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The neglected pollutants: the effects of artificial light and noise on human health

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SUMMARY

Environmental noise and light pollution contribute to a range of adverse health outcomes including heart disease and premature death. Yet light and noise remain neglected pollutants, poorly understood and poorly regulated.

Both noise and light pollution can impact negatively on human health through disrupting sleep and circadian rhythms, which leads to negative social and economic impacts.

Epidemiological evidence suggests that noise pollution can both cause annoyance and increase the risk of stroke and heart disease. Whilst the increased risk to an individual may be low, the exposure of millions of people results in a significant aggregate health burden. The World Health Organization estimates that noise pollution from traffic results in one million healthy life years lost in Western Europe every year; research from the UK Health Security Agency suggests that in 2018, 130,000 healthy life years were lost in the UK and that 40% of the British population are exposed to harmful noise levels from road traffic.

Although there is a growing body of evidence that indicates adverse health impacts of noise and light pollution, there are still significant gaps. In the case of noise pollution, research to fill these gaps should include:

- larger-scale epidemiological studies, supported by laboratory research to determine the mechanisms of harm;
- updating burden-of-disease calculations with emerging evidence;
- new metrics: we do not know the importance of pitch, peak volume and intermittency in terms of health impacts because current metrics are based on average volume of noise over a defined time period such as 24 hours;
- the subjective experience of noise, particularly in indoor environments; and
- the efficacy of interventions to reduce noise pollution on health.

The Government should establish an expert advisory group on noise pollution, as exists for air pollution, to assess new evidence for health effects and advise the Government accordingly.

Despite the common experience that light pollution is getting worse, there is no central UK monitoring of the problem, but rather citizen science and satellite imagery. This makes understanding the sources and impacts of light pollution difficult. More research is needed into measures of exposure to light pollution, especially indoors, to quantify the effects on sleep and health. Research could also usefully be conducted into the positive effects of light on health, for example through light therapy to improve sleep.

Whilst more research is needed to update and refine our understanding, it is already recognised that noise and light pollution must be regulated. But the current Government approach is confused. Noise and light sit uncomfortably under the aegis of pollutants regulated by the Department for Environment, Food and Rural Affairs (DEFRA). The 25 Year Environment Plan briefly mentions noise and light pollution, but with no specific targets and seemingly little impetus from central government to address them.

DEFRA should lead the development of analysis for noise and light pollution in order for the next five-year Environmental Improvement Plan to include specific targets for their reduction, setting an overall framework for regulation. Noise targets should focus on reducing the overall burden of disease with targeted interventions. For light pollution, setting a target will require quantification of the problem—through an agreed methodology—and monitoring. The Government should explain how regulatory and policy action on noise and light pollution will be used to deliver the targets. The five principles for good environmental management set out in the Environment Act 2021 and the Environmental Policy Principles Statement should be applied to the management of light and noise pollution as well.

We welcome DEFRA's new noise pollution mapping tool and improved estimates for exposure, but unless this is followed up by policy action to reduce the impact of noise pollution, it will not result in public health benefits. The Government must use its new model to assess cost-effective interventions to reduce the disease burden from noise. Furthermore, the mapping tool measures only the average volume of noise over a defined time period, such as a whole day, and does not take into account the pitch of the sound or loud peaks of noise that could have a bigger health impact, for instance through sleep disturbance, than the average sound level.

DEFRA has the lead for regulating noise and light pollution, but many of the levers to act on these pollutants lie in other departments, such as the Department for Transport and the Department for Levelling Up, Housing and Communities (DLUHC). DEFRA told us it viewed its role as highlighting problems for other departments to act on, but this is not adequate. The Government must strengthen interdepartmental co-ordination on these issues; it must be clear where within each department responsibility lies.

However, there is further confusion which makes it impossible to know whether regulation is effective. Responsibility for acting on noise and light pollution generally lies with local authorities, which come under DLUHC, and there is no requirement for local authorities to report back to DEFRA on complaints about noise and light pollution and the impact, for example, of the National Noise Policy Statement for England. So even where there is a policy in place, the evidence is not being collected to see whether it is effective. Local authorities are under-resourced and have to balance a range of demands, leading to inconsistent policy implementation between local authorities, with some exemplary while others lag behind. DEFRA and DLUHC need to close the feedback loop between policy ownership and policy impact for noise. In the case of light, we urge the Government to set an overall national policy for light pollution and to provide local authorities with the resources they need to take action in line with national targets. In issuing guidance, the Government can make use of existing work from professional institutions: best practice is already understood, but not always followed.

Light and noise pollution are currently neglected pollutants, but research indicates that they are causing significant health impacts and they are of growing concern to the public. In some cases they are easy to avoid through good design, in other cases investment will be needed. A renewed focus on these pollutants, with strengthened co-ordination between departments and between central and local government, would lead to meaningful improvements in public health and quality of life in the UK.

The neglected pollutants: the effects of artificial light and noise on human health

CHAPTER 1: INTRODUCTION

1. Artificial sources of light and noise are near-ubiquitous in the modern world. When light or noise is unwanted or excessive and impacts the health and well-being of humans and other organisms, they can be referred to as light or noise pollution. These pollutants are regulated in the UK at the local level by local authorities, under policy from the Department for Environment, Food and Rural Affairs (DEFRA).
2. Scientific evidence indicating that these pollutants have an impact on human health has been growing. The World Health Organization published guidelines in 2018 for noise pollution in the European region, building on a review of the scientific literature which concluded that the thresholds for negative health impacts of noise were lower than had previously been thought.¹ Although difficult to quantify using existing satellite technology, light pollution appears to be a growing problem, in part in consequence of the roll-out of LEDs. The Royal Commission on Environmental Pollution in 2009 warned of the effects that artificial light at night could have on ecosystems and the sky at night.² Levels of light in the built environment are thought to have increased, although rigorous measures are absent.
3. This report focuses on the health effects of chronic exposure to environmental light and noise and not on acute occupational exposures which would be regulated by the occupational health and safety authorities. The scope of our inquiry is effects on human health, but we acknowledge that there is also significant evidence for impacts on non-human animals.³ Our report first considers the scientific evidence for these health impacts and then the Government's overall policies on light and noise pollution.
4. We are grateful to all who provided their views in our seminars, committee visit and in oral or written evidence and to Professor Russell Foster, who acted as Specialist Adviser to the committee.

1 World Health Organization, *Environmental noise guidelines for the European Region* (30 January 2019): <https://www.who.int/europe/publications/i/item/9789289053563> [accessed 23 June 2023]

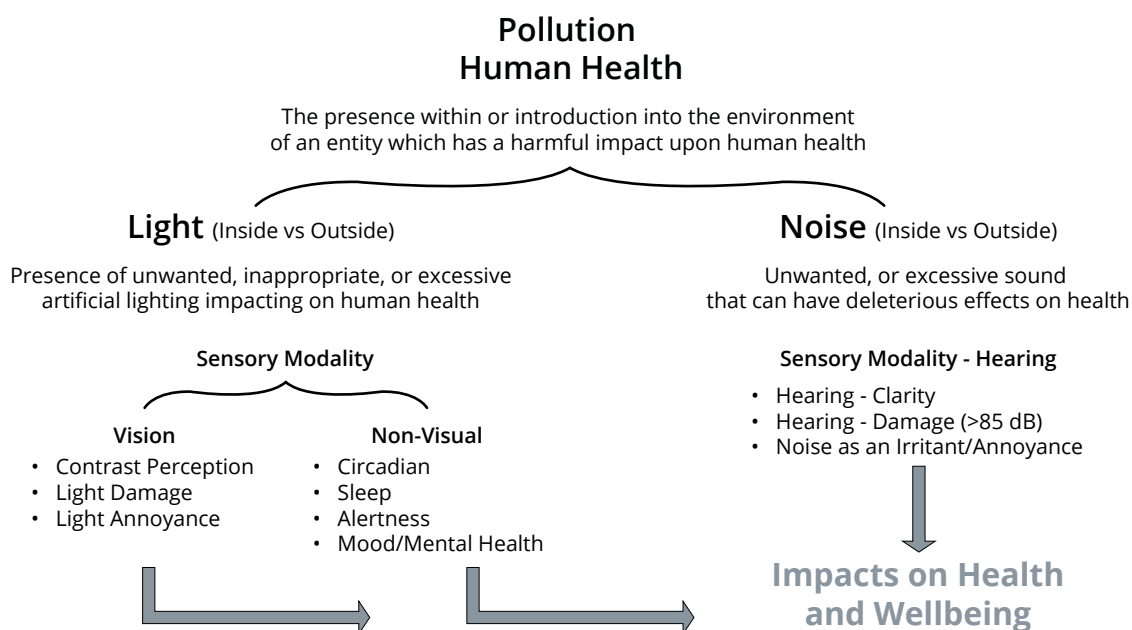
2 The Royal Commission on Environmental Pollution, *Artificial Light in the Environment* (27 November 2009): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/228832/9780108508547.pdf.pdf [accessed 23 June 2023]

3 [Q 144](#) (Rebecca Pow MP); [Q 99](#) (Emma Marrington); and The Royal Commission on Environmental Pollution, *Artificial Light in the Environment* (27 November 2009): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/228832/9780108508547.pdf.pdf included many citations to literature about the impact of artificial light at night on a range of ecosystems. [accessed 23 June 2023]

CHAPTER 2: SCIENTIFIC EVIDENCE OF HEALTH EFFECTS

5. This chapter summarises the scientific research basis for the current understanding of the impacts of artificial light and noise on human health. It outlines the existing literature and some uncertainties that need to be addressed by further research.

Figure 1: Schematic of light and noise pollution impacts on health and wellbeing



Source: Schematic prepared by Professor Russell Foster, outlining definitions of light and noise pollution and some mechanisms by which they can impact health and wellbeing.

Noise

6. 'Noise' generally refers to unwanted sound. Sound is characterised by acoustic properties including pitch and volume. Volume is usually measured in decibels (dB), on a logarithmic scale; when a sound is perceived to double in loudness, this corresponds to an increase of roughly 10 dB, a tenfold increase in power (see Table 1).⁴ Sounds can be continuous or intermittent; the timing and duration of a sound are also relevant to its potential effects on human health.

Table 1: The Decibel Scale

Decibel measure (dB)	Common sound
30	Leaves rustling/whisper
40–50	Average room noise
60	Background music
70	Average office noise
80	Inside an aeroplane or underground carriage

⁴ Sound science for schools and colleges, 'Decibel Scale': <https://salfordacoustics.co.uk/sound-waves/waves-transverse-introduction/decibel-scale> [accessed 23 June 2023]

Decibel measure (dB)	Common sound
90	Hairdryer
110	Nightclub or rock concert
135	Jet engines

Source: Common sounds and their relative volume in decibels. Levels of sound will vary depending on the distance from the source of the sound. Hearing Health Foundation, 'Decibel Levels': <https://hearinghealthfoundation.org/decibel-levels> [accessed 30 June 2023]

Evidence for the health impacts of noise

- In 2018, the World Health Organization (WHO) published environmental noise guidelines for the European region, which were based on systematic reviews of the scientific literature.⁵ Professor Anna Hansell, Professor of Environmental Epidemiology and Director of the Centre for Environmental Health and Sustainability at the University of Leicester, summarised its findings:

“There is obviously good evidence for annoyance and for sleep disturbance. There is now good evidence for impacts on cardiovascular disease; the strongest evidence is on ischaemic heart disease, that is, heart attacks, in relation to road traffic noise. There is some evidence on metabolic impacts, for example diabetes.”⁶

- One method of quantifying the health effects of environmental noise is by estimating the overall disease burden. The WHO and European Environment Agency estimated in 2018 that more than 100 million people were exposed to harmful levels of environmental noise pollution. They estimated that this contributed to “48,000 new cases of heart disease and 12,000 premature deaths every year in Europe. In addition, 22 million people suffer chronic high annoyance, and 6.5 million suffer chronic high sleep disturbance.”⁷ Research from the UK Health Security Agency (UKHSA) suggests that in 2018, 130,000 healthy life years were lost in the UK due to noise pollution; and that 40% of the population were exposed to harmful levels of noise pollution from road traffic.⁸
- The mechanisms behind these health impacts remain a subject of research; we heard that there are multiple pathways by which noise can affect health, summarised by Professor Hansell as “noise annoyance, sleep disturbance, fight or flight reaction, and non-specific stressor.”⁹

5 The systematic reviews were published separately, ‘Special Issue “WHO Noise and Health Evidence Reviews”’, *International Journal of Environmental Research and Public Health*: https://www.mdpi.com/journal/ijerph/special_issues/WHO_reviews [accessed 23 June 2023]

6 Q 6 (Professor Anna Hansell) The harmful level was here defined as the long-term noise exposure level above which a significant increase in negative health effects occur; the WHO’s 2018 review found this threshold to be 55 dB (averaged over a 24-hour cycle) or 50 dB (averaged overnight). World Health Organization, *Environmental noise guidelines for the European Region* (30 January 2019): <https://www.who.int/europe/publications/i/item/9789289053563> [accessed 23 June 2023]

7 European Environment Agency, ‘Health risks caused by environmental noise in Europe’ (14 December 2020): <https://www.eea.europa.eu/publications/health-risks-caused-by-environmental> [accessed 23 June 2023]

8 Calvin Jephcote *et al.*, ‘Spatial assessment of the attributable burden of disease due to transportation noise in England’, *Environment International*, vol. 178 (7 May 2023): <https://www.sciencedirect.com/science/article/pii/S0160412023002398/pdf> [accessed 7 July 2023]

9 Written evidence from Professor Anna Hansell (ALN0092)

Sleep and circadian rhythm disruption

10. Both light and noise can influence health by disrupting circadian rhythms. Professor Kenneth Wright, Director of the Sleep and Chronobiology Laboratory at the University of Colorado Boulder, described negative health effects from circadian rhythm disruption as including “insomnia, prescription of hypnotic drugs in older adults, obesity, type 2 diabetes, heart disease, elevated blood pressure, depression and cancer.”¹⁰ However, Professor Dr Manuel Spitschan, Professor of Chronobiology and Health at the Technical University of Munich, emphasised that “good light exposure [supports] the circadian system”.¹¹
11. Professor Shantha Rajaratnam, Professor of Sleep and Circadian Medicine at Monash University, discussing the effects of artificial light exposure in occupational settings, noted that, while evidence is still building towards scientific recommendations for healthy light exposure, for “particularly vulnerable populations, such as in hospitals, age care settings, and so on, we should make recommendations early”.¹² Night-shift workers are particularly vulnerable owing to the persistent disruption to their circadian rhythms. Professor Rajaratnam said that there was an “urgent need for studies in that area.”¹³
12. We heard of studies which estimate the approximate cost of sleep disruption to economies. One study by the RAND Corporation suggested “that in the UK this is around 1.86% of GDP (\$50 billion/£42 billion).”¹⁴ Some researchers have set up large-scale studies on sleep in the UK, such as the UK Sleep Census, but these are independent research projects rather than public health actions.¹⁵

Emerging evidence for health impacts of noise

13. Some studies have examined possible associations between environmental noise and other health effects. Professor Charlotte Clark, Professor of Epidemiology at St. George’s, University of London, described one such area, noting: “We think that children’s cognition generally is affected, but we do not see it consistently across all the sources”.¹⁶ Owing to the lack of confidence around these emerging health effects, they have not always been included in burden-of-disease calculations.
14. The WHO guidelines included cognitive impairment of children and tinnitus in its burden-of-disease calculations.¹⁷ However, we heard from Professor Hansell that health effects outside those currently included by the WHO had a “much lower weight of evidence, but there are suggestions that there might be impacts outside the cardiovascular system. Some studies have

10 [Q 28](#) (Professor Kenneth Wright)

11 [Q 18](#) (Professor Dr Manual Spitschan)

12 [Q 22](#) (Professor Shantha Rajaratnam)

13 [Q 26](#) (Professor Shantha Rajaratnam)

14 Written evidence from Professor Stuart Peirson, Professor Simon Kyle, Professor Colin Espie, Professor David Ray, Professor Mark Hankins, Professor Aarti Jagannath, Professor Sridhar Vasudevan, Professor Zameel Cader, Professor Vladyslav Vyazovskiy and Professor Russell Foster, University of Oxford ([ALN0074](#))

15 BBC Two Horizon, ‘The UK Sleep Census’: <https://www.bbc.co.uk/programmes/articles/10wh9mPTwTT740bz74MnY33/the-uk-sleep-census> [accessed 11 July 2023]

16 [Q 6](#) (Professor Charlotte Clark)

17 World Health Organization, *Environmental noise guidelines for the European Region* (30 January 2019) p 2: <https://www.who.int/europe/publications/i/item/9789289053563> [accessed 23 June 2023]

looked at cancer, although the findings have been quite inconsistent. A few studies have looked at noise and respiratory disease.”¹⁸

15. We heard that the evidence base for the health effects of environmental noise is growing rapidly. Dr Benjamin Fenech, Noise and Public Health Group Leader at the UKHSA, noted that, although the WHO guidelines were based on evidence published up to 2015, when UKHSA did its own review in 2022 half of the studies used were published in the last five years. This expansion of the evidence base meant that UKHSA felt the need to commission more up-to-date systematic reviews, “to make sure that we are capturing the latest evidence to inform decision-making”.¹⁹
16. **There is increasing epidemiological evidence of the harmful effects of noise on human health. Aggregated over the whole population, even small effects on the individual can be a significant public health concern. New evidence is likely to change the understanding of these effects, for example the role played by intermittency. DEFRA should work with the UK Health Security Agency and other organisations to assess the significant, growing evidence on the health effects of noise. This should include refining existing estimates for the disease burden from well-established health impacts of noise pollution, for example on the cardiovascular system. UKHSA should also assess whether health effects for which evidence is emerging, such as on the metabolic system, meet the evidentiary threshold for policy action.**

Areas for further research

17. The evidence for the negative health impacts of noise is predominantly epidemiological, as laboratory-based studies for population health are difficult to conduct.²⁰ The evidence base consists of plausible biological mechanisms with some laboratory-based studies and epidemiological studies which find a statistical association between exposure and health effects.
18. We heard that this evidence base could be expanded with additional types of study. On laboratory studies, Professor Clark said “it will be a good way to look at the mechanisms in a bit more detail, which is an area that traditionally has not been well researched.”²¹ Professor Hansell acknowledged the limitations of the epidemiological evidence when compared to the evidence for harm from other pollutants, noting “With air pollution, we tend to use much more complex models than we do in noise so far, because ... there are handfuls of studies on noise, compared with the thousands of studies on air pollution.”²²

18 [Q 6](#) (Professor Anna Hansell)

19 [Q 119](#) (Dr Benjamin Fenech) UKHSA sent the Committee examples of recently published epidemiological studies and meta-analyses: Supplementary written evidence from UK Health Security Agency ([ALN0089](#)); and Jing Huang *et al.*, ‘Road Traffic Noise and Incidence of Primary Hypertension: A Prospective Analysis in UK Biobank’, *JACC: Advances*, vol. 2, Issue 2, 100262 (31 March 2023): <https://www.sciencedirect.com/science/article/pii/S2772963X23000169> [accessed 23 June 2023]

20 Written evidence from Professor Anna Hansell ([ALN0092](#)) Professor Hansell’s written evidence includes more detail on the statistical methods used in epidemiology for noise pollution.

21 [Q 8](#) (Professor Charlotte Clark)

22 [Q 11](#) (Professor Anna Hansell)

19. One of the main ways by which noise affects health is through annoyance.²³ Annoyance generally rises with noise level, but also depends on the type of noise, with differing results found for aircraft, road and railway noise.²⁴ Dr Antonio Torija Martínez, Reader in Acoustic Engineering at the University of Salford, noted that “high-frequency or high-pitched sounds are perceived to be more annoying.”²⁵ Annoyance does not depend only on the properties of the sound but can also depend on one’s noise tolerance.²⁶
20. Annoyance is also influenced by non-acoustic factors. Professor Clark said that “sound accounts for only a small proportion of the annoyance we measure”, with non-acoustic factors including “your age, your biological sex, if it is airport noise your attitude to the airport”.²⁷ Dr Torija Martínez said perhaps as little as “30% of noise annoyance [is] related to acoustic factors”,²⁸ but more research is needed “to account for non-acoustic factors”.²⁹ Dr Fenech said “non-acoustic factors have a big role to play in improving health outcomes.”³⁰
21. The standard metrics used for measuring exposure to environmental noise involve averaging the noise levels over time.³¹ However, intermittent loud noises, with a high peak volume, might have different health impacts compared with a more constant, average, quieter noise. Professor Clark described Swiss studies that have defined metrics for intermittency and which found that the degree of intermittency of noise can explain differences in annoyance reactions.³²
22. Dr Fenech mentioned the “need [for] research using different noise exposure metrics” due to the limitations of long-term exposure metrics currently in use.³³ Asked whether DEFRA’s noise modelling included intermittency, Dr Bill Parish, Deputy Director for Air Quality and Industrial Emissions at

23 [Q 3](#) (Professor Charlotte Clark) ‘Annoyance’ is a term of art defined by a specific technical standard. ISO/TS 15666:2021, ‘Acoustics—Assessment of noise annoyance by means of social and socio-acoustic surveys, Abstract’ (May 2021): <https://www.iso.org/standard/74048.html> [accessed 23 June 2023]

24 [Q 3](#) (Professor Charlotte Clark)

25 [Q 3](#) (Dr Antonio Torija Martínez)

26 [Q 3](#) (Professor Anna Hansell)

27 [QQ 3, 5](#) (Professor Charlotte Clark)

28 [Q 7](#) (Dr Antonio Torija Martínez)—this figure specifically related to a study about aircraft noise.

29 [Q 3](#) (Dr Antonio Torija Martínez)

30 [Q 121](#) (Dr Benjamin Fenech)

31 Metrics include L_{eq} which is the hypothetical steady sound which contains the same sound energy as the variable sound over a defined measurement period. This is widespread in its use as a metric for traffic or aircraft noise. Other variants include L_{den} , which weights noise events as more severe if they occur in the evening or at night. Environmental Research and Consultancy Department and Civil Aviation Authority, *Metrics for Aircraft Noise* (January 2009): <https://publicapps.caa.co.uk/docs/33/ERCD0904.pdf> [accessed 23 June 2023]. Professor Hansell described the limitations of these metrics in her written evidence, stating: “Metrics in common use were developed in relation to annoyance and sleep e.g. L_{den} and LDN, often available as annual averages. In fact, noise at different times of day, number of noisy events (N60), divergence of a noise event from background levels (Intermittency Ratio) may be better metrics for health. As may frequency and vibration (not commonly measured).” Supplementary written evidence from Professor Anna Hansell ([ALN0092](#))

32 [Q 3](#) (Professor Charlotte Clark) A description of the SIRENE study; SwissTPH, ‘SiRENE—Short and Long Term Effects of Transportation Noise Exposure’: <https://www.swisstph.ch/en/projects/project-detail/project/sirene-short-and-long-term-effects-of-transportation-noise-exposure>; and Mark Brink *et al.*, ‘A survey on exposure-response relationships for road, rail, and aircraft noise annoyance: Differences between continuous and intermittent noise’, *Environment International*, vol. 125 (16 January 2019) pp 277–290: http://www.sirene-studie.ch/pdf/Brink_2019_A%20survey%20on%20exposure-response%20relationships.pdf [accessed 23 June 2023]

33 [Q 121](#) (Dr Benjamin Fenech)

DEFRA, confirmed it did not, and said “We will need to develop how we apply a more sophisticated approach to those scenarios.”³⁴

23. Witnesses were asked what kinds of studies should be conducted to improve the evidence base for the impacts of environmental noise on health. Areas mentioned included:
- Additional studies of railway and neighbour noise³⁵
 - Large-scale longitudinal epidemiological studies³⁶
 - Experimental and quasi-experimental (natural experiment) studies³⁷
 - Studies into the impacts of noise on mental health.³⁸
24. There are also limitations in understanding of indoor noise exposure; Professor Hansell noted that “there is little information at population level on sound indoors, which will depend on building characteristics, what else is going on in the house”.³⁹ This may be of concern because of socioeconomic disparities in the quality of housing stock, which could lead to “higher noise exposures from outdoor noise penetrating indoors.”⁴⁰
25. Witnesses agreed more research was needed into the impact of interventions to reduce noise exposure on health.⁴¹ Professor Clark said: “we do not have good studies of interventions where we change the noise exposure, or we try to, and then we assess how that impacted people’s sleep, annoyance, cardiovascular responses.”⁴²
26. Witnesses mentioned that researching the health effects of noise is intrinsically multidisciplinary and that this can cause problems in securing funding.⁴³ Dr Torija Martínez said: “We need some mechanisms to facilitate interdisciplinary research to do this. For example, it is difficult to work within different research councils.”⁴⁴
27. **More laboratory and field studies are needed to supplement epidemiological evidence and to establish the mechanisms by which noise might affect health. The current metrics used to characterise noise pollution are mostly long-term average intensity (decibel) metrics, which do not capture peak volume, pitch and intermittency. The latter influence annoyance and may correlate more closely with health outcomes but are not widely measured. Quantifying the health**

34 [Q 129](#) (Dr Bill Parish)

35 [Q 6](#) (Professor Charlotte Clark) and supplementary evidence from Professor Anna Hansell ([ALN0092](#))

36 [Q 15](#) (Professor Anna Hansell) and [Q 121](#) (Dr Benjamin Fenech)

37 [Q 6](#) (Professor Charlotte Clark). A natural experiment is an observational study which makes use of naturally occurring circumstances to observe and compare two groups—a control group and an experimental group—in order to determine the effect of a particular phenomenon. For example, a road might be closed for a period of time, allowing for the same population to be observed in experimental and control conditions to test the effect of closing the road.

38 [Q 6](#) (Professor Charlotte Clark)

39 Supplementary written evidence from Professor Anna Hansell ([ALN0092](#))

40 *Ibid.*

41 [Q 121](#) (Dr Benjamin Fenech) and supplementary written evidence from Professor Anna Hansell ([ALN0092](#))

42 [Q 6](#) (Professor Charlotte Clark)

43 Supplementary written evidence from Professor Anna Hansell ([ALN0092](#))

44 [Q 15](#) (Dr Antonio Torija Martínez)

effects of interventions to reduce exposure is important for cost-benefit analyses.

28. *The UK should seek opportunities to collaborate with similar countries, sharing research data and methodologies. Alongside these efforts, DEFRA should commission and fund a research programme into noise and health. This should include:*

- *large-scale epidemiological studies, including long-term longitudinal studies, which can make use of international big data;*
- *laboratory-based studies establishing mechanisms for health impacts;*
- *field studies establishing the indoor exposure to noise, which can contribute to mapping the indoor exposure to noise;*
- *interdisciplinary studies to understand the variation in response caused by non-acoustic factors;*
- *modelling and experimental studies into the health effects of interventions to reduce noise; and*
- *whether alternative metrics for noise, including pitch and intermittency, should be measured and used to better understand health outcomes.*

An independent advisory panel for noise

29. Some witnesses were concerned that there was no clear channel in place by which their evidence could inform Government policy. Professor Anna Hansell praised the work of the UKHSA noise team for calculating the “burden of disease from noise for all local authorities in England”, but noted that “there is no expert scientific advisory group for noise ... as there is for air pollution”.⁴⁵ She said “there is no clear policy group to go to.”⁴⁶
30. **Although UKHSA has a noise and health team which summarises research in this field for policymakers, there is no advisory group as there is for air pollution. An interdisciplinary, independent advisory panel should be established to provide independent advice to the Government and a forum for new evidence, particularly on emerging health effects and technologies, to be assessed.**

Light

Evidence for the health impacts of artificial light at night

31. Artificial light is characterised by properties, including the intensity of the light or its wavelength. Intensity can be measured using the SI unit, lux,

45 Supplementary written evidence from Professor Anna Hansell ([ALN0092](#))

46 [Q 9](#) (Professor Anna Hansell)

while wavelengths are often characterised using the colour temperature.⁴⁷ The eye operates over a wide range of intensities in lux (see Table 2).

32. Artificial light at night could influence human health by disturbing sleep and circadian rhythms.⁴⁸ The science on how light exposure influences circadian rhythms is evolving. Professor Rajaratnam noted many properties of light exposure influence circadian rhythms, including: “the duration ... intensity and the wavelength composition ... as well as the timing of the light exposure and the history of the light exposure”. He suggested that these properties should be measured in “large-scale studies”.⁴⁹

Table 2: Common light scenarios and their measurements in lux

Lux	Comparison
0.0001	Starlight
0.25–1	Full moon
80	Typical indoor lighting
400	Sunrise or sunset
500	A well-lit office
1000	Overcast day outdoors
10,000	Daylight
100,000	Intense, direct sunlight

Sources: Trong-Hop Do, ‘Performance Analysis of Visible Light Communication Using CMOS Sensors’, *ResearchGate* (February 2016): https://www.researchgate.net/publication/296477842_Performance_Analysis_of_Visible_Light_Communication_Using_CMOS_Sensors; James Druzik, ‘Guidelines for Selecting Solid-State Lighting for Museums—Figure 13—The scale of light intensities from moonlight to candlelight to sunlight’, *ResearchGate* (December 2015): https://www.researchgate.net/figure/The-scale-of-light-intensities-from-moonlight-to-candlelight-to-sunlight-and-the-range_fig5_287207122; Torchspot, ‘Lumens, Lux and Candela Explained—Lux Comparison’: https://www.torchspot.com/lumens-lux-and-candela/#Lux_Comparison_Chart; and The Electrical Counter, ‘What are Lux levels?’: <https://www.electricalcounter.co.uk/lux-levels-chart> [accessed 10 July 2023]

33. Scientists have defined a new metric, “melanopic lux”, which accounts for the wavelengths to which the circadian system is most sensitive. Professor Dr Manuel Spitschan told us that “when we are assessing or trying to measure the impact of light exposure on human health or the human circadian system, we need to take this wavelength preference ... into account.”⁵⁰ However, this metric is not widely used⁵¹ and the Circadian Neuroscience Group at the University of Oxford recommended that “all

47 Lux is a unit of illuminance defined in terms of lumens per meter squared. Colour temperature is a measure of wavelength which uses the correspondence between the temperature of a perfectly absorptive “blackbody” emitter and the peak wavelength of the spectrum of radiation it emits. Higher temperatures emit more energetic, shorter-wavelength (higher-frequency) light, with 1,000–3,000 Kelvin perceived as red-orange while 7,000–10,000 Kelvin would be perceived as blue. Dr Rüdiger Paschotta, ‘Color Temperature’, *RP Photonics Encyclopedia*: <https://www.rp-photonics.com/color-temperature.html>; ‘lux, unit of energy measurement’, *Britannica*: <https://www.britannica.com/science/lux> [accessed 26 June 2023]

48 We summarise evidence on the effects of circadian rhythm disruption on health in the section on circadian rhythms below, as it cuts across both light and noise.

49 [Q 21](#) (Professor Shantha Rajaratnam)

50 [Q 21](#) (Professor Dr Manuel Spitschan)

51 *Ibid.*

studies on light pollution use appropriate units (mel-EDI) when considering the non-visual health effects of light.”⁵²

34. Guidelines are being developed for light exposure that promotes circadian health. Witnesses referred to the “expert consensus recommendations paper”⁵³ known as the Manchester Guidelines, published in 2022.⁵⁴ These values are based on “existing laboratory data for human dose-response curves to light” which characterise how the circadian clock shifts when it is exposed to light at different intensities.⁵⁵ Whilst such laboratory-based studies are informative, they may not capture how people are exposed to light in reality.⁵⁶
35. **There are concerns that light pollution has been increasing rapidly in recent years. Evidence for the health effects of light pollution is at a less mature stage than noise pollution, but it may influence health by disrupting circadian rhythms and sleep. *The Government should commission research to establish how light intensity, wavelength, duration, time of exposure, light history and age affect the circadian system. This should move beyond laboratory-based studies and investigate more realistic light exposure patterns for humans. Such knowledge would provide an evidence base for guidelines that could mitigate the harmful effects of light pollution on human biology, including the circadian system, mood and alertness.***

Other health effects from artificial light

36. Artificial light can cause discomfort due to flicker and glare. Dr Christopher Kyba, Researcher at the Helmholtz Centre Potsdam, said that “flicker ... is an issue for a lot of individuals—again, not everybody, but some are very sensitive to it.”⁵⁷ Glare was described as “dangerous” for drivers in certain situations, and we were told it could “cause eye strain and headaches.”⁵⁸

52 Written evidence from Professor Stuart Peirson, Professor Simon Kyle, Professor Colin Espie, Professor David Ray, Professor Mark Hankins, Professor Aarti Jagannath, Professor Sridhar Vasudevan, Professor Zameel Cader, Professor Vladyslav Vyazovskiy and Professor Russell Foster, University of Oxford ([ALN0074](#)). Measurement using melanopic lux defines levels of illuminance as would be detected by melanopsin-based photosensitive retinal ganglion cells (pRGCs). These convey light information from the eye to the brain for the regulation of the circadian system. However, pRGCs do not act alone; visual photoreceptors (rods and cones) can modulate the pRGCs. As a result, the circadian system can potentially respond to light across most of the visible spectrum. Melanopic EDI (equivalent daylight illuminance) is a new unit of light intensity that accounts for the different sensitivity of the light-sensitive cells in the eye and predicts the circadian effects of light better than existing light measurements.

53 Timothy Brown *et al.*, ‘Recommendations for daytime, evening, and nighttime indoor light exposure to best support physiology, sleep, and wakefulness in healthy adults’, *PLoS Biology*, vol. 20(3) (17 March 2022): <https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3001571> [accessed 23 June 2023]

54 [Q 22](#) (Professor Dr Manuel Spitschan) Professor Dr Spitschan explained that “the recommendations included less than 1 lux melanopic EDI in the sleep environment, less than 10 lux melanopic EDI in the pre-sleep environment, and more than 250 lux melanopic EDI during daytime hours.”

55 Written evidence from Professor Stuart Peirson, Professor Simon Kyle, Professor Colin Espie, Professor David Ray, Professor Mark Hankins, Professor Aarti Jagannath, Professor Sridhar Vasudevan, Professor Zameel Cader, Professor Vladyslav Vyazovskiy and Professor Russell Foster, University of Oxford ([ALN0074](#))

56 Frida Rångtjell *et al.*, ‘Two hours of evening reading on a self-luminous tablet vs. reading a physical book does not alter sleep after daytime bright light exposure’, *Sleep Medicine*, Vol. 23 (July 2016) pp 111–118: <https://www.sciencedirect.com/science/article/pii/S1389945716300818> [accessed 23 June 2023]

57 [Q 24](#) (Dr Christopher Kyba)

58 [Q 89](#) (Ian Ritchie CBE)

37. Surveys have indicated that dazzle from car headlights is a growing problem, which may be related to the rollout of LEDs,⁵⁹ with studies suggesting they should be made dimmer in urban environments to aid contrast and avoid dazzle.⁶⁰ Dr Kyba said: “There is very little discussion between the people who create headlights and the people who create street lighting”, leading to poor interactions between the lighting types.⁶¹
38. Concerns have been raised around the LED rollout.⁶² LEDs are cheaper and more energy-efficient than traditional lighting, but this means that “more people are using more lights when they do not necessarily need to”.⁶³ Dr Luke Price, Principal Radiation Protection Scientist at UKHSA, told us “there is nothing intrinsically unhealthy about LEDs, but, if they are more energy efficient, we can use more of them and light more”.⁶⁴ Dr Kyba told us that there is evidence they contribute to light pollution: “the number of stars that people report they are able to see has dramatically decreased” since the rollout.⁶⁵
39. The UK Health Security Agency has a team that collates evidence for environmental noise and health, but there is no explicit team for light. Dr Luke Price is their light specialist and co-authored the Manchester Guidelines. He noted that they were “framed ... specifically for policymakers”.⁶⁶ Dr Edward Wynne-Evans, Director of the Radiation, Chemicals and Environmental Hazards Directorate at UKHSA, said that “On light, we want to work with other bodies to expand that [evidence] base” to quantify risks and costs from artificial light, but the evidence base was not yet good enough to carry out a cost-benefit analysis as can be done with traffic noise.⁶⁷
40. **Flicker, glare and dazzle can cause visual disturbance. There is not clear evidence that LEDs cause ill-effects in healthy people when used properly. However, there is widespread concern that the LED rollout has been associated with poor lighting practice and over-lighting. Research should be carried out in order to establish the level of risk from glare, flicker, and dazzle, for example in night-time driving.**

Mapping light pollution and human exposure to artificial light at night

41. Although there is a statutory requirement to map noise pollution, there is no such requirement for light. Emma Marrington of the charity CPRE told us

59 RAC, *Blinded by the lights—nearly one-in-four drivers think most car headlights are too bright... and the problem is getting worse* (8 March 2022): <https://www.rac.co.uk/drive/news/motoring-news/nearly-one-in-four-drivers-think-most-car-headlights-are-too-bright/> [accessed 23 June 2023]

60 Q 24 (Dr Christopher Kyba)

61 *Ibid.*

62 The EU’s 2018 review into the health effects of LEDs concluded that “there is no evidence of direct adverse health effects from LEDs emission in normal use (lamps and displays) by the general healthy population.” It found some evidence for circadian rhythm disruption from use in the evenings, but it was “not yet clear” if this was significant enough to lead to adverse health effects. Safety concerns from “high-luminance exterior sources used on some vehicles” were raised. Finally, it noted some LEDs presented health concerns due to “flicker ... at frequencies of 100 Hz and above” and concluded that as the use of LEDs is evolving, it was important to “closely monitor the risk of adverse health effects” from long-term LED use. Scientific Committee on Health, Environmental and Emerging Risks SCHEER, *Opinion on Potential risks to human health of Light Emitting Diodes (LEDs)* (June 2018): https://health.ec.europa.eu/system/files/2019-02/scheer_o_011_0.pdf [accessed 23 June 2023]

63 Q 70 (Andrew Bissell)

64 Q 124 (Dr Luke Price)

65 Q 24 (Dr Christopher Kyba)

66 Q 123 (Dr Luke Price)

67 Q 117 (Dr Edward Wynne-Evans)

that the 2016 Night Blight mapping, which they created “with consultants that looked at satellite data”, was “the baseline and currently the most detailed map for England”, but there was “a need to remap light pollution using the latest technology.”⁶⁸

42. Ruskin Hartley, CEO of the International Dark-Sky Association, explained that “scientists have estimated, based on the satellite data, that light pollution has been growing maybe by 2% or 3% per year”,⁶⁹ but this was contradicted by citizen-science projects that involve counting visible stars, which suggest that light pollution and sky glow is growing by 10% every year.⁷⁰ The reason for this discrepancy is that satellite measures are not always a reliable proxy for on-the-ground exposure.⁷¹
43. Asked about the idea of a central light map, Rebecca Pow MP, Minister for Environmental Quality and Resilience, said “We are doing it for some projects ... the CPRE does some of its own light mapping. There are a lot of limitations to our ability to do that right now ... We need more research ... to establish ... the methodology, the metrics and what we are measuring.”⁷²
44. We heard that, although it is possible to calculate a “burden of disease” estimate for noise pollution, this cannot yet be done for light. This is partially because of a lack of data about the light levels that people are exposed to at night. Dr Luke Price of UKHSA described “a series of longitudinal studies in Japan that measured the light in people’s environment, which we lack in the UK”.⁷³ Concerns were also raised about specific occupational exposures to light, such as in hospitals, which are not being measured.⁷⁴
45. **Regulating light pollution is difficult if it is not measured; our current approach is inadequate. It is also difficult to assess the health implications if it is not known how people are exposed to light pollution, particularly indoors at night. DEFRA should establish a standard methodology for tracking, monitoring and reporting on light pollution. This should be in place by the next five-year Environmental Improvement Plan cycle. The Government should commission a regular survey to track light pollution once the methodology is agreed. The research should aim to understand both indoor and outdoor exposure to artificial light at night, so its health impact can be quantified.**

Expert advisory group on circadian rhythms and light

46. There is no expert advisory group for the impacts of light pollution on human health, or on the environment more generally.⁷⁵ Ms Pow told us that “a review was done of the light issues after the Royal Commission on Environmental

68 [QQ 94–95](#) (Emma Marrington)

69 [Q 95](#) (Ruskin Hartley)

70 Witnesses pointed out that, while there must be some correlation between light pollution that affects the visibility of the night sky and light levels people are exposed to on the ground, it is not known precisely what that is. Christopher Kyba *et al.*, ‘Citizen scientists report global rapid reductions in the visibility of stars from 2011 to 2022’, *Science*, vol. 379, Issue 6629 (January 2023) pp 265–268: <https://www.science.org/doi/10.1126/science.abq7781> [accessed 23 June 2023]

71 [Q 72](#) (Andrew Bissell) explains why this is: satellites use the infrared window but blue LEDs have less in this spectrum.

72 [Q 147](#) (Rebecca Pow MP)

73 [Q 123](#) (Dr Luke Price)

74 [Q 76](#) (Andrew Bissell)

75 [Q 144](#) (Rebecca Pow MP, Dr Bill Parish)

Pollution report” in 2009, but that it concluded “there was not enough evidence to do anything to change the way we regulate”. She conceded that the “evidence is building and changing all the time.”⁷⁶ However, it is unclear who the Government would consult to assess the evidence base on the health impacts of artificial light at night, or for circadian science in general.

47. ***The Government should have a team of experts in UKHSA, on circadian rhythms and impacts of light on health to act as a single point for evidence gathering and co-opting external expertise. As the field develops, it may be appropriate to set up an independent advisory panel, as for noise and air pollution.***

Issues affecting noise and light

Possible beneficial effects of light and noise on human health

48. Professor Shantha Rajaratnam told us that, given the link between sleep and circadian rhythm disruption and mental health, there is “a unique opportunity to intervene and prevent” mental health conditions.⁷⁷
49. Light boxes can be used as treatment for mental ill-health. This involves exposing the patient to bright illumination (in excess of 10,000 lux) early in the morning to help reset the circadian clock. Professor Pierre Geoffroy, Professor of Psychiatry at Université Paris Cité, cited a meta-analysis that showed “light therapy is as efficient as antidepressant treatment [for] both seasonal and non-seasonal depression.”⁷⁸
50. Professor Geoffroy said that “the combination of the two treatments—light and antidepressants—is clearly superior to antidepressants alone.” He said that the “level of evidence ... depends on the disorder” and called for “larger, good-quality randomised controlled trials”, in particular long-term follow-up studies and effects of treatment on people with different natural sleep-wake cycles, or chronotypes.⁷⁹ The NHS website mentions light boxes as a possible treatment for seasonal affective disorder, but the NHS does not currently prescribe them.⁸⁰ Professor Geoffroy noted that research into light boxes was “much less supported compared to that for drugs, where pharmaceutical companies conduct or sponsor very large-scale studies.”⁸¹
51. Social prescribing is an approach to care that seeks to connect people to activities, groups and services in their community that can address their needs.⁸² Green social prescribing involves nature-based interventions and activities, such as walking-for-health schemes or gardening projects.⁸³ Dr Alison Greenwood, CEO of A Dose of Nature, told us that its schemes

76 [Q 145](#) (Rebecca Pow MP)

77 [Q 26](#) (Professor Shantha Rajaratnam). Daniel Freeman *et al.*, ‘The effects of improving sleep on mental health (OASIS): a randomised controlled trial with mediation analysis.’ *The Lancet Psychiatry*, vol. 4 (2017), pp 749–58: [https://www.thelancet.com/journals/lanpsy/article/PIIS2215-0366\(17\)30328-0/fulltext](https://www.thelancet.com/journals/lanpsy/article/PIIS2215-0366(17)30328-0/fulltext) [accessed 23 June 2023]

78 [Q 41](#) (Professor Pierre Geoffroy)

79 [QQ 41–43](#) (Professor Pierre Geoffroy)

80 NHS, *Treatment—Seasonal affective disorder (SAD)*, (20 May 2022): <https://www.nhs.uk/mental-health/conditions/seasonal-affective-disorder-sad/treatment/> [accessed 23 June 2023]

81 [Q 45](#) (Professor Pierre Geoffroy)

82 Natural England, ‘Social Prescribing: the power of nature as treatment’ (12 April 2022): <https://naturalengland.blog.gov.uk/2022/04/12/social-prescribing-the-power-of-nature-as-treatment/> [accessed 23 June 2023]

83 NHS England, ‘Green social prescribing’: <https://www.england.nhs.uk/personalisedcare/social-prescribing/green-social-prescribing/> [accessed 23 June 2023]

had “over 800 referrals from GPs”.⁸⁴ Natural light and sounds may play a role in the positive psychological impacts of green social prescribing.⁸⁵

52. However, witnesses agreed that more research was needed to understand the precise effect sizes and mechanisms of these positive impacts, with Dr Greenwood noting that it was “difficult to look at the effects of nature in a randomised controlled trial”.⁸⁶
53. ***The National Institute for Health and Care Excellence should review evidence for the effectiveness of therapies such as light boxes that might promote improved circadian rhythms and therefore physical and mental health.***
54. ***The National Institute for Health and Care Research should commission research to establish the mechanisms by which green social prescribing may affect health.***

84 [Q 40](#) (Dr Alison Greenwood), [Q 41](#) (Dr Alison Greenwood)

85 [Q 40](#) (Alex Smalley)

86 [Q 44](#) (Dr Alison Greenwood) and [Q 41](#) (Alex Smalley)

CHAPTER 3: PUBLIC POLICY IMPLICATIONS

Noise

National noise policy

55. The Noise Policy Statement for England (NPSE) published in March 2010 sets out the Government’s long-term vision for noise policy. The NPSE states that the Government wishes to “promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development.”⁸⁷ This is supported by three aims: to avoid significant adverse impacts on health and quality of life; to mitigate and minimise adverse impacts on health and quality of life; and where possible, contribute to the improvement of health and quality of life.
56. The Institute of Acoustics said that the NPSE did not need replacing; the focus should rather be on implementing it on the basis of the latest evidence.⁸⁸ Witnesses agreed that it provided a reasonable framework but there is a lack of implementation detail and the policy had not been emphasised enough. Paul McCullough, a member of the Chartered Institute of Environmental Health, said: “there could be a more strategic approach ... that would help to direct resources and competence in the field, which is required, particularly from a local government perspective.”⁸⁹ The Institute of Acoustics set out its vision for a more strategic approach.⁹⁰
57. Stephen Turner, who was involved in drafting the NPSE, told us: “there has been an inconsistency between local policy and national policy.” He added: “we need to re-emphasise to people that this is the policy and it should be used to direct our noise management.”⁹¹
58. Several witnesses noted that although noise pollution is mentioned in the 25 Year Environment Plan, the five-year update does not refer to noise pollution.⁹² Stephen Turner said: “It is not one of the key areas of activity for the Office for Environmental Protection. If you go to its website to see what you can complain about, noise is not listed; nor is it mentioned in this year’s environmental improvement plan.”⁹³
59. It was suggested that if DEFRA wanted to reduce noise pollution effectively there should be a target or targets against which progress can be measured. Mr Turner gave an example: “reducing over a period of time the proportion of the population exposed to a certain level of noise ... Or [reducing] the

87 Department for Environment, Food and Rural Affairs, *Noise Policy Statement for England (NPSE)* (March 2010) p 3: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69533/pb13750-noise-policy.pdf [accessed 23 June 2023]

88 Written evidence from the Institute of Acoustics (ALN0064)

89 Q 56 (Paul McCullough)

90 Written evidence from the Institute of Acoustics (ALN0064)

91 Q 58 (Stephen Turner)

92 The 25 Year Environment Plan says “We must ensure that noise and light pollution are managed effectively.” HM Government, *A Green Future: Our 25 Year Plan to Improve the Environment* (2018) p 83: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf. There is no explicit target. Neither noise or light pollution are mentioned in the Environmental Improvement Plan, which is intended as the five-year update. HM Government, *Environmental Improvement Plan 2023* (2023): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1133967/environmental-improvement-plan-2023.pdf [accessed 23 June 2023]

93 Q 66 (Stephen Turner)

number of disability-adjusted life years that noise impact causes”.⁹⁴ UKHSA’s Dr Luke Price emphasised the value of a target of the second kind: “it is about not just reducing the decibels—the noise exposure—but ultimately improving health outcomes”.⁹⁵

60. **The Noise Policy Statement for England sets a good overall framework for noise policy but should be re-emphasised. DEFRA does not collect the data that demonstrate national policy interfaces with local policy appropriately. The Government should collect data to determine whether planning authorities and other relevant parties are making use of the Noise Policy Statement for England.**
61. *There should be a specific noise reduction target for the regulation of noise pollution. Strict decibel exposure limits are impractical, but a target based on reducing the calculated exposure to, and hence disease burden from, noise pollution would allow cost-effective interventions to be pursued. This target should be in place for the next five-year Environmental Improvement Plan cycle.*

Box 1: Mapping and burden-of-disease calculations for noise pollution

DEFRA’s noise model

DEFRA is investing in a new £6 million noise mapping system. It will model time-averaged metrics of noise.⁹⁶ There are internationally agreed-on standards for modelling the contribution of different sources, including road, rail and aircraft, to these metrics. This new model goes beyond earlier models of large urban areas and major transport sources and will cover road and rail for the whole country.

Model components

The model consists of three components: input data, propagation model and receptor model.

Input data for roads and rail takes into account the topography of the road or railway, average vehicle speeds, their types, etc., to assign each section of road or rail a noise emission level.

The propagation model then accounts for the terrain and meteorology between source and receiver and calculates how the noise will be attenuated on its journey to the receiver.

The receiver model calculates the acoustic energy at the exterior of every residential dwelling, which in turn allows the population exposure to noise above a threshold and the burden of disease to be calculated for road and rail.

94 [Q 60](#) (Stephen Turner)

95 [Q 127](#) (Dr Luke Price)

96 The main metric that it will use is LAeq. L denotes loudness, A denotes “A-weighting”, which in the acoustic field means that the sound has been weighted-averaged over the frequencies of human auditory response, and “eq” denotes a time average. It generates results to noise levels of LA_{den} 40 dB (day-evening-night-time averaging) and 35 dB LA_{night} at the exterior of dwellings. The model output includes LA averages across 16-hour, 24-hour, day-, evening- and night-time periods, but does not include measures of intermittency or pitch.

Use of the model

DEFRA says that its data will be made available to other public bodies by the end of 2023, and that local authorities will be able to view the output from the model and take it into account in planning decisions. For local authorities that have acoustic modelling resources, DEFRA says the model can be used for scenario evaluation. The model is also being shared with the devolved administrations.

The calculation methods used in the model have been developed by a process that involves verification of the model results against measurement campaigns, which increases confidence in the model results. DEFRA says that “there is no verification to date of the specific implementation of the model as developed by DEFRA ... however, cost-effective options for this are currently being explored.”

Source: adapted from DEFRA’s supplementary written evidence ([ALN0094](#)).

62. One of the main policy responses to noise pollution has been to map and quantify the problem. Dr Benjamin Fenech from UKHSA explained that the number of people exposed to transport noise is known “thanks to the mapping commissioned by DEFRA and by airports”. There was also “evidence of the exposure-response relationships—which link the exposure to the health outcomes”,⁹⁷ allowing the burden of disease to be calculated. Dr Fenech noted that “the WHO guidelines were informed by more recent evidence” and the DEFRA-led Interdepartmental Group on Cost and Benefits (noise subgroup) had “commissioned a number of reviews” to assess this new evidence.⁹⁸
63. Dr Fenech noted that the Environmental Noise Directive (2006) resulted in “strategic noise mapping across entire countries”, providing the data “which allow these epidemiological studies to take place.”⁹⁹ DEFRA’s Dr Bill Parish described its new mapping effort as “a game-changer” which goes “much further than the requirements of the current directive”¹⁰⁰ and which will guide “our policy interventions—where we should be targeting them and how.”¹⁰¹ Ms Pow described it as “the first of its kind in the world.”¹⁰² However, it currently maps only average metrics for noise exposure (see Box 1).
64. As noted in Chapter 2, the WHO concluded in its 2018 Guidelines on environmental noise that the health effects of noise are likely to be greater than previously thought. Professor Anna Hansell noted that as the UK’s mapping takes account of noise on minor as well as major roads, “if you take full account of all the traffic exposures, ... that gives you higher estimates of burden of disease.”¹⁰³ However, the Government can be slow to update policy on the basis of new evidence for burden of disease calculations, with Professor Charlotte Clark describing it as “really out-of-date”.¹⁰⁴
65. **The Committee welcomes DEFRA’s noise pollution mapping and modelling exercise, which provides an opportunity for a renewed focus on noise pollution. However, mapping is only the first step: interventions to reduce the noise burden must follow. *The Government***

97 [Q 117](#) (Dr Benjamin Fenech)

98 [Q 119](#) (Dr Benjamin Fenech)

99 *Ibid.*

100 [QQ 140, 129](#) (Dr Bill Parish)

101 [Q 140](#) (Dr Bill Parish)

102 [Q 143](#) (Rebecca Pow MP)

103 [Q 9](#) (Professor Anna Hansell)

104 [Q 9](#) (Professor Charlotte Clark)

should use its mapping to identify key cost-effective interventions. The noise mapping and modelling should be made public. The Government should use this to update the burden of disease calculations used for noise pollution, including any new scientific evidence. Policy on noise pollution should be updated accordingly. This should include funding to carry out public health interventions that reduce noise burden in line with its noise reduction target.

66. ***It is essential that the Government commit to extending the mapping beyond 24-hour averaged noise exposure to include metrics of pitch, peak volume and intermittency of exposure.***

Interventions to reduce noise pollution

67. Stephen Turner noted that “understanding of how to mitigate noise is quite mature”.¹⁰⁵ Richard Greer, Fellow and Director at Arup, distinguished between addressing sound at source, intervening between source and receiver, and noise insulation at the receiver. The first includes changing tyres and road surfaces, the second sound barriers. “Noise barriers are very effective for railways, because we can put them very close to the trains. A noise barrier can straightforwardly halve the wayside noise level, a 10-decibel or greater reduction. That is a better reduction that can usually be achieved by measures at source.”¹⁰⁶
68. However, this is not the case for roads: “Because the noise source is so wide, with six lanes of highway, noise barriers might make a noticeable reduction at 3 decibels or more, but scarcely ever would we get to a halving. For highways, it is control at source, particularly through very low noise surfacing”.¹⁰⁷ (The Department for Transport’s Phil Earl noted that “there are trade-offs here between the noise emitted by a tyre and the safety of the tyre in keeping your vehicle gripping the road.”¹⁰⁸) In contrast:
- “insulation ... should always be the last place we go. We should only protect people in the home if we have exhausted everything that we can do at source and between source and receiver. None the less, noise is an unavoidable consequence of a growing, thriving and vibrant economy, so there will necessarily be times when we need to resort to noise insulation in homes to protect people.”¹⁰⁹
69. This was supported by DEFRA, which explained: “to obtain a reduction in sound ... of only 3 dB requires half of the energy in the source to be removed ... This contextualises how difficult it can be to engineer sound reduction solutions and therefore early consideration in the design phase of a project is generally more cost-effective than seeking solutions once operational.”¹¹⁰
70. John Stewart, Chair of the UK Noise Association, told us that “the two areas that most affect people are traffic noise and neighbour and neighbourhood noise.” He highlighted lower speed limits and low noise road surfaces as interventions that could be deployed “starting where the roads are noisiest.”

105 [Q 63](#) (Stephen Turner)

106 [Q 81](#) (Richard Greer)

107 *Ibid.*

108 [Q 134](#) (Phil Earl)

109 [Q 83](#) (Richard Greer)

110 Supplementary written evidence from Department for Environment, Food and Rural Affairs ([ALN0094](#))

For neighbour noise, enforcement is the key: “the laws tend to be there ... but they are not being enforced properly, partly because of a lack of resources among local authorities.”¹¹¹

71. Interventions at source are not always possible. Mr Stewart highlighted freight trains, where the problem includes vibration as well as noise. But for passenger trains “there are technical ways of improving the rails and the trains’ wheels, which can reduce the noise quite considerably.”¹¹²
72. In assessing different interventions to reduce noise pollution, cost-effectiveness and practicability are two considerations. Richard Greer made the case that “there is an important distinction to be made between new projects ... and our existing network. For new projects ... the UK is on a par and in many respects leads the way.” However, retrofitting the existing network is less common. As Mr Greer told us: “building a noise barrier next to a new road or railway is one thing, but retrofitting it can be much more expensive and there can be engineering practicability issues.”¹¹³
73. **The hierarchy of interventions for noise pollution should be: reduce, restrict, remodel. It is generally more effective to reduce noise at source, through planning and engineering, than it is to restrict transmission using sound barriers or to remodel the receiver’s environment with sound insulation. Mapping and modelling tools should be used to identify the most cost-effective interventions to reduce the disease burden of noise pollution, including determining where retrofits make sense. Information on how to reduce noise pollution must be made available at the planning stage for infrastructure projects, as intervention at source is generally more effective.**

Light

A national statement of light pollution policy

74. In contrast to noise pollution, there is no national Government strategy for tackling light pollution. Witnesses said little attention was paid to the topic. Stuart Morton, Professional Head of Highways and Aviation Electrical Design at Jacobs, told us “it would absolutely be beneficial to have a national strategy.”¹¹⁴
75. In 2009 the Royal Commission on Environmental Pollution published *Artificial Light in the Environment*.¹¹⁵ This considered the loss of viewing of the stars, the effects of poorly designed lighting and the effects of artificial

111 [Q 109](#) (John Stewart)

112 *Ibid.*

113 [Q 81](#) (Richard Greer)

114 [Q 74](#) (Stuart Morton)

115 The Royal Commission on Environmental Pollution, *Artificial Light in the Environment* (27 November 2009): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/228832/9780108508547.pdf [accessed 23 June 2023] The report made a number of recommendations, including that: the highways authorities and local authorities reassess the lighting of roads against road safety and crime reduction benefits; the sale of all new external and floodlighting be accompanied by best practice guidance on avoiding light pollution and minimising nuisance; there should be explicit consideration of light in planning policy; and that DEFRA—and equivalent bodies elsewhere in the UK—take the lead in co-ordinating inter-departmental activity on artificial light.

light on nature. The All-Party Parliamentary Group for Dark Skies in 2021 set out ten policies for the Government to reduce light pollution.¹¹⁶

76. DEFRA responded to the royal commission in 2010,¹¹⁷ and again in 2014 with a Policy Update.¹¹⁸ This set out the steps that DEFRA had taken to address light pollution since the report, including a consultation on statutory nuisance exemptions, providing information—drawn up in collaboration with CPRE, the Campaign for Dark Skies and the Institute of Lighting Professionals (ILP)—on minimising light pollution and research projects on a range of light-related topics. However, Ruskin Hartley, CEO of the International Dark-Sky Association, said that “almost every recommendation ... is still valid and should still be done but has not been”.¹¹⁹
77. WSP, an international consulting firm, said that “there have not been any definitive updates to Government policy in the intervening years [since the RCEP report] other than tweaks to relevant paragraphs of the [National Planning Policy Framework (NPPF)], of which there are few in relation to light pollution.”¹²⁰ The relevant section of the NPPF says that “Planning policies and decisions should [take] into account the likely effects ... of pollution on health.” It explicitly refers to both noise and light pollution, saying that policies and decisions “[should] limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes and nature conservation.”¹²¹
78. The ILP noted that the NPPF replaced *Planning Policy Statement 23: Planning and Pollution Control* (PPS 23) and removed lighting requirements. Allan Howard, past-President of the ILP, told us that “it was agreed that PPS 23 would be expanded specifically to include a detailed lighting section, ... but then the Government changed the planning rules and wanted to reduce a lot of red tape.”¹²²
79. Emma Marrington noted the absence of light pollution in the Environmental Improvement Plan 2023, in contrast to its mention in the 25 Year Environment Plan, alongside noise pollution. She acknowledged the existence of a national planning policy on light pollution as set out in the NPPF, but then added “there is a variable approach to it in local authorities.”¹²³
80. The Minister acknowledged that although DEFRA’s response to the 2009 royal commission report “concluded that there was not enough evidence to do anything to change the way we regulate”, this “was quite some time ago

116 All-Party Parliamentary Group for Dark Skies, *Ten Dark Sky policies for the government* (2021): <https://static1.squarespace.com/static/5e567fb65a380a76eb3c8133/t/60c72d0311d31c3137515f31/1623665931233/APPG+for+Dark+Skies+-+10+dark+sky+policies.pdf> [accessed 23 June 2023]

117 Department for Environment, Food and Rural Affairs, *The Royal Commission on Environmental Pollution (RCEP) Report on Artificial Light in the Environment: Government response* (18 March 2010): https://webarchive.nationalarchives.gov.uk/ukgwa/20130403180815mp_/http://archive.defra.gov.uk/environment/quality/local/nuisance/light/documents/rcep-artificial-light-report.pdf [accessed 23 June 2023]

118 Department for Environment, Food and Rural Affairs, *Artificial Light in the Environment: Policy Update* (December 2013): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/269402/pb14108-artificial-light-progress-dec2013.pdf [accessed 23 June 2023]

119 Q 97 (Ruskin Hartley)

120 Written evidence from WSP (ALN0076)

121 Ministry of Housing, Communities and Local Government, *National Planning Policy Framework* (July 2021) paragraph 185: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf [accessed 23 June 2023]

122 Q 70 (Allan Howard)

123 Q 97 (Emma Marrington)

now and evidence is building and changing all the time.”¹²⁴ Rebecca Pow accepted that a national policy statement on light “is certainly something that could potentially be considered.”¹²⁵

81. ***The Government should issue a Light Policy Statement for England which details the Government’s policy on minimising light pollution and the roles it expects different departments to play.***

Promoting good lighting practice

82. A significant proportion of light pollution is unnecessary and caused by bad design or poor use of LEDs.¹²⁶ The ILP told us that options existed that could help address this. For example, Andrew Bissell highlighted the adaptive tunability of LEDs: one example he discussed “has a whiter colour temperature early on in the evening but ... shifts towards a much warmer, calmer colour temperature and decreases in intensity as the evening passes, so you have a lower level of light.”¹²⁷ Ruskin Hartley described

“simple things [that] can be done to tackle light pollution ... ensuring that all new [outdoor] lights are fully shielded and point down at the ground where they are needed, and ensuring that all new lights are put on control systems so that they can be dimmed down when there are fewer people and turned off when people are no longer around.”¹²⁸

83. Organisations such as the Institution of Lighting Professionals have developed guidance on lighting installations that can minimise unwanted light pollution. Mr Howard had “developed a guidance document for the ILP, *Domestic Exterior Lighting: Getting it Right*”. However, this guidance has not always been followed by industry. Mr Howard said: “you cannot go to any of the major retail outlets and buy a luminaire, a security light with a sensor, that would do what we want it to do.”¹²⁹

84. ***Good practice guidance for lighting already exists. The Light Policy Statement and planning guidance should incorporate up-to-date guidance from the Society of Light and Lighting, the Institution of Lighting Professionals and the Chartered Institute of Building Services Engineers, on best practice for lighting.***

Light pollution as a statutory nuisance

85. Artificial light can be classed as a statutory nuisance under the Environmental Protection Act 1990 if it “substantially interferes” with the use of a home or other premises or could injure health. Councils must look into complaints of this kind and can then serve an abatement notice if they agree that a statutory nuisance is occurring.¹³⁰ A number of witnesses expressed dissatisfaction with the statutory nuisance regime, which allows for certain exemptions, including “railways and airports and transport infrastructure”.¹³¹

124 [Q 145](#) (Rebecca Pow MP)

125 [Q 148](#) (Rebecca Pow MP)

126 [Q 68](#) (Allan Howard)

127 [Q 73](#) (Andrew Bissell)

128 [Q 96](#) (Ruskin Hartley)

129 [Q 71](#) (Allan Howard)

130 Department for Environment, Food and Rural Affairs, ‘Artificial light nuisances: how councils deal with complaints’ (7 April 2015): <https://www.gov.uk/guidance/artificial-light-nuisances-how-councils-deal-with-complaints> [accessed 23 June 2023]

131 [Q 89](#) (Arfon Davies) and [Q 97](#) (Emma Marrington)

Allan Howard said: “We want those exclusions removed, and we would like it to cover any artificial light, not just from one premise affecting another premise.”¹³²

86. Asked about the nuisance regime, Ms Pow told us: “While DEFRA owns the policy on statutory nuisance legislation, it is still for the local authority to operate it”. In contrast to noise as a nuisance, “we do not have 150 years of case law on light because we brought light into consideration only in 2005.”¹³³ It is not clear whether Government tracks complaints under this regime: we were told that the analysis of complaints is “taking place at a local level.”¹³⁴
87. ***The Government should make clear that exempt facilities are still expected to conform to best-practice lighting guidelines.***
88. ***Local authorities should report on complaints about light pollution to Department for Levelling Up, Housing and Communities so that central government can compare local authorities and highlight any issues.***

Issues affecting noise and light

Implications of net-zero policy

89. The move to net zero requires widespread infrastructure changes, for example the possible widespread use of heat pumps and electric cars, which may have implications for light and noise pollution. For example, Ms Pow acknowledged that for “heat pumps, noise is now one of the issues that [we have] to deal with.”¹³⁵ Dr Antonio Torija Martínez described the “transition towards electric mobility” as “the most radical change in the soundscape we have experienced”, due to the lack of engine noise from electric cars.¹³⁶
90. Dr Edward Wynne-Evans pointed out that adapting to climate change can entail trade-offs between different risks: “if you open a window to improve your ventilation, for example, you potentially make your risk of noise exposure greater.”¹³⁷ Dr Torija Martínez highlighted the importance of researching the noise impacts of the net-zero transition, so that noise does not become a “showstopper ... a barrier to the wider adoption of air source heat pumps, electric mobility, drones etc.”¹³⁸
91. ***The Government should take steps to ensure that the implications of the technological shifts required for net zero and adapting to climate change for noise and light pollution are understood and addressed early on.***

Cross-departmental co-ordination

92. Witnesses told us that responsibility for both noise and light pollution policy is spread across Government and the lines of accountability are not always clear. Professor Anna Hansell said: “There is no clear government department to involve, so DEFRA, DfT, BEIS and [DHSC] might be involved”.¹³⁹ The

132 [Q 74](#) (Allan Howard)

133 [Q 149](#) (Rebecca Pow MP)

134 [Q 145](#) (Rebecca Pow MP)

135 [Q 151](#) (Rebecca Pow MP)

136 [Q 6](#) (Dr Antonio Torija Martínez)

137 [Q 120](#) (Dr Edward Wynne-Evans)

138 [Q 15](#) (Dr Antonio Torija Martínez)

139 [Q 9](#) (Professor Anna Hansell)

Department for Levelling Up, Housing and Communities is also involved in enacting national policies at the local level. Emma Marrington said that this means light pollution can “[fall] through the cracks.”¹⁴⁰

93. Aspects of existing DEFRA policy and existing legislation provide regulatory frameworks that can be applied across departments to regulate light and noise pollution. For example, the five environmental principles of integration, prevention, rectification at source, “polluter pays”, and the precautionary principle, set out in the Government’s Environmental Principles Policy Statement,¹⁴¹ are intended to apply to policymaking across government. These have already been legislated for in the Environment Act 2021.¹⁴²
94. Rebecca Pow told us that “while DEFRA is responsible for protecting the environment and this area, an awful lot of the levers are in other departments. A lot of them are conducting their own research. We highlight the issues to them”.¹⁴³ She added: “DEFRA works incredibly closely with at least 10 different departments and agencies ... DEFRA could not possibly hold all the experts on all those areas just to do with light and noise, because we cover all pollutants.”¹⁴⁴
95. **Light and noise pollution cut across a number of departments. The levers for acting on problems identified by DEFRA often sit in other departments, such as the Department for Transport. This is unlike other pollutants, where DEFRA takes ownership of mapping and, through public bodies, regulation. There seemed to be little co-ordination between departmental policies in these areas. *The status of light and noise pollution as policy areas under the aegis of DEFRA should be reviewed and interdepartmental co-ordination on these issues strengthened. The Government should make clear where in each affected department responsibility for noise and light pollution lies. Other departments should apply the environmental principles in the Environment Act 2021 to their approach to light and noise pollution.***

Co-ordination with local authorities

96. Witnesses told us that there is a gap between policy as set by the Government and how that policy is applied by local authorities. Emma Marrington said that, even where guidance or advice exists, “it is about having awareness among our local authorities ... [and] there are different approaches in councils.”¹⁴⁵ Andrew Bissell said that every local authority “does the minimum of asking for a light pollution assessment or statement, but some take it far more seriously than others.”¹⁴⁶

140 [Q 102](#) (Emma Marrington)

141 Department for Environment, Food and Rural Affairs, ‘Environmental principles policy statement’ (31 January 2023): <https://www.gov.uk/government/publications/environmental-principles-policy-statement/environmental-principles-policy-statement#the-5-environmental-principles> [accessed 11 July 2023]

142 Environment Act 2021, [section 17](#)

143 [Q 144](#) (Rebecca Pow MP)

144 [Q 148](#) (Rebecca Pow MP)

145 [Q 98](#) (Emma Marrington)

146 [Q 68](#) (Andrew Bissell)

97. DEFRA's Dr Parish accepted this:

“We do not audit what [local authorities] do ... nor have we imposed a burden on them to provide reports on how they are managing nuisance. In all honesty, we do not have an accurate handle on what every single local authority is doing ... if we were to ... ask for something ... we would inadvertently be providing them with an extra burden on top of the environmental health officer trying to sort out a nuisance problem.”¹⁴⁷

98. These problems with inconsistent application are compounded by shortages in resources. Guy Harding, Technical Manager at the Institution of Lighting Professionals, said that “there is not always the expertise in the local authority ... they do not necessarily have the funds to go to an external consultant.”¹⁴⁸

99. Pressed on whether local authorities had the resources to tackle the problems of noise and light pollution and enforce the existing regulations, Ms Pow responded that “that does not fall under DEFRA, because local authority funding is ring-fenced and that is a matter for DLUHC and the Treasury. It is not for DEFRA to answer that question.”¹⁴⁹

100. **It is unclear how, and how consistently, national policies are implemented at local authority level. The Committee remains unconvinced that co-ordination on these issues is sufficiently effective. DEFRA does not appear to be receiving the information it needs to conclude whether its policies are being effectively implemented by local authorities and trends in that effectiveness over time. It is also unclear whether local government actions on noise and light pollution feed back data into DEFRA about whether the policies are successful. *The Department for Levelling Up, Housing and Communities should set out what resources local authorities should have to respond adequately to light and noise pollution policies. Local authorities should be sufficiently resourced and incentivised, both in funding and access to information and expertise, to ensure they can properly regulate light and noise pollution.***

147 [Q 149](#) (Dr Bill Parish)

148 [Q 74](#) (Guy Harding)

149 [Q 149](#) (Rebecca Pow MP)

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Scientific evidence of health effects

1. There is increasing epidemiological evidence of the harmful effects of noise on human health. Aggregated over the whole population, even small effects on the individual can be a significant public health concern. New evidence is likely to change the understanding of these effects, for example the role played by intermittency. (Paragraph 16)
2. *DEFRA should work with the UK Health Security Agency and other organisations to assess the significant, growing evidence on the health effects of noise. This should include refining existing estimates for the disease burden from well-established health impacts of noise pollution, for example on the cardiovascular system. UKHSA should also assess whether health effects for which evidence is emerging, such as on the metabolic system, meet the evidentiary threshold for policy action.* (Paragraph 16)
3. More laboratory and field studies are needed to supplement epidemiological evidence and to establish the mechanisms by which noise might affect health. The current metrics used to characterise noise pollution are mostly long-term average intensity (decibel) metrics, which do not capture peak volume, pitch and intermittency. The latter influence annoyance and may correlate more closely with health outcomes but are not widely measured. Quantifying the health effects of interventions to reduce exposure is important for cost-benefit analyses. (Paragraph 27)
4. *The UK should seek opportunities to collaborate with similar countries, sharing research data and methodologies. Alongside these efforts, DEFRA should commission and fund a research programme into noise and health. This should include:*
 - *large-scale epidemiological studies, including long-term longitudinal studies, which can make use of international big data;*
 - *laboratory-based studies establishing mechanisms for health impacts;*
 - *field studies establishing the indoor exposure to noise, which can contribute to mapping the indoor exposure to noise;*
 - *interdisciplinary studies to understand the variation in response caused by non-acoustic factors;*
 - *modelling and experimental studies into the health effects of interventions to reduce noise; and*
 - *whether alternative metrics for noise, including pitch and intermittency, should be measured and used to better understand health outcomes.* (Paragraph 28)
5. Although UKHSA has a noise and health team which summarises research in this field for policymakers, there is no advisory group as there is for air pollution. (Paragraph 30)
6. *An interdisciplinary, independent advisory panel should be established to provide independent advice to the Government and a forum for new evidence, particularly on emerging health effects and technologies, to be assessed.* (Paragraph 30)
7. There are concerns that light pollution has been increasing rapidly in recent years. Evidence for the health effects of light pollution is at a less mature stage

than noise pollution, but it may influence health by disrupting circadian rhythms and sleep. (Paragraph 35)

8. *The Government should commission research to establish how light intensity, wavelength, duration, time of exposure, light history and age affect the circadian system. This should move beyond laboratory-based studies and investigate more realistic light exposure patterns for humans. Such knowledge would provide an evidence base for guidelines that could mitigate the harmful effects of light pollution on human biology, including the circadian system, mood and alertness. (Paragraph 35)*
9. Flicker, glare and dazzle can cause visual disturbance. There is not clear evidence that LEDs cause ill-effects in healthy people when used properly. However, there is widespread concern that the LED rollout has been associated with poor lighting practice and over-lighting. (Paragraph 40)
10. *Research should be carried out in order to establish the level of risk from glare, flicker, and dazzle, for example in night-time driving. (Paragraph 40)*
11. Regulating light pollution is difficult if it is not measured; our current approach is inadequate. It is also difficult to assess the health implications if it is not known how people are exposed to light pollution, particularly indoors at night. (Paragraph 45)
12. *DEFRA should establish a standard methodology for tracking, monitoring and reporting on light pollution. This should be in place by the next five-year Environmental Improvement Plan cycle. The Government should commission a regular survey to track light pollution once the methodology is agreed. The research should aim to understand both indoor and outdoor exposure to artificial light at night, so its health impact can be quantified. (Paragraph 45)*
13. The Government should have a team of experts in UKHSA, on circadian rhythms and impacts of light on health to act as a single point for evidence gathering and co-opting external expertise. As the field develops, it may be appropriate to set up an independent advisory panel, as for noise and air pollution. (Paragraph 47)
14. *The National Institute for Health and Care Excellence should review evidence for the effectiveness of therapies such as light boxes that might promote improved circadian rhythms and therefore physical and mental health. (Paragraph 53)*
15. *The National Institute for Health and Care Research should commission research to establish the mechanisms by which green social prescribing may affect health. (Paragraph 54)*

Public policy implications

16. The Noise Policy Statement for England sets a good overall framework for noise policy but should be re-emphasised. DEFRA does not collect the data that demonstrate national policy interfaces with local policy appropriately. (Paragraph 60)
17. The Government should collect data to determine whether planning authorities and other relevant parties are making use of the Noise Policy Statement for England. (Paragraph 60)
18. *There should be a specific noise reduction target for the regulation of noise pollution. Strict decibel exposure limits are impractical, but a target based on reducing the*

calculated exposure to, and hence disease burden from, noise pollution would allow cost-effective interventions to be pursued. This target should be in place for the next five-year Environmental Improvement Plan cycle. (Paragraph 61)

19. The Committee welcomes DEFRA's noise pollution mapping and modelling exercise, which provides an opportunity for a renewed focus on noise pollution. However, mapping is only the first step: interventions to reduce the noise burden must follow. (Paragraph 65)
20. *The Government should use its mapping to identify key cost-effective interventions. The noise mapping and modelling should be made public. The Government should use this to update the burden of disease calculations used for noise pollution, including any new scientific evidence. Policy on noise pollution should be updated accordingly. This should include funding to carry out public health interventions that reduce noise burden in line with its noise reduction target. (Paragraph 65)*
21. *It is essential that the Government commit to extending the mapping beyond 24-hour averaged noise exposure to include metrics of pitch, peak volume and intermittency of exposure. (Paragraph 66)*
22. The hierarchy of interventions for noise pollution should be: reduce, restrict, remodel. It is generally more effective to reduce noise at source, through planning and engineering, than it is to restrict transmission using sound barriers or to remodel the receiver's environment with sound insulation. (Paragraph 73)
23. *Mapping and modelling tools should be used to identify the most cost-effective interventions to reduce the disease burden of noise pollution, including determining where retrofits make sense. Information on how to reduce noise pollution must be made available at the planning stage for infrastructure projects, as intervention at source is generally more effective. (Paragraph 73)*
24. *The Government should issue a Light Policy Statement for England which details the Government's policy on minimising light pollution and the roles it expects different departments to play. (Paragraph 81)*
25. Good practice guidance for lighting already exists. (Paragraph 84)
26. *The Light Policy Statement and planning guidance should incorporate up-to-date guidance from the Society of Light and Lighting, the Institution of Lighting Professionals and the Chartered Institute of Building Services Engineers, on best practice for lighting. (Paragraph 84)*
27. *The Government should make clear that exempt facilities are still expected to conform to best-practice lighting guidelines. (Paragraph 87)*
28. *Local authorities should report on complaints about light pollution to Department for Levelling Up, Housing and Communities so that central government can compare local authorities and highlight any issues. (Paragraph 88)*
29. *The Government should take steps to ensure that the implications of the technological shifts required for net zero and adapting to climate change for noise and light pollution are understood and addressed early on. (Paragraph 91)*
30. Light and noise pollution cut across a number of departments. The levers for acting on problems identified by DEFRA often sit in other departments, such as the Department for Transport. This is unlike other pollutants, where DEFRA takes ownership of mapping and, through public bodies, regulation.

There seemed to be little co-ordination between departmental policies in these areas. (Paragraph 95)

31. *The status of light and noise pollution as policy areas under the aegis of DEFRA should be reviewed and interdepartmental co-ordination on these issues strengthened. The Government should make clear where in each affected department responsibility for noise and light pollution lies. Other departments should apply the environmental principles in the Environment Act 2021 to their approach to light and noise pollution.* (Paragraph 95)
32. It is unclear how, and how consistently, national policies are implemented at local authority level. The Committee remains unconvinced that co-ordination on these issues is sufficiently effective. DEFRA does not appear to be receiving the information it needs to conclude whether its policies are being effectively implemented by local authorities and trends in that effectiveness over time. It is also unclear whether local government actions on noise and light pollution feed back data into DEFRA about whether the policies are successful. (Paragraph 100)
33. *The Department for Levelling Up, Housing and Communities should set out what resources local authorities should have to respond adequately to light and noise pollution policies. Local authorities should be sufficiently resourced and incentivised, both in funding and access to information and expertise, to ensure they can properly regulate light and noise pollution.* (Paragraph 100)

APPENDIX 1: LIST OF MEMBERS AND DECLARATIONS OF INTEREST

Members

Lord Borwick (Member since 31 January 2023)
 Baroness Brown of Cambridge (Chair)
 Viscount Hanworth
 Lord Holmes of Richmond MBE
 Lord Krebs
 Lord Mitchell (Member until 25 April 2023)
 Baroness Neuberger (Member since 31 January 2023)
 Baroness Neville-Jones (Member since 31 January 2023)
 Baroness Northover (Member since 31 January 2023)
 Lord Rees of Ludlow
 Lord Sharkey (Member since 31 January 2023)
 Viscount Stansgate (Member since 27 April 2023)
 Baroness Warwick (Member until 27 April 2023)
 Lord Wei
 Lord Winston

Declaration of interest

Lord Borwick (Member since 31 January 2023)
Trustee of The Ewing Foundation for Deaf Children (a registered charity)

Baroness Brown of Cambridge
Shares in Rolls-Royce plc, maker of aeroengines

Viscount Hanworth
No relevant interests declared

Lord Holmes of Richmond MBE
No relevant interests declared

Lord Krebs
Fellow of Royal Society
Fellow of Academy of Medical Sciences
Chair of World Cancer Research Fund CUP-global review panel

Lord Mitchell (Member until 25 April 2023)
No relevant interests declared

Baroness Neuberger (Member since 31 January 2023)
Chair, University College London Hospitals NHS Foundation Trust
Chair, Whittington Health NHS Trust

Baroness Neville-Jones (Member since 31 January 2023)
No relevant interests declared

Baroness Northover (Member since 31 January 2023)
No relevant interests declared

Lord Rees of Ludlow
Co-Chair and founder of the All-Party Parliamentary Group for Dark Skies

Lord Sharkey (Member since 31 January 2023)
No relevant interests declared

Viscount Stansgate (Member since 27 April 2023)
President, Parliamentary and Scientific Committee
Fellow, Royal Society of Biology

Trustee, Foundation for Science and Technology
Trustee, Parliamentary Science and Technology Information Foundation
Baroness Warwick (Member until 27 April 2023)

No relevant interests declared
Lord Wei

No relevant interests declared
Lord Winston

Salaried employee of Imperial College London
Fellow, Academy of Medical Sciences
Fellow, Royal College of Physicians
Hon Fellow, Royal Academy of Engineering
Fellow, Royal College of Music

A full list of Members' interests can be found in the Register of Lords Interests: <http://www.parliament.uk/mps-lords-and-offices/standards-and-interests/register-of-lords-interests/>

Specialist Adviser

Professor Russell G. Foster CBE, Director of Sir Jules Thorn Sleep and Circadian Neuroscience Institute (SCNi) and Head of Nuffield Laboratory of Ophthalmology (NLO), Fellow, Brasenose College, University of Oxford

Fellow, Royal Society
Fellow, Academy of Medical Sciences
Fellow, Royal Society of Biology
Recipient of research funding from the Wellcome Trust, UKRI, Leducq Foundation and The Novo Nordisk Foundation
Co-Founder of the University of Oxford biomedical spin-out Circadian Therapeutics
Editor, Interface Focus. Publication by The Royal Society
Scientific Advisory Board, The Eden Project
Trustee, ATOM Festival of Science and Technology, Abingdon-on-Thames
Jury member for The Daylight Award
Board Member, Feldberg Foundation for Anglo-German Scientific Exchange
Vice Patron, Blind Veterans UK
Honorary Professor, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR)

APPENDIX 2: LIST OF WITNESSES

Evidence is published online at <https://committees.parliament.uk/work/7256/the-effects-of-artificial-light-and-noise-on-human-health/publications/> and available for inspection at the Parliamentary Archives (020 7219 3074).

Evidence received by the Committee is listed below in chronological order of oral evidence session and in alphabetical order. Those witnesses marked with ** gave both oral evidence and written evidence. Those marked with * gave oral evidence and did not submit any written evidence. All other witnesses submitted written evidence only.

Oral evidence in chronological order

- * Professor Charlotte Clark, Professor of Epidemiology, St George's, University of London, Population Health Research Institute [QQ 1–15](#)
- ** Dr Antonio Torija Martínez, Reader in Acoustical Engineering, Acoustics Research Centre, University of Salford
- ** Professor Anna Hansell, Professor of Environmental Epidemiology and Director of the Centre for Environmental Health and Sustainability, University of Leicester
- * Dr Christopher Kyba, Researcher, German Research Center for Geoscience, Helmholtz Centre Potsdam [QQ 16–26](#)
- * Professor Shantha Rajaratnam, Professor of Sleep and Circadian Medicine, Monash University
- * Professor Dr Manuel Spitschan, Professor of Chronobiology and Health, Technical University of Munich (TUM)
- * Professor Stuart Peirson, Professor of Circadian Neuroscience, University of Oxford [QQ 27–39](#)
- * Professor Kenneth Wright, Director of the Sleep and Chronobiology Laboratory, University of Colorado Boulder
- * Dr Alison Greenwood, Chief Executive Officer, Founder and Lead Psychologist, Dose of Nature [QQ 40–54](#)
- * Alex Smalley, PhD Fellow, University of Exeter
- * Professor Pierre Geoffroy, Professor of Psychiatry, Université Paris Cité
- ** Stephen Turner, Immediate Past-President, Institute of Acoustics [QQ 55–66](#)
- ** Peter Rogers, Chair of the Parliamentary and Public Liaison Group, Institute of Acoustics
- * Paul McCullough, Member, Chartered Institute of Environmental Health (CIEH)

- * Somayya Yaqub, Member, Chartered Institute of Environmental Health (CIEH)
- ** Guy Harding, Technical Manager, Institution of Lighting Professionals [QQ 67–77](#)
- ** Allan Howard, Past-President, Institution of Lighting Professionals
- * Stuart Morton, Professional Head, Highways and Aviation Electrical Design, Jacobs
- * Andrew Bissell, President, Society of Light and Lighting
- ** Richard Greer, Fellow and Director, Arup [QQ 78–86](#)
- * Poppy Szkiler, CEO, Quiet Mark
- * Colin Ball, Architect, Building Design Partnership [QQ 87–93](#)
- * Arfon Davies, Leader of Lighting UKIMEA, Arup
- * Ian Ritchie CBE, Architect, Ritchie Studio
- * Ruskin Hartley, CEO and Executive Director, International Dark-Sky Association [QQ 94–105](#)
- ** Emma Marrington, Landscape Enhancement Lead, CPRE, the Countryside Charity (Campaign to Protect Rural England)
- ** John Stewart, Chair, UK Noise Association [QQ 106–114](#)
- * Lisa Lavia, Managing Director, Noise Abatement Society
- ** Dr Edward Wynne-Evans, Director of Radiation, Chemicals and Environmental Hazards Directorate, UK Health Security Agency (UKHSA) [QQ 115–127](#)
- ** Dr Benjamin Fenech, Noise and Public Health Group Leader, UK Health Security Agency (UKHSA)
- ** Luke Price, Principal Radiation Protection Scientist, UK Health Security Agency (UKHSA)
- ** Dr Bill Parish, Deputy Director for Air Quality and Industrial Emissions, Department for Environment, Food and Rural Affairs (DEFRA) [QQ 128–142](#)
- ** Phil Earl, Deputy Director for International Vehicle Standards, Department for Transport (DfT)
- * Erin Cowburn, Deputy Director, Planning Policy, Department for Levelling Up, Housing and Communities
- ** Rebecca Pow MP, Parliamentary Under Secretary of State (Minister for Environmental Quality and Resilience), Department for Environment, Food and Rural Affairs (DEFRA) [QQ 143–154](#)

- ** Dr Bill Parish, Deputy Director for Air Quality and Industrial Emissions, Department for Environment, Food and Rural Affairs (DEFRA)
- ** Rhian Thomas, Policy Lead, Noise and Statutory Nuisance, Department for Environment, Food and Rural Affairs (DEFRA)
- ** Hilary Notley, Evidence Lead, Noise, Department for Environment, Food and Rural Affairs (DEFRA)

Alphabetical list of witnesses

- | | |
|---|--|
| Acoustics and Air Quality Modelling and Assessment Unit (AQMAU), Environment Agency | <u>ALN0052</u> |
| Adfree Cities | <u>ALN0068</u> |
| Alzheimer’s Research UK | <u>ALN0022</u> |
| ** Arup (<u>QQ 78–86</u>) | <u>ALN0088</u> |
| Awdurdod Parc Cenedlaethol Eryri National Park Authority | <u>ALN0019</u> |
| Dr Christopher Baddiley | <u>ALN0071</u> |
| * Colin Ball, Building Design Partnership (<u>QQ 87–93</u>) | |
| Professor Timothy Brown and Professor Robert Lucas, University of Manchester | <u>ALN0012</u> |
| BSI (British Standards Institution) | <u>ALN0061</u> |
| Buglife—The Invertebrate Conservation Trust | <u>ALN0057</u> |
| Professor Zameel Cader, Professor Vladyslav Vyazovskiy, Professor Russell Foster, Professor Stuart Peirson, Professor Simon Kyle, Professor Colin Espie, Professor David Ray, Professor Mark Hankins, Professor Aarti Jagannath and Professor Sridhar Vasudevan, University of Oxford | <u>ALN0074</u> |
| * Chartered Institute of Environmental Health (CIEH) (<u>QQ 55–66</u>) | |
| * Professor Charlotte Clark, University of London, Population Health Research Institute (<u>QQ 1–15</u>) | |
| ** CPRE, the Countryside Charity (<u>QQ 94–105</u>) | <u>ALN0083</u> |
| Cranborne Chase AONB | <u>ALN0024</u> |
| Dark Sky London | <u>ALN0020</u> |
| * Arfon Davies, Leader of Lighting UKIMEA, Arup (<u>QQ 87–93</u>) | |
| ** Department for Environment, Food and Rural Affairs (<u>QQ 128–142</u>) (<u>QQ 143–154</u>) | <u>ALN0066</u>
<u>ALN0094</u> |
| * Department for Levelling Up, Housing and Communities (<u>QQ 128–142</u>) | |
| ** Department for Transport (<u>QQ 128–142</u>) | <u>ALN0091</u> |

	Professor Nick Dunn, Lancaster University	ALN0053
	Eclipse Light Sensitive Support Group for Lupus Patients, attached to LUPUS UK	ALN0004
	Mark Edwards	ALN0021
	Professor Colin Espie, Professor David Ray, Professor Mark Hankins, Professor Aarti Jagannath, Professor Sridhar Vasudevan, Professor Zameel Cader, Professor Vladyslav Vyazovskiy, Professor Russell Foster, Professor Stuart Peirson and Professor Simon Kyle, University of Oxford	ALN0074
	Isabelle Ficker	ALN0081
	Dr Robert Fosbury, Hon. Professor (until 2022), University College London, Institute of Ophthalmology	ALN0017
	Professor Steve Fotios, University of Sheffield	ALN0036
	Dr Tom Foulsham and Professor Arnold Wilkins, University of Essex	ALN0023
	Professor Russell Foster, Professor Stuart Peirson, Professor Simon Kyle, Professor Colin Espie, Professor David Ray, Professor Mark Hankins, Professor Aarti Jagannath, Professor Sridhar Vasudevan, Professor Zameel Cader and Professor Vladyslav Vyazovskiy, University of Oxford	ALN0074
	Joy Geerrens, Brunel University London	ALN0063
*	Professor Pierre Geoffroy, Université Paris Cité (QQ 40–54)	
	Gerard Gilligan	ALN0044
*	Dr Alison Greenwood, Dose of Nature (QQ 40–54)	
	HACAN (Heathrow Association for the Control of Aircraft Noise)	ALN0056
	Professor Mark Hankins, Professor Aarti Jagannath, Professor Sridhar Vasudevan, Professor Zameel Cader, Professor Vladyslav Vyazovskiy, Professor Russell Foster, Professor Stuart Peirson, Professor Simon Kyle, Professor Colin Espie and Professor David Ray, University of Oxford	ALN0074
	Professor Anna Hansell, University of Leicester (QQ 1–15)	ALN0092
	Heathrow Airport	ALN0050
**	Institute of Acoustics (QQ 55–66)	ALN0064 ALN0093
	Institute of Acoustics and the UK Acoustics Network	ALN0038
**	Institution of Lighting Professionals (QQ 67–77)	ALN0055
*	International Dark-Sky Association (QQ 94–105)	

- * Jacobs ([QQ 67–77](#))
 Professor Aarti Jagannath, Professor Sridhar Vasudevan, Professor Zameel Cader, Professor Vladyslav Vyazovskiy, Professor Russell Foster, Professor Stuart Peirson, Professor Simon Kyle, Professor Colin Espie, Professor David Ray and Professor Mark Hankins, University of Oxford [ALN0074](#)
- * Dr Christopher Kyba, Helmholtz Centre Potsdam ([QQ 16–26](#))
 Professor Simon Kyle, Professor Colin Espie, Professor David Ray, Professor Mark Hankins, Professor Aarti Jagannath, Professor Sridhar Vasudevan, Professor Zameel Cader, Professor Vladyslav Vyazovskiy, Professor Russell Foster and Professor Stuart Peirson, University of Oxford [ALN0074](#)
- Professor Timothy Leighton, University of Southampton [ALN0009](#)
- LightAware [ALN0037](#)
- Sian Lloyd Jones [ALN0010](#)
- Dr Karen Lloyd, Lancaster University Future Places Centre [ALN0032](#)
- Professor Robert Lucas and Professor Timothy Brown, University of Manchester [ALN0012](#)
- Dr Paul Marchant [ALN0035](#)
- Neurodiverse Connection [ALN0075](#)
- * Noise Abatement Society ([QQ 106–114](#))
- * Professor Stuart Peirson, University of Oxford ([QQ 27–39](#))
 Professor Stuart Peirson, Professor Simon Kyle, Professor Colin Espie, Professor David Ray, Professor Mark Hankins, Professor Aarti Jagannath, Professor Sridhar Vasudevan, Professor Zameel Cader, Professor Vladyslav Vyazovskiy and Professor Russell Foster, University of Oxford [ALN0074](#)
- * Quiet Mark ([QQ 78–86](#))
- * Professor Shantha Rajaratnam, Monash University ([QQ 16–26](#))
 Professor David Ray, Professor Mark Hankins, Professor Aarti Jagannath, Professor Sridhar Vasudevan, Professor Zameel Cader, Professor Vladyslav Vyazovskiy, Professor Russell Foster, Professor Stuart Peirson, Professor Simon Kyle and Professor Colin Espie, University of Oxford [ALN0074](#)
- Dr Gavin Charles Rider [ALN0026](#)

- * Ian Ritchie CBE, Ritchie Studio ([QQ 87–93](#))
 ROCKWOOL UK [ALN0086](#)
 Royal Astronomical Society [ALN0029](#)
 Professor Debra Skene, University of Surrey [ALN0065](#)
- * Alex Smalley, University of Exeter ([QQ 40–54](#))
- * Society of Light and Lighting ([QQ 67–77](#))
 Soft Lights Foundation [ALN0060](#)
- * Professor Dr Manuel Spitschan, Technical University of Munich (TUM) ([QQ 16–26](#))
 Dr Wayne Thomas, University Hospitals Plymouth NHS Trust [ALN0014](#)
 Stephen Tonkin [ALN0058](#)
- ** Dr Antonio Torija Martínez ([QQ 1–15](#)) [ALN0087](#)
 UCL Centre for Research in Autism and Education (CRAE) [ALN0033](#)
 UK Acoustics Network and the Institute of Acoustics [ALN0038](#)
 UK Dark Skies Partnership [ALN0039](#)
- ** [ALN0089](#)
 UK Health Security Agency (UKHSA) ([QQ 115–127](#)) [ALN0090](#)
- ** UK Noise Association ([QQ 106–114](#)) [ALN0002](#)
 University of Surrey [ALN0054](#)
 Professor Sridhar Vasudevan, Professor Zameel Cader, Professor Vladyslav Vyazovskiy, Professor Russell Foster, Professor Stuart Peirson, Professor Simon Kyle, Professor Colin Espie, Professor David Ray, Professor Mark Hankins and Professor Aarti Jagannath, University of Oxford [ALN0074](#)
 Peter Veto, PhD [ALN0043](#)
 Professor Vladyslav Vyazovskiy, Professor Russell, Professor Stuart Peirson, Professor Simon Kyle, Professor Colin Espie, Professor David Ray, Professor Mark Hankins, Professor Aarti Jagannath, Professor Sridhar Vasudevan and Professor Zameel Cader, University of Oxford [ALN0074](#)
 Dr Alexander Waller [ALN0085](#)
 Professor Arnold Wilkins and Dr Tom Foulsham, University of Essex [ALN0023](#)
 Peter Woolliams [ALN0048](#)
- * Professor Kenneth Wright, University of Colorado Boulder ([QQ 27–39](#))
 WSP [ALN0076](#)
 The Zoological Lighting Institute [ALN0078](#)

APPENDIX 3: CALL FOR EVIDENCE

The House of Lords Science and Technology Committee is conducting an inquiry into the effects of artificial light and noise on human health. The committee invites written contributions by Friday 3 March 2023.

Background

Artificial light and noise are pervasive in the modern world and the committee will explore the extent to which unwanted, inappropriate, or excessive artificial lighting or ambient noise may have negative impacts on human health. For example, claims have been made that artificial light can disrupt sleep and circadian rhythms, which can increase the risk of heart attacks and stroke. The committee will explore the strength of the evidence for claims made about the effects of artificial light and noise on human health, the adequacy of the existing policy and regulatory framework for addressing light and noise pollution in the UK and options for reform to address any harmful effects identified.

The Committee is seeking evidence on the following questions (there is no requirement to answer all questions in your submission):

Questions

Light pollution

1. What is the state of the evidence base regarding the causes and impacts of light pollution in the UK as it relates to human health?
 - What are the mechanisms by which light pollution has an impact on human health—for example, by disrupting circadian rhythms? What are the negative impacts it can have?
 - What are the primary sources of light pollution and how well do we understand them? Is there evidence regarding which types of artificial light, in terms of frequency, duration of exposure, or intermittency, are the most harmful?
 - Is there evidence that light pollution is worsening—for example, with the introduction of LEDs and cheaper forms of lighting, or lighting with a different wavelength spectrum?
 - How reliable is our evidence base for these impacts—are there areas where we are less confident or additional studies that are needed?
 - Does the UK have a sufficient research base? Who are the main organisations conducting research into light pollution and how are they funded?
2. Where does light pollution intersect with public policy in the UK? Is the existing regulatory regime effective?
 - Are the Government agencies, departments, or local authorities currently responsible for monitoring and regulating light pollution appropriately resourced? Is there sufficient expertise within organisations charged with regulating or enforcing regulations on artificial noise?
 - Have there been any changes to Government policy following the Royal Commission on Environmental Pollution's 2009 report into artificial light in the environment? Have these been adequate?

- What role should planning authorities play in determining plans or restrictions on light pollution? Are the current guidelines on light pollution set under the Government’s advice for planning authorities adequate?
3. What recommendations would you make for changing Government policy on light pollution?
- What are the possible interventions that could be deployed to mitigate the effects of light pollution and how well understood are their effects?
 - Are there any interventions that have been pursued effectively in other countries that could be replicated in the UK?

Noise pollution

4. What is the state of the evidence base regarding the causes and impacts of noise pollution as it relates to human health?
- What are the mechanisms by which noise pollution has an impact on human health? What are the negative impacts it can have?
 - What are the primary causes of noise pollution and how well do we understand them? Is there evidence regarding which types of noise pollution, in terms of frequency or intermittency, are the most harmful?
 - Is there evidence that the impacts of noise pollution are worsening over time? Has our understanding of this issue evolved recently (e.g. in the last 10–15 years)?
 - How reliable is our evidence base for these impacts—are there areas where we are less confident or additional studies that are needed?
 - Does the UK have a sufficient research base? Who are the main organisations conducting research into noise pollution and how are they funded?
5. Where does noise pollution intersect with public policy in the UK? Is the existing regulatory regime effective?
- Are the Government agencies, departments, or local authorities currently responsible for monitoring and regulating noise pollution appropriately resourced? Is there sufficient expertise within organisations charged with regulating or enforcing regulations on artificial noise?
 - Have there been any changes to Government policy following the updated World Health Organization guidelines on noise pollution issued in 2018? Have these been adequate?
 - What role should planning authorities play in determining plans or restrictions on noise pollution? Are the current guidelines on noise pollution set under the Government’s advice for planning authorities, or the Noise Policy Statement for England, adequate?
6. What recommendations would you make for changing Government policy on noise pollution?
- What are the possible interventions that could be deployed to mitigate the effects of noise pollution and how well understood are their effects?
 - Are there any interventions that have been pursued effectively in other countries that could be replicated in the UK?

APPENDIX 4: SEMINAR HELD AT THE HOUSE OF LORDS ON 28 JUNE 2022

Members of the Committee present were Baroness Brown of Cambridge (Chair), Baroness Blackwood of North Oxford, Viscount Hanworth, Lord Holmes of Richmond, Baroness Manningham-Buller, Lord Mitchell, Lord Rees of Ludlow, Baroness Rock, Baroness Sheehan, Baroness Walmsley, Baroness Warwick of Undercliffe and Lord Wei.

Presentations were heard from:

- Dr Hannah Dagleish, Postdoctoral Research Assistant, Department of Physics, University of Oxford; and
- Professor Charlotte Clark, Professor of Epidemiology in the Population Health Research Institute, St George's, University of London.

APPENDIX 5: PRIVATE MEETING HELD AT THE HOUSE OF LORDS ON 21 FEBRUARY 2023

Members of the Committee present were Baroness Brown of Cambridge (Chair), Viscount Hanworth, Lord Holmes of Richmond, Lord Krebs, Lord Mitchell, Baroness Neuberger, Baroness Neville-Jones, Baroness Northover, Lord Rees of Ludlow, Lord Sharkey, Baroness Warwick of Undercliffe, Lord Wei and Lord Winston.

Remarks were heard from:

- Professor Russell Foster CBE, Professor of Circadian Neuroscience, University of Oxford; and
- Professor Stephen Stansfeld, Emeritus Professor of Psychiatry, Queen Mary University of London.

APPENDIX 6: COMMITTEE VISIT TO ARUP'S SOUNDLAB ON 3 MAY 2023

Members of the Committee present were Baroness Neville-Jones, Baroness Neuberger and Baroness Northover.

The Committee visited the ARUP SoundLab and ARUP ExperienceLab at Fitzroy Street, in London, where they heard presentations and experienced demonstrations of the SoundLab for road, rail, aviation and construction noise, demonstrations of virtual reality Heathrow consultation equipment, and demonstrations of the ExperienceLab for HS2 and urban planning. Members met with Richard Greer and Grace Lampkin for the SoundLab presentation, David Edge, Charles Ingea and Jamie Curran in the ExperienceLab, David Owen and Viviam Reyes presenting the demonstration on medical drones, and Henry Harris presenting the SoundLab VR demonstration on Heathrow.

APPENDIX 7: GLOSSARY

Term	Definition
Annoyance	A metric used to characterise noise pollution which relates to how disruptive the listener finds the noise. It has an international technical standard ¹⁵⁰ associated with it, and it is determined by the response to a standard set of socio-acoustic and social surveys. This metric is often used in surveys of noise and health.
colour temperature	Colour temperature ¹⁵¹ is a measure of wavelength which uses the correspondence between the temperature of a perfectly absorptive “blackbody” emitter and the peak wavelength of the spectrum of radiation it emits. Higher temperatures emit more energetic, shorter-wavelength (higher-frequency) light, with 1,000–3,000 Kelvin perceived as red-orange while 7,000–10,000 Kelvin would be perceived as blue.
circadian rhythms	Circadian rhythms, or the circadian system, refers to the body’s internal clock which results in a number of processes occurring with a 24-hour cycle. The sleep-wake pattern is an example of a prominent circadian cycle in humans.
dazzle	Refers to temporary impairment of vision due to light that is excessively bright. Can refer to the dazzle reflex, an involuntary aversion response such as blinking in response to a sudden bright light.
decibels	A measure of the energy transmitted by a sound, correlating to sound intensity. Volume is usually measured in decibels (dB), on a logarithmic scale; when a sound is perceived to double in loudness, this corresponds to an increase of roughly 10 dB. Sometimes dBA is used—the A indicates a weighting over the frequencies that the human ear responds to.
disease burden	An estimate over the sum of mortality and morbidity caused by a pollutant or illness—typically measured in “Disability-Adjusted Life Years”, or DALYs, this attempts to measure and aggregate the impact of living with illness and injury as well as premature death from the pollutant.
flicker	Flicker in lighting is rapid variation in the intensity of the lighting over time—for example, due to the way the light is wired to the mains.
glare	Glare is a general term for the reduction of visual performance or the disturbance of perception, as caused by high luminances or contrasts in luminance within a visual environment. It can refer to difficulty in seeing or discomfort due to the excessive brightness in the field of view.

150 ISO/TS 15666:2021, ‘Acoustics—Assessment of noise annoyance by means of social and socio-acoustic surveys, Abstract’ (May 2021): <https://www.iso.org/standard/74048.html> [accessed 10 July 2023]

151 Lighting design studio, ‘Colour temperature’: <https://lightingdesignstudio.co.uk/colour-temperature/> [accessed 10 July 2023]

Term	Definition
ischaemic heart disease	Heart problems caused by narrowed arteries or blood vessel inflammation which can lead to heart attacks.
LED	Light-emitting diodes—a semiconductor device which emits light when current flows through it.
longitudinal studies	Long-term studies of the health effects of some external factor which involve studying a cohort over a long period of time, collecting data on any changes that may occur.
Lux	The lux is the unit of illuminance, or luminous flux per unit area, in the International System of Units. It is equal to one lumen per square metre. It is a standard measure of light intensity as perceived by the human eye.
melanopic lux / EDI	Melanopic lux is a new unit that weights the illuminance from a source by the wavelengths that the melanopsin system, and hence the circadian system, are most sensitive to. It is therefore a better measure of light intensity as it influences the circadian system. EDI stands for “equivalent daylight illuminance” which indicates the equivalent illuminance from ordinary daylight which would provide the same stimulus to the melanopic system.
non-acoustic factors	Non-acoustic factors are factors not directly related to the acoustic properties of a sound, i.e. volume, which nevertheless influence how a person responds to a sound, including annoyance and similar effects. These factors can include personal and social factors, such as the person’s attitude towards the noise or expectations of the noise, as well as a person’s own noise sensitivity, personality traits, and ability to adapt to the noise. These can affect the level of annoyance and stress caused by noise, and the likelihood of sleep disturbance, which varies from person to person. ¹⁵²
NPPF	The National Planning Policy Framework ¹⁵³ sets out the Government’s planning policies for England and how these are expected to be applied.
NPSE	The Noise Policy Statement for England ¹⁵⁴ sets out the UK’s overall approach to noise pollution at the national level.

152 Susanne Bartels *et al.*, ‘Coping with Aviation Noise: Non-Acoustic Factors Influencing Annoyance and Sleep Disturbance from Noise’, *SpringerLink* (31 January 2022): https://link.springer.com/chapter/10.1007/978-3-030-91194-2_8#Abs1 [accessed 30 June 2023]

153 Ministry of Housing, Communities and Local Government, *National Planning Policy Framework* (20 July 2021): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf [accessed 10 July 2023]

154 Department for Environment, Food and Rural Affairs, *Noise policy statement for England (NPSE)* (15 March 2010): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69533/pb13750-noise-policy.pdf [accessed 10 July 2023]