SleepSound: Charting the Nighttime Soundscape and Sleep Quality in Hong Kong through Machine Listening and AI-supported Information Design

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ABSTRACT

Sleep is an essential part of health. One factor that affects sleep quality is soundscape, the acoustic environment as perceived. In the *SleepSound* project, we aim to collect field data and harness machine listening for an AI-supported assessment of soundscape quality for healthy sleep. Why is this important? Our initial literature review reveals that there is little known about Hong Kong's domestic acoustic environment and practically no research has been published on people's perception of their own nighttime soundscape, or how it may affect sleep. A case in point is the Noise Control Ordinance (1989), which regulates noise from e.g. construction sites but leaves much of neighbourhood environments open to interpretation. Without a deeper understanding of soundscape, solving inevitable conflicts might be left to arbitrary judgements. Given this situation, our project aims to develop methods to chart the nighttime soundscape and its impact on sleep. Restorative sleep is important for everyone and crucial for vulnerable individuals e.g. with a medical condition. The present research project builds on our recent study in a nighttime hospital ward, where patients wore sleep trackers to detect disturbances, and soundscape audio was captured. *SleepSound* will venture further by focusing on the context of domestic bedrooms for normally healthy residents in Hong Kong.

1. INTRODUCTION

SleepSound aims to investigate sleep and soundscape within domestic bedrooms in Hong Kong, to determine how sleep quality is impacted by specific sound sources As illustrated in **Figure 1**, our approach is to collect objective data with a custom Field Kit (**Section 4**), including actigraphy sleep tracking, binaural audio recording, and data logs of ambient temperature, humidity, and lighting in two surveys (N ≈ 80 over 3 nights; and N ≈ 24 over 14 nights) with pre- and post-onsite interviews to grasp individual and cultural differences. We analyse multivariate time series using a pre-trained audio neural network and develop an AI-supported prediction model, with sleep tracking logs and machine listening recordings as input for a joint assessment of soundscape and sleep quality. Finally, we outline a proof-of-concept that presents users with actionable information. Going beyond snoring detection, the app will collect individualised data, analysing all prevalent sound types that may cause annoyance and sleep disturbance in the user's environment. Field data, AI modelling, and information design generated by the project will serve research in soundscape, sleep, environmental psychology, and urban studies. It will prepare the ground for future applications in urban and interior design, nursing, and precision medicine, helping to improve quality of life.

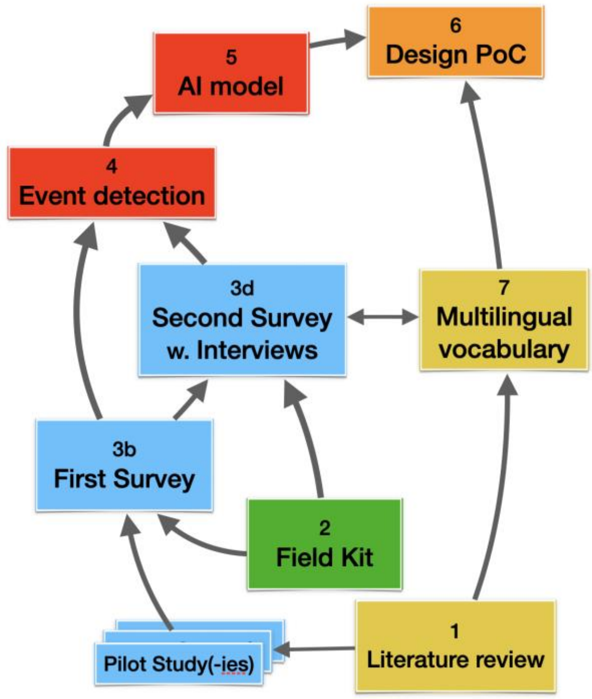

Figure 1. Overview of *SleepSound*.

2. BACKGROUND

2.1 Sleep

Good sleep is an essential component of people's health and quality of life (Banks & Dinges 2007; Chang et al. 2020). Even occasional disturbance by noise affects performance and mood (Bonnet 1985; Schulte-Fortkamp & Fiebig 2023 Section 1.3.4). Sleep problems are a major public health concern because of the negative impacts on physical and mental health (Ford et al. 2015) compounded with social and economic costs (Streatfeild et al. 2021). Notwithstanding, there is no broad consensus for what sleep quality really is. A meta-study evaluated research into environmental factors in the bedroom environment for healthy subjects using objective measurement methods (Xu & Lian 2022); however, other researchers emphasise that subjective factors must be included (Sancho-Domingo et al. 2021; Byusse et al. 1988, p. 194). Somewhat surprisingly, sleep quality might be unrelated to quantity (Fabbri et al. 2021) as there might be health issues associated with both too little (Grandner et al. 2010) and too much sleep (Jike et al. 2018). Humans display individual and culturally conditioned patterns of activity (circadian rhythm, chronotype; Cheung, Li, et al. 2023). Sleep disorders such as insomnia and apnea are core symptoms of many illnesses, including depression and generalised anxiety, which are associated with high economic and social cost (Streatfeild et al. 2021).

In Hong Kong, one study found that 39% of residents suffer from insomnia, with higher rates amongst women, and significant associations with joblessness and long-term illnesses (Wong & Fielding 2011). These rates are worryingly high by international comparison (Helsestart 2024). A study on circadian rhythms amongst patients in Hong Kong identified a dramatic lowering of physical activity during COVID-19 which adversely affected health and quality of life. The authors argued that strong community resilience would make these effects temporary (Lee et al. 2021), though it is unclear if this has come true.

Since sleep is a complex and important matter of everyone's life, it is to be expected that sleep research is a large and interdisciplinary field. Any single researcher or group would have to focus on one aspect, and thereby, aim to make a valuable contribution. Sleep quality is impacted by physical environment factors such as area and residential type (Lai et al. 2009), lighting, smell, and thermal comfort (Lan et al. 2017), and noise (EEA 2021; Smith et al. 2022; Xu & Lian 2022). Moreover, it is mediated by individual differences including genetic factors (Barclay et al. 2011), lifestyle, coping ability (Andringa 2010; Payne 2013), and auditory tolerance to noise (Fong et al. 2018; Lindborg & Friberg 2016). In the present Project we focus on *soundscape*.

2.2 Noise in Hong Kong

The quality of the acoustic environment influences our ability for core affect regulation and attention restoration (Andringa 2010) and memory reactivation and consolidation (Carbone & Diekelmann 2024). Environmental noise has a large impact on public health (EEA 2021) and in densely populated Hong Kong the situation might be dire. A noise exposure survey in 203 domestic residences found an average noise level of 63.1 dBA (To et al. 2015; we have calculated this level as the dB-averaged LAeq1h across the 20 areas in the study). As evidenced in a 2023 media report: "Noise pollution is a major problem…If it is not construction noise - rock hammers and drills - then multi-storey living brings its own cacophony of annoying sounds, including neighbours… piano playing about five times a day… vacuuming at 1 am" (Knott 2023).

The Noise Control Ordinance (NCO 1989) covers a range of issues. Regulations for noise-sources from construction sites, percussive piling (NCO Sections 6–8/A), alarms (Section 13A/B), or transport (Section 27) detail technical measures such as acceptable noise levels (e.g LAeq) that hinge on a 'noise sensitive receiver', e.g. resident or business in the closest vicinity (Environmental Protection Agency; EPA 2024/08). Rules are stricter for nighttime noises "causing annoyance to any person…11 pm to 7 am, or on a general holiday" (NCO Section 4). By contrast, NCO is vague about annoyance caused by domestic activities in the 'general neighbourhood' (EPA 2024/03), While recognising potentially disturbing sounds, including "any musical or other instrument… loud-speaker, megaphone… amplifying sound…any game or pastime… trade or business… air-conditioning… animal or bird" (NCO Part II Section 5), specifications about limits are absent from regulatory control, because the "*nature of the noise sources* [makes it] *not possible to specify fixed acceptable noise levels* or noise measurement procedures to be used in *assessing the acceptability of the noise*… noise from domestic premises and public places is to be *responsively dealt with* by the [local] Police on a *reasonableness approach*." (EPA 2024/08, Concise Guide, p. 2; our italics).

By contrast, we argue that recent advances in machine learning and artificial intelligence, outlined in **Section 2.4**, provide requisite tools to develop descriptors and measurement procedures that support a better assessment of soundscape quality in nighttime domestic premises. Our approach *does not replace* the 'reasonableness' that NCO requires of the Police, but *supports* it. It is a main goal with the Project to generate knowledge to enable human-centric design to promote better nighttime soundscape quality in residential areas and to bring NCO (1989) closer to international standards on noise annoyance (ISO 15666 2021).

2.3 Soundscape and health

Soundscape is "the acoustic environment as perceived or experienced and/or understood by a person or people" (ISO 12913-1 2018; Schafer 1977), embracing e.g. public outdoor spaces (Aletta & Kang 2018; Lenzi et al. 2021), indoor commercial spaces (Lindborg 2015, 2016), hospitals (Lenzi et al. 2024). See also the Frontiers Research Topic on *Human perception of environmental sound* (Aletta et al. 2022). The international standard for soundscape types (ISO 12913-2 2018) is based on concepts advanced by Schafer, Truax, Westerkamp, and others (Schafer 1977; Schulte-Fortkamp & Fiebig 2023).

While the negative impact of noise on health is well known, and noise levels have increased in hospitals over the past five decades (Busch-Vishniac & Ryherd 2019), the concept of *soundscape for health* (Lercher & Dzhambov 2023) might still raise eyebrows. Health aspects affected by environmental noise include hearing problems, stress, and cardiovascular health (Teixeira et al. 2021). In previous research, the first author of the present paper showed that levels of everyday-ish acoustic environments significantly affect the autonomic nervous system (Lindborg 2013). Responses are specific to the environment (Lindborg 2016) because of interactions with expectation (Payne 2013) and individual differences such as personality dimensions and noise sensitivity (Lindborg & Friberg 2016; Fong et al. 2018).

Soundscape has a natural affinity with environmental psychology. Increasingly, acoustic measurements, e.g. sound pressure level (SPL, LAeq), are complemented by perceptual ratings of qualities such as pleasantness, eventfulness, calmness, and vibrancy (Axelsson et al. 2010; ISO 12913-2 2018; Aletta & Kang 2018). By default, people understand *sound as evidence of action* (Schafer 1977), which implies that a context-dependent, robust taxonomy of constituent sound sources is crucial (e.g. Lindborg 2016; Lenzi et al. 2024).

2.4 AI model design

Machine listening (Parker & Dockray 2023) is a concept developed from machine learning (artificial intelligence, deep neural networks) for speech and music applications, and more recently, also applied to soundscape. A pre-trained audio neural network (PANN; Kong et al. 2020) can detect and classify sound events when trained on specific sound types, including those found in domestic environments (Mesaros et al. 2016). Related research produced Google's AudioSet with millions of YouTube clips classified in hundreds of sound types (Gemmeke et al. 2017). Annoyance can be predicted from individual sound sources (Mitchell et al. 2022; cf. Lindborg 2016), which via the attention mechanism in a Transformer network (Vaswani et al. 2017) yields both classification and annoyance estimation (Hou et al. 2023). Our model will explore cross-attention to achieve joint source classification and sleep disturbance prediction (**Figure 2**). In our approach, the propensity for differing sound sources to lead to sleep disturbance can thus be captured and modelled. Affective qualities and contextual factors contribute, via perceptual ratings of sound sources and ambient data logs, to the assessment of environmental quality. The main target is the precise identification of sounds that cause sleep disturbance, and by combining sleep data, soundscape descriptors, and individual differences, create an AI-supported model, which leads to a proof-of-concept application for Hong Kong residents (EMDesk & Futuro 2024).

2.5 Related research

<u>**Nighttime hospital soundscape.**</u> The first and second authors recently published a study on the perceived quality of a nighttime hospital soundscape (Lenzi et al. 2024), investigating the relationship between sound, annoyance, and sleep quality in a multi-patient neurology ward using a mixed-methods approach. Interviews were conducted with nurses (n = 7) to understand their experiences with sound. Questionnaires and Fitbit sleep tracking devices (n = 20) assessed patient sleep quality, and listeners (n = 28) annotated 429 nighttime audio recordings to identify over 9,200 sound events with associated annoyance. Results show that while snoring dominated the nighttime soundscape, staff-generated sounds such as speech and footsteps contributed more to accumulated annoyance due to their extended duration. Our results suggest that patient sleep quality can be improved by focusing on design interventions that reduce the impact of specific sounds.

<u>**Urban soundscape**</u>**.** The first and second authors examined the soundscape of a city plaza in the Basque Country as it changed during shifting Covid-19 social restrictions (Lenzi et al. 2021). We collected daily soundscape recordings and other data over three months, and experts (n = 23) annotated sound sources and associated qualities. Descriptors (rated and computationally extracted) such as acoustic richness, loudness, and prevalence of natural, vocal, and technological sounds, gave evidence to how new social regulations obliged people to adapt and reshape their social activities, for example by reducing the use of motor vehicles and spending more time outdoors.

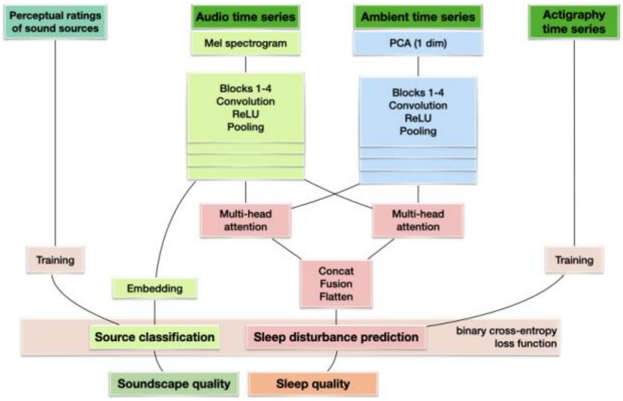

Figure 2. Model architecture (draft). Dual-branch convolutional neural network with cross-attention-based fusion (DCNN-CaF); after Hou et al. (2023).

3. RESEARCH QUESTIONS

Our proposed research on sleep and soundscape in Hong Kong is complex in that it involves all the senses. Sleep disturbances may result from external or internal factors, or a combination. External factors are due to nature (temperature, humidity, odour), machinery and human activities (light and noise pollution), and sleeping arrangement (e.g. single/couple). Internal factors are due to individual differences: sex, age, and health condition; personality traits and sensitivity to stressors such as physical comfort, light, and noise. Time patterns might evolve in circadian (~24 h), infradian (e.g. weekday/weekend, menstrual cycle), and seasonal (yearly) cycles. Our literature review indicates that there is not enough known about the nighttime soundscape in Hong Kong, and that the Noise Control Ordinance is clearly lacking in regards to domestic environments. Soundscape research offers powerful tools for understanding the influence of environmental factors on people's health and quality of life (Chang et al. 2020; Schulte-Fortkamp & Fiebig 2023). To research sleep and soundscape in Hong Kong, the proposed Project adopts a multimethodology, combining appropriate quantitative and qualitative methods (Mitchell et al. 2020; Ibáñez et al. 2018; Xu & Lian 2022). We aim to answer the following questions.

- *What characterises Hong Kong's nighttime soundscape? What are the sounds and sources, and by what actions and interactions are they generated?*
- *Under which conditions and by how much do specific sound types cause annoyance and sleep disturbance for Hong Kong residents?*
- *How can we algorithmically model soundscape impact on sleep quality, considering individual differences?*
- *What is an appropriate vocabulary, in Cantonese, English, and Mandarin, to characterise soundscape and sleep quality in domestic environments in Hong Kong?*
- *What design should an application interface have to inform lay users about soundscape quality and its impact on their sleep, and empower them with actionable information?*

4. METHODS

The 'Field Kit' (**Figure 3**) will contain sensor devices for sleep tracking (actigraphy, see **Section 4.2**), audio recording (binaural), and ambient logging (digital sensors), connected to a single-board computer (Raspberry Pi) running custom software (Puredata, Python; see Pisano & Lindborg 2024 in review), and equipped with a small user interface screen for participants to retain control of data collection. We will construct and deploy eight (8x) kits in two field data collection surveys. Note that since the design implies a fairly invasive procedure, in particular audio recordings in people's bedrooms, it is crucial to resolve ethical and privacy concerns at an early stage. As for population sampling, we control for age, gender, single/couple bedroom, and type of residential area.

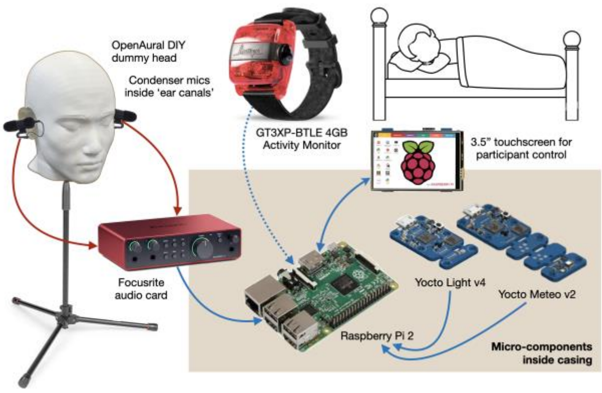

Figure 3. *Field Kit overview*. Digital and physical components, with cable connections to single-board microcomputer. Red = XLR audio. Blue = USB data. Dotted blue = Bluetooth.

In the First Survey, we measure sleep quality, soundscape quality, and participant profile in a larger group of participants (target is N = 80), over 3 consecutive nights. Participants wear sleep trackers while audio recordings are made automatically. They respond to questionnaires about sound types and soundscape quality in each evening, and perceived sleep quality each morning. Finally, they self-report demographic and other information. In the Second Survey with Interviews, we work with a smaller number of participants (N = 24) volunteering from the preceding survey. In addition to actigraphy and automatic audio recordings during up to 14 nights, participants make perceptual measurements every other evening and morning, and keep a sleep diary. This will capture granular time series data for patterns of weekday/weekend and to some extent weather. The researchers will brief the participants throughout the survey to keep their motivation up. We conduct on-site semi-structured interviews before Night 1 and after Night 14 to gain in-depth understanding of issues related to their bedroom soundscape quality and sleep.

4.1 Soundscape quality

Audio recordings. Following best soundscape practices (Mitchell et al. 2020), we will make stereo audio recordings using binaural techniques to capture the bedroom's acoustic environment. Two microphones will be inserted into a *binaural dummy head* (O'Connor & Kennedy 2021; Kennedy 2020). Note that current analysis and modelling (e.g. Hou et al. 2023) typically uses mono audio; however, stereo (binaural, Ambisonics) provides richer information and flexibility (Mitchell et al. 2020).

Ambient data logging. We select digital devices for data logging of temperature, humidity, and lighting conditions in the participant's bedroom (cf. Xu & Lian 2022, Sections 3.1.4 and 3.2.4), using an open-source approach (https://www.yoctoproject.org/).

Acoustic and psychoacoustic descriptors. Sound pressure level and room reverberation will be measured on-site by the researchers when setting up equipment using calibrated equipment (IEC 60942: 2017; cf. Lindborg 2015). Acoustic indicators (LAeq, LCeq, and Ldos[night]) and psychoacoustic (Loudness [Nx], Sharpness, Roughness) will be extracted computationally from binaural audio recordings (ISO 12913:3 2019, Section D).

Soundscape perceptual qualities (subjective, quantitative) ratings on semantic scales of sound type and qualia such as [ISO]Pleasant, [ISO]Eventful, calm, vibrancy, and more (Axelsson et al. 2010; ISO/TS 12913-2:2018; Lindborg 2015, 2016). We will develop a field ratings protocol based on our experience and best practices (Mitchell et al. 2020), in particular employing scales to measure to what extent participants perceive that specific sound sources and events may have affected their sleep (as in Lenzi et al. 2024, Section 3.1.1). In analysis, perceptual ratings will be integrated with objective measurements from actigraphy and audio recordings (ISO 12913:3 2019).

4.2 Sleep quality

Sleep tracking (objective, quantitative). Actigraphy is a non-invasive method to monitor sleep as well as circadian patterns of rest and activity. A wrist-worn device can capture high resolution raw data and validated descriptors of sleep architecture (e.g. sleep time, efficiency, falling-asleep latency, fragmentation index). Actigraphy shows excellent agreement with polysomnography, the 'gold standard' (Corlateanu et al. 2017; Xu & Lian 2022), and for field data collection has a distinct advantage in that it does not alter the individual's usual sleep patterns (Landry et al. 2015; Chen, Li, et al. 2024). Note also that actigraphy can to some extent be made with accelerometers in smartphones (Langhom et al. 2023).

Self-report (subjective, quantitative). We are developing a protocol suitable for Hong Kong context, to include a *Sleep diary* (qualitative; see overview in Ibáñez et al. 2018, Section 2.3) and *Pittsburgh Sleep Quality Index* (PSGI; (Byusse et al. 1988, p. 209-) in its validated brief version (BPSQI; Sancho-Domingo et al. 2021) to assess perceived sleep quality and to help discriminate between 'good' and 'poor' sleepers.

Interviews (subjective, qualitative) are conducted pre- and post- measurements, and will be semi-structured to grasp individual perspectives, e.g. how participants experience their nighttime sleep environment, events, situations, life stories. Interviews will be conducted onsite (in their domestic premises) by a research assistant speaking Cantonese, English, or Mandarin, as appropriate.

4.3 Participant profile

Self-report (subjective, quantitative). The protocol will gather demographic information (age, sex, gender, occupation, single/couple status, residence; note that Hong Kong areas vary greatly in characteristics, which influences residents' lifestyle and sleep habits (Nag & Pradhan 2021). Furthermore, we determine Chronotype (aka Circadian rhythm type) with the *reduced Morningness/Eveningness Questionnaire* (rMEQ; Adan & Almiral 1991; note the validated Chinese version, e.g. Cheung et al. 2023); Noise sensitivity (Weinstein's index, in Heinonen-Gozunov's revised version; note the related concept of noise tolerance, cf. Fong et al. 2018); and Personality traits, e.g. NEO-P-I (Costa & McCrae 1992) or Ten-Item Personality Index (Gosling et al. 1992; Lindborg & Friberg 2016; Lindborg 2013).

5. PILOT STUDY

We conducted a pilot study in Hong Kong in September-October 2024.

Participants & procedure. Online questionnaire with QuestionPro. Convenience and snowball sampling. After consenting, participants (N = 10) self-rated Circadian Type (CT; estimated with rMEQ), and Sleep Quality (SQ; BPSQI), and measured Acoustic Quality (AQ; LAeq1min, LCeq1min) in their bedroom with an iPhone app, NoiseLab-Lite.

Results. Participants: age mean 27, range 21…31 years; 8 female; all students; no hearing problem. SQ: mean 0.65, range 0.53…0.73 (scale 0…1: higher is better quality). CT: 4 morning, 6 evening. AQ: 5 low, 5 high noise level.

Analysis. We conducted linear regression with Sleep Quality as outcome. A parsimonious model (adj. R^2 = 0.83) was found with AQ as significant predictor (ß = -0.47, p = 0.011*), i.e. higher noise level was associated with lower sleep quality; and a significant interaction between AQ and CT (ß = -0.81, p = 0.001**), i.e. for Evening types this effect was stronger.

Sound Types, The participants named 25 sounds in total, which were interpreted in four categories (ISO 13912:2 2018). Prevalence and mean pleasantness (scale: -2…+2) were: Traffic 28%, -0.57; Other 48%, -1.1; Humans 20%, 0.0; Nature 4%, 1.0. The most common sounds were: air conditioning (36%, -1.1), car (16%, -0.75), home appliances (12%, -1.0), traffic (12%, -0.33), and movement (12%, 0.33).

These results from a small investigation indicated a significant association between higher noise level in participants' bedrooms and lower sleep quality, which was pronounced amongst Evening circadian types, aka 'night owls'. Noise from air conditioning was the most commonly heard, and perceived negatively. A few sound types were positive, such as other people's movement or actions, and nature sounds. Human and nature sound types were more often heard by Morning types, aka 'early birds'.

6. CONCLUSIONS

The *SleepSound* project aims to contribute to public health in Hong Kong and potentially beyond by investigating how the nighttime soundscape affects sleep quality at domestic premises. Good sleep is essential to quality of life, and crucially important for vulnerable citizens e.g. with a medical condition. In this project, we harness machine listening to design an AI-supported assessment of soundscape quality for healthy sleep.

In our preliminary review of the research literature in the field, we have identified a lack of knowledge about Hong Kong's soundscape and its impact on sleep. We must ask: *In what way, and by how much, are the specific sound sources found in local domestic acoustic environments interacting with people's circadian rhythm and sleep quality, given individual differences such as noise tolerance and personality traits, and environmental factors such as weather?* The Noise Control Ordinance (NCO 1989; EPA 2024) regulates noise emission from various sources, such as traffic and construction piling, but leaves the judgement of nuisance in domestic and neighbourhood environments open to interpretation, stating only that it must be 'reasonable'. By contrast, our project takes a data-driven approach that intersects urban studies, public health, and data science. We collect field data, develop a machine listening model, and outline an information design capable of producing a joint assessment of soundscape and sleep quality that pertains to the acoustic and social context.

The first goal is to collect data on sleep and soundscape in Hong Kong in two field surveys using a custom-build Field Kit. The second goal is to analyse time series data to establish associations between specific sound types and sleep disturbance answering central research questions. Thirdly, we will be preparing the next-step development of an application. Looking further ahead, the proof-of-concept and design plans for an integrated digital solution will increase the potential for collaboration with an industrial partner at a real-world, patented, commercial application. We will follow an established pathway towards commercialisation of research such as the stages of Technological Readiness (EMDesk & Perfecto 2024). Our product would be a smartphone application expanded with sensing devices for high-quality sleep tracking and environmental logging. Smartphones can be quite powerful e.g. using movement tracking to predict sleep states in research applications such as *mindLAMP* (Langholm et al. 2023). Our approach goes further by combining actigraphy with environmental sensing, especially sound, for greater depth and precision.

There is potential to involve the general public in citizen science projects on soundscape research for better health. One large-scale application would be to develop an application for a wearable, continuous 24/7 monitoring of sound sources that have an annoying and potentially harmful impact on people in their daily life - at work, children at school, sensitive people with underlying disorders. We believe there is great interest in creating a precise, affordable, and personalised AI-supported solution to help improve soundscape and quality of life.

The ultimate goal with the *SleepSound* project is to empower general audiences by directly addressing some of the underlying physical and environmental issues that impact on health and quality of life in Hong Kong, initially in regards to sleep and the domestic soundscape. The findings and knowledge generated by the Project will inform standardisation processes and policy making in the context of updating and modernising the Noise Control Ordinance, which dates from 1989. In future research we will seek to collaborate with health services in Hong Kong for clinical studies aimed at developing novel approaches for improving the soundscape in hospitals, continuing our research on the nighttime soundscape in convalescence wards (Lenzi et al. 2024). Clinical studies must take into account the interoperability of complex systems, security of patients, confidentiality of data, and standardisation to enable upscaling. Our research will help address the high rates of insomnia in Hong Kong, which may affect other places where people sleep in the same room or unit, such as school/company residency, nursing homes, and Hong Kong's 'subdivided rental units'.

In conclusion, we expect the *SleepSound* project to make significant contributions to understanding soundscape for healthy sleep. Our research will reach well beyond academia to feed public interest in understanding how soundscape affects their sleep; propose ways to mitigate against noise; help resolve noise-related neighbourhood grievances; support future policy development; and create an AI-supported assessment of sleep and environmental quality preparing for a 'SleepSound app'.

The field data collection, and deep analysis of the relationships between soundscape, acoustic and environmental descriptors, and sleep quality in a sample of the population, will provide knowledge for researchers in urban studies, sleep medicine, perception psychology, social sciences, and policy. It will prepare the ground for future applications in urban and interior design, nursing, and personal health. The goal is to help improve quality of life in Hong Kong, and beyond.

Acknowledgments

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