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# Transportation Noise and Public Health Outcomes: Biological Markers and Pathologies

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# Defining Environmental Noise

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- Environmental noise has been defined as **any unwanted sound created by human activities that is considered harmful or detrimental to human health and quality of life** (Murphy and King, 2014)
- Specifically, environmental noise refers only to noise produced by human interaction with the environment

# Why is it a problem?

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- In the EU, problems with noise are often rated at the highest level together with global warming
- “Environmental noise leads to a disease burden that is second in magnitude only to that from air pollution, among environmental factors in Europe” (WHO, 2011)
- Transport is the main source of environmental noise in urban areas
- Taking all exposure to transportation together, WHO estimate that 50% of EU population live in areas of acoustical discomfort where noise is considered to have adverse health impacts

# Sources of Environmental Noise

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- Transportation

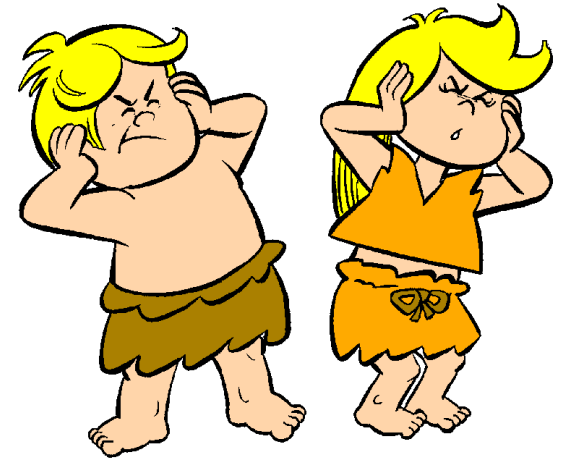
- Road, rail, air, sea

- 1. Engine noise 2. Rolling Noise

- Occupational noise

- Industry

- Noise nuisances – alarms, anti-social behaviour etc

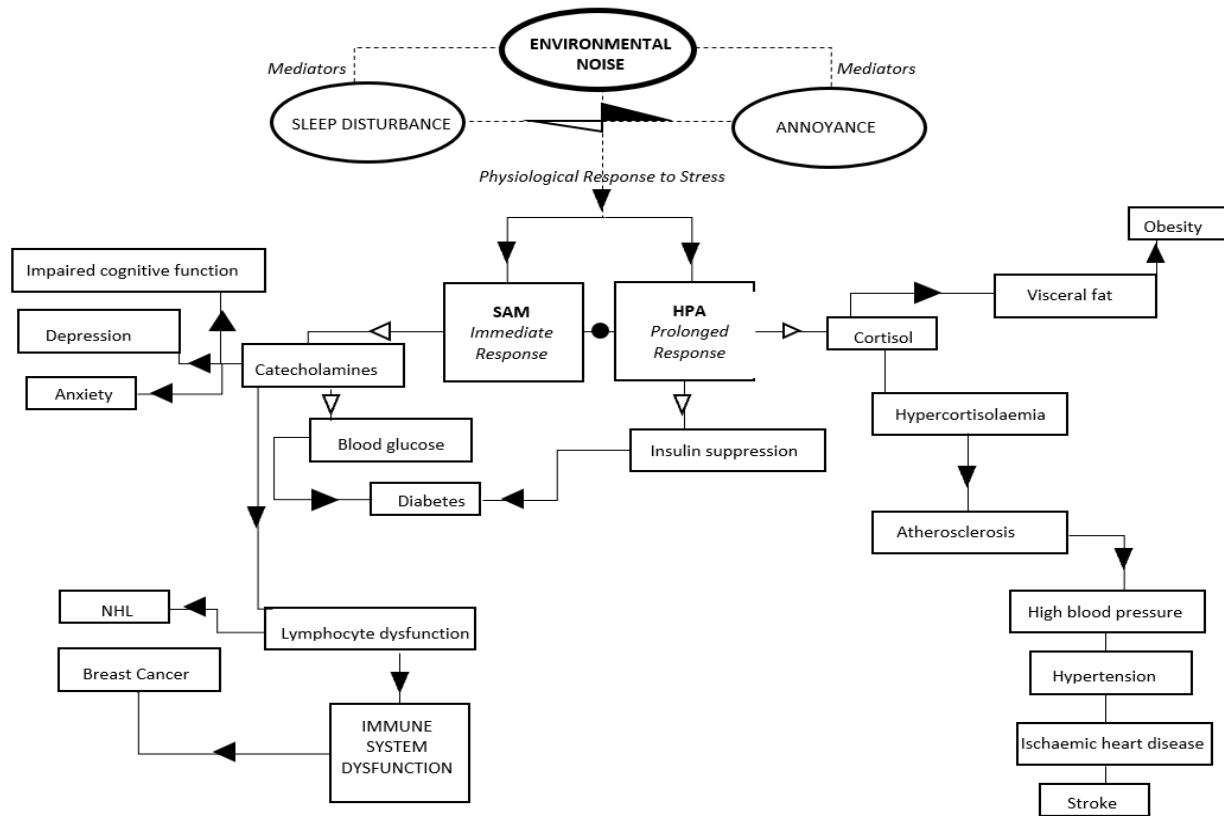


# The Noise-Health Relationship

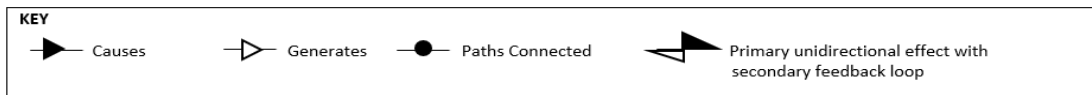
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- Non-auditory effects of environmental noise are not a direct result of sound energy
- They are the result of noise as a general stressor
- Relatively well understood nonauditory effects of noise include sleep disturbance, annoyance, heart disease, as well as effects on cognitive outcomes such as speech communication, and cognitive performance

# Physiological Noise-Health Relationship



**Figure 1:** Physiological Response to Environmental Noise



# Noise and Public Health

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## ➤ Annoyance

- Negative emotions – anger, disappointment, unhappiness, anxiety, depression, demotivation etc
- Considered as health stressors

## ➤ Children particularly susceptible

- Cognitive impairments - central processing and language comprehension
  - Reading, attention span, problem solving, memory negatively affected







# Breast Cancer

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- Sleep disturbance inhibits the production of melatonin which reduces breast cancer carcinogenesis through suppression of antioxidant processes and new blood vessel formation
- Sørensen et al. found that road and rail sources of environmental noise had the potential to increase the risk for ER- tumour types
- Hegewald et al. found that exposure to aircraft noise was associated with an increased risk for ER negative breast cancer, with environmental noise from road and rail sources less evident
- However, a recent study on a cohort of 57,053 Danish participants, which included 1,759 breast cancer patients, Roswall et al. found no association between road traffic noise and mortality, either overall, or in relation to ER+ or ER- tumour types

# Diabetes

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- Diabetes is first of all caused by inducement of the hypothalamus-pituitary-adrenal axis (HPA axis) activity resulting in cortisol overproduction and insulin suppression
- Controlling for air pollution, Sørensen et al. found that exposure to road traffic noise was associated with type 2 diabetes, with higher noise levels, and the longer the period of time exposed, associated with higher risk
- Roswall et al. found a significant association between road traffic noise and increased risk for diabetes, but not in relation to rail traffic noise
- Research by Tobías et al. found that, for populations over 65 years, for every 1 dB increase in night-time road traffic noise, the risk for diabetes related mortality rose by 9.4%

# Obesity

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- Oftedal et al. found no association between road traffic noise and obesity in a general population from the city of Oslo; positive associations were found in a cohort of women who were highly sensitive to noise
- In a study of 57,053 middle-aged participants, Christensen et al. found an association between road traffic noise and obesity (only a significant association for rail noise over 60dB)
- Pyko et al. found that transportation noise exposure was correlated with an increased risk for obesity from all three sources, with aircraft noise the strongest predictor
- Nicole found that all measurements of obesity were correlated with road traffic noise. As such, every 10 dB increase in road traffic noise over a 5 year period was correlated with an increase of .35 cm in waist circumference and an increase of .18 in Body Mass Index (BMI)

# Fertility (fetal & infant development)

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- Christensen et al. found a relationship between exposure to road traffic noise and long term conception of between 6 and 12 months
- In a meta-analysis of 29 studies, Dzhambov et al. found that pregnant women exposed to noise levels greater than 80dB were at significantly higher risk for having SGA, gestational hypertension, and babies with congenital malformations
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- In an analysis of 70,000 birth records in Vancouver, Gehring et al. found that road traffic noise exposure increased the risk for LBW, controlling for socio-economic indicators and air pollution
- For aircraft noise, a study of 160,460 births in Japan, found significant correlations between aircraft noise and LBW
- On the other hand, in a study of 75,166 births in Denmark, Hjorteberg et al. found that exposure to traffic noise did not affect a new-born baby's size or weight; a study of 6,438 births in Barcelona, Spain (Dadvand et al.) also found no significant associations

# Noise and Health in the EU

TABLE 3.1 Burden of Disease from Environmental Noise in Europe

Noise-Induced Exposure	Public Health Impact
Annoyance	587,000 DALYs <sup>a</sup> lost for inhabitants in towns >50,000 population
Sleep disturbance	90,3000 DALYs for EUR-A <sup>b</sup> inhabitants in towns >50,000 population
Cardiovascular diseases	61,000 years for ischaemic heart disease in high-income European countries
Tinnitus <sup>c</sup>	22,000 DALYs for the EUR-A adult population
Cognitive impairment in children	45,000 DALYs for EUR-A countries for children aged 7–19 years

- 1 in 3 people annoyed during the day; 1 in 5 sleep disturbed at night (from transport noise alone)
- 1-1.6 millions healthy life years lost every year

# Burden of disease

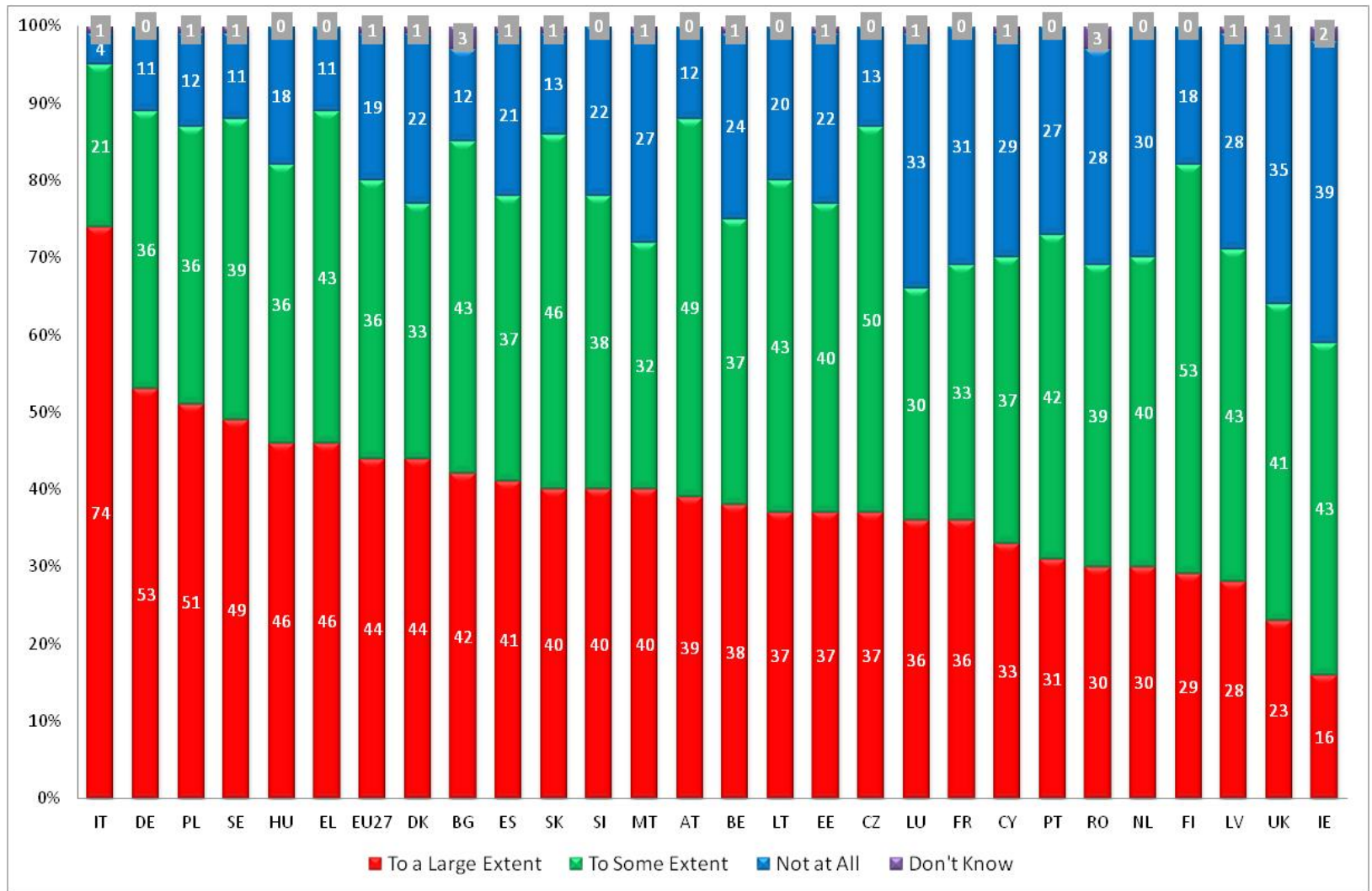
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- **1 in 3** people annoyed during the day; **1 in 5** sleep disturbed at night (from transport noise alone)
- At least **100 million people** in the EU are affected by road traffic noise above the assessment threshold specified in the END (55dB Lden)
- Over **83 million** Europeans are exposed to harmful levels of noise from night-time road traffic (above 50 dB Lnight)
- At least **1.6 million** healthy years of life are lost due to road traffic noise in Western Europe

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*Source: WHO/JRC, 2011; EEA, 2017*

# Does Noise Affect Human Health?



# WHO Guidelines (2018) – Transportation Noise

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- For average noise exposure, the GDG **strongly** recommends reducing noise levels produced by road traffic noise below 53dB  $L_{den}$  as road traffic noise above this level is associated with adverse health effects
- For night noise exposure, the GDG **strongly** recommends reducing traffic noise levels produced by traffic noise during night time below 45dB  $L_{night}$  as road traffic noise above this level is associated with adverse effects on sleep



# WHO Guidelines – Railway Noise

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- For average noise exposure, the GDG **strongly** recommends reducing noise levels produced by railway traffic below 54dB  $L_{den}$  as railway noise above this level is associated with adverse health effects
- For night noise exposure, the GDG **strongly** recommends reducing noise levels produced by railway traffic during night time below 44dB  $L_{night}$  as railway noise above this level is associated with adverse effects on sleep

# Legislation - END 2002/49/EC

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- European Noise Directive (END) (2002) – statutory instrument
- Aims to provide a common basis for addressing problem of environmental noise in EU
- To develop common assessment methods and indicators for noise –  $L_{den}$  and  $L_{night}$
- To increase public awareness about noise
- To disseminate information in a manner that is easy for everyone to understand

# What must be mapped?

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- Cities with pop. >100,000 must produce strategic noise maps and action plans every 5 years
- All major roads (with more than 6 million vehicle passages a year)
- Rail lines (with more than 60000 train passages a year)
- Airports (with more than 50000 movements a year)
- Industrial sites must be mapped for noise pollution

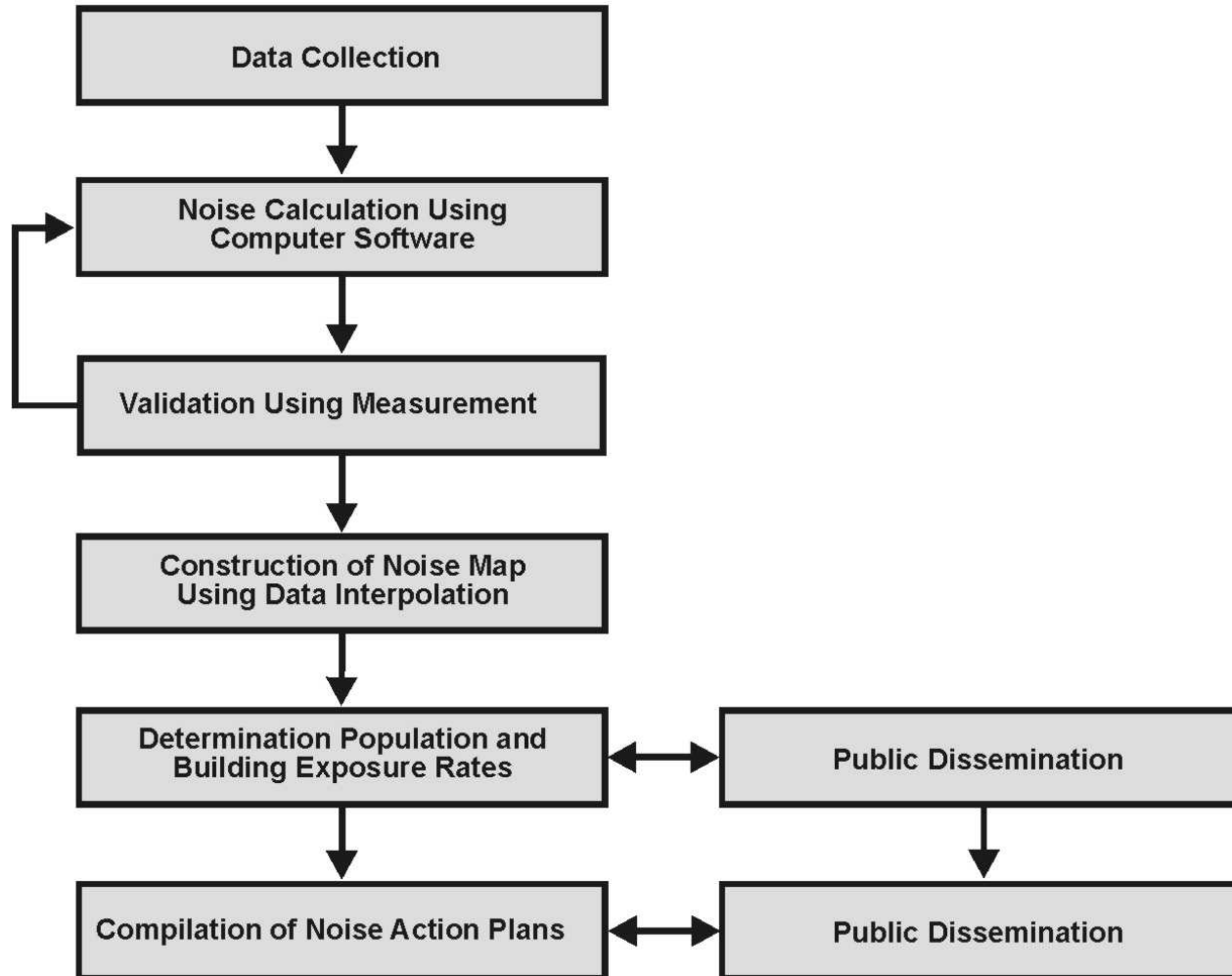
# What must be mapped?

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- Estimates of noise population/building exposure must be given for specified decibel cohorts for 24hr ( $L_{den}$ ) and night-time noise ( $L_{night}$ )
- Three phases so far – 2007, 2012 and 2017

# The Noise Mapping Process

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# Action Planning is a Process!

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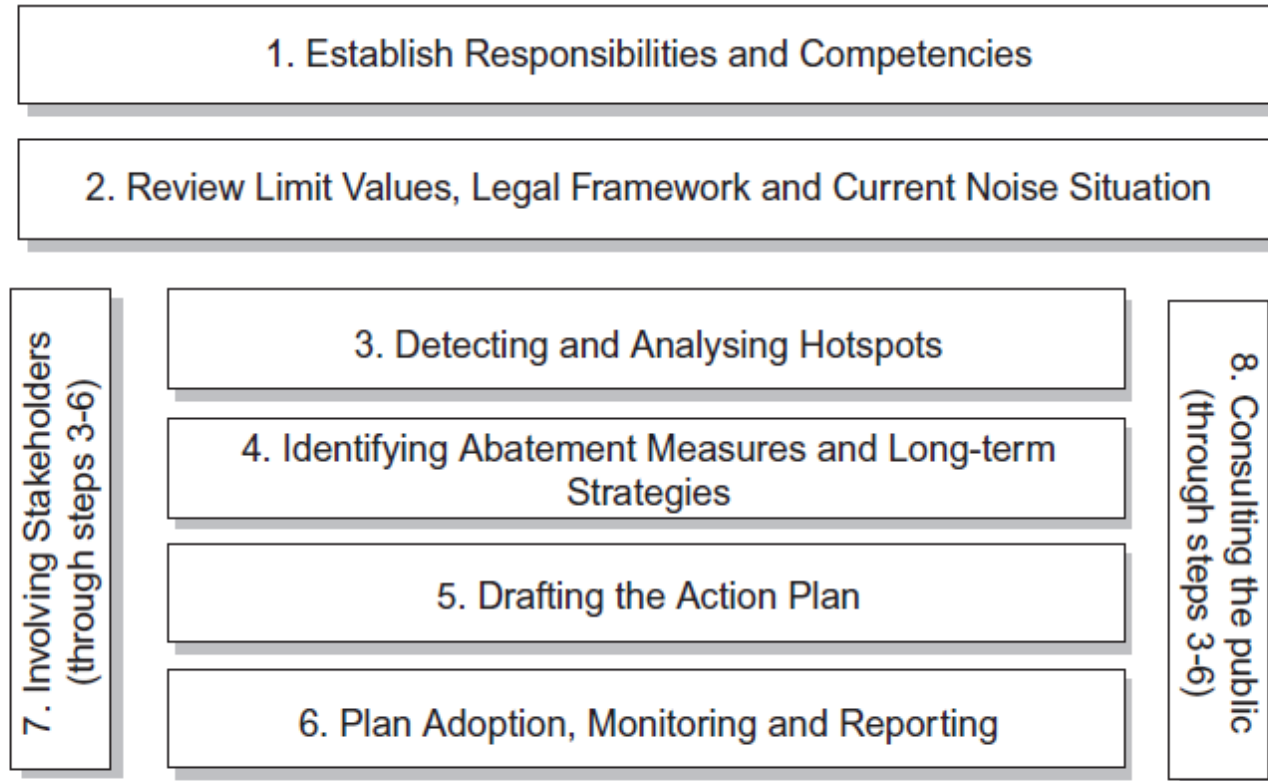


FIGURE 7.1 Overview of the action planning process. *Source: Adapted from Kloth et al. (2008).*

# Noise-Health Project

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- Part of a wider study attempting to understand/investigate the relationship between environmental noise exposure from transportation and resultant health outcomes
- Using household level data (TILDA/HI) the objective is to investigate the relationship between noise levels at the most exposed facades of buildings (modelled) and health outcomes
- In assessing noise-health relationships we are keenly interested in understanding the role of moderators, mediators, and confounders in assessing health risk from transportation noise exposure



# TILDA Outcome Variables

Table 1: Candidate variables from TILDA

Type	Variable	Description	Source
Outcome	Sleep	Trouble falling asleep	CAPI
		Trouble waking up too early, unable to fall back asleep	CAPI
		Number of hours slept on week-night (note: not available in W1)	CAPI
Depression	Depression	CES-D score	CAPI
		Categorised CES-D score	CAPI
Anxiety	Anxiety	HADS score	CAPI
		Penn State Worry scale score	SCQ
Quality of life	Quality of life	Total CASP score	SCQ
		Pleasure domain of CASP score	SCQ
Heart attack	Heart attack	Self-reported heart attack diagnosis in past	CAPI
Stroke	Stroke	Self-reported stroke diagnosis in past	CAPI
Cancer	Cancer	List self-reported cancer diagnosis in past (specifically breast, colon and NHL)	CAPI
Other chronic conditions	Other chronic conditions	List self-reported chronic condition diagnosis in past (specifically chronic lung disease, asthma, Parkinson's disease and dementia)	CAPI
Hypertension	Hypertension	Objective measure of hypertension	HA
		Self-reported hypertension diagnosis in past	CAPI
Diabetes	Diabetes	Self-reported diabetes or high blood sugar diagnosis in past	CAPI
		Objective glycated haemoglobin (HbA <sub>1c</sub> ) test	HA
Cognitive impairment	Cognitive impairment	Mini mental state examination (MMSE)	CAPI
		Montreal cognitive assessment (MOCA)	CAPI
		Verbal fluency	HA
		Immediate and delayed recall	HA
		Colour trails 1 and 2	HA
		Sustained attention to response task (SART)	HA
Obesity	Obesity	BMI (kg/m <sup>2</sup> )	HA
		Self-reported weight and height	CAPI
Physical lethargy	Physical lethargy	Total metabolic equivalent minutes spent on vigorous activities, moderate activities and walking in past 7 days	CAPI
		Categories of physical activity engaged in	CAPI



# Moderators, Mediators and Confounders

Table 1: Candidate variables from TILDA

Type	Variable	Description	Source
Moderator	Medical conditions	Any long term or limiting long term illness	CAPI
		ADL or IADL	CAPI
		Any difficulty following conversation with one person	CAPI
	Medications	Medications taken on regular basis	CAPI
		Number of medications reported	CAPI
		Anti-depressant medication	CAPI
	Building type	House type (i.e. detached, semi-detached etc.)	CAPI
Year property built		CAPI	
Mediator	Alcohol consumption	High/low risk for surpassing Dept. of Health guidelines for weekly limit on standard drinks	SCQ
		CAGE alcohol scale score	SCQ
	Smoking	Smoker or not	SCQ
	Length of tenure	Years living in current residence	CAPI
	Loneliness	UCLA loneliness scale	SCQ
		Participation in social groups	CAPI
		Social connectedness score	CAPI
Confounder	Age	Age of respondent	CAPI
	Gender	Gender of respondent	CAPI
	Income	Weekly household disposable income	CAPI
		Gross total assets in quintiles	CAPI
	Marital status	Marital status of respondent	CAPI
	Education	Highest level of education completed	CAPI
	Perceptions	Respondent's perception of hearing	CAPI

CAPI: Computer-assisted personal interview

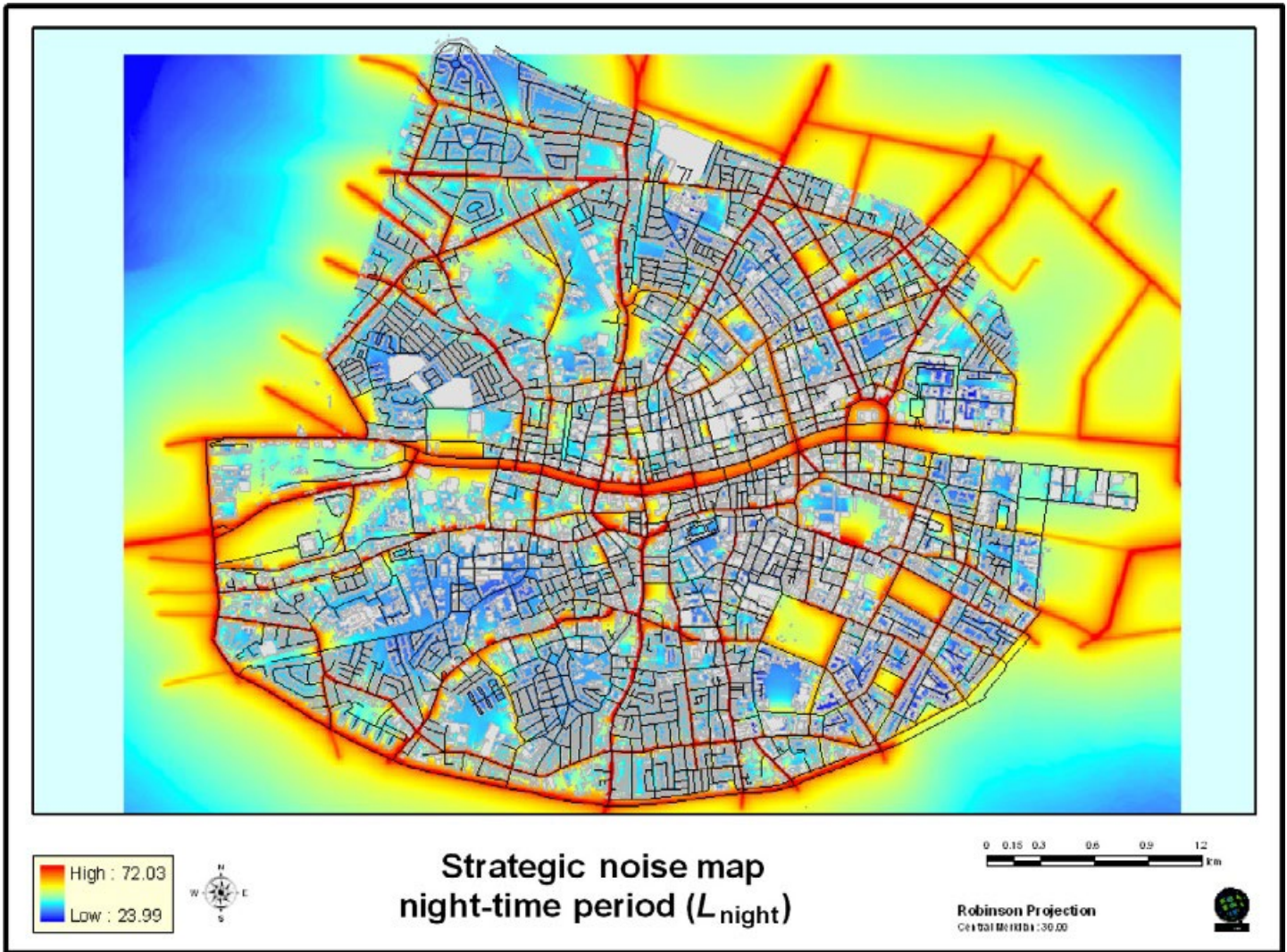
SCQ: Self-completion questionnaire

HA: Nurse-led health assessment

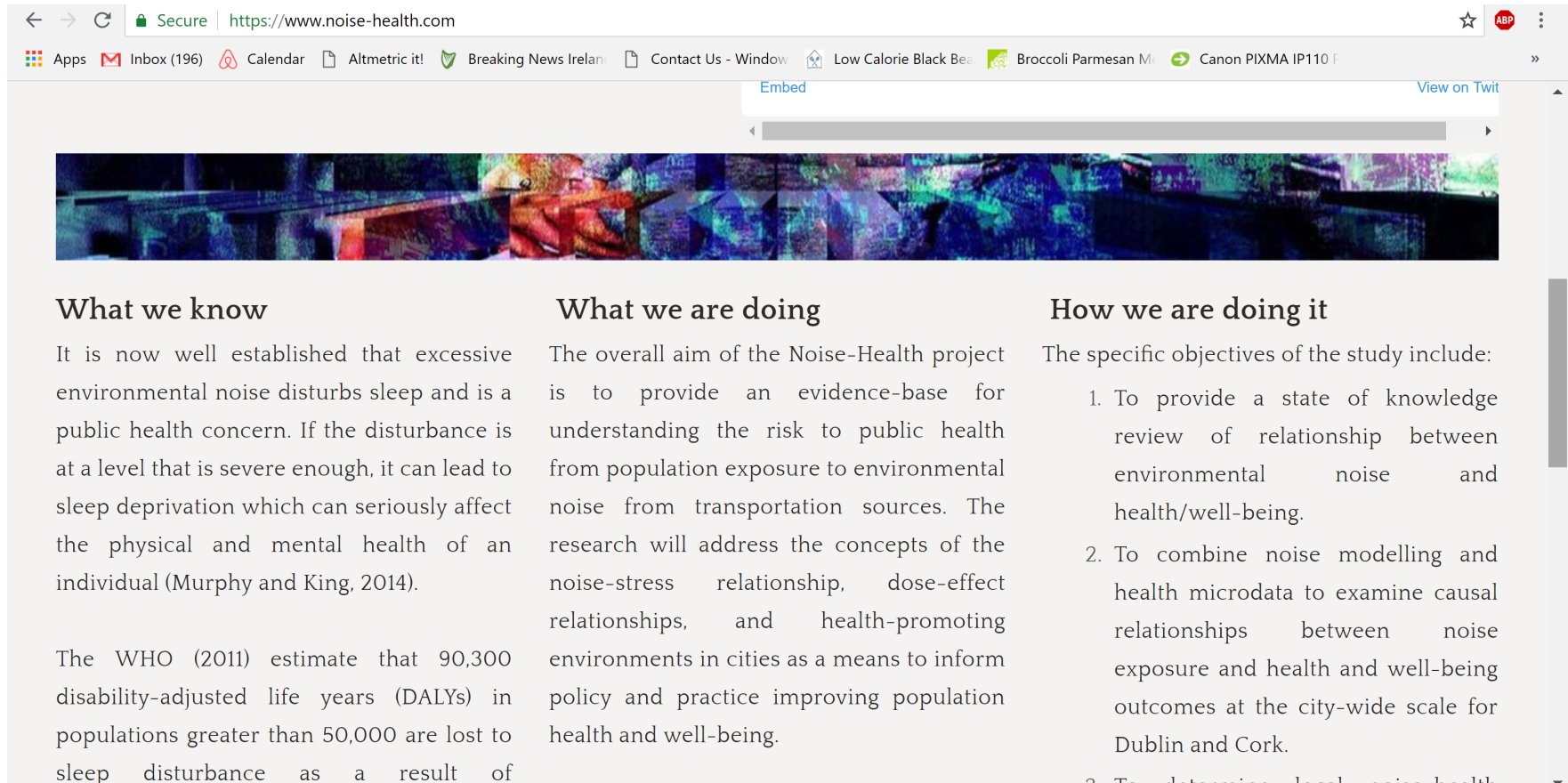
# TILDA Sub-sample Sizes

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<b>Local authority area</b>	<b>TILDA sample</b>	<b>Percentage of Dublin sample</b>
Dublin City	877	43.81
Dún Laoghaire-Rathdown	457	22.83
South Dublin	401	20.03
Fingal	267	13.34
Total	2,002	100.00




# Noise-Health Website



← → ↻ Secure | https://www.noise-health.com

Apps | Inbox (196) | Calendar | Altmetric it! | Breaking News Ireland | Contact Us - Window | Low Calorie Black Be | Broccoli Parmesan M | Canon PIXMA IP110 F

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## What we know

It is now well established that excessive environmental noise disturbs sleep and is a public health concern. If the disturbance is at a level that is severe enough, it can lead to sleep deprivation which can seriously affect the physical and mental health of an individual (Murphy and King, 2014).

The WHO (2011) estimate that 90,300 disability-adjusted life years (DALYs) in populations greater than 50,000 are lost to sleep disturbance as a result of

## What we are doing

The overall aim of the Noise-Health project is to provide an evidence-base for understanding the risk to public health from population exposure to environmental noise from transportation sources. The research will address the concepts of the noise-stress relationship, dose-effect relationships, and health-promoting environments in cities as a means to inform policy and practice improving population health and well-being.

## How we are doing it

The specific objectives of the study include:

1. To provide a state of knowledge review of relationship between environmental noise and health/well-being.
2. To combine noise modelling and health microdata to examine causal relationships between noise exposure and health and well-being outcomes at the city-wide scale for Dublin and Cork.
3. To determine local noise health

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# Thank you!