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# Urban energy: The Effects of Sound and Light Exposure On Sleep and Overall Health — Research Review

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According to Brown et al. (2015), there is a global shift of urbanization from the developed to the developing world. As the urbanization of our larger cities continue to expand, we are constantly inundated with various stimuli. Specifically an excess and variety of light forms and sound exposures have significantly increased for those who live in urban landscapes. This paper outlines where the sources of light and sound pollution come from, how this type of pollution may impact our health, and how this can be addressed.

## Light Exposure in an Urban Landscape

### Sources of light pollution

Light pollution is defined as the excessive or inappropriate use of artificial light that has the ability to cause adverse effects on ecology, human health, and the natural environment.<sup>1</sup> In urban centres, street lighting alone accounts for approximately 40% of light pollution. Other contributors include security lighting for homes, businesses, and commercial buildings as well as floodlights and display lighting for advertisements, billboards, and sporting venues.<sup>1</sup> These various sources form different types of light pollution, as seen in Table 1. Since the early 20th century artificial light has become ubiquitous in our society, most notably in urban centres. Currently, 99% of the population in the United States and Europe are exposed to light pollution, and the use of light at night continues to increase by 6% each year.<sup>3</sup> This exposure has been long overlooked and considered a benign side effect of modern life, however current research is shedding light on its deleterious effect on many physiological processes.

### Impacts on human physiology

The primary concern in regards to light pollution is its disruption of our natural circadian rhythm and the resulting effect on neuroendocrine physiology and the HPA axis.<sup>2</sup> Circadian rhythm is a biological process that operates on a 24-hour cycle and controls sleep, hormone production, metabolism, and gene expression.<sup>4</sup> The

**TABLE 1: Types of Light Pollution<sup>2</sup>**

#### **Sky glow**

Light 'glow' or halo that is seen over large towns and cities at night

#### **Glare**

Escaped horizontal light from unshielded sources such as street lighting

#### **Over illumination**

Excessive use of artificial light for signage or buildings

#### **Light intrusion or trespass**

Stray light or unwanted light from floodlights or streetlights entering into homes or bedrooms

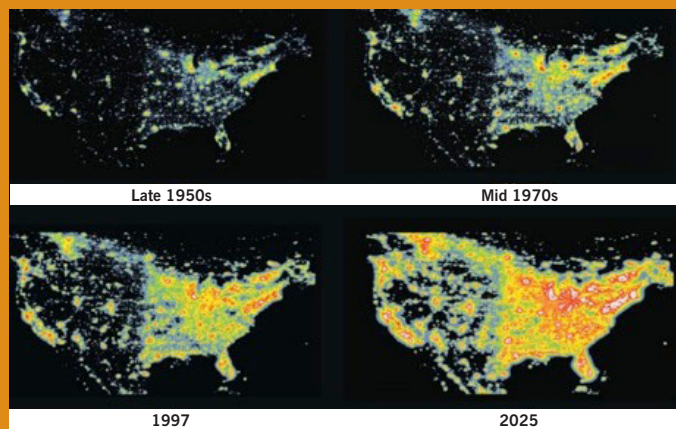
superchiasmatic nucleus (SCN) is a small area of the hypothalamus that controls the circadian rhythm, and thus the above biological processes as well. It is directly affected by light exposure through specialized retinal ganglion cells that project from the retina to the SCN.<sup>4,5</sup> The SCN also controls proper melatonin production via the pineal gland, although nervous pathways also exist between the SCN and other organs including the heart, pancreas, adrenal glands, adipose tissue and liver.<sup>6</sup>

The majority of research conducted on whether light exposure at night affects disease, has focused on shift-worker populations. This is beyond the scope of this article as we are most interested in incidental and low levels of nocturnal light exposure. However, a growing body of research is now focusing on light pollution as a risk factor and has shown that even exposure to dim light at night can affect disease progression.<sup>3,8,9</sup> Additional human studies have shown a clear dose dependent response between exposure to light (in regards to both intensity and wavelength) and melatonin suppression.<sup>10,11</sup> Thus, the concept of melatonin suppression and chronodisruption on disease progression can also be cautiously extrapolated to the deleterious effects of light pollution on human physiology.

### Cancer

Light pollution has recently been identified as a risk factor in the development of cancer in humans due to its unfavourable effects on circadian rhythm and decreased melatonin production.<sup>17</sup> Melatonin is a powerful antioxidant that is consumed by the body during

FIGURE 1.

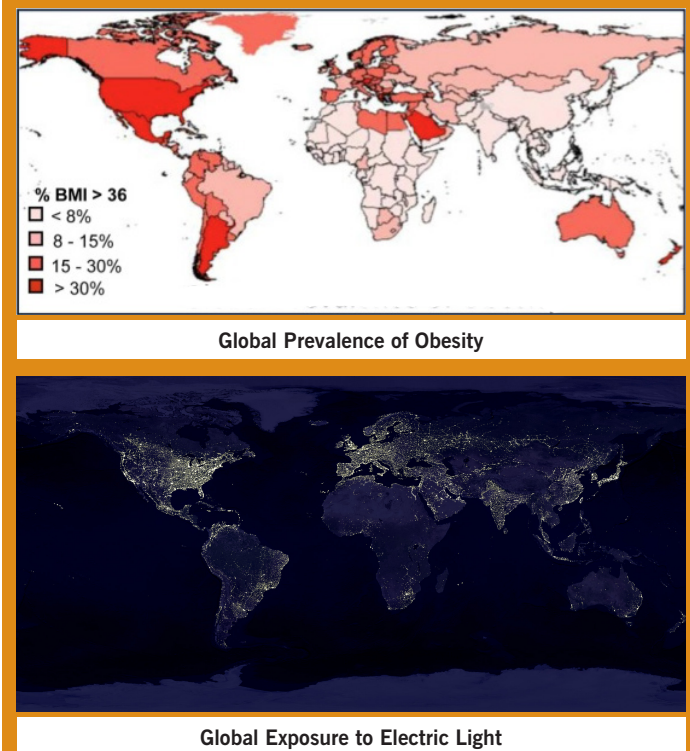


Source: www.lightpollution.it.

the day and replenished at night by the pineal gland.<sup>6</sup> However, the anti-cancer effect of melatonin goes beyond its well known antioxidant properties. *In vivo* studies have shown melatonin to directly inhibit cancer growth by decreasing tumor uptake of linoleic acid (LA), whose metabolites are necessary for tumor metabolism and growth.<sup>13,14</sup> Furthermore, melatonin suppression has been linked to increases in estrogen levels, which is a known risk factor for estrogen dependent cancers such as endometrial and breast cancer.<sup>17,18</sup> Although breast cancer has historically been the most well researched cancer type with regards to light exposure, additional studies suggest that light pollution may be also be affecting rates of colorectal, prostate, and endometrial cancer.<sup>12-14,18</sup> A 2010 study showed a strong positive correlation between global exposure to light pollution and incidence rates of breast cancer, but no relationship with lung, liver, or colorectal cancer.<sup>19</sup> Clearly more research is needed to investigate the degree to which light pollution affects the development of cancers worldwide.

### Metabolism and Obesity

Exposure to light pollution at night can also impact metabolism and lead to weight gain and obesity via alterations in hormone signaling, disruption of the circadian clock, and impairment of sleep.<sup>11</sup> Hormones such as glucagon, insulin, and leptin are all released in circadian rhythm, along with genes that control the metabolism of sugars and biosynthesis of cholesterol.<sup>11</sup> Rodent studies have shown that a disruption of circadian clock genes in both central and peripheral tissues causes increased susceptibility to metabolic syndrome and obesity, including impaired glucose regulation and defective insulin production.<sup>11</sup> In addition, mice exposed to only dim light at night exhibited an increase in adipose tissue and weight gain.<sup>20</sup> In humans, a recent study concluded that light exposure at night in the home was associated with higher body weight, elevated BMI, increased waist circumference, and elevated cholesterol levels.<sup>21</sup> There also exists geographical epidemiological data that shows the parallel relationship between increases in light pollution and obesity rates worldwide,<sup>11,22</sup> however these results could be due to confounding factors such as lifestyle and diet habits also found in industrialized nations that predispose the population to obesity.

FIGURE 2. Geographical colocalisation between increased BMI and exposure to artificial light.<sup>22</sup>

### Cortisol and HPA Axis Disruption

Cortisol is another important hormone released in a diurnal pattern, with levels lowest around midnight that build and peak in early morning in response to daylight.<sup>23</sup> This rhythmic secretion is directly controlled by the SCN's modulation of the HPA axis as well as through sympathetic innervation of the adrenal gland.<sup>24</sup> Thus, light exposure that disrupts circadian rhythm via the SCN can also have a negative effect on cortisol levels and lead to chronically high cortisol levels. Abnormal pulses of cortisol can also occur throughout the night in response to frequent waking, a common side effect of exposure to light pollution.<sup>25</sup> This disruption of cortisol rhythm and the HPA axis has far reaching health effects that include mood disorders such as depression and anxiety, chronic stress and adrenal fatigue, as well as insomnia and sleep disorders. The link between circadian disruption and mood disorders has been documented in numerous studies, however specific research in regards to light pollution is lacking.<sup>26</sup> A 2012 study concluded that rodents chronically exposed to dim night during the night exhibited depressive-like behavioural changes,<sup>27</sup> however no human studies to date have replicated these findings.

### Not all light is created equal

It is not just the overall presence of light pollution that needs to be considered, but also the intensity and wavelength of the light we are exposed to. Blue light with wavelength from 430nm-510nm has the largest effect on circadian rhythm disruption as well as melatonin

suppression compared to other wavelengths.<sup>28</sup> Energy efficient LEDs as well as electronic screen displays are two of the most popular sources of blue light and are both heavily used. In regards to intensity, current studies have determined that less than 100 lux (a measure of illuminance) is enough to disrupt molecular circadian rhythm and cause melatonin suppression. This intensity is comparable to urban sky glow and is commonly found in sleeping areas during the night.<sup>8,11</sup> Furthermore, there is a clear dose dependent relationship in regards to light intensity and melatonin suppression, where high intensities of light suppress melatonin levels more severely than lower intensities.<sup>29</sup> These findings have numerous practical implications in regards to reducing light pollution and protecting against its detrimental effects as seen below.

**TABLE 2: Comparison of Lux Illuminance Levels From Various Sources**

Light Source	Approximate lux
Dim candle light	1.5
Night time sidewalk or parking lot	50
Dim room lighting	100
Overcast day	1000
Full daylight	10 000

#### ***Reducing light pollution exposure in your environment***<sup>2,3,30</sup>

- Avoid the use of exterior globe lights or floodlights, which produce a large amount of wasted light. Use timers, dimmers, or sensors in order to shut off lights when they are unneeded.
- Lower the wattage of outdoor lighting and choose warm white bulbs in place of bright white LEDs.
- Reduce your exposure to blue light after dark and before bedtime by limiting use of TVs, laptops, cellphones and other electronic displays. Alternatively, color temperature apps or blue light filters are now available that can reduce blue light emitted from devices.
- Ensure a dark bedroom by using blackout curtains and turning off all unnecessary lighting such as hallway and bathroom lights.
- If night-time waking is common, use warm light fixtures with dimming capability to reduce the intensity of exposure and melatonin suppression.
- If exposure to light pollution is unavoidable, properly timed supplemental melatonin may help offset the detrimental effects.<sup>12,13,17</sup>

A growing body of research is showing that light pollution does not only prevent us from viewing the stars and galaxies of the night sky, but has a wide range of detrimental effects that affects humans as well as wildlife and ecology. As the world population and urban centres continue to grow, exposure to light pollution and its detrimental effects will only become more ubiquitous.

### **Noise Pollution in an Urban Landscape**

Noise pollution is also a growing concern, especially in the developing urban landscapes of Canada. Various factors such as urbanization, increased population density, increased economic growth and increased motorized transportation are major contributing sources of environmental noise.<sup>31</sup>

Specifically, the urban soundscape (noise environment) is shaped by a combination of noises from transit systems (road, rail and air traffic), construction and industry noises, population density (neighbours, radio, television, bars and restaurants) and other sources.<sup>32-35</sup> As humans, we are particularly susceptible to sound exposure because we cannot switch-off our auditory system;<sup>32</sup> and now we are understanding how noise affects our health in a number of ways.

#### ***What is Sound?***

Noise as environmental pollutant, is measured as an A-weighted sound, expressed as dB (A) (decibels A-weighted). This measurement considers the rate of sound pressure levels at different frequencies in a way that is comparable to the human ear. Although sound levels fluctuate throughout the day, sound levels are measured over a period of time (16-hour days or 8-hour nights).<sup>36</sup> Noise in the urban landscape is measured at maximum noise weighted levels, and not measured by the human experience of noise.<sup>37</sup>

Examples of dB (A) measurements include: sound at the threshold of hearing is 0dB (A), sound of falling leaves is 10-20dB (A), vacuum cleaner is 55-65dB (A), location close to a main road or highway is 70-80 dB (A), pop music concerts is 100-110 dB (A), while sound at 130dB (A) will cause pain.<sup>38, 39</sup>

Currently Health Canada does not have enforceable noise guidelines or thresholds,<sup>36</sup> but guideline sound thresholds have been proposed by the Environmental Protection Agency (EPA), and the World Health Organization (WHO). Most urban policies and provincial suggestions regarding sound exposure follow the EPA or WHO recommendations.

In 1974, the EPA established that the upper limit outdoor noise levels which adversely affect health and welfare are at 70dB (A) over a 24-hour exposure (for example, to avoid hearing loss). For constant sound exposure, 55dB (A) outdoors and 45dB (A) indoors were set as upper limits to prevent activity interference and annoyance.<sup>40</sup> Since then, the WHO has also suggested that outdoor environmental noise should not exceed 45dB (A) and 50dB (A) for daytime and nighttime periods to prevent a potential psychosocial effects.<sup>35, 40, 41</sup>



**TABLE 3: Upper Limit Threshold Guidelines for Noise Exposure<sup>35,36,38</sup>**

Health effect	Threshold/Guidelines
<b>Annoyance*</b>	
Moderate annoyance, outdoor living area	50 L <sub>Aeq</sub> , 16 h <sup>35</sup>
Serious annoyance, outdoor living area	55 L <sub>Aeq</sub> , 16 h <sup>35</sup>
Annoyance, school playground	55 L <sub>Aeq</sub> , 16 h (During Play) <sup>35</sup>
Annoyance, difference between baseline and project	>6.5% difference in % HA <sup>36</sup>
<b>Sleep Disturbance</b>	
Sleep pattern	<60 L <sub>Aeq</sub> , 8hr (23:00-07:00hr) <sup>38</sup>
Subjective sleep quality	40 L <sub>Aeq</sub> , 8hr (23:00-07:00hr) <sup>38</sup>
Mood next day	<60 L <sub>Aeq</sub> , 8hr (23:00-07:00hr) <sup>38</sup>
Increased average movement when sleeping	42 L <sub>Aeq</sub> , 8hr (23:00-07:00hr) <sup>35</sup>
Self-reported sleep disturbance	42 L <sub>Aeq</sub> , 8hr (23:00-07:00hr) <sup>35</sup>
Use of sleep aid drugs and sedatives	40 L <sub>Aeq</sub> , 8hr (23:00-07:00hr) <sup>35</sup>
Environmental insomnia	42 L <sub>Aeq</sub> , 8hr (23:00-07:00hr) <sup>35</sup>
Sleep disturbance, outside bedrooms	45 L <sub>Aeq</sub> , 8hr (23:00-07:00hr) <sup>35</sup>
Sleep disturbance, night noise guidelines	40 L <sub>Aeq</sub> , 8hr(23:00-07:00hr) <sup>35</sup>
Sleep disturbance, interim target	55 L <sub>Aeq</sub> , 8hr (23:00-07:00hr) <sup>35</sup>

\*Annoyance defined as: feeling of resentment, displeasure, discomfort, dissatisfaction, or offense when noise interferes with someone's thoughts, feelings or actual activities.<sup>35,36,38</sup>

### ***Common Sound Decibels found in an Urban Setting***

Now that we know what the upper limit sound exposure guidelines are, it is important to answer the question: What are the sound levels currently in an urban landscape?

McAlexander et al. measured the variations in noise levels on the street at 60 locations across different times of the day in Manhattan, New York. These areas were chosen to reflect regions of low, medium and high street-level noise. Although variations varied between boroughs, time of day, traffic level and nearby conditions, the majority of noise measurements were >70dB (A) of ongoing sounds. When there were additional sounds like emergency vehicles (sirens), or ongoing construction, sound levels were in excess of 80dB (A). Overall, it was found that more than 90% of the chosen areas exceeded the recommended exposure limits, therefore these levels have the potential to cause auditory and non-auditory health effects.<sup>33</sup>

Brown et al. also assessed noise pollution in Hong Kong. Hong Kong has one of the world's highest population densities with the most of the population living in high rise buildings, including buildings of 50 storeys or more, surrounded by high intensities of road traffic.<sup>43</sup>

In Canada, the guidelines have only been established around occupational exposure limits. To give you an idea of occupational limits, here are the levels of noise allowed:

**TABLE 4: Upper Level Exposure Limits in an Occupational Setting<sup>42</sup>**

	Continuous Noise		Impulse/Impact Noise	
	Maximum Permitted Exposure Level for 8 Hours: dB(A)	Exchange Rate dB(A) +	Maximum Peak Pressure Level dB(peak)	Exchange Rate dB(A) +
<b>Canada (Federal)</b>	87	3	-	-
<b>British Columbia</b>	85	3	140	-
<b>Alberta</b>	85	3	-	-
<b>Saskatchewan</b>	85	3	-	-
<b>Manitoba</b>	85	3	-	-
<b>Ontario</b>	85	3	-	-
<b>Quebec</b>	90	5	140	100
<b>New Brunswick</b>	85	3	140	-
<b>Nova Scotia</b>	85	3	-	-
<b>Prince Edward Island</b>	85	3	-	-
<b>Newfoundland and Labrador</b>	85	3	-	-
<b>Northwest Territories</b>	85	5	140	100
<b>Nunavut</b>	85	3 or 5	140	-
<b>Yukon Territories</b>	85	3	140	90

Exchange Rate: as sound increases, the time exposure allowed decreases. Therefore for every 3dB(A) increase, the allowed time exposure is halved. For example, one would be allowed to be exposed to a 90dB(A) for a 4-hour exposure time according to the Federal Jurisdiction.

In 10,077 dwellings, the daytime sound exposure was found to be between 30-80dB with a mean of 58.5dB, and median of 59dB. Nighttime noise exposure ranged from 42-69dB.<sup>44</sup>

There is no city in Canada that can compare to the urban landscapes of New York and Hong Kong, however the bigger cities are moving in this direction. For example, in 2013, the City of Toronto had done a noise assessment in downtown Toronto to assess the potential health impacts of the proposed Billy Bishop Airport expansion.

The results of their assessment are found in the table below. The current calculated noise levels that exist in downtown Toronto in wards 14, 18, 19, 20, 27, 28, 30 and 32 are listed in Table 5:

**TABLE 5: Health Impact Assessment. Proposed Expansion to Billy Bishop Toronto City Airport.<sup>45</sup>**

LOCATION	Evaluation of Annoyance (Daytime Exposure)		Evaluation of Sleep Disturbance (Nighttime Exposure)	
	L <sub>day</sub> (dBA)	L <sub>day</sub> with Airport close by	L <sub>night</sub> (dBA)	L <sub>night</sub> (dBA) with airport close by
<b>2m Elevation</b>				
Stadium road	55	61	46	51
Toronto Music Garden	64	65	55	56
Harbour Square	58	59	49	50
Ward's Island	47	51	39	41
Harbour Side Co-op Homes	61	62	51	52
Windward Co-op Homes	56	62	47	52
Little Norway Park	57	62	48	52
<b>15m Elevation</b>				
Stadium road	57	64	49	53
Toronto Music Garden	67	67	58	58
Harbour Square	60	61	51	52
Ward's Island	48	52	39	41
Harbour Side Co-op Homes	58	63	50	53
Windward Co-op Homes	60	62	50	52
Little Norway Park	60	64	51	54
<b>70m Elevation</b>				
Stadium road	62	65	53	55
Toronto Music Garden	72	72	64	64
Harbour Square	65	65	56	56
Ward's Island	48	51	40	41
Harbour Side Co-op Homes	69	69	60	61
Windward Co-op Homes	64	66	56	57
Little Norway Park	66	67	58	58

Likely to Cause Annoyance

Likely to Cause Sleep Disturbance

### Impact of Noise on our Health

#### Impact of Noise on Sleep

The impacts of noise on health has mainly been studied in laboratory settings which mimic exposure to noises caused by aircrafts, railways and road traffic. What has been found is that the main health burden of noise is annoyance and sleep disturbance.<sup>46,47</sup> Annoyance refers to the feeling of resentment, displeasure, discomfort, dissatisfaction or offense when noise interferes with someone's thoughts, feelings or actual activities.<sup>35,36,38</sup>

Humans recognize, evaluate and react to environmental sounds even while asleep.<sup>48</sup> While asleep, chronic low grade noise particularly affects the autonomic nervous system (ANS). One non-invasive way to measure ANS function is through heart rate variability (HRV).

Sim et al. investigated the effects of different types of noise on the ANS by measuring HRV pre and post noise exposure to background traffic, speech, and mixed noise (~50dB(A)) in resting adults. HRV before and after low frequency sounds increased HRV indicating a higher sympathetic nervous system arousal with acute noise level.<sup>49</sup> By having a higher sympathetic activation during noise exposure, the body reacts to handle this stressor. For example, a person experiences increased heart rate, blood pressure, disrupted restorative power of sleep, awakenings/arousals, less deep sleep and rapid eye movement sleep, early awakenings in the morning.<sup>35,49,50</sup> Consequently, sleep disruption can have negative effects on waking psychomotor performance, memory consolidation, poor work or school performance and increased risk of accidents.<sup>35</sup>

Many studies have also demonstrated a dose-response relationship between noise exposure and sleep disruption. Bodin et al. studied the impact of how different levels of exposure affected sleep and noise annoyance; and whether having access to a quiet side (bedroom faces green space versus the road) affected sleep and noise annoyance. What they found was that there was a positive relationship between combined noise exposure (road traffic and railway noise) and self-reported poor sleep quality for each 5dB (A) increase. They also found that approximately 50% of those with no access to a quiet side were annoyed at noise levels of 50-54dB (A), while those that had windows facing a green space did not reach annoyance until >60dB (A). Having a bedroom towards a green space was associated with lower risk of poor sleep quality (p=0.048). However the benefit of having a window face a green space did not make a difference in overall sleep disturbance.<sup>51</sup>

#### Effect of Noise on Cardiovascular Health

Many studies have also demonstrated the effects of noise exposure on cardiovascular health. These studies have demonstrated noise exposure can increase blood pressure, heart rate and increase the risk of hypertension, ischemic heart disease and myocardial infarction (MI).<sup>52-56</sup>

From a cellular perspective overnight noise exposure can negatively impact blood vessel function. Schmidt et al. investigated the impact of overnight airport noise on endothelial function and morning

plasma adrenaline levels. Schmidt et al., exposed men and women to nighttime noise in the form of a recording of the same aircraft noise. The first aircraft noise was played back after 39.5 minutes to facilitate sleep onset, and the last aircraft noise was played at 415 minutes. The overall groups were Control (noise exposure of 49.6 dB (A)), Noise 30 (noise exposure of 59.9 dB (A)), and Noise 60 (noise exposure of 50.9 dB (A)). What Schmidt et al found was a dose-dependent decrease in minimum PTT after noise nights, which had a trend of mirroring changes in systolic blood pressure ( $p=0.11$ ). With increasing number of noise events, subjects reported a greater deterioration in sleep quality ( $p=0.001$ ). Specifically with venous function, they saw flow mediated dilation of the endothelial tissue was blunted in a dose dependent manner to noise exposure ( $p=0.02$ ). Therefore the more severe the noise, the greater the endothelial dysfunction (blood vessel constriction). A marked increase in plasma adrenaline concentrations were also seen between control and noise groups ( $p=0.0099$ ).<sup>52</sup>

Fuks et al. conducted population based, prospective cohort study in a highly urbanized Ruhr area in western Germany with a total of 4,814 men and women 45-75 years of age. They wanted to investigate how long term exposure to urban background particulate matter and traffic noise on blood pressure and hypertension in a population-based sample. They found a trend that residential proximity to high road traffic was linked to elevated systolic and diastolic blood pressure with higher point estimates and linear trend in subjects living close to heavy-duty traffic. Long-term road traffic noise exposure >60dB at the residence was linked to higher blood pressure.<sup>53</sup>

Lastly, Babisch et al. studied the risk of road traffic noise and incidence of myocardial infarction in a hospital-based case control study in Berlin. With each patient, outdoor traffic noise was determined via noise maps of the city. They found specifically in male subjects who lived in the streets with an average noise exposure during the day of more than 70dB (A) had an increased risk of MI compared to those who lived in the street with levels less than or equal to 60 dB (A). Once again a dose response relationship was seen where higher risk was seen with increasing traffic noise. Noise levels of 65-70dB (A) outdoors have been considered to have adverse health effects of noise.<sup>35,36</sup> No higher MI risk was found in women with respect to traffic noise level.<sup>56</sup>

Overall, noise pollution from an urban landscape can range anywhere between 55-70dB(A) and with Canadian urbanization, these noise levels will most likely increase and eventually reach levels similar to Netherlands, Sweden, New York and Hong Kong. At these levels noise impacts our ANS first, which contributes to our sleep disturbance and cardiovascular risk.

Below is a summary of nighttime noise exposure ranges and health effects in those limits provided by the WHO.<sup>35</sup>

**TABLE 6: Nighttime Noise Exposure ranges and Health Impact**

L <sub>night</sub> , outside (time 23:00-07:00)	L <sub>night</sub> , outside (time 23:00-07:00)
<30 dB(A)	<ul style="list-style-type: none"> <li>Individual sensitivities</li> <li>No substantial biological effects are observed</li> </ul>
30-40 dB(A)	<ul style="list-style-type: none"> <li>Increased: body movements, awakenings, self-reported sleep disturbance and arousals.</li> <li>Intensity of effects depends on nature, source of, and number of events.</li> <li>Vulnerable groups are more susceptible</li> <li>Biological effects are modest</li> </ul>
40-55 dB(A)	<ul style="list-style-type: none"> <li>Adverse health effects are observed</li> <li>Must adapt lifestyle to cope with noise at night</li> <li>Vulnerable groups more severely affected</li> </ul>
>55 dB(A)	<ul style="list-style-type: none"> <li>Situation is considered increasingly dangerous for public health</li> <li>Adverse health effects occur frequently</li> <li>Sizable proportion of population is highly annoyed and sleep disturbed.</li> <li>Cardiovascular risk increases.</li> </ul>

### Finding a Solution: What we can do to mitigate the harmful effects of our environment

We have all learned about the concept of nature cure and more studies are confirming the importance of “green living spaces” in an urban environment. Kaplan et al. emphasized the importance of having access to urban nature: nearby trees, opportunities for gardening and places for taking walks, for the well-being of urban residents.<sup>57</sup> Gidlof-Gunnarsson et al. found that green-area availability also moderates a resident’s noise response. They found that when residents have “better” availability to green areas in an urban environment, fewer of them perceive noise as a neighborhood problem, have less annoyance with traffic noise, were more likely to walk and exercise in their neighbourhood, and experienced less stress related psychosocial symptoms (feeling “stressed,” “tired,” or “irritated/angry”).<sup>58</sup>

In terms of prevention of the negative health impact of noise exposure, we as naturopathic doctors can assist patients in implementing several relevant lifestyle changes, which include:

**1. Address the Autonomic Nervous System:** Focus on maintaining homeostasis in the ANS with your modality of choice. By implementing botanical medicines, acupuncture, nutritional changes in combination with self-care practices of breathing, mindfulness, or meditation, we can ultimately modulate the stress response to sound exposure and assist the body in regulating its circadian rhythm, neuroendocrine, and hormonal systems.

**2. Focus on Nature Cure:** educating about the importance of incorporating components of urban nature in all parts of our environment, from the office, to our homes, green rooftops and more. Nature overall contributes to restorative processes. Restorative

environments (specifically natural ones) provide relief and help individuals recover from cognitive mental fatigue when the information process or attentional capacity has been overused. Natural environments are important for recovery or recharging of this capacity.

**3. Address dietary and lifestyle concerns as obstacles to the healing process:** Vitamin C supplementation has been shown to negate endothelial dysfunction that occurs with noise exposure.<sup>52</sup> A diet rich in fruits and vegetables can provide a natural source of antioxidants, flavonoids, and phytonutrients to offset the oxidative stress associated with noise pollution.

## Conclusion

With a global shift towards urbanization from the developed to developing worlds, we cannot help but be exposed to increased levels of light and noise pollution. As naturopathic doctors we can empower and educate our patients on what the sources of these pollutants are, how they affect our body and how to mitigate the health impacts. 🌱

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