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An assessment of residential exposure to environmental noise at a shipping port

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ABSTRACT

The World Health Organisation has recently acknowledged that contrary to the trend for other environmental stressors, noise exposure is increasing in Europe. However, little research has been conducted on environmental noise exposure to handling activity at shipping ports. This paper reports on research examining the extent of noise exposure for residents within the vicinity of Dublin Port, Ireland using the nation's largest port terminal as a proxy for port noise. In order to assess the level of exposure in the area, long-term measurements were undertaken at the most exposed residential façade for a period of 45 days to determine the extent of night-time exposure that was above levels recommended by the World Health Organisation. The indicators L_{90}, L_{eq} and L_{Max} were used to determine exposure levels. The results show that exposure is above night-time guideline limits set down by the WHO, above Irish levels for the assessment of noise mitigation and highlight the extent to which port noise can be a significant environmental stressor. The research also investigated the extent of low-frequency noise (which is associated with greater health issues) from night-time port handling activity and found a significant low-frequency component indicating the negative health issues that might arise from port noise exposure more generally. We also undertook semi-structured interviews with residents to qualitatively assess the self-reported impact of prolonged night-time noise exposure for local residents.

1. Introduction

Since the establishment of the European Noise Directive in 2002, there has been a significant improvement in awareness among the general public and policymakers about the relationship between human exposure to environmental noise and related public health concerns (Murphy and King, 2010). As a result, the importance of environmental noise pollution in shaping urban, environmental and public health policies throughout the EU and internationally is increasing albeit at a relatively slow pace. The recent publication by the World Health Organisation (2011) of its seminal *Burden of Disease from Environmental Noise* document sets out not only the evidence-base on the health effects of environmental noise in Europe but also attempts to quantify the extent of the problem. The report estimates that DALYs[1] lost due to environmental noise are '…60,000 years for ischaemic heart disease, 45,000 years for cognitive impairment of children, 903,000 years for sleep disturbance, 21,000 years for tinnitus and 587,000 years for annoyance' (WHO, 2011, 101). The evidence emerging from the document informed the recently established WHO European health policy — Health 2020.[2] Moreover, the document elucidates the extent to which noise pollution is a serious public health problem pointing out that noise pollution ranked second among a series of environmental stressors for their public health impact in a selection of European countries. Indeed, contrary to the trend for other environmental stressors (e.g. second hand smoke, dioxins and benzene), which are declining, noise exposure is actually increasing in Europe (WHO, 2011, 1).

Since the introduction of the Directive and with it the initiation of the strategic noise mapping process (see Murphy and King, 2010), there has been significant and large-scale research undertaken in the EU investigating the extent of population exposure to noise. Notable examples in the EU include Murphy et al. (2009); Garai and Fattori (2009); Licitra (2011); Murphy and King (2011) and Vogiatzis (2012), but similar research has also been initiated in other jurisdictions (see Ausejo et al., 2010; Lam and Ma, 2012; Wang and Kang, 2011). As a result of the completion of the first phase of noise mapping, the EU estimates that 40.2 million citizens suffer from excessive exposure to night-time road traffic noise alone; when aircraft, rail and industrial sources are also considered the figure rises to 48.8 million (Guarinoni et al., 2012).

The health issues associated with excessive exposure to environmental noise pollution (particularly from transportation sources) are now fairly well-established and extensively documented (see King

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[1] Disability-adjusted life years

[2] http://www.euro.who.int/en/what-we-do/event/first-meeting-of-the-european-health-policy-forum/health-2020.

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and Davis, 2003; Muzet, 2007; Murphy et al., 2009; Pirrera et al., 2010). The primary impacts are annoyance and sleep disturbance (Murphy and King, 2011), with night-time noise as the major source of concern. Urban traffic noise is the main noise source followed by neighbourhood noise and then aircraft noise (Muzet, 2007). The reported effects on sleep disturbance tend to be a reduction in the sleep period, arousals, awakenings, sleep stage modifications and autonomic responses (e.g. change in heart rate) (Babisch et al., 2005; Carter, 1996; Vallet et al., 1983). Moreover, the reduction in sleep quality has secondary impacts (generally felt the day after disturbance) including fatigue, low work capacity, reduced cognitive performance, changes in daytime behaviour as well as mood changes and associated negative emotions. In fact, recent research findings by Rabat et al. (2005) suggest that chronic exposure to environmental noise can lead to a permanent disruption in sleep.

The relationship between low frequency environmental noise exposure and health related problems has been less of a focus in the academic literature than noise in the traditional A-weighted bands. Although exact definitions are difficult to pinpoint, low frequency noise is generally taken to be noise from 10 Hz to 200 Hz with noise below 20 Hz being referred to as infrasound (Leventhall, 2004). Most walls in buildings tend to be deficient in attenuating noise in the low frequency region (Leventhall, 2003) meaning that residential exposure to low frequency noise is an even greater problem than in the normal frequency range; obviously this is a considerable problem from the viewpoint of environmental noise exposure and public health issues.

Moreover, the available evidence suggests that low frequency noise may have even more detrimental impacts on public health than noise in A-weighted frequency bands. The WHO recognises the special place of low frequency noise as an environmental problem suggesting that 'low-frequency components in noise may increase the adverse effects considerably' (Berglund et al., 1999, 61). Persson and Bjorkman (1988) and Persson et al. (1990) found that dB(A) underestimates the level of annoyance for low frequency noise. This, along with other related work implies that noise at low frequencies is considered more annoying by individuals (Berglund et al., 1996; Broner, 1978; Pawlaczyk-Luszczynska et al., 2010). Moreover, related research has also found that low frequency noise has a greater degree of 'unpleasantness' than noise in the A-weighted frequency bands (Inukai et al., 2000; Nakamura and Inukai, 1998). Exposure to low frequency noise also causes sleep disturbance (Leventhall, 2003) and its associated secondary effects with the WHO (Berglund et al., 1999) noting that it 'can disturb rest and sleep even at low sound levels'. Indeed, Ising and Ising (2002) have shown that noise, perceived as a threat, stimulates the release of cortisol in the body which may interrupt recreative and other sleep qualities. Their work has demonstrated that low-frequency noise seriously impacts on the sleep quality of children. Moreover, Persson-Waye et al. (2002) have shown that adult exposure to low frequency traffic noise is associated with greater degrees of fatigue and a negative mood.

Other research on low frequency noise and health has indicated that it has an impact on peripheral task performance (Kyriakides and Leventhall, 1977) while more recent research has shown it negatively affects demanding verbal tasks in the work environment (Persson-Waye et al., 2001). Ising and Ising (2002) demonstrated that compared to a control group, children exposed to low frequency noise have significantly more problems with concentration and memory. In public surveys conducted to assess subjective well-being for individuals exposed to low frequency noise, Møller and Lydolf (2002) found multiple self-reported health effects including disturbance when falling asleep, awakenings, frequent awareness of the noise, irritation, and disturbance when reading. Other effects reported were insomnia, lack of concentration, headaches, and palpitations. A laboratory study by Persson-Waye et al. (1997) showed that subjects exposed to low frequency noise were less happy and had a poorer social orientation. Moreover, Persson-Waye and Bengtsson's (2002) work suggests that low frequency noise represents 44% of all noise complaints in Sweden.

Very little research has been undertaken in the academic literature analysing the extent of environmental noise at shipping ports even though industrial noise is a strategic noise category in the existing Environmental Noise Directive (END) of the EU (EU, 2000; Murphy and King, 2010). Even less has been conducted analysing residential exposure to low frequency noise as a result of port-related activity. Some exceptions exist including the EU-funded NoMEPorts project which aims to reduce noise, noise-related annoyance and health problems of people living around industrial port areas. That project recently produced a 'Good Practice Guide on Port Area Noise Mapping and Management' document which outlines a common approach for port area noise mapping and management within the context of the Environmental Noise Directive (van Breeman, 2008). In addition, Bing and Popp's (2009) research on Hafencity port in Hamburg highlighted the role of urban planning in devising a solution to reduce residential exposure to port noise in the area. The solution included day-time and night-time noise limits (less than 30 dB(A) with slightly opened window at night) and a permanent supply of fresh air. Moreover, a recent study conducted at Leghorn and La Spezia terminals, Italy investigated port workers exposure to noise and offered potential solutions for noise reduction (Luzzi and Barbieri, 2009). These included changes in shift operations, noise reduction at source (e.g. replacement of air vents and silencers of rubber tyre gantry cranes, introduction of trailers with 'silent blocks') as well as changing ship docking power supplies from generators to electric cable systems.

Bearing the foregoing context in mind, the current study investigates residential noise exposure at a shipping port in Dublin, Ireland, with particular emphasis on low frequency noise content. The research had two core objectives. The first was to investigate the extent of night-time noise in the study area during periods of night-time port activity and non-activity.[3] Thus, we assessed whether an environmental noise problem exists in the area during night-time. The second was to specifically assess the presence of a low-frequency noise problem in the area during night-time port activity versus non-activity. In this regard, the research investigated the merit of using the dB(C-A) indicator as a means of detecting low frequency environmental noise in conjunction with 1/3 octave analysis for assessing noise at narrower frequencies. We also used interviews with residents of the area to qualitatively gauge self-reported subjective views of the dose–effect relationship in the study area.

2. Methods

2.1. Context

Dublin port is Ireland's largest port by volume of tonnage handled and number of vessels received on an annual basis (Dublin Port Company, 2012). The port is a state-owned commercial company charged with operating and developing Dublin Port. In an Irish context Dublin Port is unique in that all cargo handling activities are provided by private sector companies who compete against each other. Activity at the port has increased dramatically over the last twenty years and the recent Dublin Port Master Plan, 2012–2040 envisages conservative estimates of throughput growth of 2.5% per annum until 2040 handling up to 60 million tonnes of goods at that point (Dublin Port Company, 2012).

In Dublin, Marine Terminals Ltd (MTL) operate a terminal for the Dublin Port Authority at Pigeon House Road in Dublin Docklands. It is a Lo/Lo (lift on/lift off) container terminal and is Ireland's 'largest and most modern container terminal' (McDonald, 2011) with three (45 tonne) ship to shore gantry cranes which can handle up to and including Panamax size vessels. Secondary handling of cargo is carried out by four (40 tonne) rail mounted gantries (RMG's) which are aided by various ground-handling equipment and there are also 300 reefer points.[4] The berth is 700 metres long (see Fig. 1). The facility is located

[3] We define port-activity as activity associated with the loading/unloading of a container ship including industrial and associated ground transport noise.

[4] A reefer point is the power supply that a refrigerated container plugs in to.