Institution: Imperial College London

Unit of Assessment: 02 Public Health, Health Services and Primary Care

Title of case study: Reducing noise exposures to improve cardiovascular health

Period when the underpinning research was undertaken: 2008 - 2017

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Marta Blangiardo	Chair in Biostatistics	2005 - present
Lars Jarup	Reader in Environmental Medicine and Public Health	1998 - 2010
Anna Hansell	Reader in Environmental Epidemiology	2002 - 2018
Daniela Fecht	Lecturer in Geospatial Health	2003 - present
John Gulliver	Senior Lecturer	2010 - 2018
Mireille Toledano	Mohn Chair in Population Child Health & Director Mohn Centre	2002 - present
Paul Elliott	Director of SAHSU, Chair in Epidemiology and Public Health Medicine	1995 - present

Period when the claimed impact occurred: 2014 - 2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact (indicative maximum 100 words)

Noise is regarded as the second most important environmental pollutant after air pollution. The team at Imperial College have been pioneers in research on the long-term health effects of environmental noise exposures from transport sources, identifying a link between aircraft and road traffic noise with cardiovascular disease and mortality. These findings have been widely used as evidence to guide policies and public health interventions concerning health risks from noise exposures in the UK and beyond, having influenced *inter alia* the 2018 WHO Environmental Noise Guidelines for the European Region and the debate around expansion plans at Heathrow Airport.

2. Underpinning research (indicative maximum 500 words)

Global air and road traffic have increased steadily over the last two decades and effects of transport noise on human health, especially risk of cardiovascular disease, have become a growing public health concern. The hypothesis is that noise exposure provokes a stress response and release of stress hormones, which in turn affect cardiovascular disease risk factors such as blood pressure and heart rate. Imperial College is a leader in this research area through delivery of three linked programmes of work: i) the HYENA (Hypertension and Exposure to Noise near Airports) study led by Jarup (1-3); ii) a study of aircraft noise and cardiovascular disease near Heathrow (4) undertaken by the UK Small Area Health Statistics Unit (SAHSU) at Imperial College; and iii) road traffic noise in relation to cardiovascular disease, all-cause mortality (5) and birth weight (6), also carried out with SAHSU.

The HYENA study involved 4,861 participants ages 45-70 years living near a major airport (including Heathrow) for at least five years in one of six European countries (1). Blood pressure was measured at home visits and questionnaire data obtained on health, socioeconomic, and lifestyle factors. Noise exposure was assessed using modelled estimates. For 10 dB higher night-time aircraft noise, odds ratio (OR) for risk of hypertension was 1.14 (95% confidence interval [CI], 1.01–1.29), with similar findings for road traffic noise (1). There was evidence of increased anti-

hypertensive use in both the UK and Netherlands HYENA samples, as well as increased use of anxiolytic medications in relation to aircraft noise (2). In addition, there was an association between night-time average aircraft noise and self-reported heart disease and stroke among participants who had lived at the same address for ≥ 20 years, with OR 1.25 (1.03–1.51) per 10 dB (3).

SAHSU holds a detailed database of postcode-level individual health records including mortality and hospital admissions by specific cause, and birth outcomes, linked with geographical, environmental (e.g. noise) and socio-economic data. This unique database allows the Imperial College researchers to robustly investigate disease and health risks in neighbourhoods with adjustment for covariates such as age, sex, ethnicity, deprivation, and a smoking proxy (lung cancer mortality). They showed that high levels of aircraft noise near Heathrow Airport were associated with increased risks of mortality and hospital admissions for stroke, coronary heart disease and cardiovascular disease with relative risks (RRs) for mortality of 1.21 (0.98–1.49), 1.15 (1.02–1.30) and 1.16 (1.04–1.29), respectively. RRs for hospital admissions were similar, with narrower CIs (4). Subsequent work investigated health risks associated with traffic noise across a population of 8.6 million people (5), and birth weights for 540,365 singleton term live births, in London (6). Daytime road traffic noise was associated with increased risk of hospital admission for stroke with RR 1.05 (1.02–1.09) in adults, and 1.09 (1.04–1.14) in the elderly (≥75 years) in areas at >60 versus <55 dB. Night-time noise was associated with stroke admissions only among the elderly. Daytime noise was also associated with all-cause mortality in adults with RR 1.04 (1.00–1.07) in areas at >60 versus <55 dB (5). There was little evidence for an effect of road traffic noise on birthweight once the effects of air pollutants were taken into account (6).

3. References to the research (indicative maximum of six references)

(1) Jarup, L., Babisch, W., Houthuijs, D., Pershagen, G., Katsouyanni, K., Cadum, E., Dudley, M.L., Savigny, P., Seiffert, I., Swart, W., Breugelmans, O., Bluhm, G., Selander, J., Haralabidis, A., Dimakopoulou, K., Sourtzi, P., Velonakis, M., Vigna-Taglianti, F.; HYENA study team (2008). Hypertension and exposure to noise near airports: the HYENA study. *Environmental Health Perspectives*, 116:329-333. DOI.

(2) Floud, S., Vigna-Taglianti, F., Hansell, A., Blangiardo, M., Houthuijs, D., Breugelmans, O., Cadum, E., Babisch, W., Selander, J., Pershagen, G., Antoniotti, M.C., Pisani, S., Dimakopoulou, K., Haralabidis, A.S., Velonakis, V., Jarup, L., HYENA Study Team (2011). Medication use in relation to noise from aircraft and road traffic in six European countries: results of the HYENA study. *Occup Environ Med*. 68:518-24. DOI.

(3) Floud, S., Blangiardo, M., Clark, C., de Hoogh, K., Babisch, W., Houthuijs, D., Swart, W., Pershagen, G., Katsouyanni, K., Velonakis, M., Vigna-Taglianti, F., Cadum, E., Hansell, A.L. (2013). Exposure to aircraft and road traffic noise and associations with heart disease and stroke in six European countries: a cross-sectional study. *Environ. Health*. 12: 89. DOI.

(4) Hansell, A.L., Blangiardo, M., Fortunato, L., Floud, S., de Hoogh, K., Fecht, D., Ghosh, R.E., Laszlo, H.E., Pearson, C., Beale, L., Beevers, S., Gulliver, J., Best, N., Richardson, S., Elliott, P. (2013) Aircraft noise and cardiovascular disease near Heathrow airport in London: small area study. *BMJ*: 347. DOI.

(5) Halonen, J.I., Hansell, A.L., Gulliver, J., Morley, D., Blangiardo, M., Fecht, D., Toledano, M.B., Beevers, S.D., Anderson, H.R., Kelly, F.J., Tonne, C. (2015). Road traffic noise is associated with increased cardiovascular morbidity and mortality and all-cause mortality in London. *Eur Heart J*;36(39):2653-61. DOI.

(6) Smith, R.B., Fecht, D., Gulliver, J., Beevers, S.D., Dajnak, D., Blangiardo, M., Ghosh, R.E., Hansell, A.L., Kelly, F.J., Anderson, H.R., Toledano, M.B. (2017). Impact of London's road traffic air and noise pollution on birth weight: retrospective population based cohort study. *BMJ:* 359**.** DOI.

Key funding:

- European Commission, Directorate General Research, Quality of Life and Management of Living Resources, Key Action 4 Environment and Health, €2,270,000
- ESRC, Future Leaders Fellowship, £261,883
- European Commission, FP7-ENV-2008-1, €104,891
- NERC, Environmental & Exposure Health Initiative, £342,406
- Medical Research Council, MRC Centre Programme, £2,290,000
- MRC/Health Protection Agency, SAHSU, £2,380,000
- MRC/Public Health England, SAHSU, £2,400,000

4. Details of the impact (indicative maximum 750 words)

The work by Imperial College on health effects around Heathrow Airport and its leadership role in large UK and European studies have provided clear evidence on associations between aircraft and road noise exposures and cardiovascular disease risks. This research has contributed to international guidance to reduce health risks from noise exposures for populations in the UK and throughout Europe. Evidence on health effects near Heathrow has been used by central government, the local authority (Hillingdon) and a campaigning organisation HACAN (Heathrow Association for the Control of Aircraft Noise).

Internationally, both the Imperial-led HYENA study (1-3) and Imperial research on cardiovascular disease risks around Heathrow (4) have been key pieces of evidence cited extensively in the World Health Organization's (WHO) 2018 Environmental Noise Guidelines for the European Region [**A**]. The guidelines provide a detailed review of the evidence and meta-analyses of available data including results of the Imperial studies. To reduce health effects, the WHO strongly recommended that suitable measures be implemented to reduce aircraft noise levels below 45 dB L_{den} (day-evening-night) and road traffic noise below 53 dB L_{den}, as aircraft and road traffic noise above these levels are associated with adverse health effects.

The European Environment Agency (EEA) has published a health impact assessment of noise pollution in Europe, and used the Imperial College results (3, 4) to derive exposure-response relationships for stroke occurrence and death [**B**]. A report for the European Commission declared that exposure to excessive noise was the "*second-worst environmental cause of ill health after ultra-fine particulate matter*" and cites the Imperial College work as evidence of the link between aircraft noise and cardiovascular disease [**B**]. Furthermore, a report for the European Parliament on Impact of aircraft noise pollution on residents of large cities cited Imperial College's work (1,4) as evidence of effects of aircraft noise on hypertension and cardiovascular disease [**C**].

Imperial's work has been used to update the evidence on aircraft noise and health effects by the UK Civil Aviation Authority (report CAP 1164 in 2014 and CAP 1278 in 2016) [**D**]. The reports gave a detailed account of the results of the Floud et al. (3) and Hansell et al. (4) studies, concluding with respect to Floud et al, "*This study provides a valuable insight into the associations between road traffic and aircraft noise and these particular health outcomes*" and "*given the association for those residents who had lived at the same address for 20 plus years, the results suggest that the relationship between aircraft noise exposure at night may be strengthened over time, and could be cumulative in nature*".

The 2014 UK Civil Aviation Authority report CAP 1164, summarising the Imperial research, was cited as evidence in the impact summary prepared by the Department of Transport in support of the statutory night flying restrictions at Heathrow, Gatwick and Stansted (published, following consultation, by the Department of Transport in 2014). Citing CAP 1164, the impact statement read: "*The Government recognises that aviation noise is the primary concern of local communities near airports… There is evidence to suggest that long term exposure to noise at night can lead to adverse health effects, such as hypertension and cardiovascular disease*." The impact statement goes on to say: "*The Government's overall policy on aviation noise is to limit and, where possible, reduce the number of people in the UK significantly affected by aircraft noise*." [**D**].

Noise pollution was at the core of the controversy around the Heathrow expansion. The Imperial College study of health effects of aircraft noise near Heathrow (4) was cited in the parliamentary debate on aircraft noise on 20 April 2016, with the then Minister of State at the Department of Transport, Robert Goodwill, quoted in Hansard as follows: "*I want to assure the House that the Government are acutely aware that noise is a major environmental concern around airports. I had a briefing earlier this week from the Aviation Environment Federation, which presented some very important research—not least from Imperial College, a well respected institution—on the effects on cardiovascular disease and other diseases*." [**E**]. The Imperial College study (4) has been cited by HACAN [**F**], and by Hillingdon local authority in its 2019 response to the Heathrow Airport Expansion Statutory Consultation [**G**].

The Airports Commission commissioned a selective review of the literature [**H**] to assess the strength of the evidence generated from "*high quality, robust, large-scale epidemiological field studies of aircraft noise exposure*", including the Imperial College studies on aircraft noise and hypertension, medication use and cardiovascular disease.

The Hansell et al. (4) study received worldwide attention. It had extensive media and public interest and was accompanied by a short video explaining the results which was published on the BMJ website alongside the original publication in October 2013. The findings were covered by 41 news outlets worldwide. The Altmetric score is 554, placing this in the top 5% of all research outputs scored by Altmetric.

More recent work from Imperial on health effects of road noise has been cited in official reports for government. This includes SAHSU's work on cardiovascular risks associated with road traffic noise, cited in the final independent report (2019) to advise the Scottish government on Cleaner Air for Scotland Strategy [**I**]. A review of evidence relating to environmental noise exposure and health in the context of the Interdepartmental Group on Costs and Benefits (ICGB(N)) was recently (2020) completed by Arup on behalf of Defra [**J**]. This concluded that the SAHSU study on road traffic noise and birth weight in London was high quality and stated: "*For the UK context, the evidence from the large-scale study by Smith et al. (2017) is compelling and …at present for the UK it is appropriate to consider that there is no effect of road traffic noise on birth weight*" (page 56).

5. Sources to corroborate the impact (indicative maximum of 10 references)

[**A**] http://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2018/environmental-noise-guidelines-for-the-european-region-2018 (see pages 34,35,37,64-67,151,154). Archived here.

[**B**] https://www.eea.europa.eu/publications/noise-in-europe-2014 (see pages 41-42) (archived here) and https://op.europa.eu/en/publication-detail/-/publication/89612982-1e4d-11e6-ba9a-01aa75ed71a1/language-en/format-PDF (see page 57). Archived here.

[**C**] https://www.europarl.europa.eu/RegData/etudes/STUD/2020/650787/IPOL_STU(2020)650787_EN.pdf (see pages 11, 32). Archived here.

[**D**] Two Imperial-led studies extensively described in Civil Aviation Authority reports: https://www.aef.org.uk/uploads/CAP-1164_Aircraft-noise_and_health-1.pdf (see pages 6-10; archived here) and http://publicapps.caa.co.uk/docs/33/CAP%201278%20MAR16.pdf (see pages 14-21, paras 2.27-2.53; archived here). CAP-1164 summary of the evidence cited in https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/330355/night-noise-impact-assessment.pdf (see page 4; archived here).

[**E**] https://hansard.parliament.uk/Commons/2016-04-20/debates/16042033000001/AircraftNoise (archived here).

[**F**] https://hacan.org.uk/?cat=10 (archived here).

[**G**] https://archive.hillingdon.gov.uk/media/41657/Hillingdon-response-to-Heathrow-Expansion-consultation/pdf/Hillindgons_Full_Consultation_Response.pdf (see page 226; archived here)

[**H**] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/446311/noise-aircraft-noise-effects-on-health.pdf (see pages 2-3, page 10). Archived here.

[**I**] https://www.gov.scot/publications/cleaner-air-scotland-strategy-independent-review/pages/15/ (see footnote 35). Archived here.

[**J**] Arup. 2020. Review of Evidence Relating to Environmental Noise Exposure and Specific Health Outcomes in the context of the Interdepartmental Group on Costs and Benefits. http://randd.defra.gov.uk/Document.aspx?Document=14685_ReviewofEvidenceRelatingtoEnvironmentalNoiseExposureandSpecificHealthOutcomes.pdf [Online] 2020. (see pages 50, 52 and 56). Archived here.