The impact of noise in early childhood settings

A New Zealand perspective

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Excessive noise levels in early childhood centres have a direct impact on the learning of young children, as well as on the wellbeing of teachers. Psycho-acoustic studies show that noise is a key factor contributing to elevated adult stress levels and annoyance, leading to lower levels of adult sensitivity to children's needs and fewer direct interactions with them. Longer term, local and international research indicates correlations between excessive noise in early childhood education (ECE) centres and health problems, such as to hearing loss, voice strain, obesity, diabetes, and cardiac conditions. Noise as a chaos factor in early childhood settings undermines wellbeing of both adults and children. Because noise negatively impacts on quality relationship and communication, children's language development is also impacted.

Yet noise within New Zealand early childhood settings is under-researched, under-regulated, and under-monitored. Drawing on local and international research and on a survey of New Zealand early childhood teachers, this article recommends regulating for the creation of quieter environments for the benefit of teachers and learners, the adults and children in early childhood settings.

Introduction

Early childhood environments are often noisy. Children enjoying themselves—negotiating, inventing games, and learning social skills—can be a noisy business. Similarly, children not enjoying themselves are also major sources of noise, such as when they are upset, and struggling with emotions, impulses, attachment disorders, illness, and sensitivities to crowds, noise, and strangers. Infant and toddler classrooms are spaces where it is common to find crying children.

Adults contribute to the noise—teachers are talking and sometimes calling loudly. They also make decisions about music running in the background. The activities undertaken and the facilities themselves also add to the environmental noise that surrounds the adults and children: air conditioning, doors, furniture scraping on floor surfaces, plus toys and musical instruments all add to the potential melee (Cielo & Cappellari, 2008; Gebauer et al., 2016; Manlove et al., 2001; Shin, 2011).

Sound can be amplified by poor acoustically designed environments, including hard surfaces for floors, walls, and ceilings. Also, neighbourhood noises are likely to increase environmental noise in a centre, unless it is well insulated acoustically. For some centres, neighbourhood noise can include sirens, rail, air or road traffic, construction, and other industrial activity. Excessive environmental noise has been shown to affect the cognitive, emotional, and physical development of children (Dzhambov & Dimitrova, 2017; Evans et al., 2001; Matheson et al., 2010). When city planning allows early childhood services to be built in industrial areas, or adjacent to major roadways, these neighbourhood features will have a significant impact on the soundscape experienced by very young children and their teachers.

Licensing and regulation requirements in New Zealand (Ministry of Education, 2018) include that early childhood services take all practical steps "to ensure that noise levels do no unduly interfere with normal speech and/or communication, or cause any children attending distress or harm" (HS15) (p. 22); that sufficient and suitable space

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is provided with regard to "noise control" (Reg 45) (p. 12), and that "all reasonable steps are taken to ensure health and safety of children" (Reg 46) (p. 19), including provision of "quiet spaces" (PF1) (p. 12).

However, licensing and regulation are not necessarily sufficient to ensure adequate controls on noise, as experienced by children and teachers. In addition, while Worksafe regulates early childhood settings as workplaces, the Health and Safety at Work Act 2015 does not consider the impact of noise on children in early childhood settings. Further, the normal tools for mitigating noise in the workplace—in particular use of earmuffs—are impractical in an early childhood setting (Gardner et al., 2014; McLaren & Dickson, 2005).

When children are crowded in any space, noise can quickly exceed safe levels, and especially if this occurs frequently, the impact can be detrimental to the psychological and physical wellbeing of both children and adults. Excessive noise levels over long periods are not the only cause of harm. Sudden loud events, particularly close to the aural canals, can also cause longlasting or permanent damage.

For more information on the science of sound, see Box 1.

Research findings

In 2017–18, a major survey of early childhood teachers was undertaken by one of the authors, Susan Bates, using social media. With approval

BOX 1 THE SCIENCE OF NOISE IN EARLY CHILDHOOD SETTINGS

Noise is commonly defined as "unwanted sound"; however, a more comprehensive definition is:

> Noise is a sound that is audible to an individual and has definable characteristics that modify the individual's emotional and informational responses to that sound from pleasurable or neutral to adverse. (Thorne, 2008, p. 213)

This definition recognises the effect the sound has on a person, and this effect can vary significantly with their health status, time of day, and many other factors. Commonly, people also talk about the loudness of a particular sound or noise. This is the individual's perception of the sound which varies with the informational and emotional engagement associated with this sound. For example, crying babies cause early childhood teachers—and other adults—to strongly engage informationally and emotionally and so are perceived to be louder relative to other sounds.

Three important factors that affect the perception of sound indoors are the sound pressure level (commonly measured as decibels), how reverberate (reflective) the space is (measured by the reverberation time), and background or ambient sound pressure level.

The measurement of sound is complex, so different descriptors or measures have been developed. One of the most common measures is the A-frequency weighed time average level ($L_{Aeq,t}$) over a time period. This is measured in the engineering unit of decibels or dB. Because this unit uses a non-linear scale, you cannot add dB values together directly; an increase of 3 dB anywhere along this scale is a doubling of the sound pressure squared. So, 53 dB has twice the sound pressure squared of 50 dB. An increase of 10 dB is an increase of 10 times the sound pressure squared. An increase of 20 dB (two lots of 10 dB) is 10 x 10, or 100 times the sound pressure squared.

Background noise in early childhood settings is recommended not to exceed 35 dB. This is difficult to achieve for any early childhood setting near a main road or in an industrial area. Sleep environments should not exceed 40 dB, but in early childhood settings sleeping children are often in environments with background noise levels of 63–69 dB.

In office environments, adverse health and productivity effects occur about 50 dBL_{Aeqa}. Levels above 75 dB L_{Aeqa} become a concern for potential hearing damage in adults, with many countries adopting an occupational workplace noise limit of 85 dB L_{Aeq} for an 8-hour working day. Early childhood environments regularly exceed this limit and studies show averages as high as 87 dB across a working day. This level of noise is damaging, physically and psychologically.

The reverberation time (RT) is the time it takes for sound pressure to drop away to being inaudible after the sound source has stopped. Large spaces have longer reverberation times than smaller spaces, but the controlling factor is how sound absorbent (or reflective) the surface (floor, ceiling, walls) coverings are.

The signal to noise ratio (SNR) indicates whether or not speech can be heard over background noise. This measurement is particularly important when considering language learning for infants, toddlers, children (and adults) with English as a second language, or who have hearing or speech difficulties or impairments. Young children have not yet adapted to tuning into to a specific frequency and blocking out background noise. The recommendation for infants is that the directed speech should optimally be 15 dB L_{Aeq} higher than the ambient noise in order for an infant to hear. The recommended level in an infant room is between 35–55 dB $L_{Aeq.}$ Normal adult conversation is about 65 dBa (ASHA, 2005).

The Lombard effect (also called the "café" effect) occurs when people involuntarily speak more loudly in order to be heard over others. Pitch, syllable length, and loudness are increased in order to maximise audibility, or SNR.

While adults are at risk of hearing loss at 85 dB L_{Aeqa} or higher, for children it is above 75 dB, but quality of life, emotional stress, and communication are diminished at much lower levels.

For more information on the science of noise, and of safe levels of noise, see:

- Hannah, L., Page, W., & McLaren, S. (2016). A review of occupational noise in New Zealand. *Acoustics New Zealand, 29*(1), 4–26. https://www.acoustics.org.nz/sites/www.acoustics.org.nz/files/journal/pdfs/Hannah_L_NZA_2016.pdf
- Health Link BC. (2019). *Harmful noise levels*. https://www.healthlinkbc.ca/health-topics/tf4173

from NZ Ethics, early childhood teachers were asked 72 questions designed to gauge the health and wellbeing of early childhood teachers. Self-identifying as early childhood teachers, 702 responses were received. For more information about the survey and its results, see Bates (2018, 2019) and Bedford et al. (2018).

Of those responding, 44% (378 responses) indicated that their working environments were "too noisy" either "often" or "very often". Only 10% of respondents indicated that their working environments were "rarely/never" noisy.

The survey asked whether teachers suffered from a range of stress-indicative physical symptoms. In comparing the results from teachers in the noisiest centres with those from quieter centres, the following health conditions were more often reported as experienced "often in the previous 12 months":

- feeling worn out
- sleeplessness
- anxiety and worry
- back pain
- stiffness
- ringing in ears.

One of the survey's advantages is that correlations can be made between "too much noise" and manageable workplace features such as teacher:child ratios. Of particular interest is the clear correlation between noise and group size. The survey results indicate a tipping point; the respondents indicated that when a group size reached 30 or more children, there were high correlations with noise and other stressors.

A limitation of this survey method is that there is limited scope to determine objectively that an environment is "too noisy". However, the survey's findings are in line with local and international studies that found early childhood settings are loud enough to be a risk to health and wellbeing (see, for example, McLaren & Dickinson, 2009; Newman, 2005; Sjodin et al., 2014.) In addition, a Dutch study found correlations between self-assessed stress levels and measurable levels of heightened cortisol amongst early childhood caregivers (Groeneveld et al., 2010).

While this survey does not fully research the stressors and health issues raised by teachers, their experiences as reported are worthy of further analysis. What follows is a two-pronged literature review: how "too much" noise impacts on wellbeing generally in early childhood services consideration as well as impacting more specifically on language development which can be slowed down because of poor communication with caregiving adults, a side effect of "too much noise".

Literature review

While children's health and adults' health can be researched and understood separately, the reality is that, in early childhood settings, they are entwined. When noise levels are too high, there are correlations with raised cortisol levels in both adults and children, which in turn contribute to stress and aggravating health conditions (Groeneveld et al., 2010; van Kamp & Davies, 2013; Werner et al., 2015). Groeneveld et al. (2010) found that, when caregivers experienced high stress, this was also evident in high cortisol levels, and that this was particularly damaging for children with behaviour difficulties, such as limited ability to adapt to change, high activity, and low emotional regulation.

In New Zealand, there are currently no guidelines for children's hearing safety, but local research has found that noise levels in early childhood settings regularly exceed safe levels (McLaren & Dickinson, 2003, 2009; Shin, 2011). Peak noise levels can occur for multiple reasons, but distressed children crying is a predictable reason that is validated by research (see, for example, McLaren & Dickinson, 2009; Shin, 2011). Ratios and group size are generally determined by management of an early childhood setting but have to meet minimum regulatory requirements. There are currently no regulations limiting group size in early childhood settings (Ministry of Education, 2018).

There is limited regulation of acoustic design of early childhood buildings and facilities. Shin (2011) reported that, of the six Auckland early childhood settings in her study, the centre that was most recently built and custom-designed—with its open plan design, partial walls between rooms, and generous use of glass for natural light and ventilation—had the worst acoustics.

Children's wellbeing is detrimentally affected by noise, both noise intensity and different types. Research on traffic and aircraft noise registered near schools and daycare facilities in Europe showed a lowering of children's cognition and aspects of children's memory, as well as rising blood pressure and high cortisol levels (Dzhambov & Dimitrova, 2017; Matheson et al., 2010). In a study of six early childhood settings in Auckland (three kindergartens and three private childcare services), Shin (2011) found that, even without any children present, none met recommended levels of background noise set for early childhood services by the World Health Organization.

An increasingly common injury for teachers is voice strain. This is an area of concern for teacher health, as it can be permanent. Voice injury can be due to a variety of factors, including stress and depression, air quality, as well as overuse (Leão et al., 2015).

According to Basner et al. (2014), for adults, excessive noise correlates to various health risks, both auditory (hearing loss) and non-auditory (hypertension, stress, annoyance, obesity, and heart disease). Exposure to excessive noise, particularly if it is prolonged, can result in gradual hearing loss. Such hearing loss is irreversible. The only study on hearing loss in New Zealand in early childhood, published in 2009, found that a significant percentage of teachers were exposed to unsafe noise levels and that half of the participants showed a likelihood of incurring hearing loss, and the authors' recommendations for regular screening of teachers has gone unheeded (McLaren & Dickinson, 2009).

Noise in an environment contributes to the social and emotional phenomenon called chaos. "Household chaos" and crowding in the home have been shown to negatively affect parent–child interactions, and increased child withdrawal and aggression (Corapci, 2010; Mills-Koonce et al., 2016). Many early childhood centres are also crowded and noisy. However, "chaos" in early childhood environments has been barely researched.

According to Jeon et al. (2016), there is little research of teacher sensitivity in chaotic environments, although Swedish researchers found preschool teachers had the highest increase in noise-related ill health amongst different occupations studied (Sjodin et al., 2014). They also found that, although acoustic measures (such as floor coverings) reduced employee fatigue, these environmental interventions typically only reduced the level by 3–5 dB. The single biggest contributor to reducing noise, and noise events, is fewer children in the space. This is in line with what Shin (2011) found in Auckland: the presence of children—the number of children—is the single most important factor in noise levels.

The psychological and physical health of caregivers and the environmental "chaos"—under-controlled environmental activity, including noise—will dictate the frequency, duration, and quality of adult–child interaction (Hart & Risley, 1995; Weisleder & Fernald, 2013). These

interactions are essential for children's development, socially, cognitively, and physically (McLaren & Dickinson, 2009; Shin, 2011).

Noise affects communication. Research documents that noisy early childhood settings are made noisier by the "café effect" whereby children and teachers raise their voices in order to be heard—thus adding to the noise (Gardner et al., 2014; Shin, 2011). In noisy environments, adults have more abilities to decode meaning than do very young children. Children's ability to listen is compromised in a noisy environment. Infants in particular listen in a broad range of frequencies. Listening to speech for them is therefore more cognitively demanding (Leibold et al., 2016). Infants aged between 5 and 9 months are only able to hear their own name when it is higher than the background noise-scape (Newman, 2005).

Similarly, toddlers aged between 28 and 30 months have difficulty learning new words in noisy environments. If they have previously learned the words in fluent speech in a quiet environment and mapped to objects, they are able to mitigate the use of new words in noise. This is a skill that develops with maturity, but not for all children. Some children's ability decreases. The ability to perceive speech also improves when attention is more sustained, again indicating that cognitive development enhances auditory development and the ability to hear speech in noise, while the ability to hear and remember enhances cognition in a development spiral (Thompson et al., 2017).

According to Weisleder and Fernald (2013), toddlers who experienced more child-directed speech at 19 months had larger vocabularies at 24 months. Infants with slow growth in language are likely to have later difficulties in language skill. Infants must not only hear words but also hear them in context, providing practice at interpreting language. That language must be directed at the infant, and the infant must be able to hear it. Words and conversations only overheard do not contribute to building infant language skill, and background noise will interfere with the infant's perception. Parent or caregiver verbal engagement is crucial for children's learning development.

Discussion

"Too much noise" can be understood as a "tip of the iceberg" in terms of a wide range of underlying causes. It can also be seen as an "amplifier" of those causes and contribute to a wide range of poor teacher behaviours. In this study, teachers in the noisiest environments were more likely to describe a lack of patience, "snapping" at children, poorer relationships with both colleagues and management, higher levels of frustration, and fatigue, along with less motivation and emotional availability. Indicators show a relationship between illness, psychological distress, and chaotic environments. Noise is a major contributor to this. Underlying causes are like to include too many children, low staffing, and poor working conditions.

These environments can be understood as "chaotic"; such environments set the scene for interpersonal crises. Bullying may be more prevalent because psychological health is lower, and because chaos creates bullying behaviours (Hodson et al., 2006). Higher rates of infection and injury among teachers in the noisiest rooms may also point to overcrowded environments, as well as lowered immunity from high "presenteeism" (working when ill). Adults in these conditions who are already managing pain and other medical conditions may be more sensitive to noise, and more likely to describe their workplaces as "too noisy".

Environments that are "too noisy" are recognised as stressful. The result is in raised levels of cortisol (Groeneveld et al., 2010; van Kamp & Davies, 2013). This hormone impacts on emotional wellbeing and leads to heightened annoyance, resulting in poorer flexibility and patience with co-workers and children. Children with specific needs—developmental, psychological, and physical—require even more adult-directed interactions. According to the research data from this study, when teachers are unable to provide this level of attention because of large group sizes and insufficient staff, the teachers' wellbeing, sense of self-efficacy, and perceptions of doing the job well, are all affected.

This study indicates high correlations between noise, and a number of workplace stressors. There is a high probability that in a centre that is "too noisy" what is causing the noise is also creating and amplifying other occupational stressors that impact on psychological wellbeing and affect physical health. There were also correlations between environments that are "too noisy" and environments where teachers experienced or witnessed bullying by staff and management.

Those in the noisiest rooms clearly have poorer working conditions than their colleagues in quieter early childhood settings. In this study, teachers in the noisiest early childhood classrooms reported noise, workload, and managing children's behaviour equally as their main stressors. While the physical environment plays its part in how sound travels and amplifies in an early childhood classroom, management decisions also appear to have a critical role in how "noise as stressor" is managed. Non-contact time is essential for teachers to relieve stress. Rest breaks and adequate staff rooms are important mediators to noise, providing recovery periods for hearing mechanisms and respite from rising stress levels.

The auditory development of young children is not fully understood, and is subject to individual variables (Thompson et al., 2017) and, for this reason, caution should be exercised when considering the effects of noise in ECE. However, research shows that high noise levels and long reverberation times interfere with children's speech perception, particularly the very young (Manlove et al., 2001; McMillan & Saffran, 2016; Peng & Wu, 2018). Children's auditory skills are significantly correlated with reading skills (Leibold et al., 2016; McMillan & Saffran, 2016).

However, children who are not getting secure, responsive relationships or who are stressed from too much noise and overcrowding may display difficult behaviours. In addition, children's health and language acquisition is strongly affected by adult-directed interactions so that the psychological and physical health of adults is of primary importance to children's wellbeing and education.

Children with underlying health conditions and learning disorders will struggle to learn language in noisy settings. For example, those suffering from glue ear or ear infections will struggle to hear and therefore to develop language capacity. Similarly, children with particular sensitivity to noise (for example, many of those on the Autism spectrum, and a subset of "gifted" children) may become agitated and stressed, employing reactions of fight, flight, or freeze. In noisy environments, children may become withdrawn, anxious, aggressive, or hyperactive (McLaren & Dickinson, 2005; Shin, 2011).

Conclusion

Early childhood services are problematic to regulate effectively. As a workplace, early childhood services regularly exceed the noise limits set by the Health and Safety at Work Act, and the guidelines for mitigating that noise include

the use of earmuffs—a practice that is rarely seen in early childhood services (Gardner et al., 2014). As the "growing up" space for very young children who spend long hours in early childhood services, there are guidelines that seek to minimise noise, but these are problematic to achieve—given that other regulations, such as group size, ensure that the major source of excessive noise (the number of children in a room) continues to acceptable, and given that early childhood services can be built in industrial areas and on major thoroughfares.

In addition, the lived experiences of adults in early childhood settings is cause for concern, not only because of the immediate issues of their health and wellbeing, but also because of the limited range of effective tools available to teachers. Shin (2011) found that nearly all the teachers in her research were concerned about noise levels in their centres, and 66% of them felt powerless to make any significant changes.

There are, indeed, actions that teachers can make to bring about a quieter environment for children (see Box 2), but the most powerful changes have to be made by designers and managers. This starts with how the centre is built and where it can be built, and continues with decisions made about furnishings, wall coverings—and especially about how many children are placed in each classroom.

Regulatory change is required to address these issues.

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BOX 2: NOISY CENTRE? WHAT YOU CAN DO

If you are a teacher, you can discuss with your colleagues the decisions you make that impact on noise levels. This could include how teachers communicate across the room. Playing background music and loud ring tones on phone are areas where teachers can choose to reduce the noisy soundscape. You can systematically notice "peak" noise—and consider what patterns emerge. For example: Is there sufficient equipment for the number of children? What do children find difficult to share? Similarly, is your programme planning appropriate for these children? Or, said another way: Is there a close alignment between what children want to do and what teachers expect them to be doing?

Teachers can also reconsider how resources are organised and stored (metallic containers are more resonant than ones made of "softer" materials, for example). There may be opportunities to soften reflective surfaces by putting fabric on walls and ceilings and bringing in mats or carpets for floor coverings. However, these are also areas where owners and management would have more resources and responsibility.

In addition to considering how to soften surfaces, management and owners can also reduce noise levels by reducing group size, improving teacher:child ratios. In addition, they can encourage teachers' resilience and recovery time from stressors by providing comfortable staff rooms and adequate non-contact time. Outdoor areas for active play—even during inclement weather—help reduce noisy indoor environments on rainy days.

If you are a policy adviser to the Ministry of Education, you can check for yourself what the noise levels are occurring currently in early childhood settings by commissioning updated research. Working towards regulatory reform—smaller group sizes and improved ratios between teachers and children—will have multiple benefits for the wellbeing of the teachers and children who inhabit early childhood settings for a substantial part of their lives and are directly impacted by how environments are regulated and mandated.

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