafe demographics. We expected that there may be high percentages of older people in quieter cafes, based on this demographic having higher rates of hearing loss. This, however, was not demonstrated in our results. Our results also did not show a significant difference in cafe noise level preference between those with hearing sensitivity or loss and those without hearing impairment, which disproves one of our hypotheses.

When patrons were asked, noise was ranked as less important than food, location, "other", coffee, and atmosphere as a factor influencing cafe choice. However, when the patrons were prompted with a question that asked whether they thought noise was an important factor, 62.8% said yes. This would tend to indicate that we are not always aware of noise even though it may be a subconscious annoyance which suggests a trend of normalisation of increasing noise levels.

Even though the difference between strata for those that said noise influenced their decision on café choice, when

	Quiet *n = 9*	Medium *n = 10*	Loud *n = 10*	NZ Census Data 2006/**ACC 2006
Demographics:				
Male sex – n (%)	14 (60)	11 (44)	20 (44)	218000 (48.5%)
Age (median)	38	45	42.5	35.3
Ethnicity – n (%):				
European	19 (86)	26 (93)	39 (88)	80.75%
Asian	2 (9.1)	1 (3.6)	3 (6.8)	8.3%
Maori	0	1 (3.6)	0	12.8%*
PI	0	0	1 (2.3)	7.95%*
Middle Eastern/Latin American/African	1 (4.5)	0	1 (2.3)	1.25%*
From Wellington – n (%)	16 (70)	21 (75)	30 (68)	
Primary reason for café choice – n (%):				
Food	5 (22)	8 (29)	14 (31)	
Coffee	2 (8.7)	5 (18)	9 (20)	
Location	7 (30)	6 (21)	11 (24)	
Price	0	2 (7.1)	0	
Atmosphere	3 (13)	1 (3.6)	3 (6.7)	
Other	5 (22)	4 (14)	8 (18)	
No Reason	1 (4.3)	2 (7.1)	0	
Noise-related:				
Existing hearing sensitivity/loss – n (%)	4 (18)	11 (39)	13 (30)	**10-13%
Noise rating of café – n (%):				
Quiet	4 (19)	5 (16)	4 (9.1)	
Comfortable	14 (66)	16 (52)	20 (46)	
Loud	3 (14)	8 (26)	17 (39)	
Too loud	0	2 (6.5)	3 (6.8)	
Perception of contribution to noise – n (%):				
Kitchen noise	1 (4.3)	3 (11)	3 (6.7)	
Children	1 (4.3)	1 (3.6)	1 (2.2)	
Coffee machine	6 (26)	2 (7.1)	2 (4.4)	
Other people talking	3 (13)	8 (29)	13 (29)	
Acoustics	2 (8.7)	1 (3.6)	6 (13)	
Music	7 (30)	10 (36)	18 (40)	
None	1(4.3)	0	1 (2.2)	
Other	2 (8.7)	3 (11)	1 (2.2)	
Have you asked for music to be turned down before – n (%)	6 (26)	9 (32)	15 (35)	

PI = Pacific Islander
**p < 0.05*
***ACC 2006 data (REF)*

Tab. 2: Demographic information and patron perceptions of cafe noise from the patron questionnaire.

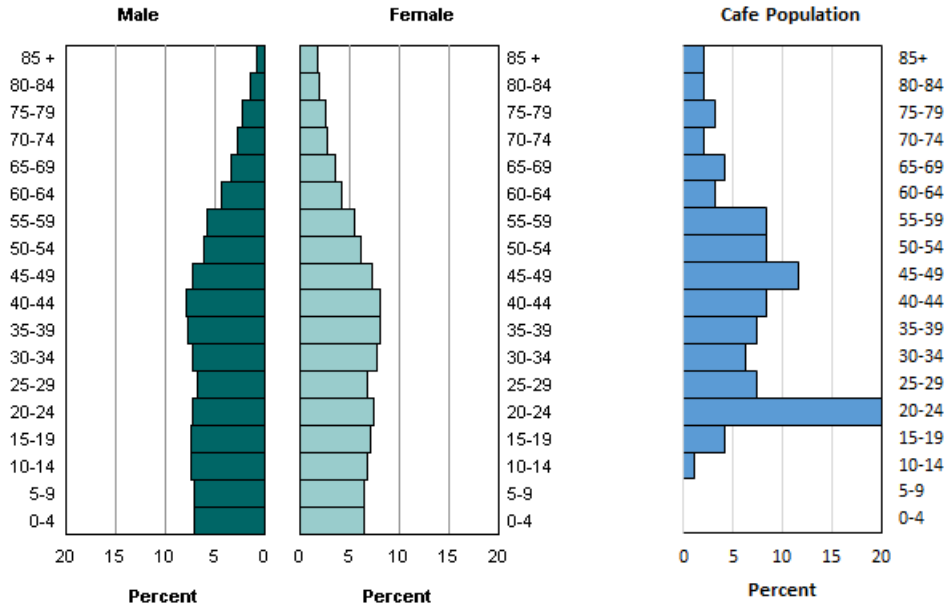

Fig. 4: Wellington age demographics (left) compared to cafe patron demographics (right).

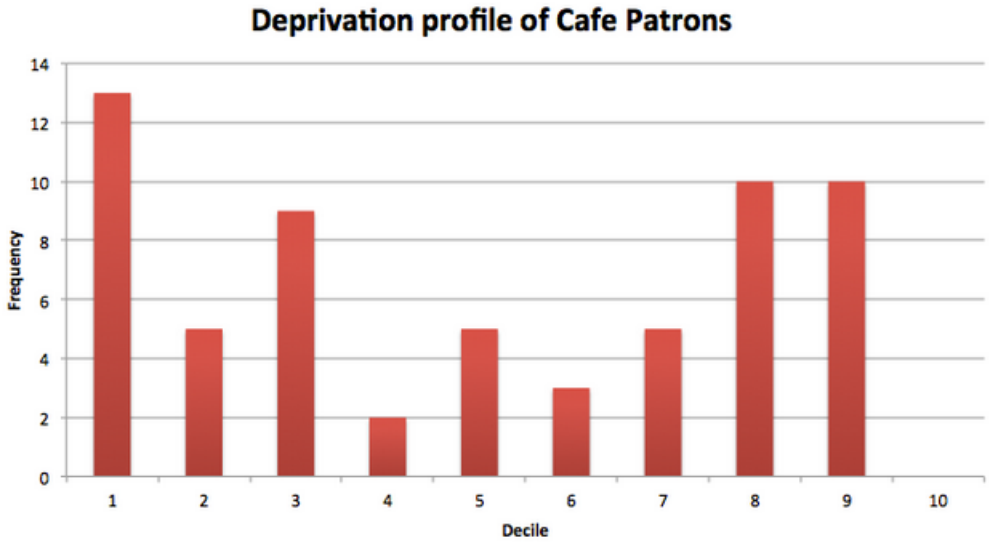

Fig. 5: Graph showing deprivation profile of cafe patrons as determined by Wellington suburb of residence.

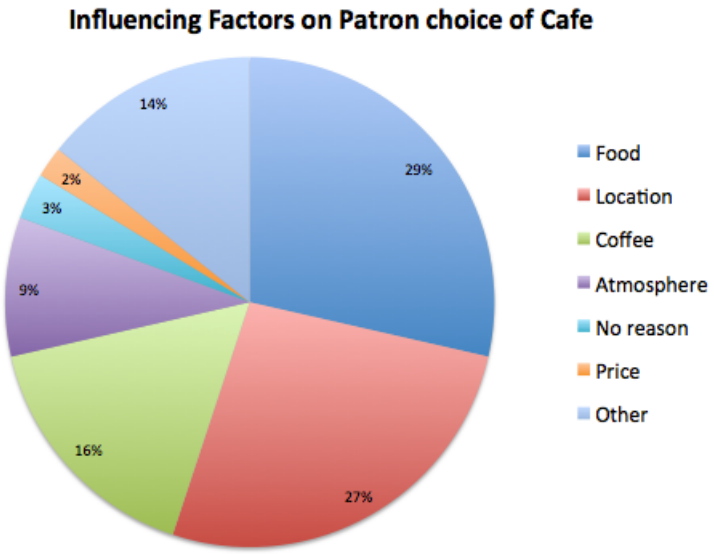

Fig. 6: Pie graph showing the factors influencing patron's choice of cafe.

prompted, was not significant, there was some variation amongst strata. (45.5% of those in low noise cafes, 67.9% in medium and 68.2% in high, said noise influenced them - results could be due to chance as they are not statistically significant). This difference was in contrast to our hypothesis that people who ranked noise as an influencing factor would be found in the quieter cafes. Conversely we found that as cafes got louder more patrons said the noise influenced their decision in choosing a café. One thing our survey failed to capture was if noise influenced their decision in a positive or negative way. The failure to capture this may have resulted in a loss of a potential finding as those in the noisier cafes may like noise and those in the quieter cafes may not like noise. Further research is needed in this area for this to be quantified.

We found no evidence to support the hypothesis that social exclusion may result from cafe noise levels on the basis that there was no statistically significant difference in age, gender, ethnicity and SES between the three tertiles. However, this assumption is based on our findings from cafe patrons and we cannot comment why those not at the cafe chose not to attend.

Patron perceptions of current noise levels showed no significant difference across the cafe tertiles. For example, the percentage of patrons in the low, medium and high level cafes who perceived noise levels as being too loud (0%, 6.5% and 6.8% respectively) did not differ between each strata at a level that was statistically significant. This further supports the idea that increasing noise levels are becoming normalised. Patrons who felt comfortable requesting the cafe staff to turn down music volume had an average age of 48 years, compared to those who had not (38 years, $p = 0.015$). These patrons were also, on average, from a higher SES (NZdep decile 3.4) compared to an average of 5.7 ($p = 0.004$) for those who had never asked for music to be turned down.

All owners/managers would turn the music down if asked by a patron but only 30% would consider making permanent acoustic changes. This finding is not surprising considering the results from our patron questionnaires show that noise is not an important factor when selecting cafes. Just over half of owners/managers (56.5%) said they were not concerned that high noise levels could affect people in the cafe and subsequently, would not be willing to invest money into making their cafe more acoustically comfortable. Only 26.1% of owners/managers knew of

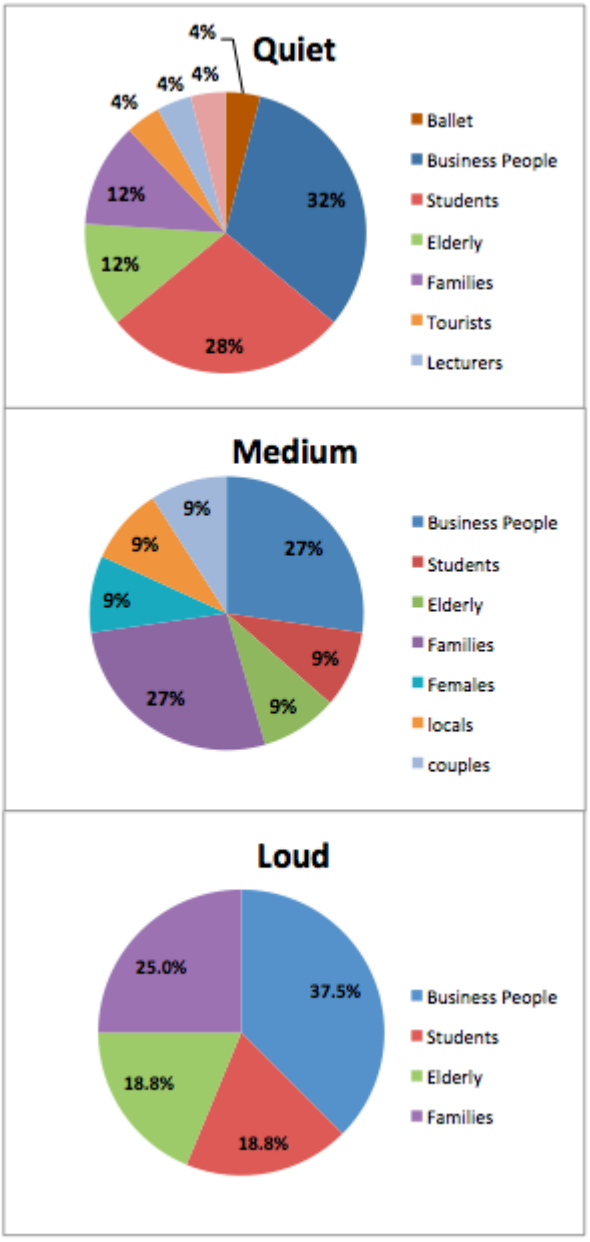

Fig. 7: Pie charts comparing the main types of patrons in quiet, medium, and loud cafes.

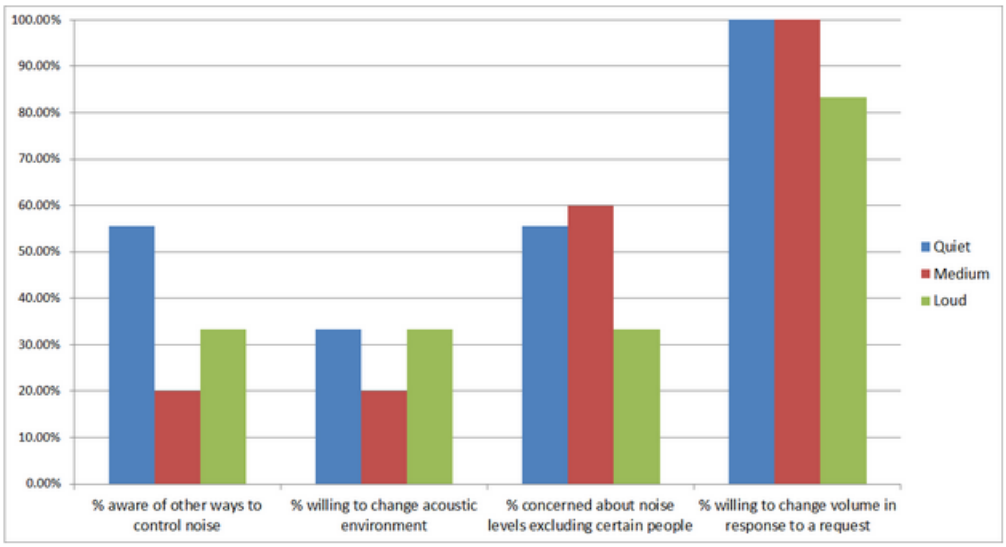

Fig. 8: Cafe owner/manager responses to acoustic noise control.

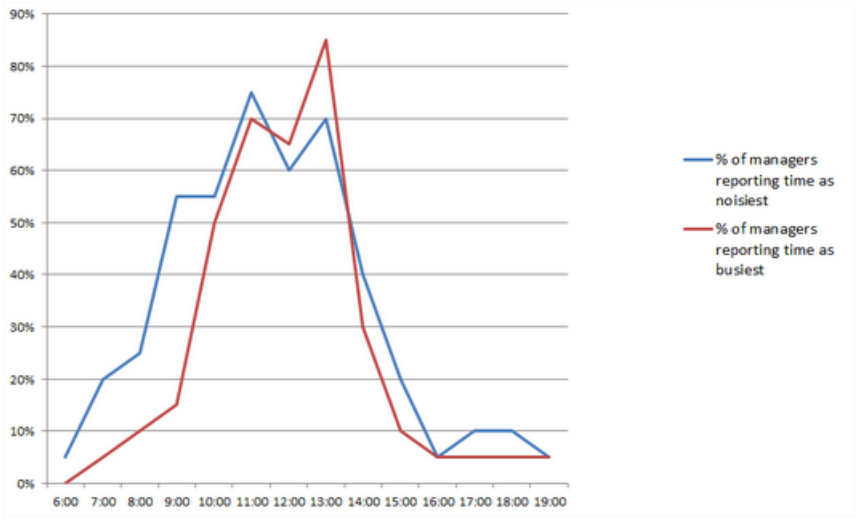

Fig. 9: Comparison between busiest times of day and noisiest time of day by manager opinion.

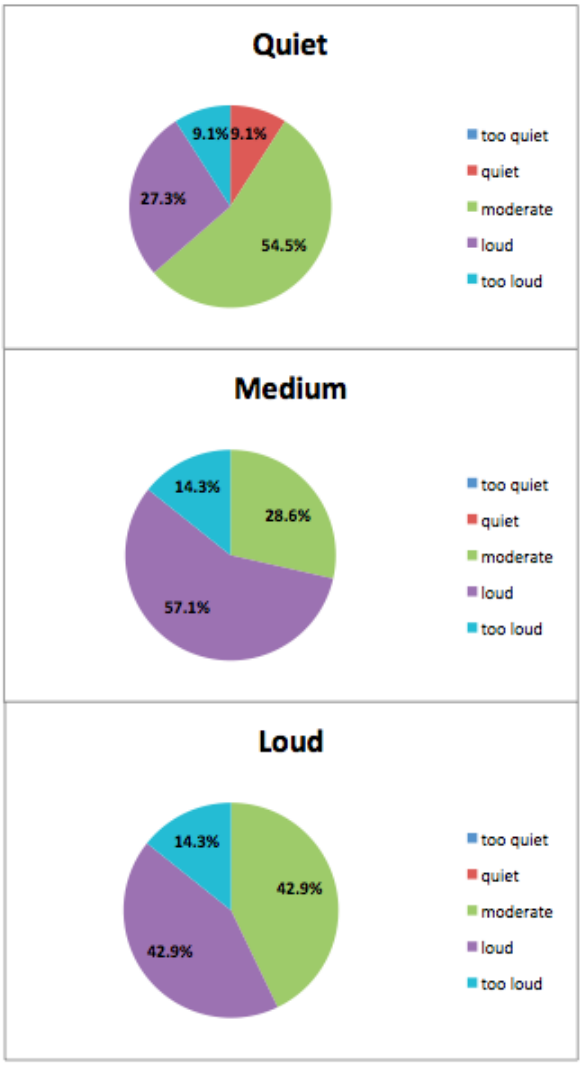

Fig. 10: Pie charts showing managers' perception of relative cafe noise level.

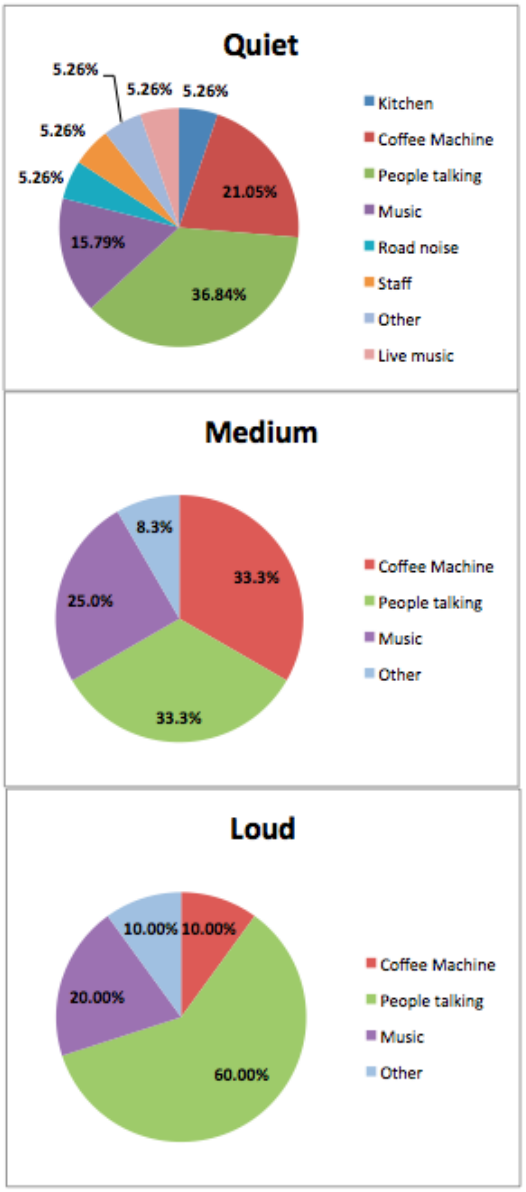

Fig. 11: Pie charts comparing the main contributers to cafe noise, as perceived by managers.

some permanent ways in which cafe noise could be reduced (e.g. baffling, suspended ceilings) while 47.8% of managers were not aware of these options.

When assessing the response of owners and managers to the perceived noise levels in their cafes, it became evident that such an evaluation is vulnerable to subjectivity. The owners of the louder cafes reported quieter noise levels when compared to cafe owners from the moderate tertile.

Our results showed that noise levels in even the quietest tertile of cafes had an average reading of 60.8 dB, which would result in suboptimal speech intelligibility. Normal conversational averages around 50-60 dB and needs background noise to be at least 10 dB quieter (i.e. 40-50 dB) for optimal speech intelligibility [55]. As background noise gets louder, as a reflex we speak progressively louder to be heard [48]. This is called the Lombard effect and may be contributing to higher conversational noise levels in our cafe sample (6). Our loudest tertile (average reading 70.6 dB) could result in even poorer acoustic conditions. The majority of the cafes included in our study represent acoustic environments which aren't conducive to unhindered conversation and therefore have the potential to impair the social experience. Thus, prolonged exposure to this level of noise while trying to converse in a cafe could potentially result in harm.

4.2 Cultural applicability

Our study found 2.1% of café patrons identified as Maori compared to 12.8% in the general Wellington population. This suggests that Maori are significantly underrepresented in café culture in Wellington CBD [53]. Our data does not explain why Maori do not attend cafes but we can speculate as to why this might be, in regards to the idea of social exclusion. Firstly, it could suggest social exclusion from café culture, and the social opportunities afforded by it, by race and/or culture. Secondly, Maori may get the same level of social opportunities from places other than cafes such as the marae. And thirdly, this result could suggest concomitant social exclusion by socioeconomic status as Maori are overrepresented in low socioeconomic segments in society. Social exclusion is a particularly significant issue among Maori as it has been found to be a major determinant of youth suicide [44]. For these reasons, it is vital to investigate the causes of under-representation of Maori in café culture through future studies. A qualitative study involving interviewing participants who identify as Maori about their thoughts and reasons about going to cafes could be one option. While it may be possible that Maori get the same level of social opportunities from places other than cafes, e.g. marae, that is not directly supported by the results of our study.

4.3 Study design - strengths & limitations

Being a cross sectional study, it was very difficult to make a causal inference between noise levels and social exclusion and our results only provided us with a snapshot in time of Wellington CBD cafe patronage. The study was designed in such a way as to minimise bias and potential error, however there were still areas where these crept in that could be altered in future studies of a similar nature. Randomisation of patrons was used to eliminate any selection bias of patrons and to accommodate for confounding. The low (32%) dropout rate of the cafes gave more power and meaning to our results due to reduced confounding and bias. All cafes had noise levels recorded but some dropped out of the study when patient and manager surveys were requested and permission was not given, however statistical analysis showed that the noise recordings taken in these cafes were not statistically different those of the cafes that remained in the study so it is unlikely this had a great effect on our results. Noise level recordings were taken on two separate days in order to improve the reliability of the results obtained. Although we could not use the noise dose buttons we had initially hoped to use, we used calibrated iPhones to measure the noise levels which made our results more accurate and precise. When interviewing patrons, the interviewer's were instructed to not use leading questions so as to not bias the patrons and influence their answers. Recorder bias was also limited by randomising data collection groups to cafes to ensure no cafe was visited by the same group twice. There were however sources of bias and error that need to be addressed. It was very difficult to perceive the effect of noise on social exclusion because as demonstrated by the results there were a multitude of reasons why certain patrons chose certain venues to eat at.

Patrons were affected by cost, food and coffee quality and location more so than they were by noise levels whciih didn't even rank in the top five influencing factors . The effect of the randomisation was also affected by the small sample size available to survey in some venues. Some had so few patrons, that all patrons were interviewed in order to get a large enough sample size, effectively negating the effect of the randomisation. There were two main sources of bias during the study. The first relates to the administering of surveys to patrons who were not seated alone. In these instances, the interviewee was likely to be influenced by the other person(s) present and in some cases the additional people interjected with their own thoughts and feelings during the interview. The other main source was the subjective nature of the examination of the acoustic environment. The examination was only a brief glance with approximate measurements and percentages given by the researcher, which were very open to interpretation, and a variation between researchers undoubtedly existed.

Another source of potential error that was encountered was the refusal to participate of patrons who were in business meetings in the cafes, which will have introduced selection bias. These patrons are a large part of the cafe population and it is more likely that they would be having their meetings in more quiet settings. Exclusion of this population will have likely led us to underestimate the effect of noise levels on cafe patronage.

As mentioned in the results section of the paper, the demographics of our sample population do differ quite substantially from that of the population of the Wellington area (8). So it would be difficult to say if our results could be extrapolated to be representative of the population of the Wellington area. Therefore it is unlikely our results are generalizable to the greater population of Wellington. It is also difficult to generalise our results as they were only taken as a snapshot in time of the Cafes in the Wellington CBD and only interviewed patrons who were at the cafes at that particular time which introduces errors when trying to generalise to the wider community.

4.4 Implications for research and recommendations

Future research

Our study looked at those patrons attending the cafe and subjective perceptions on noise. In order to appropriately deal with the issue of social exclusion, a further qualitative study of those with noise impairment or sensitivity might be appropriate inquiring to their cafe attendance or other social outlets. We thought it would also be interesting to see an intervention study conducted, in which a select cafe or group of cafes underwent surveying of patrons, and then modifications were undertaken to reduce 'unnecessary noise' in the cafe. A subsequent survey period to assess patron satisfaction would then be carried out. This may be able to prove to managers and cafe owners that simple and cheap noise reduction techniques can have a considerable effect, whilst helping our goal of improved health in our communities. These outcomes may be considered in the context of previous research, such as Christie et. al.'s [48] study of subjective noise perception of patrons in relation to their expectations and preferences, compared to the objective measures. Here it was found that patrons in cafes in the Wellington CBD found noise levels acceptable, and further, that they perceived the main source of background noise to be coming from other patrons. Another study conducted by Zemke et al. [49] found that customers in their studied restaurant had overall satisfaction with the noise levels, further backed up by a similar study by Raab et. al. [50], which found that noise influenced satisfaction but didn't have an effect on customer loyalty.

After looking at the quantitative noise recordings that we took in the cafes sampled, we believe that in the case of the louder cafes, a study that looks into noise exposure for cafe employees may be appropriate. The WHO states that people should not be exposed to excessive noise from the environment giving multiple values (from 70 db to 85 db) for different exposures [20], and the New Zealand Department of Labour states that workers should not be exposed to noise exceeding 85 dB(A) for more than 8 hours [56]. This may be occurring in our cafe's leading to preventable damage.

Barriers to change

Market forces can compel café managers to take the most profitable, yet legal, option rather than the one that benefits consumer health. This was reflected in the attitudes of the café managers interviewed, who on the whole only seemed interested in making changes to improve soundscapes of their café if it was likely to result in an overall profit for their business. This is an unfortunate yet all too common ethical issue that flies in the face of egalitarian principles. However, it is a crucial issue to tackle. One possible solution is to increase public awareness of the negative impacts of high levels of noise. In addition to satisfying the ethical responsibility of informing the public about harmful exposures when clear evidence exists, it would also drive changes in café soundscapes using the same powerful market forces that are currently disincentivising change.

Recommendations

If noise is highlighted as a health issue to the public, not just for auditory health, but factors such as stress and cardiovascular risk, we could start to see change in the near future. We believe that education of the public will be required prior to effective interventions being implemented. This could be the basis of a further intervention where different groups could receive education on environmental noise and we could see how their perceptions or their abilities to detect noise change. This would give us valuable information on how to best educate the general public on the harmful effects of noise. A pertinent issue that our qualitative data has raised is that although owners/managers were willing to turn down the noise of a stereo, they were very much less willing to invest money into installing materials and structural features that would reduce noise. It is therefore difficult for us to now make suggestions, as we must first determine where the responsibility lies for dealing with this issue. One way would be to create codes and regulations at a local or central government level regulating building materials, fixtures and furniture. However, enforcing these would be an incredibly difficult task for the local authorities concerned, and lead to the failure of the intervention. Therefore, we need to make business owners see the potential benefits in some of these technologies, as for a lot of them; they don't detract from the atmosphere of the cafe, and if implemented at the beginning, are not as costly as most might think. For example, the average mean room sound absorption coefficient (MRSAC), or how much noise is absorbed, in the cafe sample was 0.0931. If 20% of the least-absorptive available wall space was covered in acoustic panelling (NRC=0.95) this could be improved to 0.206. Or to 0.375. if 50% was covered [52].

When discussing with A/Prof Wyatt Page, he suggested "...that with a $1000 investment, we could potentially see a drop of 6-7 dB in a cafe's noise." [55] 6-7 dB being a significant decrease, as for each 3 dB change, we see a reduction by half in the noise intensity which is closely related to health effects. This could mean that reducing noise levels in cafes' is a feasible task and that potential wider implications on health can be minimised.

Reflexivity

As a group of 18 fourth year medical students our initial reactions to this study demonstrated a lack of perceived awareness surrounding the impact of noise and a variation in attitudes regarding cafe culture. Many students failed to see the purpose of this study and viewed it as being irrelevant to public health. This could be linked to the fact that many students did not have a great understanding of noise induced hearing loss and did not see it to be an immediate health concern. This highlights how noise is being normalised in today's society as mentioned earlier in this report. Students also appeared to have mixed opinions on what demographics would contribute to cafe patronage. After conducting a survey amongst the students we found that most believed those who attended cafes were those who could afford it rather than a specific age group or cultural subset (see Figure 12). These attitudes however changed substantially as we came to learn about the health impacts, both auditory and non-auditory, of noise and we now see investigating noise exposure in public spaces as being relevant to public health.

5 Conclusions

This study failed to find any variation in patron demographics (age, sex, and ethnicity) across the three noise level strata of cafes. Furthermore, the results failed to sup-

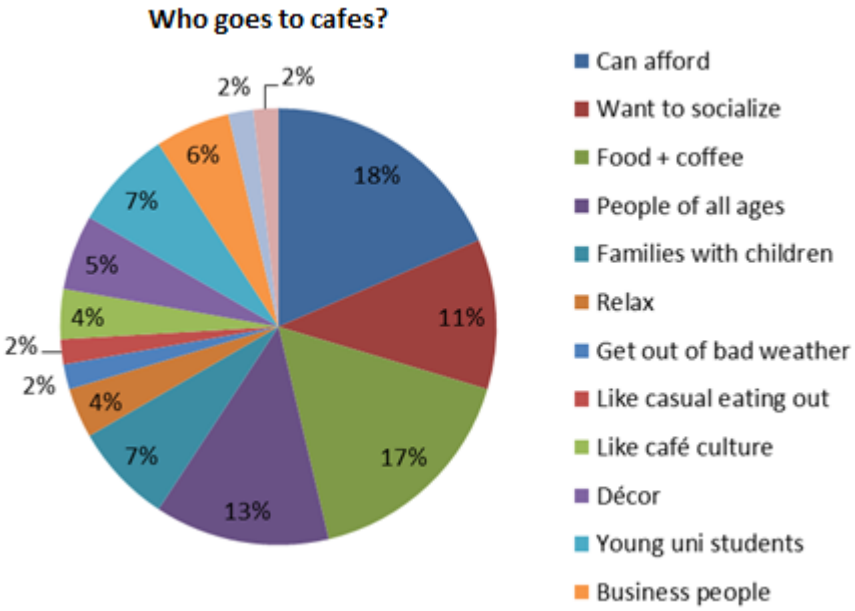

Fig. 12: Student group's perceptions about who goes to cafes.

port our hypothesis that noise levels would affect patronage. Although the likes of Maori and other ethnic groups were seen to be underrepresented in this study, we cannot conclusively state that these social groups are being systematically socially excluded from the café experience. While we can comment on the demographic of patrons at the time of interviews we cannot draw conclusions about those who are not present at the cafes. With regards to patrons' attitudes towards café noise, this study found that noise levels of a café do not play a significant role in the selection of a café. Another pertinent issue that our data has raised is that although owners/managers were willing to turn down the noise of a stereo, they were very much less willing to invest money into noise reducing technologies. In conclusion, we have highlighted the fact that despite increasing tolerance to noise in today's world, there is general apathy and a lack of awareness about the wider social implications of increasing noise. Therefore, it is our belief that there is a broad scope for future research, specifically when addressing concerns of social and wider health implications of increasing noise.

Acknowledgements

We would like to thank our project supervisors, Dr. Hera Cook, and Dr. Lucy Telfar-Barnard. We would also like to thank Assoc. Prof. Wyatt Page from Massey University, and Dr. Keri Lawson-Te Aho, from the University of Otago, Wellington.

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A Appendix - 'Initial data' template

Initial Data Template

Date:

Metservice Weather (at start): Metservice Weather (at finish):

Names of collectors:

Note: *Record from a central table, handheld or resting on a soft surface at 45° with microphone pointing upwards.*

Name of Cafe	Address	Time of Recording (Start)	Number of Patrons (first two minutes of recording)	Number of Patrons (last two minutes of recording)	Maximum Noise Level (dB)	Minimum Noise Level (dB)	Average Noise Level (dB)	Number of doors permanently open	Number of windows open	Music Present (Y/N)

B Appendix - Acoustic observations template

Acoustic Observation of Cafe

Name of Recorder:

Name of Café:

Time + Date:

Weather Conditions:

dB: ave, (min-max):

Approximate number of chairs:

- ☐ 0-15
- ☐ 16-30
- ☐ 31-60
- ☐ 60+

Number of total tables:

- ☐ 0-5
- ☐ 6-15
- ☐ 16+

Number of people inside the café:

% of patrons in each age range:

<12 ……..
<30 ……..
<65 ……..
65+ ……..

Children's area:

- ☐ Yes
- ☐ No

Suspended ceiling:

- ☐ Yes
- ☐ No

Kitchen visible:

- ☐ Yes
- ☐ No

Number of waiters/waitresses: ……

Approximate Ceiling height: ……

Floor materials:

- ☐ Wood
- ☐ Concrete
- ☐ Carpet
- ☐ Tiles
- ☐ Lino
- ☐ Other:

Wall materials:

- ☐ Wood
- ☐ Concrete
- ☐ Plaster
- ☐ Carpet
- ☐ Brick
- ☐ Gib board
- ☐ Other:

Internal Walls? ☐ Yes (#) …… ☐ No

Soft furnishings (curtains, cushions, couches, carpet);

……

……

……

Music Type: ……

C Appendix - Letter to cafe managers

UNIVERSITY of OTAGO

Te Whare Wānanga o Otāgo

Wellington School of Medicine
University of Otago
23A Mein Street
Newtown
Wellington

28/04/2014

Dear Manager,

We are fourth year medical students from the University of Otago, Wellington conducting a research project on noise levels in cafes. We would be very grateful if you were willing to participate in a study of sound levels in cafes. Our aim is to find out what sound levels café patrons find comfortable.

For our study, we would like to:

- Measure sound levels at your café (non-intrusive).
- Interview the café owner or duty manager about the demographic of patrons and the acoustic environment (5 minutes maximum).
- Interview up to 5 patrons about their café experience (5 minutes maximum per patron).
- Noting the general acoustic environment of the café.

We will report results from this study in a presentation to the Public Health Department, University of Otago Wellington on Friday, May 16 at 10.30am in the Small Lecture Theatre, Wellington Medical School Campus, Newtown. You are warmly invited to attend. We are also happy to provide you with a copy of the report if you wish.

No identifying information (cafes names, address etc.) will be included in our final report and all information obtained will remain confidential. This study has been granted ethical approval from the University of Otago Ethics Committee. All participants are able to withdraw from the study at any time, without providing a reason for doing so.

If you have any questions regarding this study, please feel free to contact:
Project Supervisor – Hera Cook - hera.cook@otago.ac.nz, 021 02872236
Project Leader – Charlotte Legge - legch314@student.otago.ac.nz, 027 555877

We greatly appreciate your involvement in our study.
Thank you very much for your time.

Kind regards,

Charlotte Legge
Project Leader - The Public Health Research Team C1

D Appendix - Manager questionnaire

Manager Questionnaire

Name of interviewer:

Café Name:

Permission to record interview: ☐ Y ☐ N

Permission gained to interview patrons: ☐ Y ☐ N

1. **General age group of patrons:**
   - ☐ <30
   - ☐ <65
   - ☐ 65+
2. **Main types of patron groups**
   - ☐ Families
   - ☐ Business people
   - ☐ Students
   - ☐ Elderly
   - ☐ Other.....
3. **Busiest times of the day?**
   - ☐ Morning (9-11am)
   - ☐ Lunchtime (11am-1pm)
   - ☐ Afternoon (1pm-3pm)
4. **Noisiest times of the day?**
   - ☐ Morning (9-11am)
   - ☐ Lunchtime (11am-1pm)
   - ☐ Afternoon (1pm-3pm)

5. What contributes most to the noise levels of your café?

- ☐ People talking
- ☐ Music
- ☐ Coffee machine
- ☐ Road noise/traffic
- ☐ Other (plates/cutlery clatter/chairs scraping)

6. **Music:**
   a. Style?.....
   b. Who governs music volume?.....
   c. Would you be willing to change the volume of music if asked by patrons? .....

7. What do you think of the noise levels in the café at peak times? (circle one)

1 (very quiet) **2** (quiet) **3** (moderate) **4** (loud) **5** (too loud)

7. **Are you aware of ways to moderate noise levels without lowering music volume? (explain about baffling, suspended ceilings etc.)**

8. **Would you consider changing the acoustic environment to lower noise levels? (e.g. Installing baffling or suspended ceilings?**

9. **Does it concern you that high sound levels in your café can discourage customers with hearing lo**

E Appendix - Patron questionnaire

Patron Questionnaire:

1. Have you been to this cafe before? ☐ Yes ☐ No

a. If **yes**, what do you like about it?

1. Food
2. Coffee
3. Location
4. Price
5. Atmosphere
6. No reason
7. Other .....

b. If **no**, why did you choose it?

8. Food
9. Coffee
10. Location
11. Price
12. Atmosphere
13. No reason
14. Other .....

Relating to noise specifically:

2. How do you rate the noise currently?

15. Too quiet
16. Quiet, but okay
17. Comfortable
18. Loud, but okay
19. Too loud
20. No comment

3. Does noise level influence what cafes you choose to go to?

4. Are you sensitive to noise or have any hearing loss?

21. Yes
22. No

5. What do you feel contributes to the noise the most?

23. Kitchen noise
24. Music
25. Other people talking
26. Children
27. Coffee machine
28. Road noise
29. Other noise

6. Would you feel comfortable asking the café staff to turn down the music?

About the patron

Gender:

30. Male
31. Female

Year of Birth:

Ethnicity:

Are you from Wellington?

☐ Yes ..... ☐ No.....

Occupation:

Thank you for your participation!

F Appendix - Ethics proposal

G Appendix - Glossary

A-weighted decibels (dBa): A standard weighting for the dB scale. The dBa gives different weightings to sound waves at different frequencies. Excluding those that are above or below the range of human hearing, and instead focusing of the particular frequencies that most affect us.

Decibel (dB) scale: A logarithmic scale to measure sound pressure level. A two-fold increase in sound energy will cause the sound pressure to increase by 3 dB. A ten-fold increase in sound energy will cause the sound pressure level to increase by 10dB, which is perceived as about twice as loud [1].

F-time weighted: An f-time weighted data set has a recording taken every 125ms. This allows the extraction of a set of discrete numbers from an analogue recording.

LAeq: A type of average, the LAeq represents the continuous sound level which would contain the same amount of total energy as the highly time-sensitive dB reading.

Mean room sound absorption coefficient (MRSAC): evaluating how much of the energy of a sound wave is lost on average upon reflection off the walls/floor.

Noise reduction coefficient (NRC): An arithmetic average of the proportional sound lost at frequencies of 250Hz, 500Hz, 1000Hz, 2000Hz. It is then used to find the MRSAC using the formula MRSAC = (NRC1*A1 + NRC2*A2 +...+ NRCn*An) / (A1+A2+...+An).

Permanent threshold shift: hearing loss due to the degeneration of hair cells and associated nerve fibres that results from repeated or sustained exposure to sound levels >85dBA [11].

Social exclusion: a process by which certain groups are systematically disadvantaged because they are discriminated on the basis of their ethnicity, race, religion, sexual orientation, caste, descent, gender, age, disability, HIV status, migrant status or where they live. Discrimination occurs in public institutions, such as the legal system or education and health services, as well as social institutions like the household [43].

Sound pressure level: A logarithmic measure of the effective pressure of a sound relative to a reference value. It is measured in decibels (dB) higher than a reference value. The reference sound pressure in air is 20Pa which is thought to be the human hearing threshold at a sound frequency of 1000Hz [1].

Temporary threshold shift: a temporary loss of ‘dullness’ of hearing in response to exposure to sound levels >85dbA which recovers within 16-24 hours of the exposure [11].