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HEALS

Health and Environment-wide Associations based on Large population Surveys

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http://www.heals-eu.eu/

D1.3 A critical review of how much of the difference in disease between socioeconomic and other social groups can be explained by differences in the "group" exposome

WP1 Overview of scientific state of the art

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"Socioeconomic status (SES) and other social markers of disadvantage are important disease risk factors to be considered within HEALS. However, these social group descriptors may mask a common exposomic phenotype, with shared exposures such as prevalence of cigarette smoking, alcohol consumption, diet etc. This Task will review the published evidence to try to understand how much of differences in disease risk with SES or other social factors can be explained by the exposome. This task will be performed in close collaboration with WP10." HEALS Work Plan

Given that close collaboration with WP10 was required we also prevent results of task 10.1 in this document:

> Task 10.1 Establishing the state of the art of the relationship between socio-economic status and environmental exposure
>
> "It is important to investigate the evidence of relationships between socio-economic status and exposure to pollutants, i.e. to investigate how time-activity patterns, indoor pollution and concentrations in microenvironments change with changing SES. The literature will be closely examined, and results passed to Task 3.3.2 to implement." HEALS Description of Work

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Contributors:

Christian Schieberle & Naixin.Li (Univ Stuttgart): contributed to appendix 2 and introduced the concept of heat maps

Mercè Garí & Joan O. Grimalt (IDAEA-CSIC): contributed to appendix 1

Ken Dixon (IOM): contributed to literature searches

1. Introduction

1.1 Definition of socioeconomic status

There is no single definition of socioeconomic status (SES) [1] but it can be said to embody an array of social and economic resources: material capital such as money and goods, human capital such as skills, knowledge, prestige or power, and social capital - beneficial social connections [2-5]. These resources can be deployed in order to protect and promote health. Disease, disability and premature death are higher for lower socioeconomic groups, two or three times higher in the EU for example [6].

Just as there is no single definition of SES there is no single measure [1]. When considering a measure it is important to think about the level of the measure: person, household or area. A respondent might rely on resources from other household members but might not know details about those resources when asked. Relying on area level measurements reduces individual respondent burden but an inhabitant might not be typical of local people.

The traditional measures of SES are education, income and occupation (social class) [7]. Other commonly used and available measures include employment status, neighbourhood deprivation, lone parents, housing tenure and car access [8, 9]. Each of these measures has advantages and disadvantages (see table 1.1). When choosing a measure it is important to take confounding factors into account. For example lone parents are more likely to be women and older people are less likely to be lone parents, more likely to have paid off a mortgage and are more likely to be retired than having a current occupation. There have been different measures of SES proposed for children and young people as many usual measures may not apply [10]. Numbers are also an issue. Small numbers of unemployed people or single parents for example may reduce the chances of finding a significant result whereas most people can be categorised by housing tenure or neighbourhood deprivation [11]. However it is necessary to consider to which it is useful to explore extreme levels of poverty within a sample – for example being unemployed may reflect more severe disadvantage compared to living in rented accommodation. Sometimes composite measures of disadvantage may be useful to consider the poverty gradient [12] in which more and less extreme disadvantage can be monitored [8]. Another advantage of a composite measure over the inclusion of many single SES measures is that it reduced the risk of multi-collinearity given that all these indicators are intended to measure the same underlying construct.

Some factors we would not include as a measure of SES per se but are instead factors that increase vulnerability to low SES. These include age, gender, ethnicity and marital status. We consider the former three of these vulnerable groups in further analyses in the appendices.

Here we have not differentiated between measures of SES in our review. We would recommend using more than one measure, combined into a composite index, in order to overcome the shortcomings of individual measures. Methods of combining measures

include factor analysis or weighting different indicators or using a count of the number of indicators of high or low socioeconomic status [8].

Relationships with health differ depending on the indicator of SES and the health condition thus it may therefore be beneficial to measure the underlying causes of the association between SES and health [13]. The rest of this deliverable is devoted to this.

Table 1.1 Some common SES measures

Measure	Advantages	Disadvantages
Education	All children have the potential to be educated	• Education systems change over time • It may be difficult to match foreign and local qualifications • It may be difficult to conduct cross country comparisons • Younger people may not have finished their education
Income	Intuitively what we think of when thinking about economic position	• People may be unwilling to state their income • Utility of income depends on the number of people it needs to support • People may not be aware of other people's income in their household • People's income may vary and be difficult to estimate
Occupation	Traditional measure of SES particularly in the UK	• An accurate measure of social class requires time consuming coding of an array of information (e.g. job title, size of organisation, number of employees, skill) using an official coding scheme • Many people may not have an occupation e.g. students, retired • Some suggestion that traditional class boundaries are breaking down with the demise of heavy industry leading to weaker relationships with health [13]
Economic status	All adults can be coded (overcomes disadvantage of occupational codes)	• Working or not working is not particularly helpful as high SES groups are more likely to become students and retirees may have a high income, housewives/husbands may have a high income partner • Distinguishing unemployed people may lead to small numbers • People not working for health reasons may lead to confounding
Neighbourhood deprivation	Allows people to be classified without gaining personal information	• Only provides information about the average for an area- a person could be rich in a poor area and vice versa • Information about areas necessary • Data at small area resolution is preferable but may not be available
Lone parents	Often in extreme disadvantage	• May have small numbers • Age and often gender dependent • Extent of disadvantage may depend on local culture
Housing tenure	Numbers without a home usually	• May miss young people living with their parents who may class themselves as 'other' rather than

	negligible	parental tenure • age dependent • Utility depends on the national housing tenure profile and legal framework
Car access	Easy to ask about and measure	• Congestion and public transport availability mean this is increasingly a poor measure of SES in cities • Some people may forego a car for environmental reasons

1.2 Literature searches

The searches undertaken for deliverable 1.3 and task 10.1 are outlined in table 1.2. For deliverable 1.3 there was a general search on SES and health. This was restricted to articles that mentioned these terms in the title only to increase relevance and to constrict the number of articles included to a manageable level. There was also a boost search on chemicals found in the body. For task 10.1 there were boost searches on air pollution, ventilation and time activity. However some of the articles retrieved by searches undertaken for 1.3 were relevant for 10.1 and vice versa. Two databases were ultimately established: 1.3 (socioeconomic status and health-891 papers) and 10.1 (focus on exposures-261 papers)

Table 1.2 literature searches contributing to 10.1

Organisation	*Search terms*	*Databases*	*Records*
1. WP1 literature search			
University of Bristol	socioeconomic status & health in ti	Web of science	985
IOM	Pubmed/Medline in ti & major topic area	PubMed/ Medline	434
			1419
2. Internal markers of exposure			
Consejo Superior de Investigaciones Científicas	TITLE(socioeconomic OR SES OR socio* OR "social class" OR disadvantage OR poverty OR affluence OR income OR wealth) AND TITLE(environmental OR exposure OR pollutant OR pollution OR human OR "POPs" OR pesticide* OR "persistent organic" OR OC OR organochlorine OR HCB OR hexachlorobenzene OR DDT OR DDE OR PCB OR polychlorobiphenyl OR organobromine OR PBDE* OR BDE OR polybromodiphenyl OR metal* OR mercury OR Hg OR DBP* OR "disinfection by-product" OR THM OR trihalomethane*) AND ABSTRACT(inequalit* OR "social grade" OR disparit* OR hazardous OR "Health behav*" OR smoking OR tobacco OR alcohol* OR obes* OR overweight OR "physical activity" OR exercise OR sedentary OR alcohol OR diet OR "take away" OR "junk food" OR food OR "fast food" OR drugs OR heroin OR	CSIC (own publications), Science direct	127

	cannabis OR "individual differences" OR genetics OR genes OR personality OR"self-esteem" OR occupation OR "working conditions" OR psychology OR scroungers OR lazy OR passiv* OR "work ethic" OR stamina OR perseverance OR "self-control" OR "Stanford marshmallow" OR "delayed gratification" OR arrogant OR aggressive OR assertive* OR control OR dominance OR height OR dyslexi* OR risk OR disability OR "learning difficulties" OR "health awareness" OR "green space" OR garden OR park OR nature OR outdoors OR leisure OR television OR gambling OR sport OR walk* OR urban OR rural OR "rubbish dump" OR housing OR landlord OR "private rent*" OR heating OR damp OR mould OR overcrowding OR transport OR vehicle OR car OR education OR qualifications OR unemployment OR "insecure employment" OR "zero hours contracts" OR "short term contract" OR accident OR security OR crime OR safe OR insecurity OR disruption OR trauma OR breakdown OR violence OR IPV OR "social services" OR adoption OR "in care" OR pension OR benefits OR ethnic* OR indigenous OR gender OR women OR discrimination OR prejudice OR divorce OR marital status OR widow OR "single parent" OR friend* OR "social capital" OR "social network" OR "social comparison" OR lonel* OR church OR religio* OR clubs OR "voluntary associations" OR volunteer OR trust OR "health care" OR "inverse care law" OR Medicaid OR "health insurance" OR ambulance OR "health promotion" OR age OR lifecourse OR "teenage parent")		
3. Air pollution			
University of Stuttgart	title(Socioeconomic OR SES OR inequalit* OR disparit* OR "social class" OR "social grade" OR disadvantage OR poverty OR affluence OR income OR wealth OR "health variations") AND tak("Health behav*" OR smoking OR tobacco OR alcohol* OR obes* OR overweight OR "physical activity" OR exercise OR sedentary OR alcohol OR diet OR "take away" OR "junk food" OR food OR "fast food" OR drugs OR	Science Direct	196

	heroin OR cannabis OR "individual differences" OR genetics OR genes OR personality OR"self-esteem" OR occupation OR "working conditions" OR psychology OR scroungers OR lazy or passiv* OR "work ethic" OR stamina OR perseverance OR "self-control" OR "Stanford marshmallow" OR "delayed gratification" OR arrogant OR aggressive OR assertive* OR control OR dominance OR height OR dyslexi* OR risk OR disability OR "learning difficulties" OR "health awareness" OR " green space" OR garden OR park OR nature OR outdoors OR leisure OR television OR gambling OR sport OR walk* OR urban OR " air pollution" OR noise OR pollution OR rural OR "rubbish dump" OR housing OR landlord OR "private rent*" or heating OR damp OR mould OR overcrowding OR transport OR vehicle OR car OR education OR qualifications OR unemployment OR "insecure employment" OR "zero hours contracts" OR "short term contract" OR hazardous OR asbestos OR accident OR security OR crime OR safe OR insecurity OR disruption OR trauma OR breakdown OR violence OR IPV OR "social services" OR adoption OR "in care" OR pension OR benefits OR ethnic* OR indigenous OR gender OR women OR discrimination OR prejudice OR divorce OR marital status OR widow OR "single parent" OR friend* OR "social capital" OR "social network" OR "social comparison" or lonel* OR church OR religio* OR clubs OR "voluntary associations" OR volunteer OR trust OR "health care" or "inverse care law" OR Medicaid OR "health insurance" OR ambulance OR "health promotion" OR age OR lifecourse OR "teenage parent") AND tak("air quality" OR "exposure" OR "air pollution" or "ozone" or particulate* or "nitrogen diox*")		
4. Ventilation	Socioeconomic & housing & (ventilation or insulation or windows)	Web of science, scopus, pubmed	61
5. Time activity			

University of Bristol	Socioeconomic status & time activity	Web of Science	3
IOM	socioeconomic status & time activity patterns	PubMed/ Medline, Current Contents, Embase, Scisearch, Environmental Abstracts and Ei EnCompass LIT	11
University of Bristol	Ethnicity & time activity	Web of Science	21
University of Bristol	Age & time activity	Web of Science	78
University of Bristol	Occupation & time activity	Web of Science	49
University of Bristol		Ref found after contacting author about query over other ref	1
			154
Total			1966
Exclusions due to duplication & irrelevance			814
Total in 1.3 database			**891**
Total in 10.1 database			**261**

2. Abstract classification

The abstracts were categorised to help us to understand how the exposome differs for low SES and high SES groups. Note that more references do not necessarily indicate that a pathway is more important. More references may be a reflection that the pathway is important in the US where there is most research funding for example.

2.1 Socioeconomic status and health abstracts (1.3)

Classifying the abstracts provided information on various pathways from SES to health impacts (table 2.1.1).

The first group of studies however provided *general information* rather than information on particular pathways. A small number of studies focussed on methodology rather than outcomes. A significant number (131) focussed on confirming a relationship between SES and various health outcomes rather than exploring why the relationship existed. Conversely another group of studies (88) examined multiple pathways - these will be returned to later (section 3).

The second group of studies were classified as focussing on *tangible differences*. These included demographic differences (120 studies). The relationship between SES and health could vary over the life course and a longer period of low SES could result in more negative health outcomes. Some studies focussed on women's vulnerability to socioeconomic disadvantage and health consequences. Other studies considered the relationship between disadvantage due to ethnicity and SES. Other physical differences were also studied such as genetic differences, height differences and differences due to different exposures in utero.

Many studies have considered differences in *health behaviours*. A large number (125) have explored differences in health services use for example in vaccination levels, dental levels and other screening. Other studies have considered diet from both an obesity and a nutrition point of view (65 studies). Some studies have focussed on smoking.

Over 100 studies were classified as '*world view'*. This refers to low SES groups having a different understanding of the world. This could be due to psychological differences, personality differences or health knowledge. SES is often measured through education. Cognitive differences could reduce the likelihood of attaining qualifications. Conversely acquiring an education could shape and inform world views to allow people to lead healthier lives.

A further group of studies were classified as *'supportive environment'*. Some of these suggested that socioeconomically disadvantaged people live in environments less supportive to health due to parenting received and social networks. Other studies in this group provide awareness that the extent to which low SES is disadvantageous depends on societal attitudes and consequent government redistribution of resources allowing access to a good standard of housing for example. Note that studies concerning ethnic discrimination and access to health care could also have reasonably been classified in this section.

The final classification was *internal changes*. Stress is a mechanism by which a negative environment can lead to negative internal changes to health. Other internal changes include infections, allergies and build-up of chemicals such as DDT. More detail on these internal changes is provided in appendix 1.

Table 2.1.1 Pathways between SES and health

Pathway	***Subcategories/description***	***Number of studies***
General		
Measurement	How to measure SES	7
Related to health	Study confirms SES & health relationship	131
Multiple reasons		88
Tangible		
Demographic	Age, gender, ethnicity	120
Physical differences	Genetic, height, bones, in utero	13
Sleep		2
Health behaviour		
Health service use	Access, vaccinations, dental, screening	125
Obesity/diet	BMI related/nutrition	65
Smoking		16
Miscellaneous	Sunbed use, alcohol, multiple	38
Worldview		
Psychological/cognitive	Locus of control, sense of coherence, personality, social comparisons	93
Health knowledge	Understanding of relationship between health behaviours and health	23
Supportive environment		
Parenting	Skill acquisition, children at risk	18
Relationships	Social network/support	22
Government provision	Progressive taxation increasing services	37
Housing conditions	Damp, thermal comfort	9
Internal changes		
Stress	Exposure to life events (e.g. violence) leading to feelings of stress and hormonal changes (e.g. cortisol) resulting from stressful situations	49
Chemicals within the body	Infection, allergies, toxicants	37

2.1 Socioeconomic status and environmental exposure abstracts (10.1)

The articles on exposure were divided into papers dealing with pollution (mostly air pollution) and articles concerning time spent in various activities: occupation, physical activity, location and activity type. More detail on these environmental exposures is provided in appendix 2.

Table 2.1.2 Pathways between SES and environmental exposure

Pathway	***Subcategories/description***	***Number of studies***
Pollution		
Air -	PM_{10}, $PM_{2.5}$, Ultra-fine particles, Black carbon, Oxidants, TSP, NO_2, NO_x, O_3, SO_2, CO, VOC, BSO, combined measures, perceived air pollution proximity to traffic, environmental tobacco smoke, Perchloroethylene (dry cleaning), CEDI (Radiation from medical imaging), EMF (mobile phones & power lines), Radon, THM (water)	60
Air –ventilation	Amount and quality of air that enters the home from outside	23
Noise	Noise and perceived noise	2
Time activity		
General	Location, time spent outdoors, at home, in transit, Activity type: time spent engaging in health behaviours and recreational activities	35
Occupation	Job characteristics, exposure to pollutants	58
Physical activity	General, leisure, vigorous, sedentary	84

3 Competing pathways between SES and Health

3.1 Study inclusion

There were 87 studies which were reviews or provided analysis of multiple pathways between SES and health. Given HEALS interest in environmental exposure, these papers were read in order to understand how much of differences in disease risk with SES can be explained by social as compared with environmental pathways and in particular environmental pollution. The lack of information meant that we also considered other studies from other sections providing us with 55 studies (table 3.1). About half the studies did not consider the environment instead focussing on other pathways. Others that did

include the environment did not consider the physical environment or did not differentiate the physical from the social environment. Other studies did not actually measure SES or health.

Thus some studies have considered social factors and others have considered environmental factors. Individual factors in the pathway between SES and health such as psychosocial characteristics, health behaviours and social networks can be measured cheaply through self-report. Environmental factors such as industrial emissions often need to be measured at an area level and require specialist software such as GIS. If individuals in the study are relatively few and are not clustered by area it may be difficult to include psychological, social and physical environment factors in one study.

A few studies have reviewed the area but only two were found that included statistical analysis of how much of the heightened disease risk experienced by low SES groups occurs through various pathways. Generally analysis examines whether a factor is significantly related to health rather than the amount of the outcome explained: results tend to present odds ratios rather than R-squares.

Table 3.1 Studies included in the review of competing pathways

Total studies:	Reason for exclusion	Studies excluded	Number of studies excluded
56			
267	Social characteristics only – no environmental variables included	[14] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36], [37] [38] [39] [40] [41] [42]	29
21	Social or cultural environment only but no physical environment characteristics	[43] [44] [45] [46] [47] [48]	6
18	Environment undifferentiated into social or physical environment	[49] [50] [51]	3
17	Groups differentiated by disease presence rather than SES	[52]	1
16	Did not present results for individual level factors just environmental	[53]	1
14	Described environmental improvements without direct links to health	[54] [55]	2
11	Looked at does SES explain environmental differences rather than vice versa	[56]	1
10	Did not analyse statistically whether environmental factors explained SES [57]	[58] [59] [60]	3

2	Review	[61] [62] [63] [64] [65] [66] [67] [68] [57]	8
2	Statistical analysis of how much of the relationship between SES and health can be explained by social pathways compared with environmental exposure	[69] [70]	2

3.2 Summary of reviews

Reviews have suggested a number of pathways by which the environments of low SES groups are detrimental to their health. The environment can be divided into the social environment, the physical environment and exposure to chemicals (table 3.2). Disadvantaged groups living in developing countries face even more environmental risks.

The evidence for the relationship between the physical environment and health is generally stronger than for the social environment and health due to a larger number of longitudinal rather than cross sectional studies and more objective measures of health, such as spirometry for measuring lung functioning [64]. This has led to the suggestion that environmental and occupational hazards affect the lungs of disadvantaged groups more than other organs [63]. However few studies have used objective assessments of overweight and obesity [64] so the evidence available is from poorer quality studies.

Other studies note the interconnections of factors even at different levels [64]. Examples given include parenting being affected by the built environment, parenting leading to child behaviours which shape future parenting and synergistic effects such as asthma being affected by family stress and physical environmental exposures. Other studies point to possible multiplicative effects as those with low income are more likely to be unable to afford to avoid hazards [62, 67], for example they may be paid higher salaries to work in occupations in unhealthy environments, thereby increasing risk for poorer persons in need of money [63]and are least able to deal with consequences of exposure of health[67]. Furthermore where low SES groups are clustered residentially further detrimental effects occur than if they are not clustered [68]. However there are very few studies that have considered whether exposure to multiple rather than single risks is a reason for health inequalities between low and high SES groups and the evidence is not sufficient to say whether multiple risk exposure leads to additive or multiplicative consequences [61].

Some reviews have suggested that some groups vulnerable to socioeconomic are particularly affected by environmental exposures such as particular ethnic groups [63] and women [66]. High levels of toxic chemicals have been found in women's follicular fluid and breast tissue despite women benefiting less than men from the industrial growth that led to the release of pollutants [66]. The authors suggest that to reduce inequality both governance and culture need to change to make women's over representation among the poor unacceptable and environmental pollution needs to be tackled [66].

Table 3.2 Environmental pathways between SES and health identified by reviews:

Social environment	Physical environment	Exposure to chemicals
Crowding [61]	Noise [61]	exposure to toxins and hazardous wastes [61]
greater residential mobility [61]	substandard housing [61]	ambient pollutants [61]
family turmoil and conflict [61]	abandoned lots [61]	Lead [68]
maternal partner changes (including divorce) [61]	poorer municipal services [61]	Tobacco smoke [68]
exposure to violence [61]	fewer suitable places to engage in physical exercise[61]	
Social capital [64]	less access to purchase healthy foods [61]	
raised by a teenage mother [61]	higher traffic volume [61]	
child separation from family [61]	more physically hazardous working conditions on the job [61]	
degree of structure and predictability in household routines for children (e.g., regular bedtime, eating family meals together) [61]	Cockroaches [68]	
	More access to outlets for purchasing unhealthy substances e.g. alcohol [68]	
	Tobacco advertising [68]	
Additional factors particularly relevant to developing countries [67]:		
	biological pathogens e.g. microorganisms in human waste, malaria carrying mosquitos	lead
	scarce, over-priced, poor quality or degraded natural resources	indoor air pollutants from fuel combustion
	physical hazards	
	poor sanitation and hygiene	
	inadequate water supplies	
	poor facilities for preparing and storing food	
	Limited land in cities prevents the urban poor from growing their own crops or maintaining livestock	
	traffic accidents	
	burns, scalds, and accidental fires and poisonings; falls; and floods	

	poor building material settlements on dangerous sites (e.g., flood plains, steep hillsides, and dumps) inappropriate design

3.3 Models of multiple pathways between SES and health

One of the central features of the HEALS programme is that disease causation should not be seen as a linear pathway but the outcome of complex interrelationships within the exposome. Some studies have provided visual diagrams of the interrelationship of various factors leading to associations between socioeconomic status and health. These diagrams can be useful in order to clarify thinking about the interrelationships between various features of the exposome – either one of these could be adopted or HEALS participants could develop a visual representation. They could also be useful for providing models that could be tested using data collected through EXHES. Five examples are presented here.

Figure 1 is a standard model with SES on the left and health and illness on the right with mediating factors in between. In figure 1 SES is shown as being related to health via the environment (through exposure) and via psychology (through biological responses). Both the environment and psychology determine health impacting health behaviours.

Figure 2 considers a life course perspective and illustrates how genetics and the environment interact with socioeconomic status at different point in the life course to impact health.

In figure 3 the pathway leads from exposure to health and illness. Genetics modify the risk. The pathway shows various places for interventions which could reduce health differences between the more affluent and the more disadvantaged.

Figures 4 and 5 illustrated pathways for particular vulnerable groups. Figure 4 considers pathways for young people. Given the focus on youth different levels are the neighbourhood and the family. Rather than Figure 1's differentiation of the environment and psychology, figure 4's main division is between physical and social. Nevertheless both the physical and the social are seen as giving rise to health behaviours within the individual. SES is seen as encompassing neighbourhood, family, individual, the social and the physical. These factors are seen to impact health conditions with very different aetiologies: asthma and obesity.

Figure 5 illustrates a frame work through which women's vulnerabilities to low socioeconomic status can be addressed through public policy. Such policies need to understand systematic discrimination against women, currently and historically, in addition to taking into account their caring role.

Fig 1 Simplified model of pathways form SES to health (modified from Adler and Ostrov (1999)) [65]

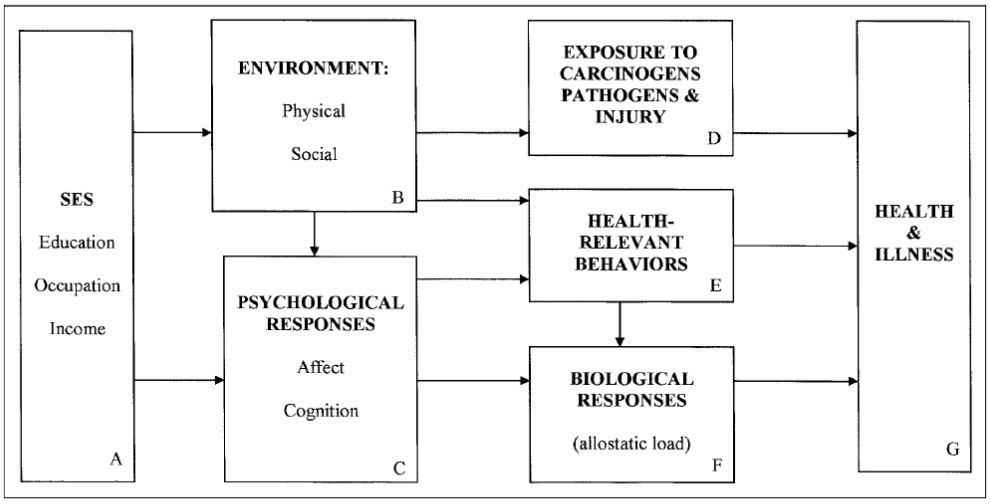


Figure 2 Potential mechanisms linking adult and childhood socioeconomic status and health [57]

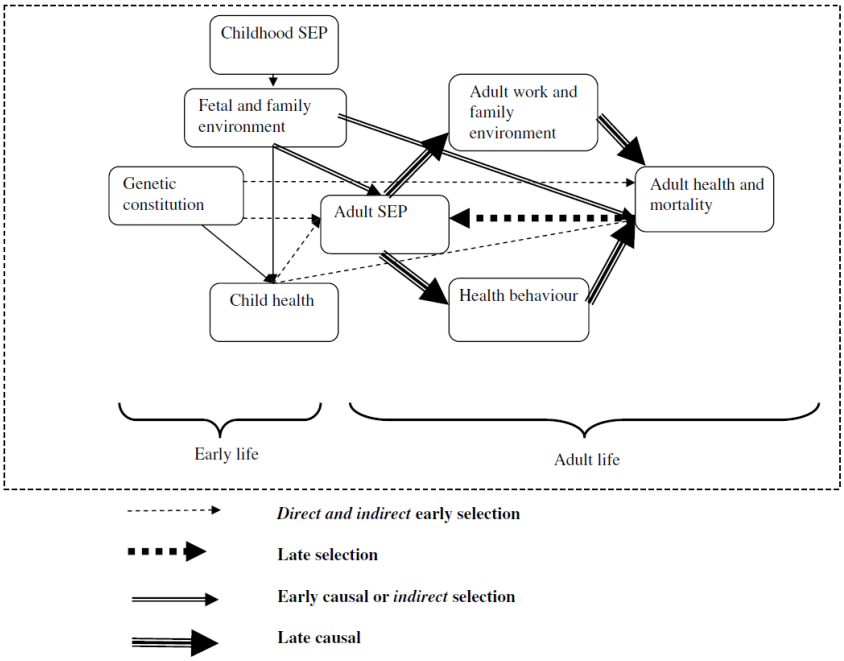


Fig 3 Illness results from an event (usually environmental exposure) occurring to susceptible person. Susceptibility is determined through genetics and degree of exposure – both of which can lead to health disparities. Such health disparities can be ameliorated. The blue boxes indicate the path to sickness and the red box contain interventions intended to reduce the risk or illness or disparities occurring [63]

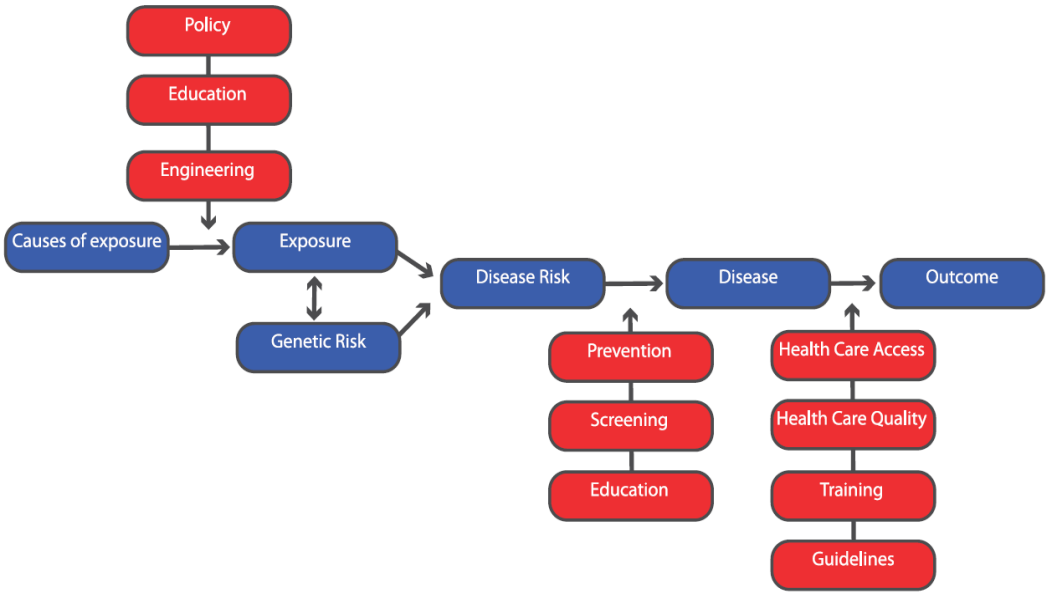


Fig 4 Proposed pathways between SES and youth health outcomes [64]

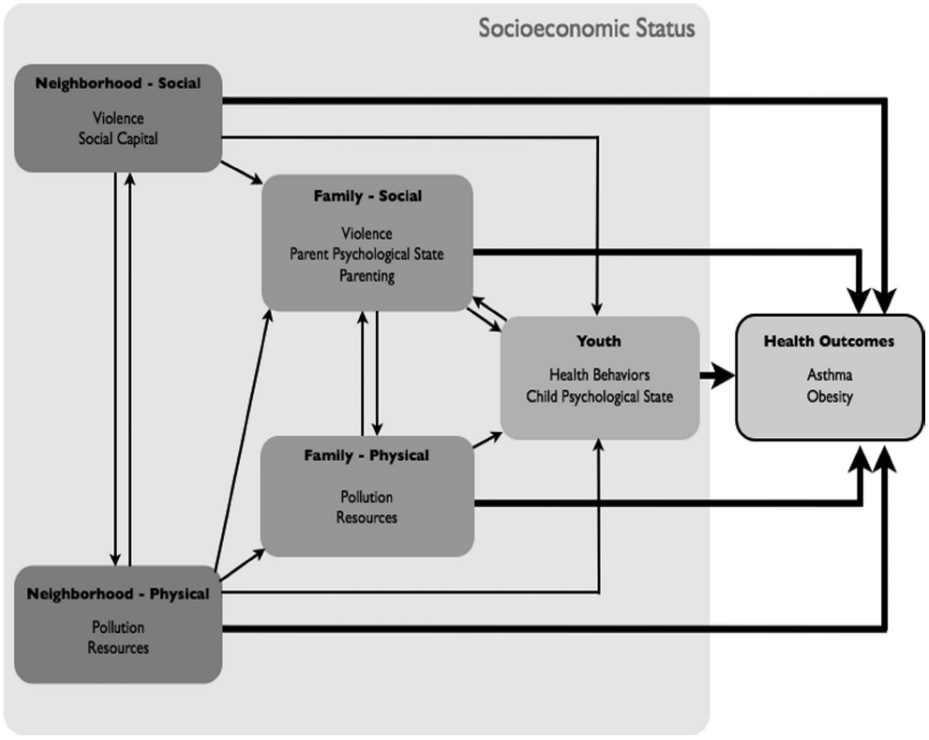
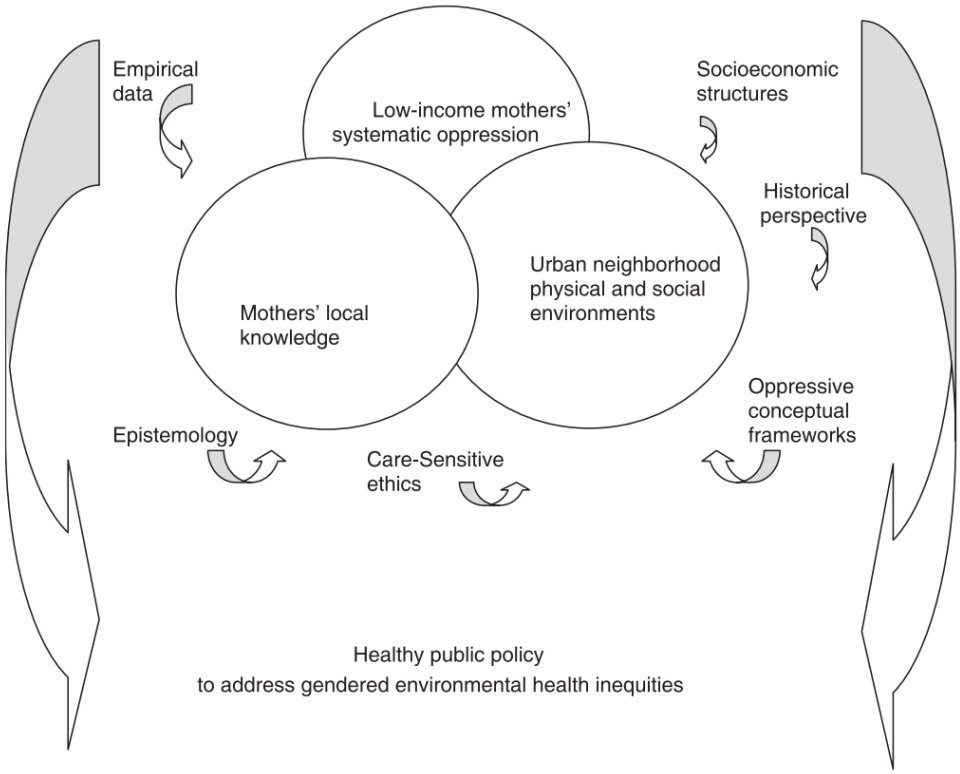


Fig 5 Ecofeminist frame work [66]



3.4 Contrasting environmental and other pathways explaining the heightened disease risk experienced by low SES groups

The aim of this deliverable is to consider how much of the difference between SES groups is due to the exposome (life course environmental exposures which include health behaviours [71]). Existing studies have other aims and thus cannot be used to answer this question. Most studies provide evidence of significant associations between one or mediators, SES and health whereas to properly answer the question raised for this deliverable studies that compare sizes of relationships for a range of mediators are needed. Only two studies were found that included the physical environment and used this approach. Details for these studies are provided.

3.4.1 Contrasting pathways between SES and respiratory health [69]

Data:

Data on 1251 women aged 55, living in Ruhr Germany and recruited to the SALIA study, were included in the analysis. SES was measured through education. Respiratory health was measured through spirometry and questionnaire data. Air pollution data was averaged from records of stationary monitoring sites near to the women's' homes and traffic related pollution was estimated from distance between the women's homes and the nearest major road using GIS.

Analysis:

Stepwise multiple logistic regression models were used to find the percentage change in the odds ratio of SES when other factors were progressively included in models. These factors were occupational exposure to dust gases, vapours, wet conditions or extreme temperature, current smoking, mean PM10, within 100 metres of a major road with >10 000 cars per day

Results

Low SES groups were more likely to suffer from six of seven respiratory problems. These six problems were used as outcomes in logistic regression modelling (table 3.4.1). Adding occupational exposure to the model reduced the odds ratio of low SES by 6%, adding current smoking to the model reduced the odds ratio of low SES by 10% and adding pollution exposure the odds ratio of low SES was reduced by 9%. The largest percentage reduction in the odds ratio occurred when smoking was added to models of frequent cough and bronchial asthma. However pollutant exposure was the most important for one outcome and distance to a major road was most important for three outcomes.

Conclusions

Pathways between SES and health varied for a range of respiratory outcomes

Table 3.4.1 Percent change in odds ratio of SES when various behavioural & environmental factors added to model stepwise

	>100m from major road only					
	frequent cough	frequent cough + phlegm	bronchial asthma	COPD	FEV<80 %	FVC<80 %
Occupational exposure	6	5	4	4	6	4
smoking	10	7	11	14	14	7
PM_{10} exposure over 5 years	9	10	5	18	29	20
Distance to major road	na	na	4	23	33	21

3.4.2 Contrasting pathways between SES and self-rated health [70]

Data:

5001 Danish employees aged 18 to 59 were interviewed in 1990 and 1995 as part of the Danish National Work Environment Cohort Study. SES was measured through social class score in 1990. Life style and work characteristics were measured in 1990. Global self-rated health was measured through answers to the question "how do you rate your health in general' with five response options which were dichotomised into good (very good and good) and poor (fair, poor, very poor).

Analysis

The outcome of logistic regression analysis was worsened self-rated health in 1995. The independent variables were SES, age, gender, disease, lifestyle (BMI and smoking) and work environment (ergonomic exposures, repetitive work, skill discretion, climatic exposures, job insecurity, decision authority, chemical exposure and physical exposure)

Results

Lifestyle factors (BMI & smoking) explained 17% and five work environment factors (ergonomic exposures, repetitive work, skill discretion climatic exposures, job insecurity) explained 59% of changes in the social class odds ratio of worsened self-rated health. Together life style and work environment explained 66% of the odds ratio of social class difference in self rated health.

Conclusions

Low SES employees' lower self-rated health was more related to job characteristics than lifestyle factors. Chemical and physical exposures were not main pathways.

These studies did include a variety of pathways however they did not include many of the pathways discussed in the literature. Furthermore there were within study differences between pathways.

3. Final summary

There is a clear relationship between SES and health. The exposome is likely to play a dominant role in the SES and health relationship because in general the genome appears to play a small part in disease development: possessing a genetic variant associated with a particular disease only increases the risk of disease occurring by 10 to 30% [72]. However no studies were found which contrasted genetic and environmental causes of the association between SES and health. Many studies have considered one pathway between SES and health but few have contrasted multiple pathways empirically. Even those that have compared multiple pathways have only considered a small number of options within a single study. These studies have not found stable pathways – rather pathways vary with different health outcomes. Thus it is not possible with the current state of the literature to estimate what proportion of SES differences in health is due to the exposome. However it is possible to describe some of the possible pathways.

SES differences in health may be the results of demographic differences – some population groups have less access to resources, health behaviours and differences in world view through cognitive and personality differences and health knowledge. However the extent to which low SES becomes an issue will depend on the social environment: on parenting, on supportive relationships, on government provision of health care, welfare, education and housing, on the physical environment: infrastructure, noise and air pollution. An adverse social environment can lead to stress causing internal changes and an adverse physical environment can lead to build up of some pollutants in the body.

In the appendices we considered various exposures to pollution, occupations and physical activity in more detail. We found that in general low SES groups are more exposed to air pollution but there are exceptions (i.e. there are high status neighbourhoods in central areas of some cities). They may be more exposed to contaminants through diet in particularly in developing countries and to infections. There are many features of low SES occupations which may compromise health such as low control over work and high physical demands. Other possibilities include exposure to chemicals, job security and low occupational prestige. However physical strength required for, or developed from, jobs often filled by low SES people and lack of mental strain may be health promoting in some regards. Additionally low SES people in poor health are less likely to work – the physical demands of low SES jobs require good physical health. Our findings on exposure to physical activity suggested that low SES people may undertake less leisure time physical activity but they may be at least as physically active in other domains e.g. occupation, active travel.

In general study quality was good, particularly so for occupation in terms of design, sample size and recency. In other areas more longitudinal studies could be of interest. Some of the time activity studies were quite small.

We found that a lack of studies that differentiated between SES groups in the following areas: time activity, contaminants from diet and housing ventilation. Firstly very few studies appear to have considered time activity differences by SES. More studies have looked at

age differences. Conclusions appear to be study specific and modified by whether the participant worked, season and weekday/weekend. In terms of diet, most studies focussed on the relationship between SES and obesity and very few studies had considered contaminants from diet. Thirdly very few studies had considered SES differences in housing ventilation despite recent calls for increased insulation due to climate change.

Our review also leads to some methodological recommendations. Firstly a composite SES measure may be preferable to a multitude of SES measures due to multicollinearity. The exception would be a study that aims to explore the meaning of measures in which case it would be important to recruit large numbers of unusual subjects (e.g. highly educated but low income or low education but high income). Secondly it is not possible to tell from previous studies whether ethnic differences are due to SES, culture or genetics. Ethnic group differences thus need to be understood in context. Finally if an aim of a research project is to examine exposure to pollution as a mediator between SES and health it is necessary to design the study and analysis carefully in order to do so. The methodologies used in several studies were not fit for purpose.

The literature would suggest that a study seeking to account for SES differences in health should include the external exposome differences detailed in table 4.1 and the genome differences detailed in table 4.2. An important factor that does not really fit in either of these tables is age. Lifecourse models suggest that SES differences in health can start in utero and occur throughout our lives.

Table 4.1 Exposome pathways between SES and health

Pathway	***Subcategories/description***
Health behaviour	
Health service use	Vaccinations, dental, screening
Obesity/diet	BMI related/nutrition, diet related contaminants
Physical activities	Leisure, occupational, for transport
Smoking	
Other	Sunbed use, alcohol, sleep
Supportive environment	
Parenting	Skill acquisition, children at risk
Relationships	Social network/support
Government provision	Access to health services, education for disadvantage groups
Stigma	Due to age, gender, ethnicity, disability etc
Physical environment	
Exposure to socially stress producing situations	Violence, residential mobility, family turmoil and conflict, lack of routine
Housing conditions	Damp, temperature, building materials, ventilation, infestations, hygiene, food preparation facilities
Neighbourhood conditions	Abandoned lots, graffiti, noise, advertisements, design, traffic

Access	Municipal services, places for physical exercise, purchasing points for healthy food and unhealthy substances e.g. tobacco alcohol
Exposure to chemicals	Toxins and hazardous wastes, ambient pollutants, lead, tobacco smoke
Exposure to nature	Recreation and food growing opportunities

Table 4.2 Differences created by the genome that may explain associations between SES and health

Pathway	***Subcategories/description***
Tangible	
Demographic[#]	sex
Physical differences*	height, potential for poor health
Worldview	
Psychological*	personality
Cognitive*	IQ

[#]Race is not included here because current research suggests that genetic susceptibility is a minor predictor of poor health and is not strongly patterned by race [73]
*In addition to their genetic component these are also impacted by the exposome

To conclude, there are many explanations with support from previous literature for the relationship between SES and health. However very few studies were encountered that empirically contrasted different pathways. Thus on the basis of the collated literature, we have much to learn in this area.

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Appendices for deliverable 1.3

These appendices present reviews undertaken for task 10.1. These reviews give more details about the effects of exposure, particularly to pollution, on SES. The first appendix gives details of changes inside the body due to a negative external environment and the second appendix explores exposure in terms of pollutants and time spent in various activities.

For each the review proceeded in the following manner. Firstly references to be included in the review were identified, secondly heat maps of similar papers were produced and thirdly comments were made on data quality and coverage.

The heat maps were used to show whether poorer outcomes were associated with socioeconomic status (SES) and other groups vulnerable to disadvantage. The vulnerable groups considered were certain ethnicities such as blacks in the United States, women, children and older people. For SES, ethnicity, gender and age it was considered whether subjects with higher SES, more advantaged ethnicity, male gender and of younger age were more associated, similarly or inconsistently associated, or less associated with outcomes than subjects with lower SES, less disadvantaged ethnicity, female gender and older age respectively. *Darker colours represent more studies; low SES and each vulnerable group were given a different colour to make them easier to differentiate*.

Concluding whether SES was related to an outcome was not always straightforward because some studies included more than one measure of SES. The following table (i) shows the rules as to whether a study was classified as concluding that SES was associated with the outcome or results were inconsistent if there was more than one measure of SES. This approach was taken because inconsistent results in multivariate analysis could be due to multicollinearity.

Table i. Heat map classification of whether an association between SES and an outcome was found if study presents results for multiple SES measures

Bivariate analysis	*Multivariate analysis*	*Classification*
All associated	All associated	**High SES is associated with outcome**
All associated	Not presented	**High SES is associated with outcome**
Not presented	All associated	**High SES is associated with outcome**
All associated	Some associated	**High SES is associated with outcome**
Some associated	All associated	**High SES is associated with outcome**
Some associated	Some associated	**Inconsistent**
Some associated	Not presented	**Inconsistent**
Not presented	Some associated	**Inconsistent**

Additionally there was also an issue of what was classified as an SES measure. For the purposes of 10.1 the core measures of education, income, occupation/social class and sometimes housing measures were described as SES. Marital status was not classified as an SES measure (unless it was involved in an aggregate measure and could not be disaggregated).

Appendix 1 Internal markers of a negative external environment

References were sorted in to four themes:

Stress (note references were only include if they mentioned internal changes)

Infection

Toxicants (heavy metals, persistent organic pollutants, etc.)

Additionally there is a separate section exploring diet related contaminants.

There were 39 references in the markers for external exposure database. Three were rejected for not looking at internal markers, 1 was rejected for being an animal study only, three were rejected for not including SES or vulnerable groups. Five references were added from the stress database and 1 from the pollution database. Thus there were 38 references in the review (table A1.1).

Table A1.1 Markers for external exposure

Total number of references	*Reason for exclusion or inclusion*	*Number of references excluded or included*
39		
36	Did not look at internal markers	3
35	Animal study only	1
32	Did not look at SES or vulnerable groups	3
37	Added from stress database	+5
38	Added from external pollution database	+1

The heat map (table A1.2) shows no clear messages for ethnicity and gender. For SES, studies have repeatedly found infections are more prevalent in low SES populations. Among heavy metals lead was also repeatedly found at higher levels in low SES groups but results for other heavy metals were not consistent. For other toxicants generally there were no clear associations found repeatedly. In the case of organocholorines it may be the result of different organocholorines having different patterns: levels of DDE/DDT seemed generally to be higher among low SES groups whereas PCB levels appeared to be higher in high SES groups.

The data quality was good (table A1.3). Study samples ranged from 87 to 22161. Most analyses were cross-sectional but some included longitudinal elements. All but two studies were conducted after 2000. All but 3 studies were conducted in the US, Spain or Latin America. Forty three percent of the studies were conducted in the EU. There were studies conducted with adults, children, mothers and women in the age groups who are likely to be able to conceive a child. Due to these different ages sampled we did not look at age differences within the studies.

Table A1.2 Heat map of internal markers for external exposure among SES and vulnerable groups

	SES (high vs low)			*Ethnicity*[2] *(advantaged vs disadvantaged)*			*Gender (men vs women)*		
	More	*Same/ varied*	*Less*	*More*	*Same/ varied*	*Less*	*More*	*Same / varied*	*Less*
Stress									
Cortisol	[1][1]	[2] [3][5]		[1][1]			[1]		
Lipid					[4]		[4][3]		
Infection									
Infection			[5] [6] [7] [8] [9] [10]			[10]			[10]
Immune function		[11]	[2]	[11]			[11]		
Autoimmune		[12]	[13] [14]			[15] [12] [13]		[13]	
Toxicant									
Phthalates (containers)	[16]	[17]	[18]	[16]					
THMs (water)			[19]						
Heavy metals[4]	[20] [21]	[17]	[22] [23] [24]			[25]			
Pyrethroids & organophosphates (pesticides)			[26]						
Persistent organic pollutants	[27]	[28]	[29]		[30]			[31]	[32]
β-HCH			[33]						
BDE-47			[34]						
PBDEs		[34]							
DDE/DDT	[35]		[36] [33] [37] [38]			[27]			
HCB	[38]								
PCBs	[33] [37] [38]								

[1] Rather than higher level, more variation between the early morning cortisol level and the end of the day low in cortisol
[2]white versus non white [1] white’s versus blacks [15] [12] [16] [25], white versus African American [4] [13], mother born in Europe rather than Latin America [27], country of birth Spain, Europe or Latin America [30] white compared with non Hispanic black, Mexican American, other race[10]
[3]Men with traumatic experiences had higher lipid levels but not women
[4]Heavy metals include lead [22] [23] [24] [25], mercury [20] and cadmium [21], in a multi chemical analysis higher SES individuals had higher burdens of serum and urinary mercury, caesium, thallium but inverse associations were noted with and serum and urinary lead, cadmium and antimony [17]
[5] Restricted populations: Mexican Americans only [3] low income only [4] low income African Americans [22], exocrine cancer patients [29] pregnant [30] [33], red font refers to women only and blue font to men only

Table A1.3 Study characteristics of studies of internal markers of a negative external environment

Ref	*Year*	*SES variables*	*N*	*Design*	*data*	*Outcome*	*Region*	*Age groups*
[1]	2013	Education	1693	Longitudinal	MIDAS	Linear spline model of daytime salivary cortisol	US	50-74 years
[2]	2012	SES variables: relative income, education and occupational position in a society.	Review	Review	Review	Glucocorticoid production; immune function	XXX	XXX
[3]	2013	Education	220	Longitudinal	Prenatal survey & salivary cortisol of babies at 6 weeks	6 week old infants salivary cortisol changes in response to stress task	US	Mothers and their 6 week old babies
[4]	2014	NA	452	Retrospectiv e	Surveys and exminations	High density/low density lipoprotein ratio (blood cholesterol)	Atlanta, US	18+
[5]	1996	Socioeconomic factors: family income, maternal employment.	220	Cross-sectional	clinical	Acute diarrhea and pathogenic microorganisms.	Salvador, Brazil	Children 0-5 years of age.
[6]	2002	Different socio-environmental conditions: Schooling of female responsible for house; Crowding or persons per bedroom; Number of water taps and fittings; Presence of sewage in front of the	3068	Cross sectional	Interviews and blood samples	Antibodies against Hepatitis A Virus (HAV)	Rio de Janeiro, Brazil	1-83 years of age.

		house.						
[7]	2009	Parental education; Number of biological parents residing with children; Socio-environmental conditions (sources of water supply and sanitation facilities).	440	Cross sectional	Survey & faecal samples	Ascariasis infection by presence and number of Ascaris eggs (faecal samples).	Ilobu (Osun State), Nigeria	Children 0-16 years of age
[8]	2009	Socio-economic factors: Family size; House size; Number of bedrooms; Tap water; Sewerage system; Family income; Mother's education; Social Service Program.	405	Cross sectional	Survey, sample collection, anthropometrics	Giardia lamblia infection (faeces and blood samples)	Itinga (Minas Gerais), Brazil	Children 6-71 months of age
[9]	2011	Socioeconomic factor: proportion of farmers in the population within districts.	1558	Longitudinal	National data, rodent assays	OT-specific antibodies for Scrub typhus (blood).	Taiwan	All the individuals of the population (all ages)
[10]	2009	Education, income	4319	Cross-sectional	NHANES	Factor analysis used to create infection burden variable from H.pylori, CmV, HSV-1, HAV, HBV	US	Age 6 to 16
[11]	2014	Education, income	11050	Cross-sectional	NHANES	IgG antibodies against the Epstein Barr virus (a herpes virus) (higher levels of antibodies indicates a compromised immune system)	US	Age 24-32
[12]	2005	socioeconomic status (household income,	882	Cross sectional	Epidemiology of home	Total and specific IgE antibodies (serum).	Boston, US	Women of childbearing

		poverty level, education). Race/ethnicity.			allergens and asthma study			age.
[13]	1996	socioeconomic status (type of residence, hoh yrs of education & occupation).	87	Cross sectional	Skin tests & house dust sampling	Cockroach allergen & skin sensitivity to cockroach allergen	Baltimore US	Age 5 to 17
[14]	2001	Socioeconomic factors: household income, education, race/ethnicity and area poverty.	458	Cross sectional	Epidemiology of home allergens and asthma study	Total and specific IgE antibodies (serum).	Boston, US	Women 18-46 years of age.
[15]	2002	NA	620	Cross sectional	Case control	Systemic lupus erythematous (SLE)	North Carolina and South Carolina (US)	Not reported
[16]	2012	Educational attainment. Household income. Food security status. Race/ethnicity.	1182	Cross sectional	NHANES - pooled	4 phthalate metabolites of DEHP (MEHP, MEOHP, MEHHP, MECPP); 2 phthalate metabolites of DBP (MnBP, MiBP); 1 phthalate metabolite of DEP (MEP); and 1 phthalate metabolite of BzBP (MbzP). (urine).	US	Women 20-39 years of age.
[17]	2013	Poverty income ratio (PIR)	22161	Cross sectional	NHANES	179 toxicants	US	18-74 years of age.
[18]	2013	Occupational social class. Educational level.	919	Cross sectional	Catalan Health Interview survey	Organochlorine compounds (Ocs): 4,4'-DDT, 4,4'-DDE, HCB, b-HCH and PCBs (serum).	Catalonia, Spain	18-74 years of age.
[19]	2010	Parental education. Socioeconomic status.	2037	Cross sectional	Primary Schools & water measures	Trihalomethanes (THMs): chloroform, bromoform, dibromochloroform and bromodichloroform (water).	Sabadell, Catalonia, Spain	Children 9-12 years of age.

[20]	2013	Occupational social class (unskilled mothers, partially skilled mothers or housewife vs. Skilled mothers).	302	Longitudinal	Asthma Multicentre infants cohort Study	Total mercury (Thg; hair)	Menorca island, Spain	Children at 4 years of age.
[21]	2002	Educational level.	666	Longitudinal	School data, health data, survey, samples	Trace elements (blood and serum)	Sweden	Adolescents of 15 and 17 years of age.
[22]	2006	Level of education. Employment status. Income level.	970	Longitudinal	Samples, clinical exam	Lead (blood and saliva).	Detroit, Michigan (US)	14-55 years of age.
[23]	1992	socioeconomic status.	548	Longitudinal	Prospective cohort	Lead (blood)	Port Pirie (South Australia)	Children at 2 and 4 years.
[24]	2012	Socio-economic status (low ownership of high cost items). Behavioural problems.	1041	Longitudinal	Bt20	Lead (blood)	Greater Johannesburg area, South Africa	from birth until adolescence and early young
[25]	2014	NA	Not reported.	Review	review	Lead (blood)	US	Children
[26]	2013	Low-income.	42 low-income dwellings	Cross sectional	Healthy Public Housing Initiative	Organophosphate pesticides (chlorpyrifos and diazinon) and pyrethroids (permethrin, cypermethrin and cyfluthrin) (vacuum dust and floor wipes).	Boston, US	Children 1-5 years of age.
[27]	2010	Maternal origin. Educational level.	499	Cross sectional	INMA	Organochlorine compounds (Ocs): 4,4'-DDT, 4,4'-DDE, HCB and PCBs (cord blood).	Valencia, Spain	Women of childbearing age.

[28]	2010	Educational level.	919	Cross sectional	Catalan Health Interview Study	Organochlorine compounds (Ocs): 4,4'-DDT, 4,4'-DDE, HCB, b-HCH and PCBs (serum).	Catalonia, Spain	18-74 years of age (Mean age: 45 years old).
[29]	2008	Occupational social class.	135	Cross sectional	PANKRAS II	Organochlorine compounds (Ocs): 4,4'-DDT, 4,4'-DDE, HCB, b-HCH and PCBs (serum).	Mediterranean Region of Spain	Mean age: 66.4 years. SD age: 12.6 years.
[30]	2010	Social class. Working status. Country of origin	541	Cross sectional	INMA	Organochlorine compounds (Ocs): 4,4'-DDT, 4,4'-DDE, HCB, b-HCH and PCBs (serum).	Valencia, Spain	Women of childbearing age.
[31]	2008	NA	355	Longitudinal	AMICS & a similar cohort in Catalonia	Organochlorine compounds (Ocs): PeCB, HCB and PCP (serum).	Ribera d'Ebre (Catalonia) and Menorca island, Spain	Children at 4 years of age.
[32]	2010	NA	495	Longitudinal	AMICS	Organochlorine compounds (Ocs): 4,4'-DDE, HCB and PCBs (cord blood and serum).	Menorca island, Spain	children at birth and at 4 years of age.
[33]	2011	Social class.	1259	Cross sectional	INMA	Organochlorine compounds (Ocs): 4,4'-DDT, 4,4'-DDE, HCB, b-HCH and PCBs (serum).	Guipuzcoa and Sabadell, Spain	Women of childbearing age.
[34]	2013	Social class. Educational level.	731	Cross sectional	Public Health Survey	Polibromodiphenyl ethers (PBDEs) (serum)	Catalonia, Spain	18-74 years of age.
[35]	2012	Occupational class.	112	Cross sectional	Survey & samples	4,4'-DDT and 4,4'-DDE (serum and adipose tissue).	Santa Cruz de la Sierra (Bolivia)	18-70 years of age (Mean: 31 years old; SD: 13 years old)
[36]	2012	Social class by occupation (non-manual workers vs.	1445	Longitudinal	INMA	Organochlorine compounds (Ocs): 4,4'-DDE, HCB and PCBs (maternal serum during pregnancy).	Spain	Mean age of mothers: 30.7 years. SD age

		Manual workers). Educational level.						of mothers: 4.1 years.
[37]	2012	Social class.	231	Cross sectional	Barcelona Health Survey	Organochlorine compounds (Ocs): 4,4'-DDT, 4,4'-DDE, HCB, b-HCH and PCBs (serum).	Catalonia, Spain	Mean age: 48 years.
[38]	2014	Educational level. Social class.	325	Longitudinal	INMA	POPs: Organochlorine pesticides, PCBs and PBDEs (serum and cord blood).	Asturias, Spain	Children at birth & women in childbearing age.

Diet related contaminants

The majority of references on SES and health via diet were considering obesity and vegetable consumption. Only 4 articles were considering issues related to diet related contaminants. These articles included breast feeding because of the potential for contaminants passing into infants' bodies in this way. However it should be noted that breast feeding has many advantages [39]. Parasites and toxicants from diet were found to be more common among low SES in two of the three studies. Breast feeding is higher among high SES groups however.

Table A1.4 Diet related contaminants exclusions

Total number of references	*Reason for exclusion or inclusion*	*Number of references excluded or included*
65		
39	Text not found	26
9	Healthy diet only	30
6	Under nutrition only	3
5	SES differences not provided	1
4	Conference poster abstract only	1

Table A1.5 Diet related contaminants references

Ref	*Year*	*SES variables*	*N*	*Design*	*data*	*Outcome*	*Region*	*Age groups*
[40]	2013	Education	50	Cross sectional	Questionnaire, assay of local foods and breastmilk	Aflatoxin in food and breastmilk was higher in low SES groups	Ogun State Nigeria	breastfeeding mothers
[41]	2008	Socio-Economic Index for Area Classfication	5655	Repeated cross sectional	1995, 2001 & 2004/5 National health surveys CURF for infants and children	Breastfeeding initiation and duration was higher in high SES groups	Australia	Infants and children
[42]	2014	Social class	657	longitudin	INMA	Arsenic in urine (acquired via seafood consumption) did not	Sabadell, Catalonia	Pregnant women older than 16

				al		differ by SES (note no women had a dangerous level)		
[43]	2011	Social environment: promiscuity, parents education, crowding, wastewater disposal, flooding	111	Cross sectional	Anthropometrics, observations	Presence and number of intestinal parasites was higher among low SES children	La Plata, Argentina	1-12

Conclusions and key messages for task 3.3.2

- **Toxicants:** Different forms of persistent organic pollutants and heavy metals need to be measured and analysed separately because some forms are higher among low SES whereas others are higher among high SES Low SES groups have higher levels of infections, DDE/DDT and lead. High SES groups may experience higher levels of exposure to some chemicals such as PCBs.
- **Stress:** Cortisol levels are not a good indicator of SES differences in stress (but differences in daily cycle may be of interest).
- **Infection:** Blacks maybe more likely to experience autoimmune compromise but it is unclear if this is due to environment or genetics.
- **Contaminants via diet:** Most studies focussed on the relationship between SES and obesity. Contaminants from diet were higher among low SES groups in developing countries but few studies were identified

Appendix 2 Exposure

There were five contributing searches which were either related to pollution or time activity.

Pollution

1) Exposure to pollution
    - Pollution from transport/industry
        - PM_{10}, $PM_{2.5}$, Ultra fine particles, Black carbon, Oxidants, TSP, NO_2, NO_x, O_3, SO_2, CO, VOC, BSO, combined measures, perceived air pollution
        - Noise and perceived noise
        - proximity to traffic
    - Other pollution
        - Second hand smoke, Perchloroethylene (dry cleaning), CEDI (Radiation from medical imaging), EMF (mobile phones & power lines), Radon, THM (water)
2) Ventilation

Time activity

3) Occupation (occupation was not considered as an outcome because occupation is a measure of SES. Instead the heat map is used to illustrate whether occupational characteristics mediate the relationship between socioeconomic status and health)
4) Physical activity
5) General
    - Location: time spent outdoors, at home, in transit,
    - Activity type: time spent engaging in health behaviours and recreational activities

.

1) Exposure to pollution

There were 65 references in the exposure to pollution database, 13 were excluded as the text was not available, 4 were reclassified as more appropriate elsewhere, 12 were excluded because they did not provide statistics pertaining to exposure to air pollution, 4 were excluded because they did not provide statistics differentiating SES or other vulnerable groups and 4 were excluded because their aim was to improve methodology (table A2.1.1). Thus there were 26 references reviewed. The searches were intended to uncover studies of air pollution. However a few studies that explored noise and water pollution were found.

Table A2.1.1 Exposure to air pollution – study inclusion and exclusion

Total number of references	*Reason for exclusion*	*Number of references excluded*
65		
53	Text not found	13
49	Moved to time activity database	3
48	Moved to markers of pollution database	1
36	Excluded because health not air pollution is the outcome	12
35	Excluded because smoking not air pollution is the outcome	1
30	Excluded because outcomes not presented for SES or vulnerable groups	5
26	Excluded because methodological only	4

The heat map (table A2.1.2) suggests that generally lower SES groups and more disadvantaged ethnicities are exposed to higher levels of pollution. The clearest results were for particulate matter (PM_{10}, $PM_{2.5}$). However there are many varied findings – different measures of SES within a study could lead to varying results and there were some exceptions where higher SES groups were more exposed. The heatmap for gender would suggest a possible bias towards women being more exposed. Findings for age were inconsistent.

A review of study design (table A2.1.3) shows that all studies were published in the 21st century with the exception of two in the late 1970s and one in 1985. Sample size varied widely according to the type of study. Study designs varied from population level studies combining aggregate measures of area SES with area measures of pollution for a whole country or region to the collection of detailed time activity and exposure data for around 50 participants. Statistics presented were generally cross sectional even though the research programmes from which they were derived were sometimes longitudinal. There was a global spread of studies. The majority were conducted in North America but seven were conducted in the EU and four were conducted in the Far East. Six of the study samples

were children and two were middle to older aged adults. All but two studies presented measures of exposure to air pollution by socioeconomic status.

Table A2.1.2 Heat map of exposure to pollution and SES/vulnerable groups

	SES (high vs low)			*Ethnicity*[1] *(advantaged vs disadvantaged)*			*Gender (men vs women)*			*Age (younger vs older)*		
Pollutants[2]:	*More*	*Same/ varied*	*Less*	*More*	*Same/ varied*	*Less*	*More*	*Same/ varied*	*Less*	*More*	*Same/ varied*	*Less*
PM_{10}			[44] [45] [46] [47]								[48][3]	
$PM_{2.5}$			[46] [49] [50]			[49] [50]			[50]			[50]
Ultra fine particles									[51]			
Black carbon		[52]		[52]								
TSP			[53]									[53]
NO_2	[47]	[46] [54]	[55] [44]					[55] [54]			[48][3][54]	
NO_x		[56]	[44]									
O_3	[49]	[44]				[49]						
SO_2		[44]	[47]									
CO											[48][3]	
Vehicle specific (VOC, BSO)			[44] [53]									[53]
VOC		[57] [58]	[59]		[57] [58]			[57] [58]			[58]	
Combined measure			[60][4] [61][5]	[60][4]							[60][4]	
Perceived air pollution		[62]				[62]			[62]		[62]	
Noise		[63]	[64]					[63]		[63]		

Perceived noise		[63]	[62] [64]			[62]		[62] [63]			[63]	[62]
Proximity to traffic	[65]	[44]	[55]			[55]				[65]		
Second hand smoke		[66]	[67]					[67]		[67]		
Perchloroethylene			[68] [5]			[68]						
Radiation from medical imaging		[69]										
EMF (mobile phone masts)			[44]									
Radon		[44]										
THM (water)		[44]										

Notes

Significance not provided [46] [48] [50] [53] [55] [56] [60]

[1] Ethnicities: white vs non Hispanic black and Hispanic [49]; white vs African American, Hispanic and Chinese [50]; White vs black & Latino [52]; white, Asian, pacific islander vs black and Hispanic [55]; other vs white, Mexican, Hispanic [57]; non Hispanic white, non Hispanic black, Mexican American [58]; white; & Chicano vs black [60]; German vs non German [62]; white vs African American & Hispanic [68]

[2] For definitions of acronyms see appendix 1

[3] Same given that no groups exceeded governmental safe levels

[4] 'slight' differences only[60]

[5] Subgroups only: urban areas only (rural not significantly different) [61]; in buildings with a dry cleaner only (elsewhere not significantly different) [68]

Table A2.1.3 Studies included in the exposure to pollution heat map

Ref	*Year*	*SES variables*	*N*	*Design*	*data*	*Outcome*	*Region*	*Age groups*
[44]	2008	Area level employment, income, education	England	Cross sectional	IMD2004 & outcome	Emissions, proximity, concentration	England	NA
[45]	2010	Parental education, average monthly expenses	50	Cross sectional	Survey, time activity diary, indoor & outdoor air	PM10	Korea	10 yrs
[46]	2014	Household expenditure	64	Cross sectional	Time activity diary, backpacks fixed	PM10, PM2.5, NO2	Ho Chi Minh, Vietnam	<5 yrs
[47]	2012	Area level education, unemployment, per capita income	39 cities	Cross sectional	Census & fixed site monitors	PM10, SO2, NO2	Czech Rep.	NA
[48]	2001	-	396	Cross sectional	Survey & recall time activity, measurement surveys	PM10, CO, NO2	Hong Kong	All
[49]	2013	Area level income, % in poverty, <high school education, deprivation index	N Carolina	Cross sectional	Census, exposure	PM2.5, O3	US	NA
[50]	2012	Education, Income	6226	Cross sectional	MESA Air	PM2.5	US	45 to 84
[51]	2014	-	48	Cross sectional	Time activity via GPS, belt	Ultra fine particles	Italy	25 to 60
[52]	2014	Census tract poverty, household income	1757	Cross sectional	UFH,MBMS, modelled exposure	Black Carbon	Boston, US	25 to 64
[53]	1985	% unemployed, %	49 cities	Cross-	Air pollution,	Total suspended	US	NA

		houses built before 1950		sectional	census, climate	particulate (TSP) and Benzene Soluble Organic matter (BSO)		
[54]	2001	Occupational status, education	176	Cross-sectional	EXPOLIS, personal exposures, microenvironment concentrations, questionnaire & time activity	NO2	Helsinki, Finland	25 to 55
[55]	2011	Proportion of school children eligible for free/reduced lunch	75 primary schools	Cross sectional	Passive sampling, traffic information dataset, primary school enrolment	NO2, traffic count	Florida, US	NA
[56]	2013	Car ownership, income	156700	Cross sectional	Origin destination survey, vehicle ownership, emission factors	NOx	Montreal, Canada	NA
[57]	2013	Education	544	Cross sectional	Air pollution, questionnaire, meteology, geography, ventilation	VOCs	Three US cities	Adults
[58]	2009	Education, income	Up to 1000	Cross sectional	1999-2000 NHANES VOC study	VOCs	US	20-59
[59]	2010	education	50 children	Cross sectional	Questionnaire, exposure, time activity diary	Total VOCs	Three cities in South Korea	~10

[60]	1978	schooling, income, rent, housing value	Los Angeles County	Cross sectional	Census & pollution	Combined measure	LA, US	NA
[61]	2005	Social class	39251	Cross sectional	Government survey, air quality estimates	Combined measure	England	16-79
[62]	2006	Income education occupation housing	7275	Cross sectional	Government survey	Perceived air pollution	Germany	17-98
[63]	2006	Income education	3380	Cross sectional	6 socioacoustic surveys & Nordic calculation method for noise	Noise annoyance & noise level	Oslo & Drammen Norway	16+
[64]	1979	SES definition not provided	600	Cross sectional	Surveys & digital noise recording	Noise disturbance & level	Ontario, Canada	NA
[65]	2010	Area & individual education	1.9 mln	Cross sectional	Census, city council road traffic	Distance from high traffic road	Rome, Italy	NA
[66]	2012	Income education	399	Cross sectional	Survey of mothers in clinic waiting room	Second hand smoke	Michigan, US	7 to 10 yrs
[67]	2014	Area & individual education	160 824	Cross sectional	45 and up	Second hand smoke	New South Wales, Australia	45 to 65
[68]	2013	Annual household income	66	Cross sectional	Indoor air	Dry cleaning chemical	New York, US	5 to 14
[69]	2012	Below poverty level	19063	Retrospective cohort	Medical records	CEDI	New York, US	0 to 21

More detailed results from exposure to pollution studies

This section provides an overview of qualitative and quantitative associations between SES and exposure to particles, nitrogen dioxide, ozone and other stressors including radon, ETS/SHS and Perchloroethylene.

Particulate matter ($PM_{2.5}$, PM_{10}, TSP, oxidants and black carbon)

- American Lung Association (2001)[70] is a review/summary which documented that populations living in urban areas which have low socioeconomic status (for example low income) and include a large proportion of ethnic minorities are at a higher risk of exposure to particulate matter (also nitrogen dioxide and ozone) exposure.
- Evans & Kantrowitz (2002) [71]also reviewed studies that find varying risk of exposure to ambient and indoor air pollutants like sulphur oxides and fine particulates (but also ozone and nicotine) with differing socio-economic status like residential crowding, housing quality, educational facilities, work environments, and neighborhood conditions. They conclude that low SES groups have higher exposure to multiple environmental risk factors.
- In total, 13 studies discussed the relationship between particulates ($PM_{2.5}$, PM_{10},black carbon, oxidants and total suspended particles) and SES variables, thereof four in the EU, five in the US and four in Asia.
- All studies found associations between one or more SES variables and exposure to particulate matter however Anderson et al. (1978) [60], found only very weak correlations between two measures of air pollution (a composite measure and oxidants) and socio-economic factors in Los Angeles, USA. With the exceptions of Anderson et al. (1978) [60] and Yoon Shin (1985) [53], the studies were published quite recently - after 2006.

Overview of qualitative and quantitative associations of SES and exposure to particles

- In the following all relevant quantitative and qualitative findings of the studies are grouped by the socio-economic variables considered and their relation to exposure to particles is reviewed.
- Unfortunately, not all of the studies reviewed provide quantitative associations but present qualitative findings instead (e.g. review studies). However, quantitative associations of relevant studies were determined whenever feasible. The findings are presented in the following section.

Income, poverty and household expenditure:

- Briggs et al. (2008) [44]found that regions in England with high proportion of population experiencing income deprivation are positively associated with higher ambient PM_{10} level.
- Byun et al. (2010) [45]observed increasing PM_{10} levels in children's bedrooms in families with higher monthly expenses.
- Charafeddine & Boden (2008) [72] explored the relationship between self-reported health and $PM_{2.5}$ pollution in US states with different levels of income inequality. The results did not follow the hypothesis that people living in areas with greater inequality are more vulnerable to the air pollution. Unfortunately they did not present data on absolute levels of poverty.

- Gray et al. (2013) [49] found that in North Carolina, USA, higher predicted $PM_{2.5}$ is significantly associated with lower median household income and increased levels of poverty within a census tract.
- Krieger et al. (2014) [52] found that the annual black carbon exposure is associated with the poverty of the census tract, where the participants lived; however, no significant association was found with annual household income or education.
- Mehta et al. (2014) [46] found that in urban areas in Vietnam, there were higher personal levels of both $PM_{2.5}$ and PM_{10} among poor people and also that longitudinal correlations between personal and ambient measurements of both $PM_{2.5}$ and PM_{10} were lower for poor people than for the non-poor. This leads to a disadvantage for poor people when estimating personal exposure levels from ambient measurements.
- Yi et al. (2010) [73]found that in Seoul, Korea, increase of PM_{10} by 10µg/m^3 enhances significantly the probability of preterm delivery (PTD) during the 2nd trimester in low-income groups.

Education, Occupation and Employment:

- Branis & Linhartova (2012) [47] indicated that low level of education in combination with unemployment is positively associated with high ambient PM_{10} and SO_2 levels in urban areas of the Czech Republic
- Similar results to the above were found by Briggs et al. (2008) [44]in England, even though less strong association.
- Byun et al. (2010) [45] observed that PM_{10} concentrations in children's bedrooms in Korea are higher if parental education is only high school or lower opposed to college or higher.
- Gray et al. (2013) [49] observed that higher levels of less-than-high-school education is significantly correlated with higher levels of predicted $PM_{2.5}$.
- Yoon Shin (1985) [53] built multivariate regression models to reveal the effects of air pollution, climate and socioeconomic status on the total mortality rate of 49 cities in the United States. The unemployment rate was positively correlated with total suspended particulates (TSP) and benzene-soluble organic matter (BSO) which was associated with higher mortality.
- Kohlhuber et al. (2006) [62] highlighted the importance of SES differences in pollution perception and observed that perceived air pollution (i.e. exposure to dust and exhaust gases) is higher in lower middle versus the highest income groups in Germany although educational differences for those with German qualifications did not reach significance.
- Ou et al. (2008) [74] found significantly greater risk to mortality in blue-collar workers than the never-employed and white-collar groups due to the increase of PM_{10} concentration; however, this effect was not found for education.
- Wheeler & Ben-Shlomo (2005) [61]found that with decreasing skill-level of the occupation of the head of an urban-area household in England, the odds of being exposed to more polluted air (measured by a small area AQI of combined NO_2, PM_{10}, SO_2 and benzene levels) significantly rises. However, the authors observe that the opposite seems to hold true in rural areas even though their findings are not statistically significant in non-urban areas.

Housing conditions and neighborhood deprivation:

- Briggs et al. (2008) [44] found that deprivation associated with indoor and outdoor living conditions as well as the occurrence of victimization by crime (personal and material) are both an indicator of exposure to higher ambient PM_{10} levels in England.
- Gray et al. (2013) [49] found that in North Carolina (USA) greater levels of neighborhood deprivation are significantly correlated with higher values of predicted $PM_{2.5}$.
- Yoon Shin (1985) [53] found % US city housing built pre 1950 was positively correlated with TSP and BSO but this was not a strong explanation for the city mortality rate.
- Ou et al. (2008) [74] found people living in public rental housing experience greater risk to mortality due to the increase of PM_{10} concentration.

Vulnerable groups:

- According to the findings of Gray et al. (2014) [49], census tracts with higher populations of non-Hispanic blacks are more likely to be exposed to higher (predicted) levels of $PM_{2.5}$. The same holds true – even though to a lesser extent – for census tracts with more Hispanic inhabitants.
- Krieger et al. (2014) [52] found that after controlling for socioeconomic position, the white participants experienced higher exposure to black carbon compared to black and Latino participants.
- Yoon Shin (1985) [53] suggested that the percentage of the population aged 65 years and older is the most significant predictor of a city's mortality rate.

Quantitative findings of the relevant studies

Table A2.1.4: Quantitative associations found by studies relating SES variables or outcomes to exposure to black carbon and particulate matter ($PM_{2.5}$, PM_{10} and TSP)

Study reference	**Region**	**Location (urban vs. rural)**	**SES variable or outcome [description of measurement (encoding and/or units)]**	**Specific vulnerable group, if any**	**Exposure to**	**Quantitative association found**
Branis & Linhartova (2012) [47]	Czech Republic	Urban	**Education** [mainly elementary education, little university level education] **+ Employment** [high unemployment]	-	Ambient PM_{10} (and SO_2)	PCA: Component accounts for 44.7% of dataset variability and explains high ambient PM_{10} (and SO_2) levels
Briggs et al. (2008) [44]	England	Rural & urban	**Income** [Proportion of	-	Ambient PM_{10}	r=0.26

			population experiencing income deprivation]			
	England	Rural & urban	**Employment** [Involuntary exclusion of working age population from work]	-	Ambient PM_{10}	r=0.12
	England	Rural & urban	**Education** [lack of attainment, qualification and skills]	-	Ambient PM_{10}	r=0.14
	England	Rural & urban	**Housing conditions** [Deprivation associated with indoor & outdoor living environment]	-	Ambient PM_{10}	r=0.35
	England	Rural & urban	**Crime** [Occurrence of personal & material victimization by crime]		Ambient PM_{10}	r=0.44
Byun et al. (2010) [45]	Korea (Gyeonggi-do, southwestern Seoul)	Urban	**Education** [Parental education (high school or lower = 0, college or higher = 1)]	-	PM_{10} concentration in children's bedrooms	r=-0.399 (p<0.01)
	Korea (Gyeonggi-do, southwestern Seoul)	Urban	**Income** [Average monthly expenses ("<1,500k won" = 0, ">=1,500k won" = 1)]	-	PM_{10} concentration in children's bedrooms	r=-0.326 (p<0.05)
	Korea (Gyeonggi-do, southwestern Seoul)	Urban	**Number of children** [("<=2" = 0, ">2" = 1)]	-	PM_{10} concentration in children's bedrooms	r=0.154
	Korea (Gyeonggi-do, southwestern	Urban	**Housing conditions** [(house=0, apartment=1)]	-	PM_{10} concentration in children's bedrooms	r=0.056

	Seoul)					
Ou et al. (2008) [74]	Hong Kong	Not specific	**Type of housing** public rental housing	All ages Hong Kong Chinese	Ambient PM_{10} (per 10 µg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 µg/m^3 =1.62* Poisson regression (0.44,2.82)
	Hong Kong	Not specific	**Type of housing** Private housing	All ages Hong Kong Chinese	Ambient PM_{10} (per 10 µg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 µg/m^3 =-1.19 Poisson regression (-2.39,0.03)
	Hong Kong	Not specific	**Type of housing** public rental housing	The elderly (65+) Hong Kong Chinese	Ambient PM_{10} (per 10 µg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 µg/m^3 =1.60* Poisson regression (0.43, 2,79)
	Hong Kong	Not specific	**Type of housing** Private housing	The elderly (65+) Hong Kong Chinese	Ambient PM_{10} (per 10 µg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 µg/m^3 =-1.27 Poisson regression (-2.62, 0.10)
	Hong Kong	Not specified	**Occupation group** (Never-employed)	All ages Hong Kong Chinese	Ambient PM_{10} (per 10 µg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 µg/m^3 =-1.29 Poisson regression (-3.18, 0.65)
	Hong Kong	Not specified	**Occupation group**	All ages Hong Kong	Ambient PM_{10} (per 10	ER for mortality

			(Blue-collar)	Chinese	$\mu g/m^3$ increase	with every PM_{10} increase of 10 $\mu g/m^3$ =1.15* Poisson regression (0.19, 2.13)
	Hong Kong	Not specified	**Occupation group** (White-collar)	All ages Hong Kong Chinese	Ambient PM_{10} (per 10 $\mu g/m^3$ increase	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =-1.50 Poisson regression (-3.74, 0.79)
	Hong Kong	Not specified	**Occupation group** (Never-employed)	The elderly (65+) Hong Kong Chinese	Ambient PM_{10} (per 10 $\mu g/m^3$ increase	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =-1.79 Poisson regression (-3.77, 0.23)
	Hong Kong	Not specified	**Occupation group** (Blue-collar)	The elderly (65+) Hong Kong Chinese	Ambient PM_{10} (per 10 $\mu g/m^3$ increase	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =1.45** Poisson regression (0.41, 2.50)
	Hong Kong	Not specified	**Occupation group** (White-collar)	The elderly (65+) Hong Kong Chinese	Ambient PM_{10} (per 10 $\mu g/m^3$ increase	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =-1.32 Poisson regression (-3.95, 1.39)
	Hong Kong	Not specified	**Education** (No formal)	All ages Hong Kong Chinese	Ambient PM_{10} (per 10 $\mu g/m^3$ increase	ER for mortality with every PM_{10}

						increase of 10 µg/m^3 =0.78 Poisson regression (-0.40, 1.98)
	Hong Kong	Not specified	**Education** (Primary)	All ages Hong Kong Chinese	Ambient PM_{10} (per 10 µg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =1.54 Poisson regression (0.16, 2.94)*
	Hong Kong	Not specified	**Education** (≥Secondary)	All ages Hong Kong Chinese	Ambient PM_{10} (per 10 µg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =0.54 Poisson regression (-1.00, 2.09)*
	Hong Kong	Not specified	**Education** (No formal)	The elderly (65+) Hong Kong Chinese	Ambient PM_{10} (per 10 µg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =0.76 Poisson regression (-0.47, 2.01)
	Hong Kong	Not specified	**Education** (Primary)	The elderly (65+) Hong Kong Chinese	Ambient PM_{10} (per 10 µg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 = 1.35 Poisson regression (-0.19, 2.93)
	Hong Kong	Not specified	**Education** (≥Secondary)	The elderly (65+) Hong Kong	Ambient PM_{10} (per 10 µg/m^3	ER for mortality with every

				Chinese	increase	PM_{10} increase of 10 µg/m^3 = 1.50 Poisson regression (-0.47, 3.50)
Yi et al. (2010) [73]	Seoul, Korea	Not specified	**Income** (monthly average household income, high: up to the 10th percentile)	Women	Ambient PM_{10} (per 10 µg/m^3 increase)	Percentage change in the probability of preterm birth Entire gestation: 1.87 (-2.03, 5.91); 1st trimester: 1.23(-2.01, 4.59); 2nd trimester: -0.62 (-3.74, 2.61); 3rd trimester: 2.67(-0.52, 5.96)
	Seoul, Korea	Not specified	**Income** (monthly average household income, middle: 10th–90th percentile)	Women	Ambient PM_{10} (per 10 µg/m^3 increase)	Percentage change in the probability of preterm birth Entire gestation: -0.65 (-2.03, 0.76) 1st trimester: 0.77(-0.11, 1.65) 2nd trimester: 0.58 (-0.31, 1.48) 3rd trimester: -1.56 (-2.43, -0.68)
	Seoul, Korea	Not specified	**Income** (monthly average	Women	Ambient PM_{10} (per 10 µg/m^3	Percentage change in the

			household income, low: below 90th percentile)		increase)	probability of preterm birth Entire gestation: 2.78 (-2.24, 8.05) 1st trimester: 1.09(-1.83, 4.09) 2nd trimester: 3.4 (0.31,6.58) 3rd trimester: -1.63 (-4.61, 1.45)
Charafeddine & Boden (2008) [72]	USA	Urban	**Gini index**	-	$PM_{2.5}$ concentration	-0.65 (lower limit:-1.26; upper limit: -0.04)
	USA	Urban	**Gini index** low (≤0.4051705)	-	10 µg/ m^3 increment of $PM_{2.5}$	Adjusted odds ratios 1.31 (lower limit: 1.08; higher limit: 1.58)
	USA	Urban	**Gini index** medium (0.4051705-0.4275475)	-	10 µg/ m^3 increment of $PM_{2.5}$	Adjusted odds ratios 1.18 (lower limit: 1.04; higher limit: 1.33)
	USA	Urban	**Gini index** high (>0.4275475)	-	10 µg / m^3 increment of $PM_{2.5}$	Adjusted odds ratios 1.07 (lower limit: 0.90; higher limit: 1.26)
Gray et al. (2013) [49]	North Carolina, USA	Urban & Rural	**Median household income** [IQR: US$ 13877]	-	Changes in predicted average $PM_{2.5}$ (µg/ m^3) for interquartile range (IQR) increase in census tract SES	-0.10 (p<0.001)
	North Carolina,	Urban & Rural	**Percent in poverty** [IQR:	-	Changes in predicted	0.12 (p<0.001)

	USA		10.49]		average $PM_{2.5}$ (µg/ m^3) for interquartile range (IQR) increase in census tract SES	
	North Carolina, USA	Urban & Rural	**Percent less than high school education** [IQR: 17.59]	-	Changes in predicted average $PM_{2.5}$ (µg/ m^3) for interquartile range (IQR) increase in census tract SES	0.14 (p<0.001)
	North Carolina, USA	Urban & Rural	**Percent non-Hispanic blacks** [IQR: 29.8]	non-Hispanic blacks	Changes in predicted average $PM_{2.5}$ (µg/ m^3) for interquartile range (IQR) increase in census tract SES	0.15 (p<0.001)
	North Carolina, USA	Urban & Rural	**Percent Hispanic** [IQR: 4.14]	Hispanic	Changes in predicted average $PM_{2.5}$ (µg/ m^3) for interquartile range (IQR) increase in census tract SES	0.04 (p<0.01)
	North Carolina, USA	Urban & Rural	**Neighborhood Deprivation Index** [IQR: 1.08 (higher NDI=greater deprivation)]	-	Changes in predicted average $PM_{2.5}$ (µg/ m^3) for interquartile range (IQR) increase in census tract SES	0.12 (p<0.001)
Mehta et al. (2014) [46]	Ho Chi Minh City, Vietnam	Urban	**Household expenditure**		Personal PM concentration	PM_{10}: area (1) 92 for

			[poor = lowest quintile; non-poor = 2nd to highest quintile]			non-poor vs. 113 for poor; $PM_{2.5}$: 54.7 for non-poor vs. 73.6 for poor area (2) 96.9 for non-poor vs. 113.7 for poor; $PM_{2.5}$: 64.3 for non-poor vs. 67.7 for poor
Wheeler & Ben-Shlomo (2005) [61]	England	Urban and urban fringe	**Social class** [I and II: Professional and managerial occupations]	-	OR by social class of head of household & small area AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	OR = 1
	England	Urban and urban fringe	**Social class** [IIN and IIM: semi-skilled non-manual and manual occupations]	-	OR by social class of head of household & small area AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	OR = 1.23 (95% CI: 1.15-1.32; p <0.001)
	England	Urban and urban fringe	**Social class** [IIV and V: semi-skilled and non-skilled occupations]	-	OR by social class of head of household & small area AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	OR = 1.32 (95% CI: 1.21-1.43; p <0.001)
	England	Rural and semi-rural	**Social class** [I and II: Professional and managerial	-	OR by social class of head of household & small area	OR = 1

			occupations]		AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	
	England	Rural and semi-rural	**Social class** [IIN and IIM: semi-skilled non-manual and manual occupations]	-	OR by social class of head of household & small area AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	OR = 0.93 (95% CI: 0.67-1.29; p=0.653)
	England	Rural and semi-rural	**Social class** [IIV and V: semi-skilled and non-skilled occupations]	-	OR by social class of head of household & small area AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	OR = 0.76 (95% CI: 0.48-1.18; p=0.22)
Krieger et al. (2014) [52]	Greater Boston Area, MA, USA	Urban & Rural	**Poverty** [census tract poverty (continuous)]	-	annual average black carbon exposure ($\mu g/m^3$)	β = 0.38540 (95% CI: 0.33466, 0.43615) using best-fit model (R^2=0.1699)
	Greater Boston Area, MA, USA	Urban & Rural	**Annual household income** [1 = <$12,000; 2 = $12,000 to < $36,000; 3 = $36,000– <$48,000; 4 = $48,000– <$72,000; 5 = $72,000– <$120,000; 6 = $120,000– <$144,000; 7 =	-	annual average black carbon exposure ($\mu g/m^3$)	β = −0.00271 (95% CI: −0.00705, 0.00164) using best-fit model (R^2=0.1699)

			≥$144,000]			
	Greater Boston Area, MA, USA	Urban & Rural	-	Black	annual average black carbon exposure (μg/m^3)	β = −0.02380 (95% CI: −0.04102, −0.00658) using best-fit model (R^2=0.1699)
	Greater Boston Area, MA, USA	Urban & Rural	-	Latino	annual average black carbon exposure (μg/m^3)	β = −0.03373 (95% CI: −0.06096, −0.00651) using best-fit model (R^2=0.1699)
	Greater Boston Area, MA, USA	Urban & Rural	-	Other than Black, Latino or White	annual average black carbon exposure (μg/m^3)	β = −0.03742 (95% CI: −0.07486, 0.00003) using best-fit model (R^2=0.1699)
Yoon Shin (1985) [53]	49 cities in the US	Urban	**Age** [% population of 65 years and older]	>= 65 years	Total suspended particulates (TSP)	r = 0.147
	49 cities in the US	Urban	**Employment** [% Unemployment]	-	Total suspended particulates (TSP)	r = 0.038
	49 cities in the US	Urban	**Housing conditions** [%Houses built prior to 1950]	-	Total suspended particulates (TSP)	r = 0.306
	49 cities in the US	Urban	**Age** [% population of 65 years and older]	>= 65 years	Benzene-soluble portion of TSP (BSO)	r = 0.114
	49 cities in the US	Urban	**Employment** [% Unemployment]	-	Benzene-soluble portion of TSP (BSO)	r = 0.182
	49 cities in the US	Urban	**Housing conditions** [%Houses built prior to 1950]	-	Benzene-soluble portion of TSP (BSO)	r = 0.144

Nitrogen dioxide (NO_2)

- In addition to the two reviews (American Lung Association (2001) [70] and Evans & Kantrowitz (2002)[71]), seven studies discussed the relationship between NO_2 and SES variables (three in the EU, two in the US, one in Canada and two in Asia).
- Some studies also looked at NOx.
- The studies (which were all published after 2005) found associations between one or more SES variables and exposure to NO_2 but not always in the expected direction

Overview of qualitative and quantitative associations of SES and exposure to NO_2

- Similar to the section above, all relevant quantitative and qualitative findings of the studies are grouped by the socio-economic variables considered and their relation to exposure to Nitrogen dioxide is reviewed. Quantitative associations of relevant studies are presented in the following section.

Income, poverty and household expenditure:

- Briggs et al. (2008) [44] found that in England, areas with higher proportion of population experiencing income deprivation are more exposed to NO_2 pollution.
- Branis & Linhartova (2012) [47] revealed that residents with higher salary in large cities are more likely to be exposed to NO_2 emission, which is highly related with traffic pollution.
- Mehta et al. (2014) [46] examined the relationship between poverty and exposure to NO_2 in Ho Chi Minh, Vietnam. The analyses found inconsistent relationships between personal exposure to NO_2 and SES in different areas.
- Sider et al. (2013) [56] found that in the City of Montreal, Canada, people living in areas with higher car ownership and larger vehicles are less exposed to NO_x; in contrast, people with high income and newer vehicles are more affected by NO_x.
- Stuart & Zeager (2011) [55] found that in Hillsborough county Florida, US, schools with higher proportions of economically disadvantaged pupils were exposed to higher levels of NO_2. The relationship was not strong however.

Education, Occupation and Employment:

- Branis & Linhartova (2012) [47] found that residents highly educated in urban areas are exposed to higher level of NO2 pollution.
- Briggs et al. (2008) [44] also find that in England, people excluded from employment or lack of education tend to have higher levels NO_2 exposure.
- Ou et al. (2008) [74]found that increase of NO_2 concentration lead to significant higher risk of mortality in blue-collar workers than never-employed and white-collar groups.
- Wheeler & Ben-Shlomo (2005) [61] found that in urban areas in England, lower social class households (measured by skill level in occupation of head of household) are more likely to locate in areas with poor air quality (measured by a small area AQI of combined NO_2, PM_{10}, SO_2 and benzene levels); however, in rural areas the result was reversed.

Housing conditions and neighborhood deprivation:

- Briggs et al. (2008) [44] found housing in poor condition and occurrence of victimization by crime are both indicators that positively associated with exposure to NO_2 pollution.

- Ou et al. (2008) [74] found increase in NO_2 concentration leads to greater risk of mortality on people living in public rental housing than in private housing.
- Sider et al. (2013) [56] found that in the City of Montreal, Canada, exposure to NO_x is positively related with dense and walkable neighborhoods.

Vulnerable groups:

- Stuart & Zeager (2011) [55] found black school children are at higher risk to NO_2 exposure, followed by Hispanic school children.

Quantitative findings of the relevant studies

Table A2.1.6: Quantitative associations found by studies relating SES variables or outcomes to exposure to nitrogen dioxide (NO_2)

Study reference	**Region**	**Location (urban vs. rural)**	**SES variable or outcome [description of measurement (encoding and/or units)]**	**Specific vulnerable group or ethnicity**	**Exposure to**	**Quantitative association found**
Ou et al. (2008) [74]	Hong Kong	Not specific	**Type of housing** public rental housing	All ages Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =1.53 Poisson regression (-0.05, 3.13)
	Hong Kong	Not specific	**Type of housing** Private housing	All ages Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =1.43 Poisson regression (-0.31, 3.20)
	Hong Kong	Not specific	**Type of housing** public rental housing	The elderly (65+) Hong	Ambient NO2 (per 10 mg/m^3 increase)	ER for mortality with every PM_{10}

				Kong Chinese		increase of 10 µg/m^3 =1.33 Poisson regression (-0.42, 3.12)
	Hong Kong	Not specific	**Type of housing** Private housing	The elderly (65+) Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 µg/m^3 =1.83 Poisson regression (-0.13, 3.83)
	Hong Kong	Not specified	**Occupation group** (Never-employed)	All ages Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 µg/m^3 =-0.32 Poisson regression (-2.74, 2.17)
	Hong Kong	Not specified	**Occupation group** (Blue-collar)	All ages Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =0.56 Poisson regression (-0.68, 1.81)
	Hong Kong	Not specified	**Occupation group** (White-collar)	All ages Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase	ER=0.64 Poisson regression (-2.44, 3.83)
	Hong Kong	Not specified	**Occupation group** (Never-employed)	The elderly (65+) Hong Kong	Ambient NO_2 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of

				Chinese		10 µg/m^3 =-0.25 Poisson regression (-2.86, 2.43)
	Hong Kong	Not specified	**Occupation group** (Blue-collar)	The elderly (65+) Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =1.12 Poisson regression (-0.31, 2.56)
	Hong Kong	Not specified	**Occupation group** (White-collar)	The elderly (65+) Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =2.79 Poisson regression (-0.85, 6.57)
	Hong Kong	Not specified	**Education** (No formal)	All ages Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =0.42 Poisson regression (-1.40, 2.28)
	Hong Kong	Not specified	**Education** (Primary)	All ages Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =1.83 Poisson regression (0.14, 3.54)*

	Hong Kong	Not specified	**Education** (≥Secondary)	All ages Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =-0.66 Poisson regression (-2.95, 1.68)
	Hong Kong	Not specified	**Education** (No formal)	The elderly (65+) Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =0.45 Poisson regression (-1.59, 2.54)
	Hong Kong	Not specified	**Education** (Primary)	The elderly (65+) Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ = 1.80 Poisson regression (-1.40, 4.22)
	Hong Kong	Not specified	**Education** (Primary)	The elderly (65+) Hong Kong Chinese	Ambient NO_2 (per 10 mg/m^3 increase	ER= 1.37 Poisson regression (-0.47, 3.50)
Stuart & Zeager (2011) [55]	Tampa, Florida, USA	Urban & rural (County)	**Ethnicity** [AI/AN = American Indian or Alaska Native; API = Asian or Pacific Islander; B = Black non-Hispanic; H =	American Indian, Alaska Native, Asian or Pacific Islander, Black non-Hispanic, Hispanic	NO_2	AI/AN: r=-0.16 (p<0.19) API: r=-0.29 (p<0.012) B: r=0.33 (p<0.0046) H: r=-0.018

			Hispanic; W = White non-Hispanic; M = multi-racial]			(p<0.88) W: r=-0.36 (p<0.0020) M: r=-0.11 (p<0.37)
	Tampa, Florida, USA	Urban & rural (County)	**Income** [ED = Economically disadvantaged]	-	NO_2	ED: r=0.043 (p<0.72)
Branis & Linhartova (2012) [47]	Czech Republic	Urban	**Education** [mainly university level education] **+ Employment** [high salary]	-	Ambient NO_2	PCA: Component accounts for 28.1% of dataset variability and explains high ambient NO2 levels
Briggs et al. (2008) [44]	England	Rural & urban	**Income** [Proportion of population experiencing income deprivation]	-	Ambient NO_2	r=0.30
	England	Rural & urban	**Employment** [Involuntary exclusion of working age population from work]	-	Ambient NO_2	r=0.21
	England	Rural & urban	**Education** [lack of attainment, qualification and skills]	-	Ambient NO_2	r=0.15
	England	Rural & urban	**Housing conditions** [Deprivation associated with indoor & outdoor living environment]	-	Ambient NO_2	r=0.41
	England	Rural & urban	**Crime** [Occurrence of personal &		Ambient NO_2	r=0.50

			material victimization by crime]			
Mehta et al. (2014) [46]	Ho Chi Minh City, Vietnam	Urban	**Household expenditure** [poor = lowest quintile; non-poor = 2nd to highest quintile]		Person concentrations (mean (ug/m^3)	Area (1) poor=16.1, non poor= 19.6, Area (2) poor=18.7, non poor=120
Wheeler & Ben-Shlomo (2005) [61]	England	Urban and urban fringe	**Social class** [I and II: Professional and managerial occupations]	-	OR by social class of head of household & small area AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	OR = 1 (no p-value given)
	England	Urban and urban fringe	**Social class** [IIN and IIM: semi-skilled non-manual and manual occupations]	-	OR by social class of head of household & small area AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	OR = 1.23 (95% CI: 1.15-1.32; p <0.001)
	England	Urban and urban fringe	**Social class** [IIV and V: semi-skilled and non-skilled occupations]	-	OR by social class of head of household & small area AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	OR = 1.32 (95% CI: 1.21-1.43; p <0.001)
	England	Rural and semi-	**Social class** [I and II: Professional	-	OR by social class of head of	OR = 1 (no p-value given)

		rural	and managerial occupations]		household & small area AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	
	England	Rural and semi-rural	**Social class** [IIN and IIM: semi-skilled non-manual and manual occupations]	-	OR by social class of head of household & small area AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	OR = 0.93 (95% CI: 0.67-1.29; p=0.653)
	England	Rural and semi-rural	**Social class** [IIV and V: semi-skilled and non-skilled occupations]	-	OR by social class of head of household & small area AQI (combined NO_2, PM_{10}, SO_2 & benzene; lower is better)	OR = 0.76 (95% CI: 0.48-1.18; p=0.22)
Sider et al. (2013) [56]	Montreal metropolitan region, Quebec, Canada	Urban	**Car ownership + Income** [Categories: "Older vehicles", "High car ownership, larger vehicles" and "High income, newer vehicles"]	-	NO_x exposure	Older vehicles: β = −0.408 (t-statistic: −5.507); High car ownership, larger vehicles: β = −0.856 (t-statistic: −9.747); High income, newer vehicles: β = 0.115

	(t-statistic: 1.535);

Ozone (O_3)

- In total, three studies discussed relationship between ozone and SES variables, thereof one in EU, the US and Asia respectively. They were published after 2008 and all found the association of one or more SES variables with exposure to O_3.

Overview of qualitative and quantitative associations of SES and exposure to O_3

- Similar to the section above, all relevant quantitative and qualitative findings of the studies are grouped by the socio-economic variables considered and their relation to exposure to ozone is reviewed. Quantitative associations of relevant studies are presented in section □.

Income, poverty and household expenditure:

- Briggs et al. (2008) [44] found that regions in England with more people experiencing income deprivation are more likely to be exposed to higher ambient ozone.
- Gray et al. (2013) [49] found that in North Carolina, USA, an interquartile range (IQR) increase of median household income enhances the predicted average O_3 level.

Education, Occupation and Employment:

- Briggs et al. (2008) [44] found that in England, people excluded from employment or people lack of education are more likely to experience exposure to O_3.
- Gray et al. (2013) [49] observed that IQR increase in the portion of people with less-than-high-school level education is negatively statistically significant correlated with changes in predicted O_3 level.
- Ou et al. (2008) [74] found ozone related to greater risk of mortality on blue-collar workers than the never-employed or white-collar groups. In contrast, education did not contributed to the effect that much.

Housing conditions and neighborhood deprivation:

- Briggs et al. (2008) [44] revealed that deprivation associated with housing conditions and the occurrence of victimization by crime is an indicator of exposure to higher ambient O_3 levels in England.
- Gray et al. (2013) [49] found that in North Carolina (USA) greater levels of neighborhood deprivation are significantly correlated with lower values of predicted O_3.
- Ou et al. (2008) [74] found people living in public rental housing experience greater risk to mortality due to the increase of O_3 concentration, but this effect is less obvious compared to PM_{10} and NO_2.
-

Quantitative findings of the relevant studies

Table A2.1.7: Quantitative associations found by studies relating SES variables or outcomes to exposure to ozone (O_3)

Study reference	Region	Location (urban vs. rural)	SES variable or outcome [description of measurement (encoding	Specific vulnerable group, if any	Exposure to	Quantitative association found

			and/or units)]			
Briggs et al. (2008) [44]	England	Rural & urban	**Income** [Proportion of population experiencing income deprivation]	-	Ambient O_3	r=-0.35
	England	Rural & urban	**Employment** [Involuntary exclusion of working age population from work]	-	Ambient O_3	r=-0.27
	England	Rural & urban	**Education** [lack of attainment, qualification and skills]	-	Ambient O_3	r=-0.21
	England	Rural & urban	**Housing conditions** [Deprivation associated with indoor & outdoor living environment]	-	Ambient O_3	r=-0.40
	England	Rural & urban	**Crime** [Occurrence of personal & material victimization by crime]		Ambient O_3	r=-0.50
Gray et al. (2013) [49]	North Carolina, USA	Urban & Rural	**Median household income** [IQR: US$ 13877]	-	Changes in predicted average O_3 (ppb) for interquartile range (IQR) increase in census tract SES	0.11 (p<0.001)
	North Carolina, USA	Urban & Rural	**Percent in poverty** [IQR: 10.49]	-	Changes in predicted average O_3 (ppb) for interquartile range	-0.12 (p<0.001)

					(IQR) increase in census tract SES	
	North Carolina, USA	Urban & Rural	**Percent less than high school education** [IQR: 17.59]	-	Changes in predicted average O_3 (ppb) for interquartile range (IQR) increase in census tract SES	-0.16 (p<0.001)
	North Carolina, USA	Urban & Rural	**Percent non-Hispanic blacks** [IQR: 29.8]	Non-hispanic blacks	Changes in predicted average O_3 (ppb) for interquartile range (IQR) increase in census tract SES	-0.15 (p<0.001)
	North Carolina, USA	Urban & Rural	**Percent Hispanic** [IQR: 4.14]	Hispanic	Changes in predicted average O_3 (ppb) for interquartile range (IQR) increase in census tract SES	-0.01 (p<0.01)
	North Carolina, USA	Urban & Rural	**Neighborhood Deprivation Index** [IQR: 1.08 (higher NDI=greater deprivation)]	-	Changes in predicted average O_3 (ppb) for interquartile range (IQR) increase in census tract SES	-0.13 (p<0.001)
Ou et al. (2008) [74]	Hong Kong	Not specific	**Type of housing** public rental housing	All ages Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$

						=0.64 Poisson regression (-0.57, 1.88)
	Hong Kong	Not specific	**Type of housing** Private housing	All ages Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =1.40 Poisson regression (-0.01, 2.83)
	Hong Kong	Not specific	**Type of housing** public rental housing	The elderly (65+) Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =0.70 Poisson regression (-0.51, 1.93)
	Hong Kong	Not specific	**Type of housing** Private housing	The elderly (65+) Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =1.26 Poisson regression (-0.33, 2.87)
	Hong Kong	Not specified	**Occupation group** (Never-employed)	All ages Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase)	ER for mortality with every PM_{10} increase of 10 $\mu g/m^3$ =1.07 Poisson regression (-0.86, 3.03)
	Hong Kong	Not specified	**Occupation group** (Blue-collar)	All ages Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of

						10 µg/m^3 =3.72 Poisson regression (1.40, 6.10)**
	Hong Kong	Not specified	**Occupation group** (White-collar)	All ages Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =-0.64 Poisson regression (-1.52, 0.25)
	Hong Kong	Not specified	**Occupation group** (Never-employed)	The elderly (65+) Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =1.39 Poisson regression (-0.62, 3.44)
	Hong Kong	Not specified	**Occupation group** (Blue-collar)	The elderly (65+) Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =4.24 Poisson regression (1.52, 7.04)**
	Hong Kong	Not specified	**Occupation group** (White-collar)	The elderly (65+) Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =-0.51 Poisson regression (-1.59, 0.58)
	Hong Kong	Not specified	**Education** (No formal)	All ages Hong Kong	Ambient O_3 (per 10 mg/m^3	ER for mortality with every

				Chinese	increase	PM_{10} increase of 10 µg/m^3 =-1.02 Poisson regression (-2.56, 0.53)
	Hong Kong	Not specified	**Education** (Primary)	All ages Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =0.71 Poisson regression (-0.83, 2.28)
	Hong Kong	Not specified	**Education** (≥Secondary)	All ages Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =-0.72 Poisson regression (-2.31, 0.88)
	Hong Kong	Not specified	**Education** (No formal)	The elderly (65+) Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 =-1.24 Poisson regression (-2.83, 0.37)
	Hong Kong	Not specified	**Education** (Primary)	The elderly (65+) Hong Kong Chinese	Ambient O_3 (per 10 mg/m^3 increase	ER for mortality with every PM_{10} increase of 10 µg/m^3 = 0.81 Poisson regression (-0.92, 2.57)
	Hong Kong	Not specified	**Education** (Primary)	The elderly (65+) Hong	Ambient O_3 (per 10 mg/m^3	ER for mortality with every

	Kong Chinese	increase	PM_{10} increase of 10 µg/m^3 = 1.42 Poisson regression (-0.80, 3.68)

Other stressors (Radon, ETS/SHS)

Radon:

- Briggs et al. (2003) [75] found that the in Northamptonshire, England, people who spend more time at home (for example, the elderly, the infirm and non-working young mothers) are more likely to be exposed to radon.
- Briggs et al. (2008) [44] found that radon concentration is negatively related with income, employment, education, health, crime and living environment, but positively related with barriers to housing and services.

ETS/SHS:

- Bonevski et al. (2012) [67] found that in Australia, participants who live in a flat/unit, apartment, mobile home were more likely to report being exposed to second hand smoke (SHS) compared to people living in houses. Exposure is also less reported by people with higher education level, household income and paid hours of work.
- Ren et al. (2012) [66] interviewed mothers from urban low-income families in Detroit and found that unplanned children of non-smoking mothers experienced higher levels of exposure to ETS compared to the planned children.

Perchloroethylene

- Storm et al. (2013) [68] found that the mean indoor air perchloroethylene levels are much higher in minority and low-income households if there was a dry cleaner connected to their building.

2) Ventilation

Ventilation is measured by the air exchange rate AER. This is the number of times that the air within a space changes within 1 hour [76]. Outdoor particles can enter indoor environments by convection (through an open window or by the air conditioning system) or by infiltration through cracks and fissures in the housing envelope [77]. Very few studies have directly reported results on SES differences in ventilation. These studies suggested that there could be poorer ventilation in dwellings occupied by low SES due to lower likelihood of mechanical ventilation and less likelihood of opening windows due to fear of crime.

Table A2.2.1 Reasons for exclusion

Total number of references	*Reason for exclusion*	*Number of references excluded*
23		
16	Text not found	7
6	Excluded because outcomes not presented for SES or vulnerable groups	10
5	Moved to air pollution	1

Table A2.2.2 Reference details

Ref	*Year*	*SES variables*	*N*	*Design*	*Outcome*	*Region*	*Age groups*
[76]	2014	Apartments vs houses [in Finland low income is more associated with apartments]	Review	Review	Air exchange rate is lower in flats, particularly new built flats but mechanical supply and exhaust ventilation can improve the situation If not radon levels are higher	Finland	NA
[78]	2014	Apartments (more owners) vs houses	2755 parents	Cross sectional	Range hoods and bathroom exhaust fans more common in	Seoul South Korea	1 to 8

		(more renters)			apartments where high SES live (but not mechanical ventilation in bedrooms)		
[79]	2001	Social class	4168	longitudinal	In childhood (1937-1939) children in higher social class households were more likely to be living in houses assessed as having very good ventilation. In 1998 higher levels of all cause mortality were associated with poorer ventilation in childhood but smoking was not controlled for.	16 areas of England & Scotland	Children followed up for 60 years (post war)
[80]	2014	Income	24 homes	Cross sectional	Homes of low income inhabitants had lower ventilation rates but significance was not tested	Agra India	NA
[81]	2014	Fear of crime	Review		People afraid to open windows due to fear of crime		

Time activity

3) Occupational exposure

There were 58 references in the occupation group in the database. For 39 of these references full text was available. Four studies were moved to the physical activity database and two studies were excluded for lack of relevance. Thus 33 papers were reviewed (table 3.1).

Table A2.3.1 Inclusions and exclusions from the occupation review

Total number of references	*Reason for exclusion*	*Number of references excluded*
58		
39	Unable to access full text	18
35	Outcome was physical activity rather than health	4
34	Literature review which only gave one cursory mention of SES	1
33	Study of consequences of air pollution from industry for general population	1

The studies were grouped by outcome into general health; injury, pain and disability; mental health, specific health outcomes and non health outcomes (table 3.2). Note that general health is a reflection of mental health as well as physical disease burden. The majority of the studies found indications that high SES participants were healthier than low SES participants. Nevertheless two studies found no or inconsistent differences between SES groups in injury, pain or disability and four studies did so for mental health. No studies found that overall low SES were healthier. The quality of the studies was excellent in terms of design and sample size with many studies having some sort of longitudinal element. The studies were all conducted in developed countries (see also table 3.4) with a slightly higher proportion of studies conducted in the EU compared with outside. The majority of the studies included working age participants but a few included older people with a reflection back on their working lives and one looked at high school students entering the work force.

SES measures were often economic activity, particularly social class of occupation and education. Rather than considering each measure separately the heatmap (table 3.3) explores job related factors that the studies suggested to be important in explaining health. Some studies,

indicated in bold font (and asterisks in the totals column), attempted some sort of mediation analysis, to indicate that the job related factors were the reason for the relationship between SES and health, other studies simply included job related factors in their analysis or it was not possible to conclude from the analyses that a particularly job related factor was responsible.

The job related characteristics included in many of the studies were informed by Karasek's 1979 demand control model [82] in which job stress is said to result from job strain which arises from a combination of low decision latitude (otherwise known as job control) and heavy job demands. Some of the studies disaggregated job demands into physical demands and psychological demands. Physical demands are associated with low SES jobs. Some studies rather than just considering physical demands singled out the low skill and monotony as an issue rather than physically demanding work. Exposure to physical hazards was considered as was exposure to chemicals and air pollution. Some studies did not consider particular features of jobs but instead entered types of job e.g. agriculture, services into the analysis. Other aspects of jobs studied included satisfaction, prestige (including opportunities for advancement), social support from colleagues and or management, job security (e.g. whether permanent) and hours worked (such as short work, long hours). Some studies also compared employed and non employed as access to the workforce could be important. High SES tend to score higher on psychological demands and in some cases exposure to a job related factor associated with low SES jobs was found to be associated with better health.

The job related characteristic most found to significantly predict health was job control which was mentioned by nine of the 32 studies, four of which implied that is was a mediating characteristic between SES and health. Physical demands and demands generally were also found to explain health differences. Thus it is not surprising that five studies found job stress and job strain to predict health. The other important factor is that people outside the labour market are often less healthy and that low SES workers participation in the labour force may be more tenuous that white collar workers.

Occupation and vulnerable groups

Most of the studies considered SES itself rather than vulnerable groups. One study [83] found that immigrants were less likely to become disabled possibly due to a health migrant effect and the lack or opportunities available in non-risky jobs. Older workers tended to be more likely to experience ill health [84] but this was not job related. Many studies analysed men and women separately or even only included one gender in their analysis. No clear differences however emerged between genders in the heat map, but there was a possibility that women were more

affected by job security and men were more affected by monotonous low skilled work. A study of single mothers in three European countries found that the relationship between lone parenthood, employment and health depended on the culture and policies of each country [85].

Occupation summary

Results from the studies included in this review suggests that features of occupations which may explain why low SES is linked to poor health include control over work, physical demands and being in work itself. Other possibilities include exposure to chemicals, job security and occupational prestige. However physical strength required for or developed from jobs often filled by low SES people and lack of mental strain may be health promoting in some regards. The datasets available for analysis were good quality being large and often having a longitudinal element. However many studies had not undertaken analysis which would allow the reader to be certain that each job related factor was responsible for the relationship between SES and health.

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Table A2.3.2 Relationship between SES and Health in studies exploring the relationship between SES, occupation and health

	High SES are healthier	*No or inconsistent differences between SES groups and health*	*Low SES are healthier*	*SES and health relationship not provided*	*N cross-sectional/ longitudinal / / review*	*N EU/ Non EU*[6]	*Sample size median & range*[7]	*Year published median & range*	*N*
General	[74,84,86-98] [85,99]				10/6/1	9/7	6k (0.6-600k)	2008(1994-2014)	17
Injury, pain & disability	[83,97,100-102]	[96,103][1]		*[104]*[3]	3/4/1	4/3	8k (1k-719k)	2009(1995-2014)	8
Mental health	[96,97,105,106]	[94,98,107-109][2]			4/6/1[5]	4/7	9k (0.2-28k)	2009(2003-2013)	9
Birth outcomes	[110]								
Cancer	[97]				1/3/1	4/0	13k(3k-280k)	2008(1995-2010)	5
Chronic conditions	[88,97,111]								
CVD	[97,112]								
Not health				*[113,114]*[4]	*0/2/0*	*1/1*	*NA*[8]	*2009 & 2011*	*2*
TOTAL									*32*[9]

[1]Possible issue with SES measurement[103]: all sample were health care workers differentiated by childhood SES

[2]Inconsistent relationships were: relationship for women but no relationship for men[94]; positive relationship between SES and mental health for workers but inverse for non workers [107]; weak relationship in one study and no relationship in another study [109];

[3]Study looked at work divided by physical activity level rather than SES per se [104];

[4]Outcomes were time outside [113] and self esteem/mastery [114]

[5]Two studies included cross-sectional and longitudinal analysis

[6]All countries were high income. The review [97] included studies from many countries and is not included

[7]Does not include studies where sample size had to be estimated
[8]Sample sizes were 0.7k and the second study modelled results for the population of Portugal
[9]Some studies reported on more than one outcome (see column 2)

Table A2.3.3 Heat map of job related factors that might link SES to health

	General	*Injury, pain & disability*	*Mental health*	*Specific (birth outcomes, cancer, chronic conditions, CVD)*	*Total*[4]
Stress/Strain	**[86]**[1] **[91]** [95][2]	**[97]**	**[97]**		5****[5]
Demands/time pressure	[94][3]		[109] **[106]**[3] [108]	**[110]**	5**
Control/decision authority/skill discretion	**[86]** **[96]** **[89]** [94] [98]	[96]	**[106]** [109] [94]	**[110]**	10****
Monotonous /low skill/skill utilisation	[91]	[83]	[108] [109]		4
Physical demands/ required posture/same arm movements	**[87]** [93] **[89]** [91]	[103] [96]	[96]		7**
Physical disturbances/hazards	[91]			**[110]**	2*
Chemicals/physical exposure	**[74]**			**[97]** **[112]**	3***
Type	[95] [84]	[100] [101]			4
Satisfaction	[95]				1
Pride/occupational standing/progression	[95]		[96] [108] [109]	**[97]**	5*
Social support	[93]		[108] [109]		3
security	[91] [90] [93] [84]	[83]			5
Hours	[93] **[89]**				2*
In workforce	[88] [99] [85]	[102]	**[107]** **[105]**	[111] **[88]**	8***
Inverse (i.e. high SES more problems or 'problem' exposure associated with better health)					
Psychological demands	**[87]** **[89]**		[108]		3**
Strain	**[97]**			[97]	2*
Time outside				[113]	1
Physical demands	[94]	[104]	[94]		3
Physical exposure	[94]		[94]		2

	16	8	8	5	30[6]

[1]**Bold font** indicates study suggests that this factor is at least partially responsible for the relationship between SES and health.
[2] Plain font indicates that this factor significantly predicted health but either study methodology did not allow the reader to conclude that the factor was responsible for the relationship between SES and health or the study did not directly set out to focus on this.
[3]Blue font indicates men only and red font indicates women only
[4]Total indicates the number of times the factor was found to be important
[5]* indicates the number of times the factor was found to be an explanation for the relationship between SES and health
[6] One study [92] did not provide job related reasons for SES health differences but suggested that occupation was important and in a second study the job related factor studied (chronic work strain) did not quite reach significance [114].

Table A2.3.4 Summary of studies

Ref	*Year*	*Outcome*	*Country*	*Age range (yrs)*	*Data*	*Design*	*Sample size*
		GENERAL					
[86]	2009	general health complaints	Canada	average 39	NPHS	longitudinal	3419
[87]	2008	general health complaints	Netherlands		occupational health surveillance data	cross-sectional	595
[74]	2008	general mortality	Hong Kong	age 30 plus	LIMOR - death registrations	longitudinal	24357
[97]	2010	general mortality	Review		review	review	
[88]	1995	general self rated health	Netherlands	25 to 64	LS-SEHD	longitudinal	13391
[89]	2005	general self rated health	Sweden	20 to 64	ULF	cross-sectional	5982
[90]	1996	general self rated health	Sweden	20 to 65	ULF-reinterviewed	longitudinal	5104
[91]	2009	general self rated health	Switzerland	20 to 64	Swiss Health Survey	cross-sectional	10101
[93]	2014	general self rated health	Switzerland	18 to 64	Swiss health survey	cross-sectional	6950
[95]	2010	general self rated health	US	mean age 41	GSS	cross-sectional	3151
[96]	2008	general self rated health	Wisconsin, US	54 to 65	WLS	longitudinal	4495
[99]	1994	general self rated health	GB	18 to 59	health and lifestyle survey	cross-sectional	3756
[85]	2012	general self rated health	Britain, Italy, Sweden,	25 to 59	GHS, National Health Survey, ULF	cross-sectional	6476

[98]	2008	general self rated health	Canada	25 to 60	NPHS	longitudinal	4886
[92]	1999	general sickness absence	3 Finnish towns	18 to 63	employee records	cross-sectional	2793
[84]	2014	general sickness absence	Spain	16 to 75	Government data (n= sick leaves)	cross-sectional	598988
[94]	2005	Sf36 PCS	Helsinki, Finland	~50	3 surveys	cross-sectional	8947
		INJURY PAIN AND DISABILITY					
[102]	2004	functional limitations	US		Hispanic Established Population study of the Elderly (n estimated)	cross-sectional	*3000*
[104]	1995	hip fracture	Toronto Canada	55 to 84	survey	case-control	1333
[101]	2014	injury	Korea	20 to 59	KNHANES	cross-sectional	11837
[97]	2010	injury and musculo-skeletal disability	Review		review	review	
[103]	2013	low back pain	Denmark		Danish health care worker cohort	longitudinal	1661
[96]	2008	musculoskeletal	Wisconsin, US	54 to 65	WLS	longitudinal	4495
[100]	2008	obstructive sleep apnoea	Sweden	35 to 75	MigMed	longitudinal	12938
[83]	2013	permanent disability	Spain	21 to 64	Government data MCVL	longitudinal	718958
		MENTAL HEALTH					
[108]	2003	depressive symptoms & impaired psychological wellbeing	Sweden	42 to 58 (at second interview)	survey and professional examinations	longitudinal & cross-sectional	367

[107]	2010	major depression	Canada	mean age 46	NPHS	longitudinal	9589
[97]	2010	mental health	Review		review	review	
[98]	2008	Psychological distress	Canada	25 to 60	NPHS	longitudinal	4886
[96]	2008	psychological distress & depression	Wisconsin, US	54 to 65	WLS	longitudinal	4495
[109]	2013	psychological health inequalities	Japan	mean forties	J-Hope & internet survey	longitudinal & cross-sectional	10951
[105]	2012	self rated psychological health	Skane Sweden	18+	public health survey	cross-sectional	28198
[106]	2004	cortisol	UK London	45 to 58	Whitehall II	longitudinal	181
[94]	2005	Sf36 -mcs	Helsinki, Finland	~50	3 surveys	cross-sectional	8947
		SPECIFIC OUTCOMES					
[110]	2008	specific birth outcomes	Sweden	Mothers' 19 plus	government data	longitudinal	279757
[97]	2010	specific cancer	Review		review	review	
[97]	2010	specific chronic conditions	Review		review	review	
[111]	1996	specific chronic conditions	GB	age 20 to 59	GHS (n estimated)	repeated cross sectional	*500000*
[88]	1995	specific chronic conditions	Netherlands	25 to 64	LS-SEHD	longitudinal	13391
[97	2010	specific CVD	Review		review	review	

]							
[112]	1995	specific CVD	Copenhagen Denmark	53 to 75	Copenhagen male study	longitudinal	2974
[113]	2009	OTHER time outside	Portugal	population	Air pollution, census data & time activity data	longitudinal	*10543000*
[114]	2011	self esteem/mastery	Midwest US	high school	YDS	longitudinal	769

4) Physical activity exposure

There were 84 references in the physical activity database (table 4.1) and for 60 the full text was accessed. Four extra references were added from the occupation database because physical activity was the outcome whereas six references were moved to the time activity database, twelve other references were not included because physical activity was not included as an outcome (e.g. the outcome was health, fitness or weight) and four references were excluded because they did not include analysis of different SES or vulnerable groups. Thus there were 42 references that were reviewed.

Table A2.4.1 Inclusions and exclusions from the review

Total number of references	*Reason for exclusion*	*Number of references excluded*
84		
60	Unable to access full text	24
64	Added from occupation database	(+4)
58	Moved to time activity general database	6
46	Physical activity not analysed as an outcome	12
42	SES and vulnerable groups not analysed	4

The studies were grouped by outcome into the type of physical activity (general, leisure, occupational, household and activity for transport), level of physical activity (intense or walking (note that walking for transport was included under transport)) and physical inactivity (also including sitting and screen time) (table A2.4.2). SES, ethnicity, gender and age were included in analyses. For SES, studies were split into whether higher SES groups did more, the same or less physical activity than low SES groups. The ethnic groups studied were categorised as relatively advantaged or disadvantaged in the countries sampled. The ethnic groups (advantaged SES group listed first) were white compared with African American and American Indian/ Alaskan Native and Hispanic [115], Chinese compared with Malay and Asian Indian [116], born in Australia compared with born elsewhere [117,118], non Hispanic white compared with non Hispanic black and Hispanic [119], Jews compared with Arabs [120], white compared with non white [121,122], Caucasians compared with African Americans [123], white, black and Latino [124], white, Asian/Pacific Islander, black, Hispanic, American Indian [125], white compared with black [126], European American, African American, Hispanic American [127]; white, black, Hispanic [128]. Whether men did more, the same, or less physical activity than women was also

included as was whether younger people did more physical activity than older people. Studies with inconsistent results were included with studies who found no differences between groups.

The heat map reveals that the most consistent finding was that high SES groups do more leisure time physical activity than low SES groups. There are suggestions that they may do less transport related physical activity and possibly have more inactive, sitting or screen time. For ethnicity there were more inconsistent results – often because more than one ethnic group would be studied and results would not reach significance for all groups. The heat map implies that men may do more physical activity (except housework, commuting and walking generally). Patterns of physical activity by age were less clear perhaps because of the different age groups included in various studies (see table 3). There was a possibility that younger people may do more leisure time physical activity.

Table A2.4.2 Heat map of physical activity SES and vulnerable groups

	SES (high vs low)			*Ethnicity (advantaged vs disadvantaged)*			*Gender (men vs women)*			*Age (younger vs older)*		
Physical activity	*More*	*Same/ varied*	*Less*	*More*	*Same / varied*	*Less*	*More*	*Same/ varied*	*Less*	*More*	*Same/ varied*	*Less*
Type												
General	[129]** [130] [131]	[115] [132] [133]	[134]	[123]	[115] [133] [128]#		[135] [136] [137]#			[138]	[115] [139] [138]	[133]
Leisure	[115] [134] [139]* [116] [140] [138] [117] [119] [118] [124] [141] [142] [143]	[141] [98]		[117] [118] [124] [126]	[119] [115] [116]		[136] [116] [126] [144]*		[119]	[145] [116] [119] [118] [124]	[115]	[146] [117]
Occupational		[115] [116] [139]	[134] [147] [148]##		[115] [116]		[136] [116]	[148]		[146]	[115] [116] [148]	[147]
Housework		[115] [116]			[115]	[116]			[136] [116]	[115]		[146] [116]
Transport		[149] [140]	[117] [139]* [120] [116]		[117]	[120] [116]	[136]		[116]	[117]		[120] [116]
Level												
Intense	[118] [138] [125] [150]	[139] [118] [140]		[118] [127]#	[115] [125]					[118] [125]		

Walking	[119]	[135] [121]			[121] [119]			[135] [121] [119]		[121]	[135]	[119]
Inactive/ sitting/ screen-time	[151] [152] [138] [134]	[139]	[118] [122] [129] [153]	[123]	[122]		[154]	[155]*		[122]		

* Restricted populations: Blue font indicates men only and red font indicates women only; some studies analysed populations restricted in other ways: only obese[155], only Mexican Americans with diabetes [144], only Blacks [139]. Note there were also age restrictions in some studies (see table 3)
**No difference in fitness levels were found
Significance not given
Split leisure time physical activity into sport and other activities

More details about the studies and study quality are found in table A2.4.3. All but two of the studies were published from 2000 onwards. Five studies only included children. Ten studies only included middle age and older. Most studies were from high income countries but five studies from middle income countries are included. 25 of the studies involved samples from outside the EU; 13 studies were conducted in North America and four in Australia. Most studies used data from research programmes or one off surveys although a few used government health survey data. All the analyses appeared to be cross sectional even though some of the programmes were collecting longitudinal data. Sample sizes ranged 125 to over 70000 with a median of 3809 (excluding the review).

Summary of physical activity

It is important to collect physical activity data at work, during leisure time and when commuting. High SES individuals appear to do more leisure time physical activity but perhaps not other types of physical activity.

Table A2.4.3 Physical activity study details and design

Ref	*Year*	*SES measures (if applicable)*	*Age groups*	*Location*	*data*	*Design*	*Sample size*
[98]	2008	income	25 to 60	Canada	NHPS	Longitudinal	4886
[115]	2000	education and income	women over 40	US	survey	Cross sectional	2912
[116]	2010	index of education, income, housing	adults	Singapore	survey	Cross sectional	4750
[117]	2010	education	age 18 -48	Victoria, Australia	READI	Cross sectional	4108
[118]	2000	education and economic status	20-69	Australian cities	RFPS	Cross sectional	7935
[119]	2005	education	18+	US	NPAS	Cross sectional	6626
[120]	2014	NA	school children (age 9 to 15) and parents	Israel	Parent & student surveys	Cross sectional	1755
[121]	2008	education, income, employment	25+	Atlanta, US	SMARTRAQ	Cross sectional	13065
[122]	2003	Brazilian SES indicator	20+	Pelotas, Brazil	survey	Cross sectional	1374
[123]	2009	NA	65+	US	NHANES	Cross sectional	1752
[124]	1997	Education	NA	US	Behavioral Risk Factor Surveillance System Survey	Cross sectional	NA
[125]	2002	Education, income, economic status	55-79	US	Women's Health Initiative observational cohort	Retrospective	71837

					study		
[126]	2013	education, family income, perceived adequacy of income, and ownership of financial assets.	70-79	Pittsburgh & Memphis, US	Health ABC	Longitudinal	3075
[127]	2007	NA	Adolescents & young adults	US	Add Health	Cross sectional	2284
[128]	2008	Na	30-79	Boston, US	BACH survey	Cross sectional	2301
[129]	2004	Area & school type (private/public)	12 & 13	Istanbul Turkey	biochemical, anthropometrical and cardiorespiratory fitness measurement and behavioural indices: dietary habits, estimation of energy and nutrient intake and physical activity assessment	Cross sectional	510
[130]	2007	Review	10 to 21	Western countries	34 studies, 20 of which were high quality 1970 to 2007		
[131]	2009	life course SES score and childhood and adult subscores: longest-held occupation of the participant's father during her childhood; whether the participant's childhood	60 to 79	UK	British Women's Heart and Health Study	Retrospective	2915

		home amenities; whether the participant had shared a bedroom as a child; whether, during the participant's childhood, her family had access to a car; the age at which the participant completed full-time education; the longest-held occupation of the participant and her spouse; the participant's current housing tenure; and the participant's current automobile access and pension arrangements					
[132]	2011	Parental occupation & school area	9, 14 or 18	Luxemburg	Luxemburg physical activity, motor performance and health survey for children and adolescents	Cross sectional	823
[133]	2013	occupation	Working adults	UK	Self report questionnaires at 3 time points	longitudinal	509
[134]	2012	education, income, occupation	18-79	Germany	GNHIES98	Cross sectional	3809
[135]	2009	education & income	18 to 65	Azorean Archipelago	Azorean physical activity and health study	Cross sectional	7330

[136]	2013	NA	average age 46	Malaysia	Health screening	Cross sectional	686
[137]	2013	NA	Over 18	Scotland	2 SHS	Cross sectional	16770
[138]	2007	average provincial income and average provincial income inequality, individual income social class and education	16-74	Spain	National Health Survey	Cross sectional	19324
[139]	2014	car ownership	mean age 41	Soweto, South Africa	Birth to twenty	Cross sectional	812
[140]	2003	education & material conditions (number of cars, bathrooms, housing tenure)	50-59 years	France & Northern Ireland	PRIME	Cross sectional	9757
[141]	2003	Parental occupation	16 followed up to 32	Tampere, Finland	3 questionnaires	longitudinal	1471
[142]	2014	Education	18+	RS, Bosnia and Herzegovina	National health survey	Cross sectional	4015
[143]	1998	Father's occupation	25 to 74	Eindhoven, Netherlands	LS-SEHD	longitudinal	16722
[144]	2004	NA	17+ but 70% over 50s	US	NHANES	Cross sectional	505
[145]	2001	NA	60 years plus	US			6569
[146]	2011	NA	age 35 to 69	Alberta, Canada	Tomorrow project	Cross sectional	15591
[147]	2013	education and occupation	>=40	England & Scotland	HSE & SHS	Cross sectional	11168
[148]	2005	Education & income	20-65	Israel	Telephone survey	Cross sectional	406
[149]	2009	educational attainment,	age 20-65	Adelaide, Australia	survey	Cross	2194

		individual income, area level income				sectional	
[150]	2001	Individual deprivation (home& car ownership & overcrowding)	18 to 94	London, UK	Postal survey	Cross sectional	658
[151]	2014	education	25-64	Spain	National Health Survey	Cross sectional	59478
[152]	2014	education, income, area level income	48+	NSW, Australia	SEEF	Cross sectional	40000
[153]	2009	Education, income, class, area	Adults	Scotland	SHS	Cross sectional	7079
[154]	2013	NA	5 to 8	Germany	Survey	Cross sectional	151
[155]	2012	NA	age 14 to 18	Netherlands	Go4it	Cross sectional	125

5) Time activity – general

Only 12 true time activity studies that presented differences between SES and/or vulnerable groups were included in the review (table A2.5.1). However some of the papers included in the external pollution review because they presented data on air pollution also presented time activity results[45] [46] [48] [51].

Table A2.5.1 Inclusions and exclusions from the review

Total number of references	*Reason for exclusion*	*Number of references excluded*
35	Refs in time activity and multiple outcome	
8	Not time activity study or cant access full text	27
14	References added from PA database	*(+6)*
17	References added from pollution database	*(+3)*
16	Only SES & vulnerable groups difference presented was age and that was only between 5-6 year olds	1
15	In Spanish & no clear differences presented	1
14	No SES and vulnerable group differences presented	1
13	Study covers methodology only	1
12	Time in activities not presented (purpose of activity focussed on to model car crash likelihood)	1

Table A2.5.2 Coverage of time activity studies

	Age	*Gender*	*Ethnicity*	*SES*
Indoors	[156] [157] [158] [159] [160] [161] [162] [75] [163]	[157] [159] [160] [161] [75]	[161]	[158] [159] [160] [161] [163]
Outdoors	[156] [157] [158] [159] [160] [162]	[157] [159] [160]		[158] [159] [160]
Transit	[156] [157] [158] [160] [161] [162] [75]	[157] [160] [161]		[158] [159] [160] [161]
diet	[156] [164]			
PA	[156] [159] [164]	[159]		[159]
Children's activities	[165]	[166]	[165,166]	[166]
ETS away from	[163]	[163]		[163]

home				

[156] diet refers to water only [158] Pregnant women only (age refers to age of stage of pregnancy); [159] SES is employed vs unemployed only; [161] indoors – home and work/school were separated, transit included highway only [165] Children with disabilities only; [164] [166] children only

Coverage rather than significance is shown in table A2.5.2 as there were lots of individual differences between activities. All studies but two took place outside the EU (all in North America except one in China). Most studies have looked at age. Similar numbers of studies have looked at SES and gender. However one of the studies that included SES was of pregnant women, another only considered SES in terms of employed and unemployed only and a third was undertaken in a middle income country (China). The sample sizes are as follows: Study [156] n=249, Study [157] n=5011, Study [158] n=62, Study [159] n=206, , Study [160] n=1608, Study [161] n= 663 study [162] compares Canadian study n=2381 with American n=9386; study [75] n=976; study [163] n=1427; study [164] n=174, study [165] n=427, study [166] n=6338.

There was very little overlap between studies. Some measured engagement, others measured % of day but there were a few studies which used 'time per day'. Additionally there was little overlap in activities measured. Even if they were measuring similar activities sometimes they broke the activities down into different aspects whereas other studies measured the activity as a block. For example time at home could be measured in total or broken down into time spent in different rooms or undertaking different activities within the home.

The few activities that were measured in a similar way in more than one study are tabulated below (tables 5.3 to 5.6). Activities that were only mentioned by one study are provided in the next section, study by study. The tables are colour coded by shading (green specifies outdoors, orange- home, pink- transit, purple -physical activity, dark blue -smoking and light blue- diet).

Hours per day spent outdoors (table A2.5.3) differed markedly between studies. Subjects in the Chinese study spent rather longer outside, although the gap was less obvious for children. This may be due to varying times of year [162]. Pregnant women and infants spent very little time outside at all. Men appeared to spend more time outside than women.

The three studies that presented hours per day spent at home (table A2.5.4) were roughly equivalent. Infants spent the largest proportion of their day at home and working age people the least. Men appeared to spend slightly less time at home than women in all but one study. The one study that looked at education differences in Europe found no significant differences [163].

Working age people generally spent the longest time in transit (table A2.5.5) although in the Chinese study the amount was similar for children. Men appeared to spend slightly longer in transit than women. High SES groups appeared to spend slightly longer in transit. Times spent in transit were fairly comparable between studies – although the study that only presented highway use [161] recorded slightly lower times.

There were two studies that presented time spent undertaking vigorous and moderate exercise (table A2.5.6) by age. For working age adults times spent engaging in vigorous exercise were comparable but age patterning was different. For moderate activity both

studies recorded highest levels among working age adults. For children and older adults physical activity levels were consistently higher in one study. One of these studies and another study presented details of time spent TV watching at the week end. Times were not dissimilar for both studies.

Table A2.5.3 Hours per day spent outdoors

	Hours per day	*ref*
Age		
<1yr	00:57	[157]
1-4 yrs	01:49	[157]
5-11 yrs	01:48	[157]
12-19 yrs	01:29	[157]
20-59 yrs	01:19	[157]
60+ yrs	01:19	[157]
1st trimester pregnancy	0.00 (0.00–0.00)	[158]
2nd trimester pregnancy	0.15 (0.07–0.24)	[158]
3rd trimester pregnancy	0.42 (0.22–0.62)	[158]
0–15	1.6	[160]
16–64	4.3	[160]
>64	3.9	[160]
<11	00:34-03:23	[162]
11 to 17	00:35-03:53	[162]
18+	00:33-02:28	[162]
Gender		
Male	01:33	[157]
Female	01:14	[157]
Male	3.7	[160]
Female	3.2	[160]

Table A2.5.4 Hours per day spent at home

	Hours per day	*ref*
Age		
<11	15:31-18:57	[162]
11 to 17	14:53-16:44	[162]
18+	13:57-16:39	[162]
<1yr	21:23	[157]
1-4 yrs	17:44	[157]
5-11 yrs	17:07	[157]
12-19 yrs	16:40	[157]
20-59 yrs	16:02	[157]
60+ yrs	18:38	[157]
Adults	17.7	[75]
Students	14.8	[75]
School children	14.9	[75]
1st trimester pregnancy	14.4 (13.3–15.4)*	[158]
2nd trimester pregnancy	16.1 (15.3–17.0)*	[158]
3rd trimester pregnancy	16.9 (16.0–17.8)	[158]
< 60 yrs	15.85	[161]
>= 60 yrs	19.48	[161]
Gender		
Male	17.22	[161]
Female	17.91	[161]
Male	16:24	[157]
Female	17:08	[157]
Males	17	[75]
Females	15.7	[75]

Table A2.5.5 Hours per day spent in transit

	Hours per day	*ref*		*Hours per day*	*ref*
Age			*SES*		
<11	00:37-00:58	[162]	Illit/prim	0.8	[160]
11 to 17	00:46-01:10	[162]	Mid/High	1.2	[160]
18+	01:17-01:34	[162]	College+	1.2	[160]
<1yr	00:29	[157]	Less than high school diploma	0.17	[161]
1-4 yrs	00:46	[157]	High school diploma	0.36	[161]
5-11 yrs	00:49	[157]	Undergraduate school	0.39	[161]
12-19 yrs	00:50	[157]	Graduate school	0.35	[161]
20-59 yrs	01:30	[157]			
60+ yrs	01:03	[157]	*<5000*	*1.1*	[160]
			5000–20000	*1.3*	[160]
Adults	1.1	[75]	*20000–50000*	*1.2*	[160]
Students	1.2	[75]	*>50000*	*1.2*	[160]
School children	1.3	[75]			
			Less than $24,999	0.17	[161]
	0:49±78		$25,000 – $74,999	0.39	[161]
Children		[156]	$75,000 or more	0.52	[161]
Young adults	1:20±102	[156]			
Older adults (65+)	0:58±74	[156]			
0–15	1.1	[160]			
16–64	1.1	[160]			
>64	0.3	[160]			
< 60 yrs	0.37	[161]			
>= 60 yrs	0.24	[161]			
Gender					
Male	01:18	[157]			
Female	01:14	[157]			
Male	0.44	[161]			
Female	0.21	[161]			
Male	1.3	[160]			

Female	0.9 [160]	

Table A2.5.6 Minutes per day (unless otherwise specified) in two physical and one sedentary activities

	Vigorous exercise		*Moderate exercise*		*Watching TV*		*ref*
Age							
Children	99±134		90±117				[156]
Young adults	128±178		191±216				[156]
Older adults	35±127		144±203				[156]
	Weekday	weekend	Weekday	weekend	Weekday	weekend	
Children	126	142	192	213	110	121	[159]
Parents	79	106	219	219	110	129	[159]
Older adults	114	135	168	185	205	238	[159]
Preschool children						2.3hrs ± 1. 3	[164]
School age children						2.7 hrs ± 1.3	[164]

Table A2.5.7 Summary of time activity studies

Ref	*Date*	*SES measures*	*Gender & ethnicity measures & results*	*Outcomes*	*Location*	*Age measures & results*
[156]	1999			VOCs, metals, particulates	Ohio, Indiana, Michigan, Illinois, Wisconsin, Minnesota	children more soil/grass/leaves, lie on floor, vigorous exercise, less likely to, smoke, shower or clean; young adults travel most; older adults drink water most
[157]	2014		women spent 44 minutes longer indoors and men spend 20 mins longer outdoors	time spent indoors /outdoors	Canada	Adults spent most time in vehicles, infants spent least time in indoor locations not including their home), children spent most time outside
[158]	2009	income & not working	pregnant women spend more time at home in later stages of pregnancy	time at home	Canada (compared with US)	
[159]	2011	Employed adults spent more time using a computer on the recall day than unemployed adults, and employed older adults bought gas more often. We also observed that unemployed parents of young children,	In households with young children, mothers of young children were less likely to watch TV and use computers than fathers. However, mothers spent more time on vigorous outdoor activities than	Time spent in microenvironments	California.	In general, fathers of young children spent more time at places for work, shopping, eating and errands than mothers; however, when all adults were considered, females were more likely to visit a food store than males. Male doers spent more time in other

	overwhel- mingly female, spent more time on moderate and vigor- ous activities, and visited food stores more often than employed parents.	fathers. We note that our population had a large number of stay-at-home mothers. Older male adults reported a higher frequency of moderate outdoor activities, purchasing gas, barbequing, and visiting other types of stores than older females. The only sex differences in activities for young children that we observed were for boys spending more time engaged in vigorous activities and using computers than girls.			locations, like public parks and health clubs. In addition, girls who went to school or daycare spent more time at school than boys. Age effect was also examined within each age group. Older parents of young children were less likely to spend the whole day at home and more likely to spend time in transit and other locations, like parks and museums, than younger parents of young children. Time sleeping decreased with age for both young chil- dren and parents of young children. Among the older adult doers, time spent at work, shopping, eating and running errands decreased with age. Older adults gener- ally spent less time working than adults who were younger and had children. children younger than 6-years were more likely to watch TV, while

						children older than 6 were more likely to use a computer. Older children also spent more time on the recall day on moderate activities than younger children
[160]	2009	income, education	Males spent more time in "outdoors" and "transit", while females spent more in "kitchen" and "other indoors"	People with higher education spent less time in "outdoors", "kitchen",and "other indoors". The time spent in "office" by people with the highest education level (college or above) was 7.8 times greater than that by people with the lowest level (primary school or illiterate). The time-activity patterns by household income were similar to that by education. People with higher income spent less time in "outdoors", "kitchen", and "other indoors" but more time in "office" and "living room". However, there was no significant difference in the time spent in "transit" when household income was concerned (p = 0.261).	Chongqing China	The youth spent more time in "classroom" but less in "outdoors" than adults and senior citizens did, since most teenagers received compulsory education. Adults spent more working time in "outdoors". The youth and adults spent similar time in "transits". However, the senior citizens spent most time at home ("living room", "bed-room", and "kitchen").
[161]	2013	income, education	White, Black, Asian,	Higher education/income	3 neighbour-	Older people spent more

			Other Men spent more time on highway, blacks spent more time on the highway than asians	less time outside home and at home more at school/work. Higher income also spent more time on highway	hoods in Boston US	time outside home but less time at school/work and on the highway
[162]	2002				Canada & US (CHAPS &NHAPS)	
[75]	2003		Men spend more time at home than women	Time at home and travelling	Northants, UK	Adults, students, children (9 to 13) (students spend most time travelling & adults spend most time at home)
[163]	2007	Education	women spend less time indoors at home (except Prague and Oxford), relationship between gender & time spent at workplace varies by city, men spend less time indoors at other places, male nonsmokers have more ETS exposure outsode the home	Time at home indoors, time at workplace, time indoors at other places, ETS exposure outside the home among non smokers no SES difference in time spent at home, indoors at work; high SES more time indoors at other places and less ETS indoors away from home	Helsinki (Finland), Athens (Greece), Basel (Switzerland), Grenoble (France), Milan (Italy), Prague (Czech Republic), and Oxford (UK)	Age 19 to 60. No significant differences except <40 less time at workplaces in Basel
[164]	2009			Age: diet (preschool better than school)	US	2 to 12
[165]	2010	income, education	Caucasian vs non	no SES(participation in	Canada	physically disabled chidren

			caucasian predicts enjoying participation in a wide range of activities	afterschool activity		
[166]	2009	mother’s education, father’s education, family income, mother’s occupation and father’s occupation	Asian more likely to study	Low SES out of school activities more likely to be sedentary, more likely to work and less likely to be organised sport or community	US	high school sophomores age 15-16

More detailed results from time activity studies

Here results tables from the time activity papers are provided. The tables are colour coded as follows: green specifies outdoors, orange- home, pink- transit, purple -physical activity, dark blue -smoking and light blue- diet

Study [156] (n=249)

Table A2.5.6 % engaging in each activity over 6 days by age

[156]	Children	Young adults	Older adults
pump gas	2	14.8	6.5
soil/dirt contact*	27.8	15.7	15.6
grass/leaves contact*	31	16.8	18.3
home ETS	40.6	39.3	27.4
shower*	34.4	73.2	54.8
bathe	52.2	73.2	54.8
water drunk*	85	76	95.2
wash hands	95.6	99.6	100
smoke cigarettes*	0	31	21
indoor ETS	46.2	47.8	30 car
ETS	16.1	22.1	12.9
travel*	70	90.3	71
clean*	8	27.3	28.3
workshop	6.7	10.4	12.4
lie on floor*	68.9	23.8	2.2
vigorous exercise*	48.3	9.1	0.9
moderate exercise	68.3	65.3	73.7
n	30	188	31

Table A2.5.7 Continuous measures by age

[156]	Children	Young adults	Adults65+
water drunk (no. glasses)*	2.4±3.2	3.5±3.9	3.9±4.9
wash hands (no.)**	3.9±4.6	6.4±7.5	7.8±9.0
cigarettes (no.)	±17.4±18.4	12.6±20.8	
road travel (min)+	49±78	80±102	58±74
vehicle ETS (min)	33±65	71±85	26±65
indoor ETS (min)	265±422	330±378	404±543
clean (min)	10±37	55±95	28±75
workshop (min)	125±300	78±242	17±73
lie on floor (min)	120±155	95±142	±
ventilation (min)	673±769	693±805	600±866

vigorous exercise (min)	99±134	128±178	35±127
moderate exercise (min)+	90±117	191±216	144±203

Study [157] (n=5011)

Table A2.5.8 % of day by gender

[157]				Standard Error		Median		95th Percentile	
		% of day min	h:min	% of day	min	% of day	h:min	% of day	h:min
Male	Indoors at home	68.4	16:24	0.9	13.2	67.5	16:12	99.5	23:52
	Other indoor	19.8	04:44	0.9	12.8	15.3	03:41	47.2	11:19
	Outdoors	6.4	01:33	0.4	5.8	2.7	00:40	30.4	07:17
	In vehicle	5.4	01:18	0.5	7.6	3.7	00:20	16.7	04:00
Female	Indoors at home	71.4	17:08	0.8	11.2	72.4	17:22	99.9	23:58
	Other indoor	18.3	03:56	0.7	10.5	13.8	03:19	46.9	11:15
	Outdoors	5.2	01:14	0.3	4.8	1.4	00:20	21.8	05:14
	In vehicle	5.1	01:14	0.3	3.9	3.4	00:49	17.3	04:09

Table A2.5.9 % of day by age

[157]		mean		st err		Median		95th Percentile	
		% of day	h:min	% of day	min	% of day	h:min	% of day	h:min
<1yr	Indoors at home	89.2	21:23	1.5	21.1	93.3	22:22	99.9	23:58
	Other indoor	4.8	01:10	0.9	13.4	0	00:00	23.6	05:39
	Outdoors	4	00:57	1.1	16	0	00:00	21.2	05:06
	In vehicle	2	00:29	0.3	5	0	00:00	8.7	02:05
1-4 yrs	Indoors at home	74	17:44	1.6	22.9	71.6	17:10	98	23:30
	Other indoor	15.3	03:40	1.5	21	9.6	02:19	39.4	09:23
	Outdoors	7.6	01:49	1.3	18.9	4	00:58	31.5	07:33
	In vehicle	3.2	00:46	0.6	8	1.6	00:22	8.3	01:59
5-11 yrs	Indoors at home	71.3	17:07	1.2	17.8	70.1	16:48	95.2	22:50
	Other indoor	17.8	04:16	1.1	16.3	18.1	04:21	38.9	09:20
	Outdoors	7.5	01:48	0.6	8.1	4.9	01:11	24.7	05:55
	In vehicle	3.4	00:49	0.4	5.4	2.1	00:30	11.8	02:50
12-19 yrs	Indoors at home	69.5	16:40	2	28.9	69.2	16:36	98.3	23:35
	Other indoor	20.8	04:59	1.8	26.2	22.2	05:19	44.8	10:44
	Outdoors	6.2	01:29	1	14.8	1.4	00:20	29.9	07:10

	In vehicle	3.5	00:50	0.3	4.9	2.4	00:34	10.4	02:29
20-59 yrs	Indoors at home	66.8	16:02	0.9	12.5	64.5	15:28	99.1	23:45
	Other indoor	21.4	05:08	0.9	12.4	16.9	04:03	50.5	12:06
	Outdoors	5.5	01:19	0.4	5.4	2	00:29	25.9	06:12
	In vehicle	6.3	01:30	0.5	6.7	4.3	01:02	22.7	05:27
60+ yrs	Indoors at home	77.7	18:38	0.9	12.3	81.9	19:38	100	24:00:00
	Other indoor	12.5	02:59	0.7	10.2	8	01:55	40.6	09:44
	Outdoors	5.5	01:19	0.3	4.9	2	00:29	24.6	05:54
	In vehicle	4.4	01:03	0.2	3.5	2.4	00:35	13.9	03:20

Red font indicates high sampling variability – interpret with caution

Study [158] (n=62)

Table A2.5.10 Mean hours a day during pregnancy

[158]	1st trimester (n=11)	2nd trimester (n=62)	3rd trimester (n=54)
At/near home	14.4 (13.3–15.4)*	16.1 (15.3–17.0)*	16.9 (16.0–17.8)*
Work	5.57 (4.44–6.70)	4.26 (3.46–5.06)	3.67 (2.76–4.58)
Indoors other	2.24 (0.90–3.57)	1.56 (1.25–1.87)	1.39 (1.05–1.74)
Outdoors	0.00 (0.00–0.00)	0.15 (0.07–0.24)	0.42 (0.22–0.62)*
Car	1.11 (0.51–1.70)	0.87 (0.67–1.07)	0.81 (0.60–1.01)
Bus	0.27 (0.01–0.54)	0.24 (0.14–0.35)	0.18 (0.08–0.27)
Walk	0.44 (0.19–0.69)	0.74 (0.58–0.91)	0.60 (0.42–0.77)
Bike	0.02 (0.00–0.07)	0.06 (0.00–0.13)	0.06 (0.00–0.13)

Table A2.5.11 Hours per day at home

[158]	p		N	Time spent at home (h/day) Mean (SD)	Regression coefficient
Income	0.0002	40,000	14	17.9 (3.3)	2.6(0.6 to 4.6)
		40,000–100,000	66	17.0 (3.0)	1.9 (0.6 to 3.2)
		100,000+	47	14.8 (2.9)	0
Other children	0.003	No	84	15.7 (3.1)	-1.48(-2.8 to-0.1)
		Yes	43	17.4 (3.2)	0
Trimester*	0.0478	(11 weeks, 7–14)	11	14.4 (1.6)	0.08 (0.0 to 0.1) *
		(22 weeks, 15–28)	62	16.1 (3.3)	
		(33 weeks, 29–36)	54	16.9 (3.2)	
Workers	<0.0001	No	12	20.4 (1.3)	NA
		Yes	11 7	15.9 (3.0)	
At work on sampling	<0.000	No	32	20.0 (1.5)	3.47(1.4 to 5.5)

day	1				
		Yes	95	15.0 (2.5)	0

* entered as continuous variable weeks of pregnancy (p=.0065)

Study [159] n=206

Table A2.5.12 Duration of daily activity (minute/day)

[159]	children n=985					parents n=985					older adults n=509				
Weekday N = 511 N = 511 N = 258	% doers	mean	sd	med	90th %	% doers	mean	sd	med	90th %	% doers	mean	sd	med	90th %
Any moderate activity	91%	192	128	180	360	92%	219	173	180	480	89%	168	128	125	330
Moderate outdoor activity > 30 mins	56%	77	77	60	135	33%	85	79	60	180	31%	118	123	60	270
Any vigorous activity	77%	126	83	120	240	28%	79	53	60	140	28%	114	105	70	210
Vigorous outdoor activity > 30 mins	56%	87	88	60	150	15%	104	136	60	180	14%	97	63	80	190
Being in the garage	19%	17	43	5	25	26%	29	98	10	30	51%	58	132	20	90
Using stove	32%	36	107	15	60	65%	57	53	45	120	53%	56	67	45	120
Using computer	33%	63	76	45	120	90%	217	183	150	480	87%	160	109	125	360
Watching TV	88%	110	74	90	200	78%	110	73	120	180	93%	205	148	180	360
Being in a room with windows open	62%	380	280	300	780	64%	437	271	420	780					
Weekend N = 474 N = 474 N = 251															
Any moderate activity	92%	213	135	180	370	93%	219	160	180	480	88%	185	137	150	360
Moderate outdoor activity > 30 mins	59%	92	81	60	180	42%	107	90	75	190	34%	101	88	60	210
Any vigorous activity	74%	142	98	120	300	22%	106	101	60	240	25%	135	107	120	255
Vigorous outdoor activity > 30 mins	50%	110	75	90	210	14%	119	12	73	225	15%	115	63	105	240

								1							
Being in the garage	23%	25	81	10	30	31%	24	67	10	60	48%	46	104	20	75
Using stove	29%	32	95	15	60	58%	62	50	60	120	52%	69	99	45	135
Using computer	38%	79	110	60	140	74%	111	119	60	240	79%	114	79	90	225
Watching TV	87%	121	84	120	240	81%	129	95	120	240	89%	238	168	188	480
Being in a room with windows open	71%	401	268	325	780	66%	448	273	390	780					
Frequency of weekly activity (time/week)															
Moderate outdoor activity > 30 mins	84%	6	4	5	10	65%	4	4	3	7	49%	5	4	4	8
Vigorous outdoor activity > 30 mins	81%	6	4	5	10	51%	4	4	3	6	39%	3	3	3	7
Purchasing gas at a gas station	93%	1	1	1	2	88%	1	1	1	2					
Food store visit	85%	1	1	1	3	96%	2	1	2	3	95%	2	2	2	3
Frequency of monthly activity (time/month)															
Multi-purpose store visit	92%	2	2	2	4	97%	3	2	2	5	95%	3	2	3	5
Other store visit	83%	2	3	1	4	89%	3	4	2	5	82%	4	8	2	8
Barbeque	29%	2	2	2	5	44%	3	4	2	6	44%	4	4	3	12

Table A2.5.13 Significant differences in occurrence and duration by gender, age and employment status

[159]	occ gender			age			empl		dur gender			age			empl	
	Child	Parent	older	Child	Parent	older	Parent	older	Child	Parent	older	Child	Parent	older	Parent	older
home					y								y			

transit						o											
Place work,shop, eat, errand											m				y		
sleep												y		y			
school	o								f								
work														y			
Food store										f			o				
Shopping mall/other					o												
restaurant					o												
Public park					y					m			o				
Health club										m			o				
Any moderate activity				o			ue										
Moderate outdoor activity > 30 mins																	
Any vigorous activity	m						ue										
Vigorous outdoor activity > 30 mins		f															
Being in the garage																	
Using stove																	
Using computer				o					m		m					e	e
Watching TV		m		y													
Being in a room with windows open																	
Moderate outdoor activity > 30 mins			m														
Vigorous outdoor activity > 30 mins																	
Purchasing gas at a gas station			m					e									
Food store visit							ue										
Frequency of monthly activity (time/month)																	
Multi-purpose store visit																	

Other store visit	m
Barbeque	m

Occ=occurrence Dur=duration o=older y=younger, m=male f=female e=employed ue = unemployed

Study [160] n=1608

Table A2.5.14 Mean hours per day

[160]	age		gender		educ		Inc (annual)	
outdoor	0–15	1.6	M	3.7	Illit/prim	5.5	<5000	4.8
	16–64	4.3	F	3.2	Mid/High	4.4	5000–20000	4.5
	>64	3.9			College+	2.5	20000–50000	3.0
							>50000	2.4
transit	0–15	1.1	M	1.3	Illit/prim	0.8	*<5000*	*1.1*
	16–64	1.1	F	0.9	Mid/High	1.2	*5000–20000*	*1.3*
	>64	0.3			College+	1.2	*20000–50000*	*1.2*
							>50000	*1.2*
living room	0–15	2.2	M	*2.5*	Illit/prim	2.6	<5000	2.5
	16–64	2.6	F	*2.5*	Mid/High	2.7	5000–20000	2.8
	>64	4			College+	3.3	20000–50000	3.2
							>50000	3.2
bedroom	0–15	9.9	M	*9.6*	Illit/prim	9.9	<5000	9.8
	16–64	9.5	F	*9.7*	Mid/High	9.8	5000–20000	9.6
	>64	11.1			College+	9.7	20000–50000	10.0
							>50000	10.1
kitchen	0–15	0.7	M	1.1	Illit/prim	2.5	<5000	2.0
	16–64	1.6	F	1.7	Mid/High	1.7	5000–20000	1.4
	>64	2.5			College+	1	20000–50000	1.4
							>50000	1.1
classroom/office	0–15	7.4	M	*4.2*	Illit/prim	0.6	<5000	1.5
	16–64	2.9	F	*4.1*	Mid/High	1.9	5000–20000	2.7
	>64	0.1			College+	5.3	20000–50000	3.4
							>50000	4.5
other indoors	0–15	1	M	1.5	Illit/prim	2.1	<5000	2.2
	16–64	2	F	1.9	Mid/High	2.1	5000–20000	1.8
	>64	2.1			College+	1	20000–50000	1.7
							>50000	1.4

Italics signified non significant

Study [161] n=663

Table A2.5.15 Hours per day and % of day

	At home			Outside home			School/work			Other			Highway		
	x,¯	Sd	% day	x,¯	Sd	% day	x,¯	Sd	% day	x,¯	Sd	% day	x,¯	Sd	% day
total	17.62	(4.4)	74%	1.61	(2.5)	7%	3.2	(4.5)	13%	1.26	(2.3)	5%	0.31	(0.9)	1%
Male	17.22	(4.5)	72%	1.81	(2.8)	7%	3.35	(4.3)	14%	1.18	(2.1)	5%	0.44	(1.2)*	2%
Female	17.91	(4.3)	75%	1.45	(2.3)	6%	3.11	(4.5)	13%	1.32	(2.4)	5%	0.21	(0.5)*	<1%
< 60 yrs	15.85	(4.5)*	66%	1.42	(2.8)*	6%	5.09	(5.0)*	21%	1.27	(2.3)	5%	0.37	(0.7)*	2%
>= 60 yrs	19.48	(3.5)*	82%	1.81	(2.2)*	8%	1.22	(3.1)*	5%	1.25	(2.2)	5%	0.24	(1.0)*	1%
Ftwork, ptwork, student	13.75	(3.4)*	57%	1.12	(2.8)*	5%	7.54	(4.15)*	31%	1.05	(2.2)*	5%	0.54	(1.2)*	2%
Retired, disabled, homemaker or ue	20.09	(2.9)*	84%	1.92	(2.3)*	8%	0.42	(1.75)*	2%	1.46	(2.3)*	6%	0.16	(0.5)*	<1%
White	17.18	(4.4)*	72%	1.25	(2.4)*	5%	3.53	(4.5)	15%	1.71	(2.5)*	7%	0.33	(0.84)*	1%
Black	16.99	(4.6)	71%	0.86	(1.8)*	3%	3.51	(4.4)	15%	1.92	(2.9)*	8%	0.72	(1.9)***	3%
Asian	18.23	(4.2)*	76%	2.31	(2.6)**	10%	2.57	(4.3)	11%	0.73	(1.6)*	3%	0.16	(0.5)*	<1%
Other	18.07	(5)	76%	1.49	(2.6)	6%	3.57	(5.3)	15%	0.56	(1.4)*	2%	0.31	(0.5)*	1%

< high school	18.4		77		(3.0)**					0.9		4	0.1		
diploma	5	(4.6)**	%	2.19	*	9%	2.22	(4.3)**	9%	7	(2.1)	%	7	(0.5)	<1%
High school	17.8		74						12	1.4		6	0.3		
diploma	1	(4.2)*	%	1.49	(2.4)*	6%	2.86	(4.4)*	%	8	(2.6)	%	6	(1.2)	2%
Undergraduate	17.0	(4.38)	71						16	1.3		6	0.3		
school	6	*	%	1.22	(2.0)*	5%	3.94	(4.7)*	%	9	(2.1)	%	9	(0.9)	2%
	16.0		67						22	1.2		5	0.3		
Graduate school	4	(3.9)**	%	1.15	(2.1)*	5%	5.23	(4.6)**	%	3	(2)	%	5	(0.7)	1%
	19.2	(3.73)	80							1.1		5	0.1		
Less than $24,999	4	**	%	1.97	(2.6)**	8%	1.44	(3.4)**	6%	8	(2.3))	%	7	(0.6)***	<1%
	15.8		66					(4.8)**	20	1.5		7	0.3		
$25,000 – $74,999	2	(3.8)**	%	1.3	(2.2)*	5%	4.91	*	%	8	(2.4)	%	9	(0.7)*	2%
	14.7		61					(4.6)**	27			6	0.5		
$75,000 or more	2	(4.0)**	%	0.91	(1.9)*	4%	6.55	*	%	1.3	(2.3)	%	2	(1.1)*	2%
Don't know/	18.2		76					(5.03)*	12	0.7		3	0.4		
refused	6	(5.6)**	%	1.64	(3.4)	7%	2.86	*	%	6	(1.6)	%	8	(1.7)*	2%
	17.1		71						16	1.5		7			
Somerville	4	(4.8)*	%	0.95	(2.5)*	4%	3.95	(4.8)*	%	6	(2.5)*	%	0.4	(1.0)*	2%
South	17.3		72						15	1.4		6	0.4		
Boston/Dorchester	3	(4.4)*	%	1.3	(2.3)*	5%	3.53	(4.6)*	%	3	(2.4)*	%	1	(1.1)*	2%
	18.2	(4.10)	76			10			10	0.8	(1.8)*	3	0.1		
Chinatown	7	**	%	2.39	(2.6)**	%	2.33	(4.2)**	%	7	*	%	4	(0.4)**	<1%

*indictates significance

Table A2.5.16 Regression of time at home

	Survey 1 n=652				Survey 2 N=169			
	Weekday		Weekend		Weekday		Weekend	
	ß	95% CI	ß	95% CI	ß	95% CI	ß	95% CI
Intercept	r	(11.13, 14.19)	14.86	(13.18,	12.47	(9.18,	14.5	(10.32,

				16.54)		15.77)		18.68)
Age	**0.04**	**(0.02, 0.06)**	**0.04**	**(0.01, 0.06)**	0.03	(−0.02, 0.08)	**0.08**	**(0.01, 0.14)**
Male	−0.40	(−0.88, 0.08)	0.04	(−0.49, 0.57)	−0.35	(−1.46, 0.75)	0.01	(−1.40, 1.41)
Retired, disabled, or unemployed	**5.44**	**(4.84, 6.04)**	0.65	(−0.01, 0.06)	**4.59**	**(3.24, 5.93)**	−0.35	(−2.06, 1.36)
Education								
Less than high school diploma	**−1.19**	**(−2.15, −0.23)**	0.18	(−0.88, 1.23)	−0.58	(−2.59, 1.42)	−0.54	(−3.08, 2.01)
High school diploma	**−1.19**	**(−2.11, −0.27)**	0.99	(−0.03, 2.00)	−0.56	(−2.22, 1.11)	0.01	(−2.1, 2.12)
Undergraduate School	−0.68	(−1.56, 0.20)	**1.26**	**(0.30, 2.23)**	−0.89	(−2.43, 0.64)	−1.23	(−3.18, 0.72)
Graduate School	Ref		Ref		Ref		Ref	
Income								
Don't know/ refused	0.9	(−0.19, 1.99)	0.53	(−0.67, 1.73)	0.53	(−1.96, 3.03)	1.6	(−2.48, 3.85)
Less than $24,999	**1.46**	**(0.58, 2.35)**	**1.15**	**(0.18, 2.12)**	2.91	(−0.49, 2.64)	1.79	(−0.54, 4.12)
$25,000 – $74,999	0.33	(−0.48, 1.14)	0.43	(−0.46, 1.32)	1.07	(−0.49, 2.64)	−0.24	(−2.22, 1.75)
$75,000 or more	Ref		Ref		Ref		Ref	
Race								
White	−0.78	(−1.63, 0.06)	0.17	(−0.76, 1.10)	−0.61	(−2.42, 1.21)	−0.66	(−2.97, 1.64)
Black	−1.06	(−2.14, 0.02)	0.83	(−0.36, 2.01)	−0.76	(−2.97, 1.45)	−0.14	(−2.95, 2.67)
Asian	**−0.85**	**(−1.70, −0.01)**	0.87	(−0.05, 1.80)	0.42	(−2.29,	3.44	(−0.01,

			3.13)	6.88)
Other	Ref	Ref	Ref	Ref

Study [162] (Ns=2381,9386)

Table A2.5.17 Minutes per day

	18+				11-17				<11			
	Winter		Summer		Winter		Summer		Winter		Summer	
	Can	US	Can	US	Can	US	Can	US	Can	US	Can	US
Indoor at home	999 (±13)	971 (±7)	837 (±13)	898 (±7)***	1004 (±25)	893 (±22)**	979 (±37)	906 (±24)	1137 (±28)	1067 (±19)	931 (±35)	989 (±16)
Work/School	124 (±9)	145 (±5)	145 (±9)	125 (±5)	236 (±27)	229 (±18)	34 (±13)	85 (±12)*	87 (±18)	126 (±12)	40 (±11)	48 (±8)
Indoors/Other	175 (±10)	150 (±5)	193 (±11)	156 (±5)*	102 (±19)	187 (±21)**	144 (±28)	190 (±18)	119 (±22)	153 (±16)	208 (±31)	141 (±12)
Bar/Restaurant	32 (±4)	34 (±2)	22 (±3)	32 (±2)*	17 (±9)	15 (±4)	10 (±5)	14 (±3)	16 (±4)	7 (±1)	9 (±2)	9 (±1)
Outdoors	33 (±4)	58 (±4)***	148 (±9)	135 (±4)	35 (±8)	60 (±7)	233 (±30)	175 (±14)	43 (±9)	34 (±4)	194 (±19)	203 (±12)
In vehicles	77 (±4)	83 (±2)	94 (±6)	93 (±2)	46 (±6)	56 (±5)	41 (±5)	70 (±8)**	37 (±4)	53 (±4)***	58 (±8)	51 (±4)

Table A2.5.18 Table A2.5.17 converted to hours and minutes

18+	11 to 17	<11

	Winter		Summer		Winter		Summer		Winter		Summer	
	Can	US	Can	US	Can	US	Can	US	Can	US	Can	US
Indoor at home	16:39	16:11	13:57	14:58	16:44	14:53	16:19	15:06	18:57	17:47	15:31	16:29
Work/School	02:04	02:25	02:25	02:05	03:56	03:49	00:34	01:25	01:27	02:06	00:40	00:48
Indoors/Other	02:55	02:30	03:13	02:36	01:42	03:07	02:24	03:10	01:59	02:33	03:28	02:21
Bar/Restaurant	00:32	00:34	00:22	00:32	00:17	00:15	00:10	00:14	00:16	00:07	00:09	00:09
Outdoors	00:33	00:58	02:28	02:15	00:35	01:00	03:53	02:55	00:43	00:34	03:14	03:23
In vehicles	01:17	01:23	01:34	01:33	00:46	00:56	00:41	01:10	00:37	00:53	00:58	00:51

Table A2.5.19 % of day

	% time		% time		p
Indoor at home	65.94	(±0.83)	64.97	(±0.42)	0.0423
Outdoor at home	1.41	(±0.18)	2.5	(±0.13)	<0.0001
School/Public building	4.21	(±0.40)	3.87	(±0.20)	0.1353
Indoors — other	7.95	(±0.59)	8.39	(±0.30)	0.1968
Bar/Restaurant	1.79	(±0.23)	1.91	(±0.12)	0.3622
Outdoors — other	4.6	(±0.41)	4.23	(±0.20)	0.1054
In vehicles	5.33	(±0.28)	5.74	(±0.12)	0.013
Near vehicles — outside	0.04	(±0.02)	0.19	(±0.04)	0.0002
Office/Factory	5.99	(±0.52)	5.9	(±0.27)	0.7634
Mall/Store	2.73	(±0.27)	2.3	(±0.13)	0.0033
Indoor at home	64.3	(±0.96)	64.4	(±0.48)	0.8619
Outdoor at home	1.16	(±0.20)	2.27	(±0.15)	<0.0001
School/Public building	2.96	(±0.40)	2.38	(±0.18)	0.0065
Indoors — other	8.14	(±0.68)	8.35	(±0.34)	0.5779
Bar/Restaurant	2.12	(±0.29)	2.22	(±0.14)	0.5532
Outdoors — other	4.3	(±0.47)	4.15	(±0.23)	0.5947
In vehicles	6.01	(±0.36)	6.16	(±0.17)	0.4456
Near vehicles — outside	0.05	(±0.003)	0.22	(±0.05)	0.0012
Office/Factory	7.83	(±0.67)	7.26	(±0.33)	0.1439
Mall/Store	3.13	(±0.35)	2.57	(±0.16)	0.0024
Indoor at home	67.01	(±2.25)	61.02	(±1.52)	<0.0001
Outdoor at home	1.48	(±0.50)	2.31	(±0.42)	0.0352
School/Public building	12.12	(±1.86)	14.03	(±1.14)	0.0954
Indoors — other	6.12	(±1.67)	9.69	(±1.22)	0.0026
Bar/Restaurant	0.87	(±0.46)	0.93	(±0.23)	0.7959
Outdoors — other	8	(±1.65)	5.45	(±0.67)	0.0009
In vehicles	3.08	(±0.49)	4.87	(±0.49)	<0.0001
Near vehicles — outside	0	(±0.01)	0.14	(±0.09)	0.084
Office/Factory	0.22	(±0.35)	0.18	(±0.14)	0.8096
Mall/Store	1.1	(±0.44)	1.37	(±0.30)	0.3795
Indoor at home	72.33	(±2.38)	70.52	(±1.17)	0.1521
Outdoor at home	2.69	(±0.66)	4.07	(±0.45)	0.0025
School/Public building	5.72	(±1.21)	7.83	(±0.75)	0.0066
Indoors — other	8.74	(±1.85)	8.15	(±0.91)	0.5533
Bar/Restaurant	0.66	(±0.20)	0.47	(±0.09)	0.0564
Outdoors — other	4.25	(±1.00)	4.17	(±0.54)	0.895
In vehicles	3.66	(±0.53)	3.57	(±0.31)	0.7805
Near vehicles — outside	0.01	(±0.01)	0.05	(±0.03)	0.1481

Office/Factory	0.07	(±0.08)	0.12	(±0.09)	0.5973
Mall/Store	1.86	(±0.47)	1.05	(±0.18)	0.0001

Study [75] n=469 (Northants) n=976 (kingsthorpe)

Table A2.5.20 hours per day

		Home		travel	
		Mean	error	Mean	error
Northants	All	16.2	2.9		
Northants Questionnaire	Females	15.7	2.4		
Northants Questionnaire	Males	17	3.3		
Kingsthorpe	All	16	2.6		
Kingsthorpe Telephone	Adults	17.7	3.1	1.1	0.7
Kingsthorpe Time activity diary	Students	14.8	2.5	1.2	1.1
Kingsthorpe Time activity diary	School children	14.9	1.2	1.3	0.5

Study [164]n=174

Table A2..5.21 Differences between preschool and school aged children

[164]	Pre school	School age
servings/day of low-fat dairy	2.1 ± 1.6	1.7 ±1.5
Servings of sweetened drinks	1.4 ±1.9	2.2 ± 2.6
Hrs/day TV (weekend)	2.3 ± 1. 3	2.7 ± 1.3
Salty snacks daily	14.0%	26.1%
Sweet snacks daily	16.3%	29.5%
Dinner with parent	93.0%	80.7%

Study [165] n=427

Results from this study are not tabulated because they are a particular group. Tables are, of course, available in the paper. Younger children with special needs are likely to mainly engage in activity with their family and ethnic minorities were more likely to do so than be broad participators who enjoyed, preferred and engaged in a variety of activities [165]

Study [166] n=6338

Table A2.5.22 Means and standard deviations

[166]	sample	group 1 social	Group 2 All-Around	Group 3 Unstruc rec	Group 4 employed	Group 5 Study	
School clubs and sports	1.86 -0.75	1.80 - 0.71	2.35 -0.70	1.54 -0.65	1.89 -0.76	1.86 - 0.73	F = 173.36***
Homework (at school)	2.07 -0.5	2.07 - 0.48	2.16 -0.54	1.99 -0.46	2.16 -0.61	2.01 - 0.47	F = 22.86***
Homework (elsewhere)	2.12 -0.56	2.10 - 0.51	2.22 -0.60	1.95 -0.48	2.23 -0.65	2.17 - 0.60	F = 45.15***
Watch videotapes or DVDs (weekdays)	2.66 -0.98	2.37 - 0.88	2.87 -0.93	3.24 -0.84	3.34 -0.81	2.14 - 0.84	F = 414.40***
Watch videotapes or DVDs (weekends)	3.13 -0.9	2.81 - 0.90	3.45 -0.73	3.55 -0.69	3.72 -0.59	2.78 - 0.91	F = 347.72***
Play video games (weekdays)	1.68 -0.88	1.26 - 0.49	1.87 -0.91	2.37 -0.96	2.32 -1.03	1.37 - 0.60	F = 629.09***
Play video games (weekends)	2.01 -1.05	1.41 - 0.60	2.32 -1.06	2.86 -0.99	2.83 -1.08	1.74 - 0.85	F = 796.31***
Use computers for fun	2.33 -0.86	2.21 - 0.78	2.46 -0.82	2.31 -0.89	3.09 -0.87	2.04 - 0.72	F = 212.06***
Non-school reading	1.77 -0.55	1.74 - 0.51	1.81 -0.53	1.67 -0.56	1.95 -0.62	1.81 - 0.56	F = 31.52***
Hangout with friends	3.15 -0.85	3.45 - 0.61	3.40 -0.66	3.32 -0.75	2.84 -0.88	2.29 - 0.91	F = 554.80***
Drive or ride around	2.73	3.22	3.16	2.66	2.35	1.59	F = 621.53***

	-1.14	-0.89	-0.94	-1.12	-1.12	-0.85	
Talk with friends on the phone	3.21	3.64	3.55	2.75	3.42	2.26	F = 588.55***
	-1.03	-0.67	-0.74	-1.13	-0.85	-1.11	
Music, art, language or dance classes	1.58	1.75	2.08	1.14	1.37	1.33	F = 157.73***
	-1.04	-1.14	-1.27	-0.53	-0.85	-0.78	
Sports lessons	1.73	1.50	3.58	1.30	1.29	1.42	F = 1314.63***
	-1.15	-0.94	-0.71	-0.71	-0.77	-0.93	
Non-school sports	2.06	1.92	3.08	2.64	1.22	1.43	F = 576.64***
	-1.17	-1.10	-1.04	-1.12	-0.57	-0.84	
Hobbies, arts or crafts	2.27	2.42	2.33	2.43	2.41	1.73	F = 91.51***
	-1.09	-1.07	-1.06	-1.11	-1.13	-0.93	
Volunteering or community service	1.49	1.53	1.80	1.26	1.43	1.39	F = 76.87***
	-0.75	-0.76	-0.88	-0.57	-0.74	-0.69	
Employed	2.81	2.85	2.71	2.78	2.96	2.74	F = 13.10**
	-0.83	-0.82	-0.83	-0.82	-0.83	-0.85	
N							
Percent of total	6338	2475	940	1,113	696	1,114	
		39	15	18	11	18	

Table A2.5.23 Percentages in each profile of out of school activities

[166]	total	group 1 social	Group 2 All-Around	Group 3 Unstruc rec	Group 4 employed	Group 5 Study	
gender							chisq(4) = 667.71***
Female	49.2	65.8	43.3	20.1	45.1	48.8	
Race							chisq(20) = 152.73***
American Indian or Alaskan Native	0.6	0.5	0.6	1.2	0.6	0.4	

Asian and Pacific Islander	5.9	4.3	4.8	7.4	6.9	8.5	
African American	9.6	7.2	10.5	12.5	14.9	8.1	
Latino	10.3	8.5	10.0	12.2	10.8	12.0	
Multiracial	5	4.4	4.9	5.5	8.0	3.9	
White	68.6	75.1	69.1	61.3	58.8	67.1	
Socioeconomic status							chisq(12) = 100.23***
Lowest SES quartile	18.9	18.1	13.3	24.2	21.7	18.6	
Highest SES quartile	30.2	31.3	38.8	23.0	24.3	31.5	
Type of school							chisq(8) = 68.38***
Public	76	75.6	70.3	82.3	78.0	73.8	
Catholic	14.8	15.2	19.6	11.6	14.5	13.1	
Other private	9.3	9.2	10.1	6.1	7.6	13.1	

Shaded cell indicates not significantly different from any other leisure activity group

Conclusions and key messages for task 3.3.2

Summary

- **Exposure to pollution**: in general low SES groups are more exposed to air pollution but there are exceptions (i.e. there are high status neighbourhoods in central areas of some cities)
- **Occupation**: features of low SES occupations which may compromise health are likely to include control over work, physical demands. Other possibilities include exposure to chemicals, job security and occupational prestige. However physical strength required for or developed from jobs often filled by low SES people and lack of mental strain may be health promoting in some regards. Additionally low SES in poor health are less likely to work – the physical demands of low SES jobs require good physical health.
- **Physical activity**: low SES people may undertake less leisure time physical activity but they may be more physically active in other domains e.g. occupation, active travel.
- **Time activity**: very few studies appear to have considered time activity differences by SES. More studies have looked at age differences. Conclusions appear to be study specific and modified by whether the participant worked, season and weekday/weekend.
- **Study quality**: A variety of study designs were employed. In general study quality was good, particularly so for occupation in terms of design, sample size and recency. In other areas more longitudinal studies could be of interest. Some of the time activity studies were quite small.

Methodological recommendations:

- A composite SES measure may be preferable to a multitude of SES measures due to multicollinearity. The exception would be a study that aims to explore the meaning of measures in which case it would be important to recruit large numbers of unusual subjects (e.g. highly educated but low income or low education but high income).
- Furthermore it is not possible to tell from previous studies whether ethnic differences are due to SES, culture or genetics. Ethnic group differences thus need to be understood in context.
- There are many other job characteristics than exposure to chemicals which can compromise health.
- Measuring leisure time physical activity is insufficient- other types should be measured.
- Time activity studies need to take seasonal and weekly cycle differences into account.
- If an aim of a research project is took look at exposure to pollution as a mediator between SES and health it is necessary to design the study and analysis carefully in order to do so.

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