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REVIEW

Exploring links between road traffic noise, air quality and public health using DPSEAA conceptual framework: a review and perspective for a UK environmental health tracking system (EHTS)

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Abstract

There is evidence that hypertensive heart disease is attributed to environmental noise and air pollution in European regions. Epidemiological studies have also demonstrated the potential role of road traffic air–noise pollution in adverse health outcomes, including cardiovascular diseases such as hypertension. Despite the local implementation of the EU Directive on environmental noise and air quality, it is necessary to explore the progress and understand the impact of policy, legislation and the collection of exposure and associated health data for air and noise pollution in order to improve environmental public health. Therefore, the DPSEEA (Driving force, Pressure, State, Exposure, Effect and Action) conceptual framework model was used to systematically map and review these links and to identify relevant indicators linking air–noise pollution with cardiovascular diseases. With a focus on the EU and specifically UK situation, we critically evaluate the effectiveness of evidence-based policy implementation of action plans, summarizing existing data using modified framework model tools. We concluded that, the DPSEEA conceptual framework provides an effective review method to more effectively, conduct data surveillance monitoring and assessment, and tracking outcomes with different types of evidence in the field of environmental public health. There is great scope demonstrating the use of the DPSEEA conceptual framework to highlight the casual relationship between exposure and effects taking into account other factors such as driving force, pressure, state, exposure and action and to incorporate as surveillance information in the environmental health tracking system (EHTS).

Keywords Environmental noise · Air quality · Environmental policy · Transportation · Public health · Cardiovascular diseases · Hypertension · UK legislation

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1 Introduction

The European Environmental Agency (EEA) and the Environmental Noise in Europe (ENE, 2020) identified that urbanization, economic development activities (e.g. transport development of road lanes, increase in traffic and high construction and extension of cities) were the main drivers for the increase in environmental noise in 2020. The most common type of environmental noise among other sources is road traffic noise.

According to statutory requirements (Barnes et al., 2018b), the UK Government leads on the UK's input to International and European legislation relating to air quality, with input from the Scottish Government, and the other devolved administrations. Linking to the requirements of the EU Directives, the latest Air Quality Strategy published in July 2007 (DEFRA, 2007) established the framework for air quality improvements across the UK. Measures agreed at the national and international level are the foundations on which the strategy is based. The strategy sets out the Air Quality Standards and Objectives which have been set to benchmark air quality in terms of protecting human health and the environment. However, air quality is a devolved matter within the UK, with the Scottish Government having responsibility for the development of air quality policy and legislation for Scotland and other regions with similar responsibilities.

Emissions of nitrogen dioxide, carbon monoxide, and particulate matter (PM10 and PM2.5) emissions from road transport have fallen by 77% (4.5 million tonnes, 16,000 tonnes and 17,000 tonnes, respectively) between 1990 and 2017, but high levels of pollution still exist (Jones et al., 2019). Following more strict exhaust emission standards, emissions of numerous pollutants that are particularly harmful to human health (such as carbon monoxide, particulate matter, and nitrogen oxides) have decreased. As the UK strives to achieve net zero emissions by 2050, reducing emissions from road transportation remains a serious problem; as of the end of 2018, 0.5% of all vehicles permitted in the UK were ultra-low emission vehicles. From 255 billion miles driven on British roads in 1990 to 328 billion miles in 2018, there was a 29% rise. Due to newer vehicles' higher fuel efficiency, the total amount of fuel used for road transport in the UK remained largely consistent between 1990 and 2017. While gasoline consumption decreased throughout this time, diesel use climbed.

An individual and combined effect of noise and air pollution has been studied internationally through epidemiological analysis (Tétreault et al., 2013). Sørensen et al. (2014) showed that there were combined effects of air and noise pollution on human health resulting in increased risk of stroke. Studies have also shown that air and noise pollution has effects on cognitive functioning among children (Van Kempen et al., 2012). In other parts of the world, studies on noise and air pollution have shown that these exposures can increase the risk of viral infection due to a decreased immune system (Hjortebjerg et al., 2018).

Road traffic noise and air pollution generate considerable interest due to increase in economic and social activities in most cities that are densely populated, especially the urban areas of the UK (EEA, 2006). The transport sector is the largest source of noise and air emissions in urban environments. A Study from the UK have shown that urban areas are polluted by high frequency of noise in association with air pollution and that high car traffic volumes correlate positively with high frequency noise and air pollution, especially at night-time (Adza et al., 2023). Environmental noise from road traffic is also the target of many campaign groups in UK due to the relative air emissions and road traffic noise and air pollution have a strong correlation (Davies et al., 2009).

Despite the potential adverse effects of noise and air pollution on health, it is anticipated that the next decade will see increase transport of vehicle with passengers more than 8.3 billion affecting remarkable features of Great Britain in both residential area and commercial/business districts (TSGB, 2019).

It is significant to acknowledge the caveat on the increase in transportation and passengers as COVID restrictions has change peoples' habits and work practices.

The association between environmental noise and air pollution needs to be assessed to allow reliable action planning if threshold limits are exceeded (Murphy et al., 2010; Beattie et al., 2015). In New York, a study conducted on the association of noise level and constituent air pollutants showed that noise threshold limit was exceeded. The constituent air pollutant includes nitrogen oxides and particle pollution (also known as particulate matter). There was an association between traffic, noise, and air pollution from combustion between intraurban areas suggesting confounding evidence impacting on epidemiological studies of health-related traffic issues (Kheirbek et al., 2014).

According to ENE (2020), potential adverse effects of noise pollution include annoyance, sleep disturbance, cardiovascular disease and cognitive impairment. Studies on road traffic and environmental noise have reported an association with auditory and wider health impacts such as hearing loss and cardiovascular-related events such as myocardial infarction, hypertension, stroke and heart failure (ENE, 2020).

It has been suggested that the risk of cardiovascular disease (CVD) in European regions may be related to environmental noise and air pollution. According to British Heart Foundation (Scarborough et al., 2011), CVD is simply defined as all diseases affecting the heart and blood vessels found in the cardiovascular system. Potential and established risk factors for CVD include age, family history, smoking and physical inactivity (Scarborough et al., 2011). Evidence testing the relationship between noise, air pollution and hypertension is limited (Van Kempen et al., 2012, Gan et al., 2012, Tétreault et al., 2013; Floud et al., 2013 and Clark, 2015), but interest in this area for the UK has increased recently (Carey et al., 2016, Shin et al., 2020 and Adza et al., 2022).

According to the World Health Organization, the devolved regional Governments in the UK have implemented directives of the European Union (EU) for environmental noise and air quality (WHO, 2011). These have resulted in noise maps to meet required response to the European Parliament and Council Directive for Assessment and Management of Environmental Noise 2002/49/EC, more commonly referred to as the END (King et al., 2016).

Despite the direct association of environmental noise and air pollution and until the introduction of the Environmental Protection Act 1990 and Environmental Noise Directive (END) 1990 (Sands et al., 1991; Haigh, 1992), there were few concerns in the UK relating to road noise and air pollution (Foraster, 2013). However, this has changed in recent years and studies on their combined effects have been initiated (WHO, 2018). Some cohort studies in the UK have used the distance to major roads as a surrogate for exposure to air pollutants in relationship to cardiovascular health impact (Cai et al., 2017, 2018). Other studies have also used spatial and temporal distributions to investigate associations of road traffic noise and air pollution with cardiovascular outcomes (De Kluizenaar et al., 2013; Fecht et al., 2016). However, a research gap exists between the association of road traffic noise and air pollution with hypertension and other cardiovascular outcomes in the UK (Beelen et al., 2009), even though cohort studies are ongoing in European countries to assess issues related to traffic noise and air pollution exposures. Both road traffic noise and air pollution may be associated with hypertensive heart disease, but mechanisms may differ (Babisch et al., 2014; Pitchika et al., 2017; Fuks et al., 2017; Sears et al., 2018). Understanding the association between these pollutants and their joint effects on human health is essential for developing population-based policies for further improving health outcomes (Fecht et al., 2016). This can be explored by evaluating associations between modelled noise and air pollutants using different spatial units and area characteristics. However, results from epidemiological studies with respect to the joint cause–effect association are rare.

The public health evaluation framework models available in the literature that provide the opportunity to address the joint associations of road traffic noise and air pollution with hypertension are evaluated. Through a systematic literature review, the implementation and policy integration and assessment of progress on selected issues of the joint cause–effect relationships between road traffic noise and air quality and implications for public health, particularly in relation to the UK and its devolved nations. The aim and objective of the study were to determine the suitability of the conceptual framework as well as demonstrating the application of the conceptual framework for an environmental health tracking system (EHTS) for UK. Considering that the paper is centred on selecting a conceptual framework for EHTS in the UK, the paper would benefit from introducing what is a conceptual framework and why it is important to have one for an EHTS. A conceptual framework for the development of an EHTS relevant to the UK.

A conceptual framework model for environmental health tracking gives a systematic procedure that aids in the collection of factors and to examine issues linked to actual or predicted environmental health relationships (Edokpolo et al., 2019; Eisenberg et al., 2007; Frank et al., 2019; Harwell et al., 2019; Kyle et al., 2006; McGeehin et al., 2004). Furthermore, conceptual frameworks can join separate monitoring plan of action and assist development of new indicators, policies, legislation and plan of action (Niemeijer et al., 2008; Eriksson et al., 2017). Most common evaluations of conceptual frameworks were found to focus on five approaches: Driving Force-Pressure-State Exposure-Effect-Action (DPSEEA), Pressure-State-Response (PSR), Force-Pressure-State-Impact-Response (DPSIR), Multiple Exposures Multiple Effects (MEME) and Integrated Environmental Health Impact Assessment (IEHIA). Consequently, we focused on these conceptual framework models that were examined to fit the content of the literature search terms suitable for reporting environmental and health issues in the UK.

The researcher's synthesis of the literature on how to explain a phenomenon is represented by a conceptual framework. Given his prior knowledge of other researchers' points of view and his observations on the topic of research, it lays out the steps that must be taken during the course of the study (Regoniel et al., 2015). The conceptual framework "sets the scene" for the presentation of the specific research issue that motivates the reportable investigation based on the problem statement. The setting and problems that motivated the researcher to conduct the study are described in the problem statement of a thesis (McGaghie et al., 2001).

Environmental public health tracking (EPHT), according to the UK Health Security Agency (UKHSA), is the use of public health data to assist in the management of threats that are both environmental and other. As part of its specialized responsibilities, EPHT gathers, compiles, and analyses environmental health data to help guide measures aimed at lowering the burden of disease (UKHSA, 2022). One of the key surveillance initiatives of the UKHSA is environmental public health surveillance system (EPHSS). EPHSS development in two stages. A surveillance system for serious environmental incidents is part of the first phase. To report on the surveillance of the nature and amount of environmental health-related occurrences, this acute system connects with already-existing incident management systems, like CIRIS and HPZone.

Initial user needs and design consultations marked the beginning of the second phase. It adds the following to the acute incident surveillance system:broader environmental, exposure, and health databases for chronic events and exposures. This stage aids in investigating connections between environmental exposures and health results (UKHSA, 2022).

Stakeholders prioritized two topics for the needs of intelligence and surveillance data. It is a method that advances knowledge of environmental public health and global health, enhances risk comparisons across geographical regions, promotes openness and trust among citizens, organizations, and the commercial sector, and supports preventative decision-making (Lauriola et al,. 2020). In order to locate, gather, compile, and analyse data intelligence and information on environmental dangers, exposures, and health effects, the system adopts a thorough and systematic strategy (Lauriola et al,. 2020). In this study, selecting a conceptual framework for EHTS in the UK is key to locate, gather, compile, and analyse data intelligence and information on environmental dangers, exposures, and health, the system builds a thorough and systematic methodology.

The established Driving Forces, Pressures, State, Exposures, Health Effects and Actions (DPSEEA) framework can be strengthened with the aid of EPHT (Lauriola et al., 2020). In the context of actual drivers, pressures, and states, EPHT encourages a systematic integration of the aforementioned DPSEEA components, taking into account environmental and health characteristics.

In this study, the DPSEEA conceptual framework (Driving force, Pressure, State, Exposure, Effect and Action) was used as the basis of a review focused on the main environmental health (EH) concerns and related actions in the two policy areas of road traffic noise and air quality (Frumkin, 2016) and extended to include association with hypertension. It summarizes the process of the implementation of an indicator system based on internationally agreed legislation, methodology and comparable data and gives an insight into the development of government action plans for environmental health indicators and the approaches for selecting a common goal. It also reviews the current strategic noise and air quality mapping and monitoring networks in UK identifying challenges of integrating these environmental indicators.

2 Methods

The first phase assessed the development of a conceptual framework for environmental health tracking system (EHTS) (Edokpolo et al., 2019; Kyle et al., 2006) focused on issues of road traffic noise, air quality and public health in the UK.

A viable EHTS in UK will require:

1. Operational potential in the UK.
2. A useable conceptual framework model.
3. Emerging and specific environmental health indicators.
4. A technical operational plan for the system design.
5. Application with available data.
6. Assessment of the outcome.

3 Results

The second phase of our study demonstrated the relationship between air quality, environmental noise and cardiovascular health outcomes. A second phase demonstrated the application of the conceptual framework for an environmental health tracking system (EHTS) for UK. Literature search was undertaken using search terms relevant to education, government, information technology, computing, engineering, environmental science, physical science, health and social science sectors. The databases searched were Barbour Index, EBSCO, SpringerLink, ETHOS, Web of Science, CambridgeCore, Construction Information Service, Emerald, ScienceDirect, Scopus, Henry Stewart Journals, JSTOR, Sage Journal and World-CAT.

The literature search was restricted to the following:

- English language.
- publication in any year.

The search strategy was formulated by combining a series of keywords (the exact structure varied according to the search structure in each database):

‘’road AND traffic AND noise AND air AND pollution AND with AND hypertension”.

The literature search in step one identified 706 articles. Furthermore, the review of article focused on titles and abstracts with two aspects. The reason for exclusion of reports was in two aspects.

• Did the article report on any process that develop and harmonize UK legislation and policy implementation in road traffic noise and air quality in an urban area?

• Did the article report exposure and health data, assessment and joint cause-effect on public health, in the framework of exposure to road traffic air–noise pollution and hypertension action plan in an urban area?

The screening questions with corresponding positive responses from articles were then added to the final sample. As a result, 135 articles were identified as appropriate to include in the review (Fig. 1).

4 Discussion

The requirement of a conceptual framework is that it should have exact link between sources that effectively cause environmental change, and the causes related to effect on health with appropriate intervention put in place. Therefore, it is important to look out for the best conceptual framework component that fits a model for a UK EHTS (Table 1).

The DSPEEA conceptual framework model appears to address the criteria highlighted in the literature review. It covers the ongoing monitoring, integrated data and new data used in developing environmental health indicators. It showed the relationship of environmental exposure and health effects following their determining factors that associate environmental health tracking to public health action. Moreover, it identified intervention points along environmental health causal components and measure impacts of actions taken to improve health (Liu et al., 2012).

It allows the intersection of road traffic noise and air pollution and the link to health impacts. Links and indicators based on environmental health such as the driving force of air–noise pollution and pressure of air–noise pollution on the environment were evaluated. The pressure alters the state of the environment, exposing the population to air–noise pollution leading to adverse effects on human health, and stimulates a response in the form of

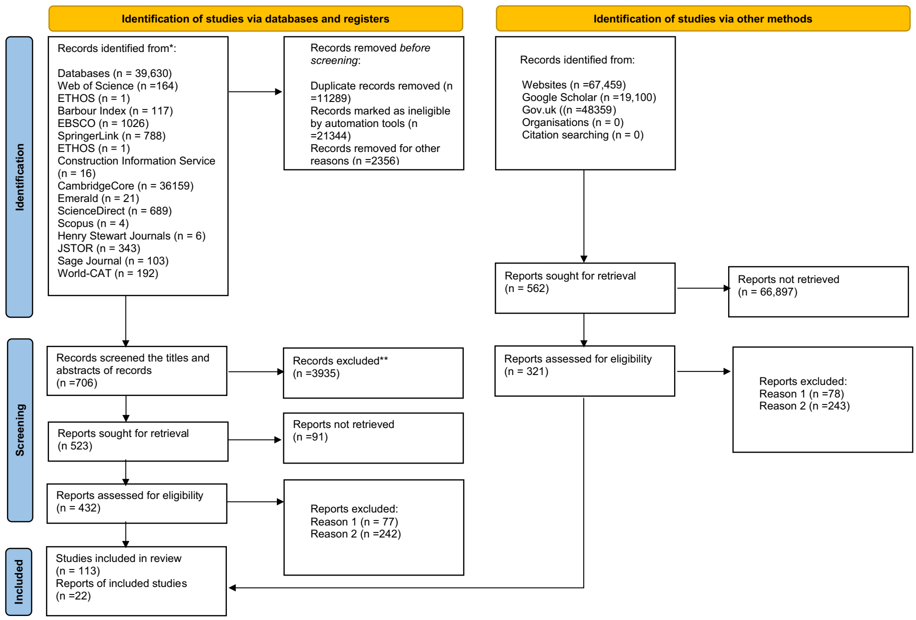

Fig. 1 Flowchart illustrating selections of studies included in this review using PRISMA diagram (Prisma, 2020)

action plan. In 1995, WHO developed the DPSEEA framework to describe the cause–effect linkages between human health and environment (WHO, 1997) as a template to frame a general procedure for analysing environmental problems and related health effects. The DPSEEA model has been modified in various studies to focus on developing adaptive, flexible and innovative approaches that relate to other areas of environmental and public health (WHO, 2004; Morris et al., 2004; Ansare et al., 2009; Liu et al., 2012; Hambling et al., 2011; Reis et al., 2015). The adoption of this framework to address this topic is summarized in Fig. 2.

4.1 Driving force

The driving force for air–noise pollution from traffic is as a result of population density, urbanization, economic growth, social development activities such as private and public transport the development of multiple road lanes, increasing traffic levels and intensive construction and renovation and extension of urban footprints. Due to the increase population across the UK (EEA, 2006), economic drivers have resulted in urbanization incorporating extensive highway systems. More recent evidence suggests that urbanization, economic development activities (industrialization, service sector) and transport are the main drivers for the increase in environmental noise (EEA, 2014; WHO, 2012; ENE, 2020). Between 1990 and 2018, road traffic increased by 29% in the UK due to growth in travel from 255 to 328 billion miles (Department for transportation, 2019).

This has driven a rapid increase in the passenger transport, raising tensions in the urban planning and in Europe has led to the END and Air quality directive. The END imposes on its members the need to present noise maps and more importantly give responsibility to

Table 1 Components of conceptual frameworks linking environment and health (WHO, 2010)

Conceptual Framework	Recommended components of a Conceptual Framework linking environment and health					
	Driving force	Pressure	State/ Hazard	Surveillance Exposure	Effect Impact Health	Action
PSR Pressure-State-Response [Levrel et al., 2009]		√		√		√
DPSIR Force-Pressure-State-Impact-Response [Wei et al., 2009]	√	√	√		√	√
MEME Multiple Exposures Multiple Effects [Change et al., 2015]				√	√	
IEHIA Integrated Environmental Health Impact Assessment [Huynen et al., 2015]	√	√	√		√	√
DPSEEA Driving Force-Pressure-State Exposure-Effect-Action [Chiabai et al., 2018]	√	√	√	√	√	√

local authorities to implement action plans for larger urban areas, major roads, railways and airports, with the aim to reduce the populations' exposure to noise. However, few members completed the second round of noise mapping and presented action plans from agglomerations (EEA, 2014; Environmental Protection, United Kingdom, 2008; DEFRA, 2011).

The UK Air Quality Strategy was implemented due to the EU directive on air quality to improve air quality across its regions through a framework that regulates and preserves the environment and the health of humans (Barnes et al., 2018a), with an increasing number of studies identifying a need to prevent global burden attributed to cardiovascular disease (Lim et al., 2012; Bromfield et al., 2013).

4.2 Pressure

The pressure on the environment drives exposure of the population in different landscapes to hazardous sound levels and concentrations of pollutants. Built environments such as residential developments, workplaces and aggregations into neighbourhoods where noisy activities are sustained for longer than 8 h per day may result in exposure of residents and employees to potentially hazardous noise emissions (Adza et al., 2021).

The increase in gross domestic product, industrialization and passenger transport exerts pressure on the environment. Mattioli et al. (2020) call into question some past assumption that there will be increase in car ownership because of individual increase in gross domestic income. Furthermore, a significant increase in transportation relating to higher frequency and longer distance of trips is expected (Barber, 2012; Krzyżanowski, 2005).

Even though noise and air pollution from cars and trucks has been reduced by more than 85% and 90%, respectively, road traffic noise has not been significantly reduced during the last 15 years (Jones et al., 2019). Therefore, it can be deduced that external cost of noise is not negligible compared to the cost of air pollution (EEA, 2014).

It has long been acknowledged that one of the pressures exerted on environment is change in use of land for the development of transportation systems (Litman (1995). The

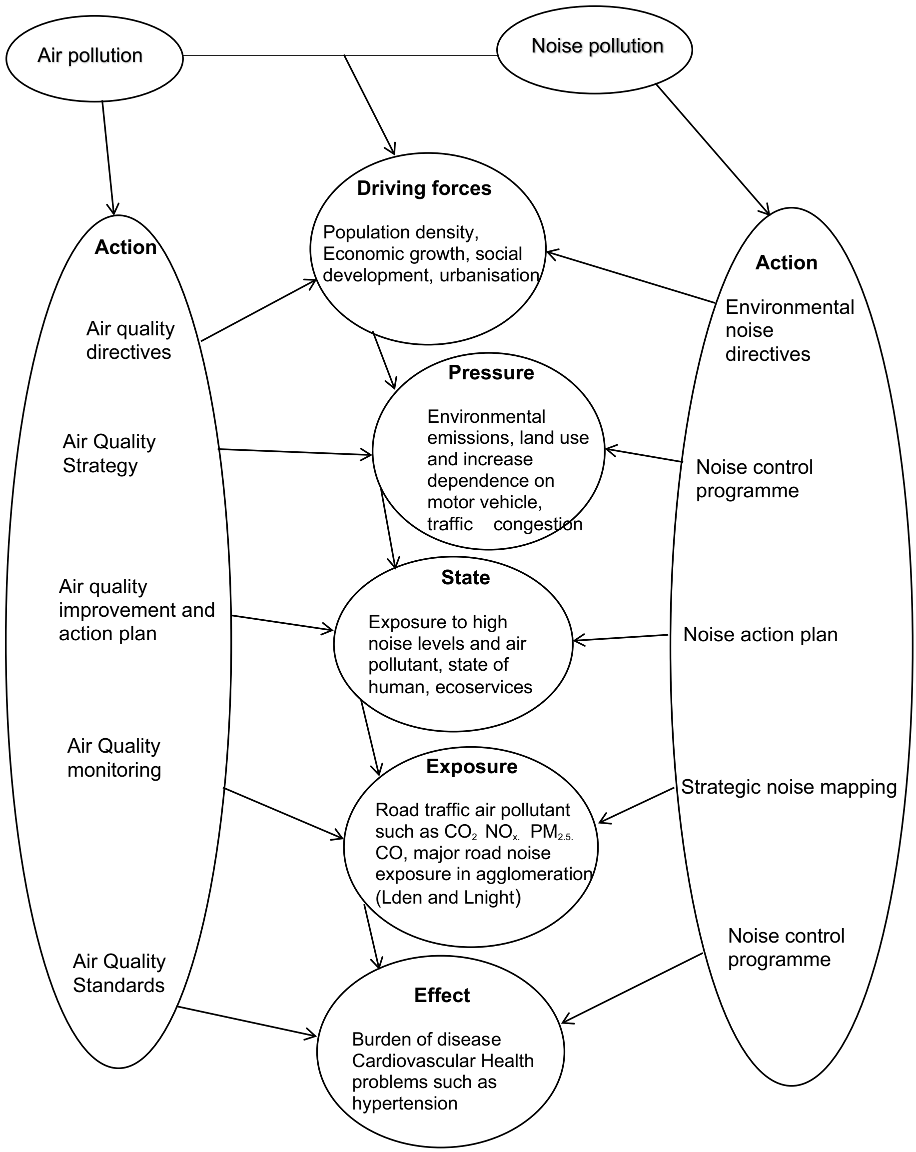

Fig. 2 Modified DPSEEA framework for the assessment of the joint cause–effect relationship between road traffic noise, air pollution and hypertension (Adza et al, 2022)

advances in extent of traffic lanes and high construction levels and the extension of cities result in modification of land use that is typically related to population growth, consequently placing most inhabitants close to road systems and its intrinsically associated air and noise pollution (Kasraian 2016). The proximity to the road network is a direct influence on employment density, land cover and population compared to rail development (Simmonds 2004), and transport infrastructure influences the decisions of residents and industry in several ways.

One of the major drawbacks exerting pressure on the environment is individual human dependency. Human behaviours such as regular use of automobile vehicle for transportation have contributed to personal vulnerability, risk of exposure, and traffic congestion or influence the intensity of environmental pressures. People prefer to be housed close to the roadside for easy movement between town and home (TSGB, 2019). Unfortunately, there is no reduction but rather pressure from the increased concentration of air pollutants in the environment such as greenhouse emissions and particulate matter. The UK government has adopted a clean air strategy (DEFRA, 2019) and air quality plan for nitrogen dioxide in 2017 to examine how it can be reduced.

4.3 State

Both road traffic noise and air pollution have common source from road traffic loads (Environmental noise in Europe, 2020). They occur on the road from the vehicle engine. The traffic noise is caused by noise frequency directly from the vehicle, created by vehicle tyres and the engine (Cohen, 2017). Inadequate regulations governing carrier emissions pollutant from non-exhaust such as vehicle tyre, brake wear and road abrasion can lead to increase in pollution emissions associated with traffic (DfT, 2019).

Air pollution is also caused by emission from the exhaust of vehicle and this emission combining with dust particle to form aerosol (Health Effects Institute (HEI), 2010). The factors influencing vehicle emissions are vehicle features, traffic activities and weather conditions. They include vehicle features (e.g. type of vehicle and fuel, function of the vehicle, vehicle engine, size of vehicle, efficiency of fuel, standards and technology for emission regulation), traffic conditions (e.g. traffic a distance, traffic capacity, average speed of traffic flow, regulation for traffic signal and limit to traffic speed) and weather conditions (wind speed, direction of wind, snow, rainfall, sunlight and temperature of air).

The state of knowledge on road noise exposure and population exposed is reported over a 5-year cycle to the EEA from 2007, 2012 and 2017 by END of the UK government (Jarosińska et al., 2018).

4.4 Exposure

Data reported from strategic noise mapping in the UK in December 2017 on the number of people in agglomerations exposed to noise from roads (Lden and Lnight) in the various regions of the UK are described below.

Figure 3 shows the average number of people in agglomerations in various countries exposed to noise from roads (Lden and LnightM). The data show that, in all the four countries of the UK, the average number of people exposed in the different noise bands was greater during the day than at night.

In Europe and under the Environmental Noise Directive (2002/49/EC), a common framework methodology for measurement of noise exposure was initiated and called the common noise assessment method. This was initiated due to differences in approach to data collection and monitoring techniques across EU member states. It was established to provide knowledge on noise levels and health-related problems of the European citizens so that an action plan and effective preventive measures would be implemented to prevent exposure to hazardous noise level (Kephalopoulos, 2012–2014). In 2017, this took effect, and a third round of strategic noise mapping was implemented, making measurements of noise at a range of frequency (from 125 to 4000 Hz) valid for road traffic. Calculations are performed in octave bands for road traffic. Environmental noise is the effect following an exposure to the frequency or wave of the noise (Brainard et al., 2004).

4.5 Effect

Figure 4 shows the level of air pollutant concentrations, particulate of matter (PM) and greenhouse gases (GHG) of road transport emissions in UK. Data source from the study by Jones et al., 2019 show enormous increase in carbon monoxide in road transport emissions by vehicles in the UK resident basis. The total emissions of GHG in the UK decreased between 1990 and 2017 by 32%. Emission of GHG related to transport in the UK has, however, risen over the same period by 6%. Therefore, in 2019, it was concluded that over 27% of emissions of GHG in UK were related to road transport (National statistics, 2019).

According to the UK Government statistics on air pollution, it is estimated that the life expectancy of every person is reduced by an average of 7–8 months, incurring a related cost of up to £20 billion each year. (EEA, 2014; Ricardo Energy & Environment, 2019). Several financial losses are incurred across regions of the UK due to the burden of disease. For example, over £2 billion is lost due to the current estimate of annual burden attributed to hypertension in England and other regions of the UK have yet to be assessed by the NHS. (EEA, 2014; Ricardo Energy & Environment, 2019). Annual effect due to long-term exposure to air pollution is equal to 28,000 to 36,000 deaths in the UK (COMEAP, 2009; 2010; 2011). A report on costs of air pollution and air quality damage reveals the update on cost damage and effect of pollutants in UK (EEA, 2014; Ricardo Energy & Environment, 2019). Similar studies have been undertaken assessing the cost of environmental noise due to hypertension in the UK (Hardingetal et al., 2013).

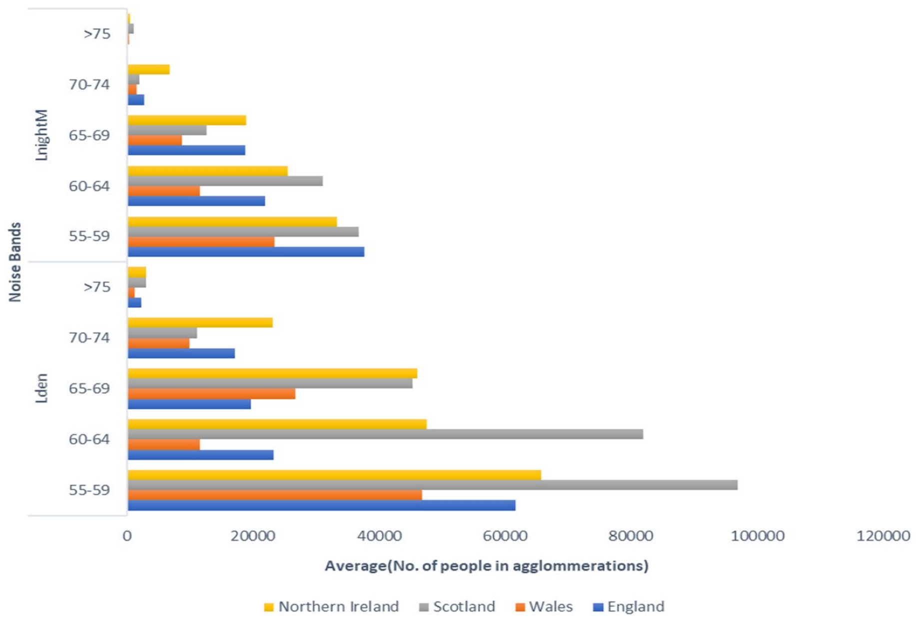

Fig. 3 Average number of people on agglomerations from UK exposed to noise from roads (Lden and Lnight) (Source: Transparency data, 2019)

Studies from the UK on road traffic noise and air pollution and their joint effect on hypertension are not clear. However, hypertension is the third most common disease in the UK according to NHS (Public Health England, 2017). In the UK, data from a health survey on estimation of prevalence of hypertension around areas in England reveal that about 11.8 million adults had hypertension, equating to 22.6% of the population (Hypertension prevalence estimates in England, 2017). Scottish Public Health Observation (ScotPHO, 2020) estimates that the risk of hypertension is high and can lead to major death cases. The prevalence sharply increased from ages 16 years and above in 2019 (ScotPHO, 2020). On the other hand, the prevalence in Wales increased by 15.8% between 2018 and 2019 and is currently the most prevalent morbidity (Quality and Outcomes Framework Statistics for Wales (QOF), 2019). Nonetheless, according to Northern Ireland Quality and outcome framework Statistics (QOF), 2020), the prevalence of hypertension is 14.0%, making it the most prevalent morbidity in Northern Ireland (Table 2).

Unfortunately, low levels of CO, PM10 and PM2.5 emissions still have implications for human health in the UK (DEFRA, 2019).

Ischaemic heart disease, lung cancers, cerebrovascular disease, and chronic obstructive pulmonary disease led to second highest death (YLLs) in UK at national and regional level according to a systematic analysis for the Global Burden of Disease (GDB) 2016 study (Steel et al., 2018). A study by Bromfield et al. (2013) shows that hypertension is a risk factor of most morbidities in the world. Therefore, the impetus to conduct prevention programmes for the world. It is estimated that about 1.6%, 9.8%, 12.6% and premature deaths in the world are caused by hypertensive heart disease (WHO, 2021; WHO, 2017), cerebrovascular disease and ischaemic heart disease, respectively. Worldwide, WHO Global burden of Disease 2013, 2015, 2017 studies have concluded that between 13.5% and 1.4% deaths are attributable to hypertension, but new causes have been added in arterial hypertension (Vox et al., 2020) and to urban air pollution (Bromfield et al., 2013).

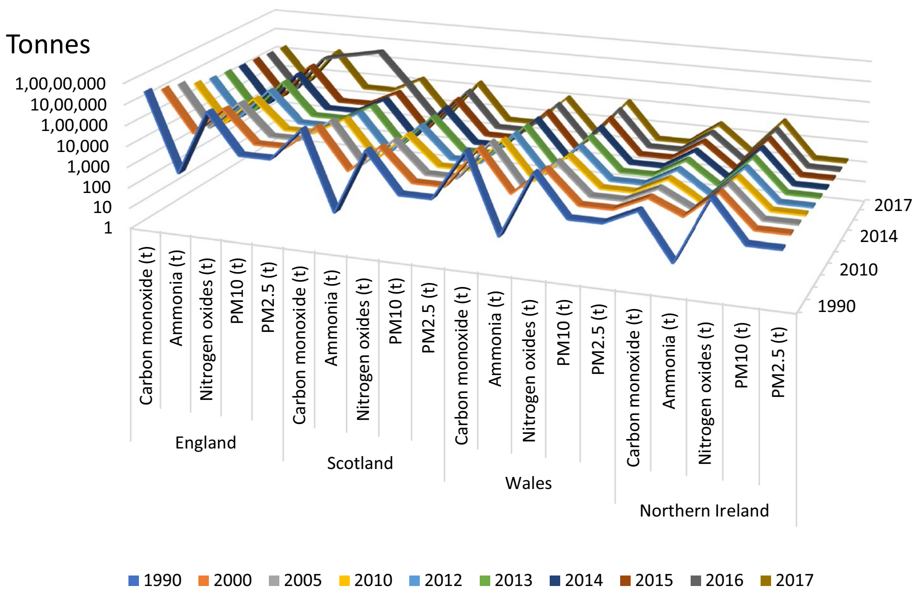

Fig. 4 Total UK Road transport emissions 1990–2017 (Source: Jones et al., 2019)

According to data from END on noise estimation of burden of disease, it is estimated that the DALYs attributable to noise effect on health output were approximately 156,000 years for heart disease for most European countries and the UK (ENE, 2020). The western Europe countries are part of those who experienced the largest DALYs lost from environmental noise, the estimations are 61,000, 45,000, 903,000, 22,000, 654,000 years for ischaemic heart disease, cognitive, impairment of children, sleep disturbance, tinnitus and annoyance, respectively. This makes sleep disturbance and annoyance most of the burden of environmental related to road traffic noise constitute in European countries and the UK. The overall consideration for the burden of disease can range from 1.0–1.6 million DALYs. This connotes that road traffic noise impacts increase every year. Approximately 1 million healthy life years are lost in the western European countries and the UK, including the EU Member States (ENE, 2020). Europe has recorded one of the highest effects following noise pollution. New cases record approximately 48,000 cases of ischaemic heart disease. Unfortunately, 12,000 premature deaths are estimated to be caused by noise in the environment from road traffic, railways, aircraft and industry (ENE, 2020).

Studies carried out in London by Halonen et al. (2015) on association of exposure to road noise with hypertension concluded that there was some association in terms of morbidity in the general population. This was due to long-term exposure effect leading to increased all-cause mortality and adverse cardiovascular outcomes, especially stroke among the elderly group.

Few studies in UK have considered the joint association of road traffic noise and air pollution with health problems. A group of researchers in London have looked at the effect of both road traffic noise and air pollution on foetal growth (Smith et al., 2017). A retrospective cohort study was conducted in Greater London setting and surroundings up to 2317 km2, UK. It included over 540 365 singleton term live births participants, making the research the largest study up to date in UK and the world. The association of the joint effect revealed that there were confounding associations between long-term exposure to traffic-related air pollution but less association attributable to road traffic noise. This means birth weight reduced after long-term exposure to air pollution especially exposure to PM2.5 traffic-exhaust, but no association was found for road traffic noise after adjustment for relevant factors. It was estimated that 3% of term low birth weight (LBW) cases in London were directly attributable to residential exposure to PM2.5 > 13.8 µg/m3 during pregnancy. The authors concluded that air pollution has effect on foetal growth in London but little evidence on the part of road traffic noise (Smith et al., 2017).

It has been suggested that road traffic noise should be considered an independent risk factor for health outcomes separate to that of air pollution as demonstrated in the studies by Smith et al. (2017) and Stansfeld et al. (2015), even though Smith et al. (2017) agree that there is limited evidence on the association between road traffic noise and birth weight.

Table 2 PAF for risk factors for all-cause YLLs rate per 100,000 population for England, Scotland, Wales, and Northern Ireland, both sexes, 2016 (Source: Steel et al., 2018)

Region	Hypertension PAF%	Air pollution PAF%
England	13·04	4·04
Scotland	14·62	3·87
Wales	15·53	3·91
Northern Ireland	14·99	3·58

PAF Population attributable risk fraction. *YLLs* Years of life lost

A narrative review by Stansfeld et al. (2015) assessed the joint association of environmental air–noise pollution with health outcomes such as hypertension, myocardial infarction, stroke, mortality and cognitive. The findings of the review show that after adjustment for air pollution, there were independent effects of environmental noise from road traffic on cardiovascular outcomes. Comparative burden of disease studies also demonstrates that air pollution is the primary environmental cause of DALYs. Environmental noise is ranked second in terms of DALYs in Europe, and the DALYs attributed to noise were more than those attributed to lead, ozone and dioxins (Stansfeld et al., 2015).

4.6 Action

4.6.1 Implementation of policy and legislation for environmental noise in the UK

Various countries have taken initiative to address environmental noise and air quality. There is mitigation measure to tackle cardiovascular health impacts as result of traffic noise and air pollution effect (Curran et al., 2013).

Government of various devolved regions in the UK has made significant steps to enable the relevant EU directives. Studies conducted by the devolved regions of the UK include strategic noise mapping for major roads, rail, airports, and industry agglomeration to check environmental noise for relevant authorities such as transport agencies to make an action plan. Various criteria were used to select the transportation links that were modelled at the major road level. Therefore, the first-round model looked at roads with more than 6,000,000 vehicle passages per year in agglomerations with a population of more than 250,000. The second-round model looked at roads with more than 3,000,000 vehicle passages per year of agglomerations with a population of more than 100,000 (one hundred thousand) and was part of the strategic noise mapping and action planning. The strategic noise maps for END Round 3 (for 2017) were produced using a computer-based prediction methodology, and the outputs can be found on the DEFRA and Noise Mapping website of various government platforms (TNAP, 2019). Strategic noise mapping methodology is based on modelled data and does not directly collect population exposure to noise levels over a range of different frequencies. In addition, the estimation of the relationship between the burden of disease and air and noise pollution has several assumptions and high levels of uncertainty. However, the assessment of road traffic noise at different noise frequency ranges has been evaluated (Kephalopoulos, 2012–2014).

Noise Action plan 2018 to 2023 was suggested by the devolved regions of the UK to deal with major agglomerations. The Glasgow action plan suggests that possible restoration actions of noise management with cost–benefit analysis will be considered from any party that proposes an action plan. Also, the action plan will be tested whether the proposed action will be useful and affordable. Currently, an agreement according to Paris agreement on zero emission vehicles (ZEV) is ongoing through transition council action plan. These action plans are focused beyond 2022 to charging infrastructure, carbon dioxide or fuel efficiency standards and regulations, pace of the transition and technology choices for zero emission heavy duty vehicles and ensure the ZEV transition is truly global (COP26, 2021).

4.6.2 Implementation of policy and legislation for air quality in UK

The EU passed an air quality directive (2008/50/EC), which devolved responses to member states monitor and manage air quality. The EU sets limits of concentrations for ambient (outdoor) air of major air pollutants which became legal agreement binding UK and the EU. The limit was binding to air pollutant which has adverse health effects on human including particulate matter (PM_{10} and $PM_{2.5}$) and nitrogen dioxide (EU Legislation & policy, 2015). The 2008 directive was made law in all regions of UK through the Air Quality Standards Regulations 2010 including integrating the 4th air quality daughter directive (2004/107/EC).

An Air Quality Improvement framework was established across UK linked to the Air Quality Strategy (2007) that was formed in line with requirement of the EU directive. Furthermore, the purpose of the strategy was to enact the Air Quality Standard and objectives to regulate air quality to protect the health of humans. However, air quality in UK is solely the responsibility of individual devolved regions (Barnes et al., 2018a). This in turn identified Air Quality Management Areas with an associated action plan to curb air quality beyond the recommended limit by national, regional and local authorities according to gravity of the air quality issues (AQMA, 2015). The local authorities of Scotland and Northern Ireland and other regions in UK under the Part IV of The Environment Act 1995 enable them to implement air quality action plan. This action plan aims to reduce pollution in an area as part of approach to the strategy objectives at a local level and to achieve air quality limit values.

The local authority is responsible under an AQMA to bring about action plan and arrange how problems will be sorted. Between 2000 and 2002, Air Quality Regulations and Air Quality Amendment Regulations in Scotland were enacted following a tighter objective for carbon monoxide, fine particulate matter and benzene. The strictest objective in UK is the fine particulate matter (PM10) (AQMA, 2015). However, Amendment Regulations on Air Quality (2016) were presented, and Scotland was the first region in the UK to embrace the WHO recommended criteria for PM2.5 fine particulate matter into legislation.

According to the Cleaner Air for Scotland (CAFS, 2016), there were thirty-eight AQMAs in fourteen local authority areas, with two announcing breaches due to emission from transport impacting on nitrogen dioxide and/or PM10. The Scottish Environmental Protection Agency (SEPA) reviews these to enforce strategy and action plans to address air quality targets. In CAFS (2017), 40 actions plans were identified to reduce air pollution. Furthermore, this action has led to targeting the greatest reductions in total constituent pollutant levels. Air quality monitoring has increased as a result and progress on model criteria for regions and major cities have improved as a result of the action being taken. As part of the action, the low emission zone (LEZ) is in progress and operates in all regions in UK especially Scotland and London to curb vehicles that produce more pollution using heavy diesel to become cleaner. Major cities have embraced the approach in UK. In Scotland, LEZ has been introduced in Glasgow (LEZ, 2018) but in London LEZ standard for heavier vehicles came in October 2020 (Tougher LEZ emissions standard) (LEZ, 2018). In 2021, other AQMAs such as (Zero Emission Vehicles Transition Council (ZEVTC)) have been established where such an approach will be supported by evidence (COP26, 2021).

Effort to reduce emission in UK can be transposed into the initiative taken to reach zero emissions (Road to zero strategy, 2018) by 2050. Hence, to target the reduction of emission, 0.5% of all vehicles with ultra-low emission were licensed at the end of 2018. Emissions of nitrogen dioxide, carbon monoxide, and particulate matter (PM10 and PM2.5) from road transport have fallen from 4.5 million tonnes, 16,000 tonnes and 17,000 tonnes, respectively, between 1990, 2002 and 2017 by 77%, (DfT, 2019).

The implementation of the regulations particularly the Euro exhaust emission limits regulation aimed to improve air quality by reducing the emissions of these pollutants (Pastorello et al., 2016). There are various guidelines stipulated by the WHO for UK and other member state for exposure to particulate of matter concentration. According to the guidelines, exposure concentration of PM 2. 5 should not be greater than 10 μg/m^3 or 25 μg/m^3 for annual mean or 24-h mean, respectively.

4.6.3 Air quality network

UK regions have monitoring networks for air pollution. The UK DEFRA handle issues pertaining to air quality management and monitoring. The government of the various regions is responsible for air quality management. Hence, they have website concerning air pollution monitoring which are used as a platform to disseminate information and counsel to adult and children (O'Brien, 2016). Various websites of the regional governments publish daily air quality forecasts, accessible to the public through the internet to report on air pollution in their area. Most of the air quality monitoring website measurements for air pollution are based on hourly limits. The results from air quality network database are single measurement points. Based on the system of banding (COMEAP, 2011), various regions in UK use Daily Air Quality Index for their forecast.

4.6.4 Estimation of a standard for burden of disease

According to WHO, population health can be estimated using disability-adjusted life years lost (DALYs). DALYs were used to estimate global burden of disease (2000–2016) for which the UK happened to be part. The disability weights show the various stages and its relative intensity to be included in a survey of determined population health. There is a different valuation method that is agreed in UK to assess hypertension; however, many countries in the western Europe also use different valuation approaches. The visual analogue scale, the time trade-off technique, and the person trade-off technique are the three valuation methods that were used to measure level of agreement of disability weight (WHO, 2018).

Several financial losses are incurred across regions of UK due to burden of disease. For example, over £2 billion is lost due to the current estimate of annual burden attributable to hypertension in England and other regions in UK are yet to be assessed by the National Health Service (NHS). In response to this environmental health issue, policies and legislation have been laid down to address and further reduce the impact of air pollution. Therefore, an action plan called prevention, detection and management of high blood pressure was developed as an approach to tackle hypertension by the support of group of leaders in both national and local government, health and academia system including the voluntary sector (Tackling High Blood Pressure, 2014). However, in 2017, an update on an additional approach to action plan added a cross-cutting initiative looking at the approaches taken in two or more of the previous action plans (Jamie, 2018).

Results of studies on the association of road traffic noise with hypertension provide a relatively consistent perspective, but studies on the joint association of road traffic noise and air pollution with hypertension are sparse.

This review highlights a lack of direct measurement of exposure data on traffic noise at different frequency ranges in UK. However, ongoing predictive exposure data are computed methodically to determine the environmental noise based on road movement in their regions coherent with the EU Directive 2002/49/EC based on road traffic noise levels and exposed population. This is limited to major roads and urban agglomerations with populations of 100,000 to 250,000. It is evident that data from noise mapping are not extended across the regions and population of UK.

Result from noise calculation is depicted in noise bands of an interval of 5 or 4-dB at L den _ 55 dB (an average of day, evening, and night) and at night (L night) _ 50 dB, but it is hypothesized in this study that different frequency characteristics of traffic noise are appropriate for a forecast of harmful health consequences for the population. They could be useful in delineating areas where noise problem exists and for setting health-related noise limits.

There is a strong guideline stipulated by the WHO for UK and other EU member states for exposure to particulate of matter. According to the guidelines, exposure concentration of PM 2.5 should not be greater than 10 $\mu g/m^3$ or 25 $\mu g/m^3$ for annual mean or 24-h mean, respectively. This is used by various air quality website subregions of UK.

According to the update on monitoring air quality in UK, the daily risk factor of exposure to concentration of pollutant, GHG and particulate of matter risk is reported daily in forecast and neglecting daily monitoring of noise. A single exposure to noise will not cause significant health effect, but the sustained exposure and average noise levels on a regular basis will be important considerations. Noise monitoring network is needed. Therefore, it is important to report daily traffic noise and the daily risk of exposure of road traffic noise.

A joint impact of air and noise pollution can be deductive even though noise has a role in hearing impairment. Noise pollution is the primary environmental cause of DALYs. Furthermore, noise may also be a risk factor for several diseases such as hypertensive heart disease. Therefore, it is expedient to assess the joint cause-effect of air and noise pollution relating to hypertension due to road traffic. However, the joint effect of environmental noise and air pollution is not clear in UK. Data on estimation of comparative burden of disease studies demonstrated in UK point out that air pollution is the primary environmental cause of DALYs (Stansfeld et al., 2015). Environmental noise is ranked second in terms of DALYs in Europe and UK, and the DALYs attributed to noise were more than those attributed to lead, ozone and dioxins (Stansfeld et al., 2015). Therefore, it is suggested that compartmental model may be a more robust approach of describing joint relationship of the burden of hypertension disease that causes the DALYs.

Air and noise pollution from urban road traffic is the most common environmental pollution issues across society. The integration of both aspects with health impacts is missing in public health assessment. Methodologies to assess their synergistic contribution are also lacking.

Challenges such as the constant and persistent increase in nitrogen dioxide, carbon dioxide and particulate of matter emissions at places and around UK along with the merger of air quality and climate change and delivery of a coherent air quality strategy. Air quality monitoring networks look at both short- and long-term limits. Integrating noise measurements needs to consider persistence of "noise scapes" for the exposed population.

Also, a study conducted in Shirdi, India, found that both noise level and air pollution exceeded the recommended limit. The authors recommended that the government should put action plans in place such as facilitating proper management traffic signals properly. Secondly, the government should divert all the traffic for another subway. Thirdly, the government should declare Shirdi city as "No Horn city". Fourthly, the government should put measures in place to control emission of particulate. Finally, they suggested that government should conduct a long-term study on concentrations of particulate matter in the spatial and temporal dimension of various cities due to current development in infrastructures (Kankal et al., 2011).

Night-time noise-related issues such as endothelial dysfunction and arterial hypertension have been proven to occur as a result of high levels of stress hormones and vascular oxidative stress due to noise exposure at night (Schmidt et al., 2013; Münzel, 2018; Herzog et al., 2019).

5 Conclusions

This work has demonstrated that a conceptual framework model can be used to map the review of joint cause–effect relationship of environmental noise and air quality monitoring link to public health in the UK. In conclusion, this work suggests that indicators such as Driving force, Pressure, State, Exposure, Effect and Action (DPSEEA) may be useful for building a conceptual framework model to progress public health assessment, integrating related factors. The review summarizes the process of the implementation of indicator system based on internationally agreed legislation, methodology and comparable data.

We propose an approach to develop understanding of links between air quality, environmental noise and health outcomes. The methodology proposed "EPHT is also a helpful tool for strengthening the established Driving Forces, Pressures, State, Exposures, Health Effects and Actions (DPSEEA) framework. EPHT promotes a systematic integration of the aforementioned DPSEEA components, taking into account both environmental and health parameters, in the context of realistic drivers, pressure and states relevant to the UK. After conducting the literature review, it was very important to get systematic approach to put together the review to relate environmental health in UK. Therefore, it was ideal to develop a conceptual framework for UK environmental health tracking and look out for the best conceptual framework component that fits the model UK EHTS. (WHO, 2010) have various recommended components of conceptual framework linking environment and health. The effectiveness of the proof of concept showed that an EHTS was feasible in UK. The introduction of conceptual framework will advocate strong achievement of the EHTS in UK. There is currently an existing Environmental Public Health Surveillance System (EHPSS) in UK, managed by Public Health England which can adopt the conceptual framework.

The selection of the DSPEEA conceptual framework model using environmental health indicators such as those from assessing the driving force and pressures of air–noise pollution on the environment. This provides the cause–effect relationship of road transport on public health from air pollution and road traffic noise as a joint cause-effect. Therefore, it is recommended that DPSEEA can be used to explore the joint cause-effect of road traffic noise and air quality link to public health for the development of appropriate policy and implementation through legislation.

The evidence from this study suggests that the different frequency ranges of road traffic noise exposure could be used to predict model of hypertension. The effect of hypertension by traffic road noise can be caused by exposure to different traffic noise frequency. Therefore, it recommended to use different ranges of frequency when considering road traffic noise exposure measurement. Different frequency ranges of traffic noise can be computed in studies to regulate confirmed health result such as hypertension.

After the “Brexit” process involving the withdrawal of the UK from the EEA in 2021, agreement did not affect the ongoing measurement and submission of strategic noise mapping (round 3) from 2017 to 2022. The UK government including devolved administrations is determined to go ahead with the 25-year plan proposal to bring about a fresh transition of existing EU law into the UK environmental law enshrining the statutory body which is independent, the Environmental Enforcement, and Audit Office, to check environmental standards and not lower the existing environmental standards (Lee, 2017). This paper has highlighted the need to continue and complete the strategic noise mapping (round 3) considering the impact of the research on the regions of the UK and its importance to public health monitoring for policy implementation.

It has been recognized that the strategic noise mapping and air quality monitoring in response to the Environmental Noise Directive (2002/49/EC) (END) (King et al., 2016) and air quality directive (2008/50/EC), respectively, were carried out. However, the action plan that was carried out in UK took place only in urban areas leading to socioeconomic inequalities. They only consider urban areas for monitoring of noise and air quality. Therefore, it is recommended that monitoring should be extended to other part of the areas in UK, which may be facing serious environmental noise and air pollution public health implications.

Furthermore, the various air quality monitoring network stations used in forecasting air pollution should be supplemented with noise monitoring in various regions of UK to assess the daily risk from environmental noise. Considering that transport and housing are fundamental to daily life worldwide, traffic road air–noise pollution links are one of the categories that is likely to gain relevance soon, given its effects upon human health and economy. The range of noise frequency can be monitored morning, evening and night at urban areas from road traffic noise exposure in communities and made available through the forecast network for individuals in various postcodes where noise is inevitable from road and other related sources of noise. This helps the council and government bodies to set safe standard, policy and legislations to regulate noise and prevent environmental health issues related to noise such as hypertension.

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