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Environmental Inequality in Austria: Sociodemographic Disparities in Perceived Environmental Quality

Felix Durstmüller

1. Introduction

In a world that is set within a paradigm of unlimited growth based on a fossil fuel economy while limited by biophysical planetary boundaries (Rockström et al. 2009), negative impacts on the environment are inevitable. Worsening environmental conditions also have a direct impact on human health and well-being. Air pollution is considered to be the single largest environmental risk to human health, causing around 400,000 premature deaths per year in Europe (EEA 2020). That is followed by noise disturbance, which can lead to severe impacts on mental and physical health and is attributed to more than 12,000 premature deaths annually in the EU (EEA 2020). Since the turn of the millennium, extreme weather events like climate change related heatwaves have also gained increasing attention and pose a significant risk to human health. During the 2003 heatwave in Europe, the excess mortality due to heat stress surpassed 70,000 cases (Laurent 2011) and under current global warming scenarios, the European Environment Agency expects an additional 130,000 deaths per year in Europe (EEA 2020).

Nevertheless, environmental pressures are hardly distributed equally across all members of society. Some are more affected, others less and some have a higher capability to adapt to adverse environmental impacts, whereas others have fewer or no means to adapt. Often it is the case that those who are economically worse off are also those who are disproportionately affected by environmental pressures. This represents a condition named environmental inequality, an issue that has been increasingly discussed since it was brought to public attention by the environmental justice movement in the 1980s. Environmental justice also describes an analytical framework for studying conditions of environmental inequality, and in the last several decades, hundreds of studies have proven the existence of various dimensions of environmental inequality (Laurent 2011; De Schutter et al. 2017). Even in Austria, a generally fortunate country in terms of its high overall level of environmental quality (Wendling et al. 2020), the existence of environmental inequality in regard to air pollution (Miklin 2019; Brenner 2019), noise pollution (Siedl 2016), siting of industrial polluters (Glatter-Götz et al. 2019; Neier 2021) and access to green space (Wimmer 2020; Neier 2020) has been proven.

However, objectively measured environmental inequality (e.g. based on pollution data) is only one part of the bigger picture. Though Ulrich Beck (1992) argued that the new (environmental) risks of our modern society cannot be observed by the human senses, this only holds for negative environmental impacts like greenhouse gas emissions or toxicity of drinking water, whereas environmental burdens like (traffic-related) air and noise pollution as well as negative health impacts due to climate change-related heat stress can, in fact, be directly perceived by affected individuals. In order to fully understand the mechanisms behind environmental inequality and to be able to design policies based on the actual needs of affected groups, it is necessary to also investigate the patterns of perceived environmental quality and exposure to adverse environmental conditions and how they constitute subjective environmental inequality.

Following the call by De Schutter et al. (2017, p.52) for more research on subjective perception of environmental burden in Austria, the study at hand aims to elucidate the sociodemographic disparities in perceived environmental quality and to compare them to results from other environmental inequality studies in Austria. Furthermore, the goal is to highlight configurations of double burden (e.g. being socially deprived and also exposed to higher levels of exposure to adverse environmental effects) in order to derive policy recommendations for ensuring a fair and equal distribution of environmental burdens in Austria following the normative claim of environmental justice (Walker 2012; Schlosberg 2007). The underlying guiding questions of this research are:

- How are environmental quality, air pollution, noise disturbance and heat stress perceived by different socioeconomic groups in Austria?
- Are these results in line with findings from Austrian studies based on objective environmental data?
- What can be done to integrate concerns of environmental justice into Austrian policymaking?

Conceptually and methodologically building upon the work by Baud and Wegscheider-Pichler (2019), who conducted the first and only analysis of subjectively perceived environmental inequality in Austria, the study at hand extends its work and contributes to the existing literature in a threefold way:

First, it uses the latest data available from the Austrian Microcensus 2019. Second, it adds the social dimensions of gender and migration background as well as the environmental dimension of climate change related heat stress. Third, it puts subjectively perceived environmental quality into perspective with objectively measured environmental inequality and aims to derive tangible suggestions for policymakers.

The remainder of this study is organised as follows. Section 2 provides an overview of the history as well as the theoretical conception of environmental justice and reviews empirical studies on environmental inequality in Austria. Section 3 describes the data used for the assessment and Section 4 introduces the methodology applied. Section 5 presents and discusses the results with a focus on configurations of double burden and contrasts them with empirical results of previous studies on environmental inequality in Austria. Section 6 discusses limitations of the study and Section 7 concludes, derives policy recommendations, and provides ideas for further research.

2. Literature Review

2.1 Environmental Justice & Environmental Inequality

In a very broad and general conception, the term environmental justice (EJ) – as part of a sustainable development paradigm – is concerned with intertwining environmental issues and social difference (Mitchell 2019; Walker 2012). The term refers to 1) a social movement with the goal to highlight and address environmental injustices and 2) an analytical concept for assessing environmental inequalities, which also serves as the underlying theoretical framework for the study at hand. Therefore, this chapter will briefly trace the emergence of the environmental justice movement, define the terms environmental justice and environmental inequality, and discuss how the concept can be applied to analyse the linkage between the living environment and the socioeconomic status of individuals.

Though the concept of environmental justice dates back to considerations in the work of Freeman (1972), the grass-root activism for racial equality in the US in the 1980s is commonly considered the origin of environmental justice. Protests against a toxic waste landfill situated in a predominately African American neighbourhood in Warren County, North Carolina, in 1982 are widely perceived as the defining episode of the EJ movement (Laurent 2011; Mohai et al. 2009). The spread of the protest movement across the country in the following years, the first empirical studies, and the landmark publication "Dumping in Dixie" by Robert D. Bullard (1990) brought the EJ debate to broader attention. This also led to the recognition of the issue by the US government, which resulted in the establishment of the US EPA Office for Environmental Justice in 1992 and Bill Clinton's executive order 12898 on environmental justice in 1994, which requires all federal agencies to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations" (US Executive Order, No. 12898, 1992). The US Environmental Protection Agency (EPA) was also the first to offer a comprehensive definition of environmental justice, which is:

> "(...) the fair treatment and meaningful involvement of all people regardless of race, colour, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. This goal will be achieved when everyone enjoys: the same degree of protection from environmental and health hazards, and equal access to the decision-making process to have a healthy environment in which to live, learn, and work" (EPA 2021).

Whereas in the US, environmental justice was well established as both a field of academic research and as a political agenda, it was not until the early 2000s that the environmental justice debate started to spill over to other parts of the world and to gain attention in Europe (Laurent 2011; Mitchell 2019). The institutional foothold of EJ in Europe can be found in the United Nations Economic Commission for Europe Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (commonly known as Aarhus Convention), with its objective "to contribute to the protection of the right of every person of present and future generations to live in an environment adequate to his or her health and well-being" by guaranteeing everybody "the rights of access to information, public participation in decision-making, and access to justice in environmental matters" (UNECE 1998, p. 3). Propelled by the Aarhus Convention, academia in Europe commenced its own empirical research, and policymakers started to integrate environmental justice concerns into social policy with England and Scotland as trailblazers (Laurent 2011). Consequently, it was the UK Environment Agency defining three core dimensions of Environmental Justice:

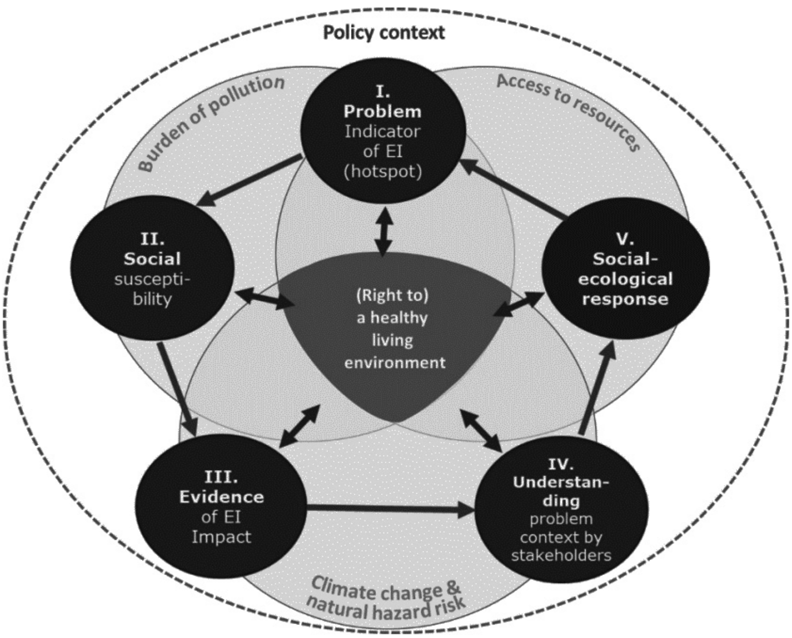
- "Distributive justice is concerned with how environmental 'goods' (e.g. access to green space) and environmental 'bads' (e.g. pollution and risk) are distributed among different groups and the fairness or equity of this distribution
- Procedural justice is concerned with the fairness or equity of access to environmental decision-making processes and to rights and recourse in environmental law
- Policy justice is concerned with the principles and outcomes of environmental policy decisions and how these affect different social groups"

(Environment Agency 2007, p.8)

Especially the first two dimensions can be found in almost all definitions of EJ and are also mentioned in the definition by the EPA (2021) above: "fair treatment" refers to distributive justice and "meaningful involvement" to procedural justice. Though the conception of environmental justice in the US and in Europe is very similar, the EJ discourse in Europe distinguishes itself from the US approach by focusing rather on social deprivation as the reason for and social policy as the measure against environmental inequality, whereas in the US aspects of ethnic and racial discrimination, which shall be addressed by legal measures, have dominated the discourse (Laurent 2011; Walker 2012). Nonetheless, environmental inequality based on ethnic backgrounds does also exist in Europe (De Schutter et al. (2017) and Neier (2021), Glatter-Götz et al. (2019), and Brenner (2019) have proven its existence in Austria (see Section 2.2)).

Another distinction worth mentioning is the one between environmental inequality (EI) and environmental justice (EJ). Environmental inequality refers to how things *are*, whereas environmental justice refers to how things *ought to be*. Therefore, environmental justice can be regarded as a *normative and prescriptive* theoretical framework for analysing and challenging inequalities. In contrast, environmental inequality is a *descriptive* concept that objectively analyses conditions of uneven distribution of negative and positive environmental impacts based on measurable data (Walker 2012; De Schutter et al. 2017). Thus, environmental inequality can be regarded as an element of environmental justice, referring to its distributional dimension, which is also the analytical scope of the study at hand.

Figure 1: Environmental Justice Framework (De Schutter et al. 2017, p.7)



However, an unequal distribution is not necessarily always and everywhere unfair or unjust (Walker 2012). Whether something is unjust depends, first of all, on the underlying concept of justice (Schlosberg 2004; Schlosberg 2007), but it is also argued that environmental injustice constitutes itself as a function of the level of exposure to an environmental hazard, the vulnerability or social susceptibility of the affected individuals, and the impact it has on them (De Schutter et al. 2017; EEA 2018). De Schutter et al. (2017) offer a framework for analysing environmental justice issues (see Figure 1) that incorporates the three constitutive factors of environmental injustice and extends it to the sphere of addressing them in the context of policymaking. It suggests five iterative steps: 1) problem identification (determining disproportionate exposure to burdens of pollution, climate change related risks or unequal access to resources), 2) analysis of social susceptibility (identifying socioeconomic deprivation as an explanatory factor), 3) evidence of impact, 4) understanding the problem and 5) developing a socioecological response on a policy level. This framework can also be used for analysing subjectively perceived environmental inequality (De Schutter et al. 2017) and thus, will be applied in this study. Steps 1–3 represent the quantitative analysis, step 4 the comparison with studies based on objective EI and step 5 the formulation of policy recommendations.

2.2 Environmental Inequality in Austria

The literature assessing environmental inequality is manifold, and hundreds of studies on the micro, meso, and macro levels have been conducted all around the globe. However, a comprehensive literature review of international studies would go beyond the scope of this study. Only studies scrutinising environmental inequality in Austria are reviewed (for overviews and meta-analyses of international environmental justice studies, see e.g. Rinquist (2005), Walker (2012), De Schutter et al. (2017), Holifield (2018), and Pasetto et al. (2019)).

In the Austrian context, mentions of environmental inequality (regarding both distribution of adverse environmental effects and distribution of environmentally harmful behaviour), theoretical considerations of environmental justice and qualitative analyses can be found in various publications (Prettenthaler et al. 2008; APCC 2014; Lanegger 2015; Wiesböck et al. 2016; De Schutter et al. 2017; Baum 2020; Miklin and Schneider 2020) and the issue has also found first considerations by the authorities (BMNT 2017). However, the body of detailed empirical analyses in the Austrian context is relatively thin and reveals that environmental inequality is a very recent field of research as almost all publications have been published within the last five years, many of them being master theses. Table 1 provides an overview of empirical studies on environmental inequality in Austria, and the most important findings will be discussed subsequently.

Table 1: Overview of Environmental Inequality Studies for Austria

	environmental factor (dependent variable)	income (socio-economic status)	education	migration background	unemployed
Siedl (2016)	noise (traffic)	0			
Baud and Wegscheider-Pichler (2019)	perceived environmental quality, air pollution, noise	–			
Brenner (2019)	air pollution (particulate matter, NO_2)	~	~	+	
Miklin (2019)	air pollution (particulate matter)			+	+
Glatter-Götz et al. (2019)	air pollution (vicinity to industrial polluters)		–	+	+
Neier (2020)	access to greenspace			–	
Wimmer (2020)	access to greenspace			–	
Neier (2021)	air pollution (vicinity to industrial polluters)	~		+	

+ positively correlating; – negatively correlating; ~ mixed results; 0 not correlating; (blank) not tested for

Using a distance-based approach based on the data of European Pollutant Release and Transfer Register (E-PRTR), Glatter-Götz et al. (2019) conducted a nationwide analysis of environmental inequality related to the proximity to industrial facilities in Austria. While they could not identify any significant linkages between living in the vicinity of an industrial polluter and sociodemographic characteristics for the state of Vienna, the results for the rest of Austria provided evidence for the existence of environmental inequality in Austria. They found that those living in neighbourhoods within 1km of industrial facilities included a higher share of residents with migration backgrounds, lower levels of education, or those who were more likely to be unemployed (in this study, unemployment was used as a proxy for socioeconomic status/income).

Following a similar approach, also based on data from the E-PRTR, Neier (2021) confirmed that higher levels of industrial air pollution correlated with a higher share of people with migration backgrounds in the area. According to his results, this especially holds true for urban areas (except Vienna). Findings of income were contradictory and not in line with results from the previous study mentioned. It was only in cities, that lower income was associated with higher levels of industrial air pollution (suggesting high levels of segregation in urban areas), whereas in rural areas, even a positive correlation between income and exposure to industrial air pollution was identified, which may come as a surprise to some.

Brenner (2019) investigated environmental inequality in the Austrian state of Styria based on air pollution data (concentration of particulate matter (PM10) and nitrogen oxide (NO_2)). Regarding income, the findings confirmed the results by Neier (2021) that in urban areas, income and air pollution were negatively correlated, whereas, in rural areas, there was a weak positive correlation. Looking at the role of education level, the results were contradictory and did not reveal a clear link between overall air pollution and the highest level of educational attainment. Levels of exposure to NO2 are the highest for more highly educated people, and levels of exposure to PM10 are the highest for people with lower levels of education. This might be explained by the fact that due to its geographical location, the Styrian capital of Graz has a disproportionately high concentration of particulate matter, and at the same time, many inhabitants have a high degree of education, as Graz is the second most important university city in Austria. Regarding migration background, Brenner's work is in line with the other publications and found strong evidence for environmental inequality based on country of origin. Austrian-born Styrian residents were the least exposed to critical levels of air pollution, whereas residents born in a foreign country had a higher chance of being exposed to harmful levels of air pollution.

Miklin (2019) performed a nationwide analysis of sociodemographic disparities in exposure to air pollution. Following a risk-based approach, the spatial dispersion of particulate matter (PM10, PM2.5) was associated with the geographical distribution of income, unemployment and foreign nationals. Her results also revealed the existence of environmental inequality in Austria and suggested that especially non-nationals and the unemployed are affected by the harmful effects of particulate matter. A nonlinear relationship between income and exposure to particulate matter was discovered: air pollution tended to rise with increasing income up to a reversing point of approximately 40,000 euros of annual income. A further increase in income was then associated with declining levels of air pollution by particulate matter. No link could be found between the share of low-skilled workers in a certain area and the concentration of particulate matter.

The only work in regard to noise pollution in the Austrian context is provided by Siedl (2016), who analysed the relationship between road traffic noise and socioeconomic status in Austria's capital of Vienna. The study introduced a neighbourhood socioeconomic position index, which combines age, sex, occupational status, level of education, ethnicity, housing conditions, and possible lone parenthood in a single composite index. However, the results did not reveal an overall significant correlation between noise levels and socioeconomic status. Only for certain registration districts (sublevels of districts) of Vienna, a double burden/blessing situation could be identified.

However, in contrast to analysing the inequality of the distribution of environmental bads, also the unequal distribution of environmental goods presents a vital dimension. Accordingly, Neier (2020), as well as Wimmer (2020), have scrutinised the access to green space and proximity to urban vegetation in Vienna. Using a segregation-based approach and utilising remote sensing data about the spatial distribution of vegetation in Vienna provided by the Sentinel-2 satellite, Neier (2020) found robust evidence that "foreigners are more environmentally segregated from urban vegetation than non-foreigners" (p.18). This especially holds true for the Viennese districts of Favoriten, Simmering, and Floridsdorf. These districts are characterised by a high share of foreign-born residents and very little green space. The results were confirmed by Wimmer (2020) using a similar methodological approach.

The common characteristic of all studies mentioned so far is that the dependent environmental variable is of objective nature, e.g. air pollution measured as the concentration of a substance per volume or the existence of an industrial facility. A publication by Baud and Wegscheider-Pichler (2019) is the only Austrian study elucidating the subjective exposure to environmental harms, e.g. the perceived disturbance of individuals by air pollution. Using survey data from the Austrian Microcensus 2015, which included an additional module about environmental conditions and environmental behaviour, they investigated the link between income and various perceived environmental burdens. It was revealed that lower-income households rated the overall environmental quality lower and reported a higher burden of air pollution and disturbance by noise. The work by Baud and Wegscheider-Pichler (2019) serves as the basis for this study in regard to the conceptional and methodological approach. However, the work at hand uses a more recent dataset (Microcensus 2019) and extends the analysis to other sociodemographic variables (migration background and gender) and the environmental dimension of heat exposure.

3. Data

The study was carried out using data from the *Austrian Microcensus 2019* (MC) survey, which was provided by *Statistics Austria*, Austria's federal statistical office. The MC is a cross-sectional survey of the Austrian population and with more than 20,000 households surveyed per quarter, it is the largest regularly conducted sample survey in Austria. It focuses on employment and unemployment as well as housing stock and housing conditions and therefore also constitutes the official Labour Force Survey and Housing Survey of Austria as required by official regulations. Participating households are selected at random from the central register of residents and all members (aged 15 or above) of a sampled household are obliged to take part in the survey. Each household is interviewed every 3 months, five times in a row. The interviews are conducted by CAPI (Computer Assisted Personal Interview) for the first interview, and CATI (Computer Assisted Telephone Interview) techniques for the following interviews. The sample of the MC is almost equally stratified along the 9 states of Austria (except Vienna has a larger sample size and Burgenland has a smaller sample size). The data is extrapolated to the total population of Austria by calibrated survey weights. Therefore, the results are representative for the overall population of Austria (for further information on the Austrian MC, see Statistik Austria (2021)).

Each year, the MC is accompanied by an additional module focusing on a special area of interest. In 2019, this additional part dealt with questions of environmental conditions and environmental behaviour (hereinafter called *environmental module*) (Statistik Austria 2020). In contrast to the main part of the MC, the participation in the environmental module was voluntary and therefore it encompassed a lower sample size of 7,021 individuals (not households), which constitutes the data base for this study. Thanks to additional sampling weights provided for this subset, the sample represents a total population of 7,371,330 individuals above 15 years of age in Austria.

Table 2 summarises the distribution of the sociodemographic characteristics of the study population. The characteristics used for analysis encompass *age, gender, level of education, occupational status, type of job, migration background, degree of urbanisation, type of family, housing conditions* and *monthly net income from employment*. The age of respondents is included as a continuous variable in analysis, but for demonstrative purposes, is given in descriptive tables in age groups. With regard to gender, it is only distinguished between *women* and *men* as the survey did not allow for any other response category. The highest level of educational achievement is classified into *tertiary, post-secondary (non-tertiary), upper secondary, lower secondary* and *primary* education along the lines of the International Standard Classification of Education (ISCED 2011) (UNESCO 2012). Concerning occupational status, it is distinguished between *working, unemployed* and *retired* people as well as *students, housewives and househusbands*, and *other* (combining persons in parental leave, military/civil service, permanently unable to work, and those, who responded with “other”). With regard to the level of the job, the categories *self-employed, upper, upper middle, middle, lower middle* and *lower* are applied. Migration background is defined as whether both parents were born in a foreign country, independently of the respondent’s place of birth. Following this definition, 20 percent of the study population exhibited a migration background. The degree of urbanisation applies the definition by Eurostat

Table 2: Sociodemographic Characteristics of the Study Population

	Percentage (%)
Age	
<25	11.4
25–34	16.1
35–44	15.8
45–54	18.1
55–64	16.7
>64	21.9
Gender	
male	48.8
female	51.2
Education	
tertiary	21.8
post-secondary (non tertiary)	20.2
upper secondary	12.9
lower secondary	32.2
primary	12.9
Occupational Status	
working	55.6
unemployed	3.2
retired	27.1
student	7.5
housewife/-husband	3.0
other (not working)	3.5
Type of Job	
self-employed	7.6
upper	9.2
upper middle	8.9
middle	17.4
lower middle	7.8
lower	10.1
not working	39.0

	Percentage (%)
Migration Background	
no	80.0
yes	20.0
Urbanisation	
thinly populated	38.1
intermediate	29.9
densely populated	32.0
Type of Family	
couple w/o children	27.8
couple w/ children	39.5
singles	20.2
single parents	7.3
other	5.3
Flats	
1 or 2	54.1
3 or more	45.9
Category of Flat	
cat. A	96.4
cat. B or below	3.6
*Income**	
M	2,391.0 € [± 980]
Mdn.	2,204.5 € [IQR 1,525.1; 3,001.1]
Total Population (*N*)	7,371,330 (**N* = 3,812,998)
Sample Size (*n*)	7,021 (**n* = 3,749)

(2021) and distinguishes between *densely* populated areas (cities), *intermediate* density areas (towns and suburbs), and *thinly* populated areas (rural areas). The type of family contains the following categories: *couples with children, couples without children, singles, single parents*, and *other*.

Housing conditions are conceptualised by two variables: first, the number of flats in the building (distinguishing between a *1 or 2 family home* and a multi-storey building containing *3 or more flats*) and second, whether the flat or house conforms to *category A* of housing or exhibits characteristics of *category B or below.* The main distinguishing feature between category A and the lower categories is whether the flat has a common heating and water heating system. Further, to be classified as category A, the flat has to comprise at least 30 m^2 of living space. Income data from wage tax registers is only available for employees. This reduces the sample size for the regression analysis to a subset of 3,749 observations, excluding persons, who are not working or are self-employed. This represents one of the major limitations of this study (further information on this shortcoming can be found in Section 6 and a (discarded) attempt to overcome this limitation by adding income data from the EU-SILC dataset is presented in Online

Appendix B.1). The monthly net income from employment exhibits a mean of 2,391 euros and a median of 2,205 euros. To allow for easier interpretation of results, in the regression models, income is modelled in hundreds of euros.

The perceived environmental conditions have been surveyed by two sets of four questions each (see Appendix A.1 for the verbatim of the questions used). In the first set of questions, the respondents were asked to rate the overall environmental conditions for four aspects (overall environmental quality, air quality, noise situation, and quantity and quality of green space) as either *good* or *bad*. Thus, the answers were included as dichotomous categorical variables in the analysis. The second set of questions evaluated the perceived personal exposure to four kinds of adverse environmental impacts: odour and fumes, dust and soot, noise, and extreme heat. Questions about personal exposure to noise, odour or fumes and heat stress were asked separately for daytime and nighttime and were answered on a Likert scale (1-5). To gain variables for the overall personal exposure to each of these conditions, the score for daytime and nighttime annoyance was added and then subsequently broken down into the three categories *low* (total score ≤ 4), *medium* (5–7) and *high* (≥ 8) exposure. Disturbance by dust and soot was assessed separately for winter and summer and the survey distinguished between general disturbance and disturbance in living quarters. For the sake of comparability, the responses were also operationalised as a single three-level index of *low, medium* and *high* exposure.

4. Methods

Statistical analysis was performed in R (R Core Team 2021) using the *survey* package (Lumley 2020) to account for complex sample survey design and to incorporate the sampling weights. Basic relationships between perceived environmental exposure and sociodemographic characteristics are displayed in crosstabulations and main findings are visualized in bar graphs using the *stargazer* and *ggplot2* packages (Hlavac 2022; Wickham 2016). For further analysis, multivariate logistic regression models were applied, which – however – were limited to the subset of 3,749 of employed persons due to the above-mentioned lack of income data for other groups. The logistic regression approach was chosen to account for the categorical character of the response variables (Hosmer et al. 2013). Unlike linear regression models that predict a numerical value of the dependent variable by the OLS method, logistic regression predicts the probability of the outcome variable to be a certain value by maximum likelihood estimation. Logistic regression represents a form of a generalised linear model that uses a logistic link function and can be stated as:

$$P(Y=1)=\frac{1}{1+e^{-z}}$$

with *P* being the probability that the independent variable *Y* takes the value 1, and *z* being a linear regression model of the explanatory variables in the form of:

$$z=\beta_0+\beta_1 * x_1+\beta_2 * x_2+\ldots$$

In order to ascertain the odds of the outcome variable taking a certain value, the probability of the variable taking this value is divided by the probability of it not taking this value, which leads to the so-called logit-transformation:

$$\log it = odds_{\log} = \log\left[\frac{P(Y=1)}{1-P(Y=1)}\right]=\alpha+\beta_1 * x_1+\beta_2 * x_2+\ldots$$

For the purpose of more intuitive interpretation, results of logistic regression models are usually presented as odds ratios (OR) accompanied by a confidence interval. Odds ratios can be retrieved by exponentiating the regression coefficients. For categorical predictors, the OR is the odds of a certain outcome of the explanatory variable in comparison to the reference category of the predictor. For continuous predictors, OR can be interpreted as the increase/decrease of odds of a certain outcome of the explanatory variables for a one unit increase in the predictor.

In the study at hand, all sociodemographic variables were tested in bivariate analysis (see Online Appendix B.2) and those which proved to be significant for at least two of the dependent environmental variables were included in the full models. As the survey questions on overall environmental quality, air quality, noise situation and quality and quantity of green space were answered in the dichotomous categories of good and bad, binomial (or binary) logistic regression was applied. To exemplify, the model for the assessment of overall environmental quality (EQ) can be stated as:

$$\log\left[\frac{P(EQ=bad)}{1-P(EQ=bad)}\right]=\alpha+\beta_1(age)+\beta_2(gender_{female})+\beta_3(education)+$$
$$\beta_4(income)+\beta_5(jobtype)+\beta_6(migration_{yes})+\beta_7(urbanisation)+$$
$$\beta_8(family_{couple\ w/o\ children})+\beta_9(family_{singles})+\beta_{10}(family_{single\ parent})+$$
$$\beta_{11}(family_{other})+\beta_{12}(flats_{2\ or\ more})+\beta_{13}(flatCategory_{B\ or\ below})$$

It can be seen that for independent categorical variables, coefficients for each category except the reference category were calculated. The models for the overall assessment of air quality, noise situation and quality and quantity of green space are conceptualised in the same form. The goodness of fit of the binomial logistic regressions models was assessed by calculating Nagelkerke's Pseudo R^2 (Nagelkerke 1991) and running the Hosmer-Lemenshow test (Hosmer et al. 2013). The values of Nagelkerke's

Pseudo R^2 suggest a rather low explanation of variance, but all models pass the Hosmer-Lemenshow test ($p \geq 0.05$) and can therefore be considered as valid models for analysing the dependent variables.

The personal exposure to odour/fumes, dust/soot, noise and heat is measured in three categories *(low, medium, high),* which exhibit a natural order. Therefore, ordinal logistic regression based on the proportional odds model was applied (Hosmer et al. 2013; UCLA 2021). The underlying assumption of this model is that the relationship between each pair of outcome groups is the same. This so-called proportional odds assumption needs to be tested before applying ordinal logistic regression, but, if fulfilled, allows for a single set of coefficients for all cutpoints, which serves the easier interpretation of the results. In these models, the proportional odds assumption was tested by applying the Brant-test (Brant 1990) as implemented in R by the *brant* package (Schlegel and Steenbergen 2020). The assumption could be verified for all models ($p \geq 0.05$). The model for perceived exposure to odour and fumes (OF) can be stated by the following two equations (values 1, 2, 3 corresponding to *low, medium, high* exposure):

$$\log\left[\frac{P(OF \geq 1)}{1-P(OF \geq 1)}\right] = \alpha + \beta_1(age) + \beta_2(gender_{female}) + \beta_3(education) + \\ \beta_4(income) + \beta_5(jobtype) + \beta_6(migration_{yes}) + \beta_7(urbanisation) + \\ \beta_8(family_{couple\ w/o\ children}) + \beta_9(family_{singles}) + \beta_{10}(family_{single\ parent}) + \\ \beta_{11}(family_{other}) + \beta_{12}(flats_{2\ or\ more}) + \beta_{13}(flatCategory_{B\ or\ below})$$

$$\log\left[\frac{P(OF \geq 2)}{1-P(OF \geq 2)}\right] = \alpha + \beta_1(age) + \beta_2(gender_{female}) + \beta_3(education) + \\ \beta_4(income) + \beta_5(jobtype) + \beta_6(migration_{yes}) + \beta_7(urbanisation) + \\ \beta_8(family_{couple\ w/o\ children}) + \beta_9(family_{singles}) + \beta_{10}(family_{single\ parent}) + \\ \beta_{11}(family_{other}) + \beta_{12}(flats_{2\ or\ more}) + \beta_{13}(flatCategory_{B\ or\ below})$$

A single set of coefficients ($\beta_1 \ldots \beta_{13}$) is then derived from the two equations. Models for the perceived exposure to dust/soot, noise and heat were conceptualised in the same form. In the following sections results for all models are presented as odds ratios accompanied by a 95% confidence interval.

7. Results

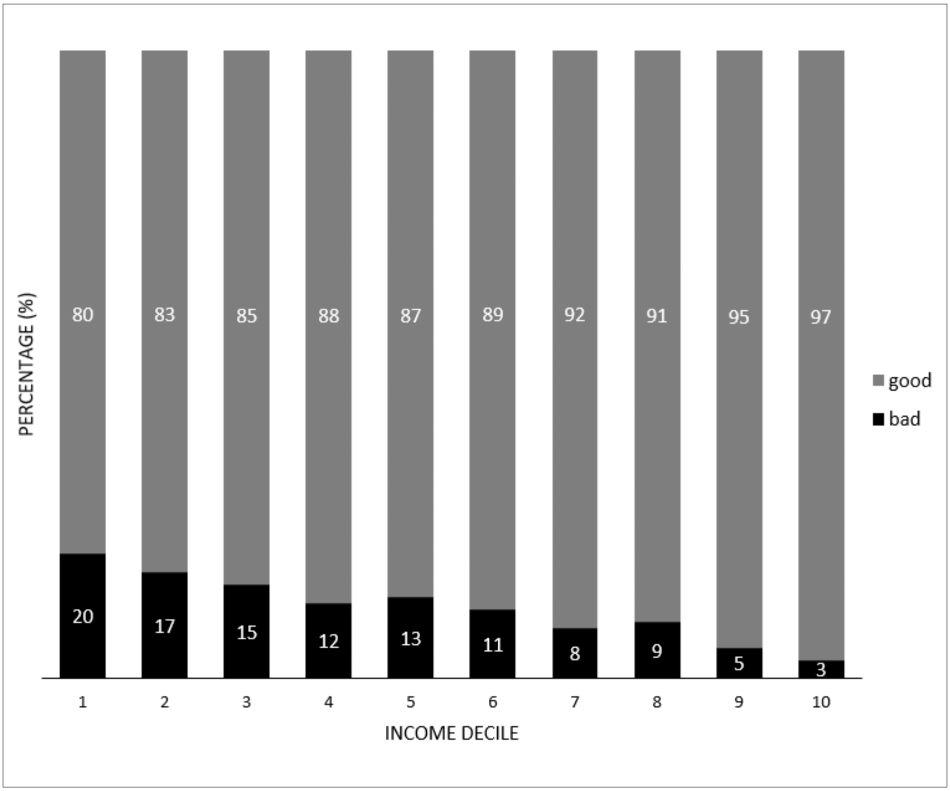
Based on survey data from 7,021 respondents on their assessment of environmental quality and their personal exposure to air pollution, noise disturbance and heat stress, the relationship between sociodemographic characteristics, and perceived adverse environmental conditions was analysed nation-wide. In addition, separate analysis was conducted for Austria's capital of Vienna, as other studies suggested significant differences between environmental inequality in Vienna and the rest of Austria. Results of the separate analysis for Vienna are presented if they significantly differ from the results of the nation-wide model.

Table 3 provides an overview of the evaluation of certain aspects of overall environmental quality and Table 4 shows the level of exposure to air pollution (odour/fumes and dust/soot), noise disturbance and heat stress. Tables 5 and 6 present the results from the multivariate logistic regression models.

7.1 Overall Environmental Quality

The assessment of the overall environmental quality exhibits a strong association with typical socioeconomic indicators. Whereas only 3 percent of people in the highest income decile rated overall environmental quality as *bad*, this number increases to 20 percent in the lowest income decile (see Figure 2).

Figure 2: Rating of Overall Environmental Quality by Income Decile



Additionally, Table 3 shows that lower levels of education and being female related to a worse rating of environmental quality. Further, differences in regard to occupational status have been discovered. Whereas only around 10 percent of people in employment and students evaluated overall environmental quality as *bad*, the percentage is higher among the unemployed (12.5%), housewives/-husbands (15.7%) and retirees (17.3%). No obvious differences in the rating of overall environmental quality could be observed with regard to the type of family, housing conditions, type of job or the age of those surveyed.

Interestingly, and contradictory to findings from most other studies, which suggest that people with migration backgrounds face worse environmental conditions (Glatter-Götz et al. 2019; Neier 2021; Brenner 2019; Miklin 2019), Table 3 shows that 91.6 percent of people with migration backgrounds rated overall environmental quality as *good*, whereas only 86.0 percent of people without migration backgrounds did. Considering the very high general environmental quality in Austria (Wendling et al. 2020), one might hypothesise that people with migration backgrounds may have an underlying perception bias, comparing the environmental quality in Austria to the environmental quality in their countries of origin, which leads to this assessment.

The evaluation of the perceived quality and quantity of green space reveals fewer differences among sociodemographic groups. Comparable to the findings for overall environmental quality, more women and lower-educated people rated the quality and quantity of green space as *bad*. Further, Table 3 also reveals a gradient in regard to age. Only 5.7 percent of respondents under the age of 25 evaluated the quantity and quality of green space as *bad*, whereas the percentage almost doubled for people aged above 64. Additionally, the degree of urbanisation and housing conditions influenced the assessment of the quality and quantity of green space.

While only about 6.5 percent of people living in thinly or intermediately populated areas perceived the quantity and quality of green space as bad, 11.0 percent of respondents in urban areas gave this rating. Of the people living in category A flats, only 7.7 percent perceived the quality and quantity of green space to be unsatisfactory, whereas 14.0 percent of individuals living in flats of category B or below did.

The influence of age and housing conditions on the assessment of the quality and quantity of green space cannot be confirmed by the logistic regression model (Table 5). Statistically significant influencing factors in the evaluation of green space are: the highest educational achievement, gender, and the degree of urbanisation. Considering that Neier (2020) and Wimmer (2020) found that especially people with migration backgrounds were suspected to be segregated from green space, one may expect a reflection of this finding in the self-report assessment of quality and quantity

Table 3: Percentage of People Rating Certain Aspects of Environmental Quality as *Bad* in Relation to Sociodemographic Characteristics

	% bad			
	Environmental Quality	Air Quality	Noise	Greenspace
Age				
<25	13.9	12.1	23.3	5.7
25–34	9.4	11.8	26.2	7.3
35–44	10.3	10.0	26.1	6.9
45–54	10.4	12.7	25.7	7.6
55–64	12.6	13.6	28.7	8.6
>64	18.2	16.1	31.1	10.2
Gender				
male	9.5	10.2	25.6	6.5
female	16.4	15.4	28.6	9.6
Education				
tertiary	5.8	12.0	27.2	6.7
post-secondary (non tertiary)	7.5	12.4	26.2	5.2
upper secondary	12.9	12.7	25.3	8.8
lower secondary	16.6	13.2	28.6	8.8
primary	22.5	15.0	27.6	11.1
*Income**				
highest decile	2.6	8.8	23.3	4.1
lowest decile	19.8	15.2	25.6	7.1
Occupational Status				
working	10.5	11.3	25.2	7.2
unemployed	12.5	17.9	37.5	9.6
retired	17.3	15.2	29.9	10.4
student	10.1	14.7	28.9	4.0
housewife/-husband	15.7	18.1	26.5	8.4
other (not working)	15.1	8.7	27.1	7.7
Type of Job				
self-employed	8.3	11.8	24.2	6.8
upper	3.9	9.0	25.8	5.4
upper middle	6.9	10.8	26.0	6.6
middle	11.2	13.7	24.9	7.1
lower middle	14.8	6.8	25.4	8.7
lower	16.9	13.3	24.8	7.6
not working	16.1	15.5	30.6	9.4
Migration Background				
no	14.0	13.2	26.8	8.4
yes	8.4	13.0	31.5	7.0
Urbanisation				
thinly populated	13.4	8.3	21.1	6.6
intermediate	11.9	11.8	26.5	6.3
densely populated	12.6	19.6	35.3	11.0
Type of Family				
couple w/o children	13.3	13.2	28.7	8.1
couple w/ children	10.0	10.0	23.4	6.4
singles	16.0	17.7	32.4	10.7
single parents	16.1	16.9	28.2	8.1
other	12.6	10.0	28.2	7.9
Flats				
1 or 2	12.1	8.8	22.3	6.5
3 or more	13.4	17.9	33.1	9.6
Category of Flat				
cat. A	12.6	12.8	27.1	7.7
cat. B or below	14.0	13.8	13.8	14.0

n = 7,021 / * *n* = 3,749

Table 4: Percentage of Low/Medium/High Exposure to Various Environmental Burdens in Relation to Sociodemographic Characteristics

	Odour/Fumes			Dust/Soot			Noise			Heat		
	% l	% m	% h	% l	% m	% h	% l	% m	% h	% l	% m	% h
Age												
<25	94.0	4.5	1.4	89.6	5.1	5.3	75.3	16.1	8.6	31.1	42.9	26.0
25–34	94.9	3.6	1.5	86.8	4.5	8.8	78.8	13.4	7.9	31.9	37.0	31.1
35–44	96.4	2.6	1.1	87.8	5.8	6.4	79.1	13.5	7.3	37.2	31.3	31.5
45–54	94.7	3.2	2.1	84.0	6.7	9.3	79.9	11.5	8.6	34.1	36.0	29.9
55–64	92.8	4.6	2.6	82.5	6.7	10.8	82.1	10.6	7.3	34.9	33.0	32.1
>64	94.4	3.7	1.8	85.5	6.8	7.7	82.7	11.2	6.1	42.0	31.3	26.6
Gender												
male	95.4	3.1	1.4	86.7	5.7	7.6	81.5	11.6	6.9	38.2	35.0	26.8
female	93.7	4.2	2.1	84.9	6.3	8.8	78.7	13.2	8.1	33.4	34.4	32.2
Education												
tertiary	95.6	3.1	1.3	84.0	6.6	9.3	75.2	16.8	8.0	38.5	32.7	28.8
post-secondary (non tertiary)	94.1	4.0	1.9	83.7	6.1	10.2	77.4	14.1	8.5	36.1	35.4	28.5
upper secondary	94.2	4.0	1.8	86.9	5.0	8.1	83.3	9.5	7.2	30.8	35.3	33.9
lower secondary	94.6	3.5	1.9	87.2	5.6	7.2	82.2	10.2	7.6	36.9	35.1	28.0
primary	93.8	4.0	2.2	87.3	6.8	5.9	83.7	11.0	5.3	33.0	35.1	32.0
*Income**												
highest decile	97.5	2.2	0.2	89.0	4.8	6.2	82.2	12.0	5.9	40.0	32.8	27.3
lowest decile	93.4	5.1	1.5	83.2	6.9	9.9	78.0	12.4	9.6	34.4	41.5	24.1
Occupational Status												
working	95.6	3.0	1.3	86.7	5.3	8.0	80.4	11.8	7.8	34.4	35.9	29.7
unemployed	89.0	8.8	2.3	81.9	8.2	9.9	73.9	16.5	9.7	33.1	33.5	33.5
retired	94.3	3.8	1.9	84.9	6.9	8.2	83.5	10.7	5.9	40.5	31.2	28.3
student	93.5	5.1	1.4	85.8	5.3	9.0	71.4	20.4	8.2	32.3	37.6	30.2
housewife/-husband	90.7	6.3	3.0	82.2	8.0	9.7	74.2	13.9	11.9	41.9	31.8	26.3
other (not working)	90.0	2.7	7.3	84.0	8.5	7.5	76.7	14.0	9.3	25.5	38.7	35.8
Type of Job												
self-employed	95.1	3.1	1.8	87.4	4.6	8.0	82.6	9.6	7.8	40.0	34.8	25.2
upper	95.7	2.7	1.6	84.1	5.5	10.4	79.8	13.2	7.0	37.1	34.8	28.1
upper middle	95.4	3.4	1.2	83.3	6.8	9.9	75.1	15.9	9.1	35.2	37.1	27.7
middle	95.4	2.9	1.7	87.1	5.5	7.4	78.6	13.9	7.6	31.9	37.6	30.4
lower middle	97.1	1.5	1.4	90.3	3.9	5.9	87.9	6.6	5.5	32.4	35.9	31.7
lower	93.3	5.3	1.4	85.6	5.8	8.5	79.8	11.5	8.7	31.5	35.0	33.5
not working	93.4	4.4	2.2	84.9	6.9	8.1	79.9	12.7	7.3	38.3	32.4	29.3

	Odour/Fumes			Dust/Soot			Noise			Heat		
	% l	% m	% h	% l	% m	% h	% l	% m	% h	% l	% m	% h
Migration Background												
no	95.0	3.5	1.5	87.0	5.8	7.3	80.7	12.5	6.7	36.2	34.7	29.1
yes	92.0	4.4	2.9	80.8	7.1	12.1	77.3	12.1	10.7	34.2	34.5	31.3
Urbanisation												
thinly populated	96.0	2.6	1.4	90.6	4.7	4.7	87.6	7.7	4.7	39.3	35.7	25.1
intermediate	95.3	3.4	1.3	86.8	5.6	7.6	81.6	11.5	6.9	36.4	33.4	30.2
densely populated	92.1	5.2	2.7	79.0	8.0	13.0	69.6	18.9	11.5	31.1	34.7	34.2
Type of Family												
couple w/o children	94.0	4.4	1.6	85.9	5.9	8.3	80.0	13.0	7.0	39.0	32.5	28.5
couple w/ children	95.6	2.8	1.6	88.7	4.6	6.7	81.3	11.4	7.4	35.0	37.4	27.5
singles	94.1	4.0	2.0	81.6	8.1	10.3	78.6	12.2	9.1	34.1	33.1	32.8
single parents	91.4	5.1	3.4	80.2	8.9	10.9	76.1	15.6	8.3	29.2	31.9	38.9
other	95.9	2.9	1.2	86.3	6.1	7.7	81.9	13.6	4.4	39.7	35.3	24.9
Flats												
1 or 2	95.7	3.0	1.3	89.3	4.8	5.9	85.7	9.2	5.1	38.6	34.6	26.9
3 or more	93.2	4.5	2.3	81.6	7.4	10.9	73.4	16.2	10.4	32.5	34.8	32.7
Category of Flat												
cat. A	94.6	3.6	1.8	85.8	5.9	8.3	80.8	12.4	7.6	35.8	34.8	29.4
cat. B or below	93.4	5.4	1.3	84.3	8.8	6.8	82.4	12.7	4.9	35.2	31.9	32.9

n = 7,021 / * *n* = 3,749

Table 5: Determinants of Perceived Environmental Quality (Binomial Logistic Regression).

	Environmental Quality		Air Quality		Noise Situation		Greenspace	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age	1.01	(0.99;1.02)	1.01**	(1.00;1.02)	1.01***	(1.01;1.02)	1.00	(0.99;1.02)
Gender								
male	1.00		1.00		1.00		1.00	
female	1.61***	(1.17;2.21)	1.58***	(1.15;2.17)	1.36***	(1.11;1.68)	1.45**	(1.00;2.09)
Education	0.66***	(0.57;0.75)	0.98	(0.86;1.12)	0.94	(0.86;1.03)	0.77***	(0.64;0.94)
Income	0.97***	(0.96;0.99)	0.99	(0.97;1.01)	1.00	(0.99;1.01)	0.99	(0.97;1.01)
Job Level	1.08	(0.81;1.06)	1.11	(0.77;1.05)	0.99	(0.91;1.12)	0.95	(0.87;1.29)
Migration Background								
no	1.00		1.00		1.00		1.00	
yes	0.65*	(0.40;1.05)	1.02	(0.69;1.52)	1.13	(0.85;1.50)	0.99	(0.61;1.62)
Urbanisation	1.03	(0.84;1.27)	1.51***	(1.22;1.86)	1.26***	(1.09;1.45)	1.40**	(1.07;1.83)
Type of Family								
couple w/o children	1.00		1.00		1.00		1.00	
couple w/ children	1.10	(0.79;1.55)	1.01	(0.70;1.46)	0.87	(0.68;1.11)	1.02	(0.67;1.54)
singles	1.11	(0.75;1.65)	1.26	(0.88;1.81)	1.02	(0.78;1.32)	1.00	(0.65;1.54)
single parents	1.27	(0.78;2.09)	0.96	(0.58;1.60)	0.8	(0.55;1.17)	0.94	(0.48;1.85)
other	1.14	(0.51;2.55)	0.75	(0.35;1.59)	1.00	(0.58;1.71)	0.79	(0.35;1.80)
Flats								
1 or 2	1.00		1.00		1.00		1.00	
3 or more	1.29	(0.93;1.80)	1.64***	(1.18;2.27)	1.39***	(1.09;1.77)	1.35	(0.92;1.98)
Category of Flat								
cat. A	1.00		1.00		1.00		1.00	
cat. B or below	0.88	(0.49;1.59)	1.01	(0.48;2.10)	0.89	(0.57;1.39)	1.69	(0.83;3.46)
Pseudo-R^2_{NK}	0.15		0.1		0.09		0.81	
HL-Test	x^2 = 12.7; p = 0.12		x^2 = 8.43; p = 0.39		x^2 = 12.0; p = 0.15		x^2 = 15.3; p = 0.05	
n = 3,749								

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

The odds ratio (OR) indicates the odds for the respective category of environmental quality being rated as *bad*.

Table 6: Determinants of Perceived Environmental Exposure (Ordinal Logistic Regression)

	Odour/Fumes		Dust/Soot		Noise		Heat	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age	1.02	(0.99;1.04)	1.02***	(1.01;1.03)	1.00	(0.99;1.01)	1.00	(0.99;1.01)
Gender								
male	1.00		1.00		1.00		1.00	
female	1.08	(0.69;1.69)	1.13	(0.85;1.50)	1.36**	(1.07;1.73)	1.13	(0.95;1.35)
Education	1.02	(0.84;1.25)	1.02	(0.91;1.15)	1.04	(0.94;1.15)	0.91**	(0.84;0.99)
Income	0.97***	(0.95;0.99)	0.99**	(0.97;1.00)	0.99	(0.98;1.00)	1.00	(0.99;1.01)
Job Level	0.96	(0.75;1.22)	0.94	(0.82;1.08)	0.98	(0.87;1.11)	1.04	(0.96;1.12)
Migration Background								
no	1.00		1.00		1.00		1.00	
yes	1.53	(0.88;2.68)	1.55**	(1.10;2.18)	0.94	(0.68;1.29)	0.85	(0.67;1.07)
Urbanisation	1.55***	(1.17;2.06)	1.51***	(1.26;1.82)	1.41***	(1.21;1.65)	1.19***	(1.06;1.33)
Type of Family								
couple w/o children	1.00		1.00		1.00		1.00	
couple w/ children	0.86	(0.51;1.48)	1.02	(0.73;1.42)	0.91	(0.70;1.18)	1.06	(0.87;1.28)
singles	1.13	(0.66;1.96)	1.66***	(1.20;2.29)	1.08	(0.82;1.42)	1.13	(0.91;1.40)
single parents	1.20	(0.56;2.57)	1.15	(0.71;1.86)	0.93	(0.61;1.42)	1.10	(0.81;1.51)
other	0.76	(0.26;2.29)	0.85	(0.39;1.86)	0.60*	(0.35;1.04)	0.63**	(0.42;0.94)
Flats								
1 or 2	1.00		1.00		1.00		1.00	
3 or more	0.67*	(0.43;1.06)	1.12	(0.83;1.50)	1.35**	(1.05;1.74)	1.12	(0.91;1.36)
Category of Flat								
cat. A	1.00		1.00		1.00		1.00	
cat. B or below	2.58*	(0.94;7.13)	0.99	(0.54;1.81)	1.28	(0.80;2.06)	1.44	(0.90;2.29)
n = 3,749								

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

The odds ratio (OR) indicates the odds for the respective category of environmental quality being rated on a higher level.

of green space, but no significant relationship in that regard is exhibited by the model.

7.2 Air Pollution

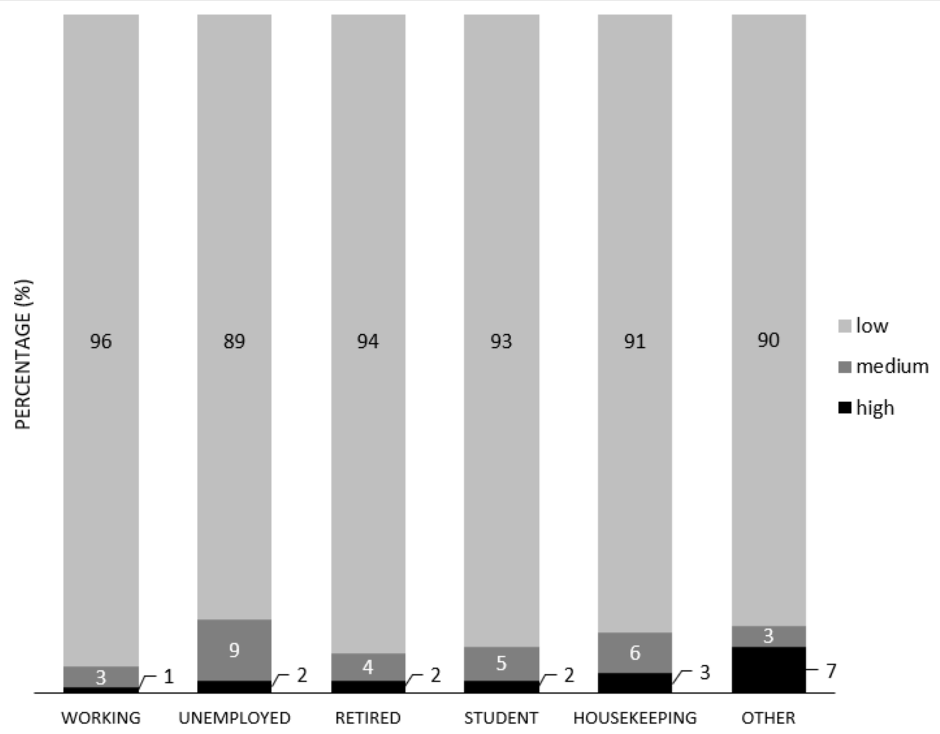
Exposure to air pollution was assessed by three questions. The first question surveyed the assessment of overall air quality and the second and third enquired about personal exposure to unpleasant odour and fumes or exposure to dust and soot, respectively. The observed results differ between the assessed categories but still exhibit a general tendency in the relationship between air pollution and socioeconomic status. As visible in Table 3, respondents who rated overall air quality as bad tended to be older, female, unemployed and live in densely populated areas in buildings containing multiple flats. Looking at the personal exposure to odour and fumes as well as to dust and soot, configurations of double burden become even more evident. As seen in Figure 3, only four percent of people in employment perceived medium or high levels of exposure to odour and fumes, whereas within the group of the unemployed, this number increases to 11 percent. Respondents from the highest income decile also reported a lower exposure to unpleasant odours or fumes compared to people from the lowest income decile (98 and 93 percent, respectively).

Again, it is the degree of urbanisation that exhibits a decisive role in both exposure to odour/ fumes and dust/soot (see Table 4). Pollution of the personal living space was additionally linked to the housing conditions of the respondents. 10.9 percent of people living in multi-storey buildings reported a high level of exposure, whereas only 5.9 percent of respondents in a 1 or 2 family home rated nuisance by odour or fumes as high. Similarly, also those residing in flats that do not meet up-to-date conditions of living space (category B or below) reported higher levels of unpleasant odour or fumes in their living environment.

Table 4 also shows a difference in perceived exposure to air pollution in regard to whether one has a migration background or not. For instance, only 13.1 percent of people without this background report medium or high levels of exposure to dust and soot, whereas within the group of people with migration backgrounds 19.2 percent felt exposed to medium or high levels of dust and soot.

In regard to the perceived personal exposure to air pollution, the regression models confirm that lower income groups feel disproportionately affected by odour and fumes as well as dust and soot. Table 6 shows that a decrease in monthly net income by 100 euro increases the odds of being exposed to higher levels of unpleasant odour and fumes by 3 percent. Similar results could be obtained for the relationship between income and the exposure to dust/soot [OR 0.99; 95% CI 0.97-1.00]. This confirms the results by Glatter-Götz et al. (2019), who also identified a negative correlation between air pollution and socioeconomic status.

Figure 3: Perceived Level of Exposure to Odour & Fumes by Occupational Status



In almost all empirical studies on environmental inequality in Austria, migration background was a main determinant of facing worse environmental conditions in regard to air pollution (Glatter-Götz et al. 2019; Neier 2021; Brenner 2019; Miklin 2019). These results can only be partially confirmed. The level of exposure to dust and soot exhibits a significant relationship to whether one has a migration background or not. The odds of being exposed to higher levels of dust/soot are 55% higher for people with migration backgrounds. However, neither the assessment of overall air quality, nor the level of exposure to odour and fumes, showed a correlation with whether one has a migration background. These findings are also contradicting the assessment of overall environmental quality by people with migration backgrounds (see above) and therefore point to a complex relationship in perception of environmental burdens by people with migration backgrounds. To validate the results for the influence of migration background (defined as both parents being born in another country), also different operationalizations of migration background (*citizenship* (Austrian vs. non-Austrian) and *country of birth* (Austria vs. other)) were applied to the models, but yielded similar results and therefore confirm the original results.

In contradiction to the findings of Glatter-Götz et al. (2019), no significant linkages between the assessed indicators of air pollution and education could be identified in the full model. Though they are geographically very different, the Austrian states of Vienna and Tyrol reported the highest levels of perceived exposure to both odour/fumes and dust/soot. Therefore, a separate analysis for these regions was performed to allow for a more detailed analysis of high exposure areas and possible differences between a solely urban environment (Vienna) and the rather rural state of Tyrol. Results can be found in Online Appendix B.3 are mostly in line with the findings from the nationwide model. In both states, the association of lower income with higher levels of perceived exposure to unpleasant odour and fumes are confirmed. Especially in Tyrol, this relationship is very distinctive: a decrease of 100 Euros in income increases the odds of being exposed to higher levels of perceived exposure to odour and fumes by 8 percent. However, the association of lower income with higher levels of perceived dust/soot exposure could not be confirmed in either Vienna or Tyrol. Further interesting findings include a very strong correlation between migration background and levels of perceived exposure to odour and fumes in Tyrol [OR 3.86, 95% CI 1.39-10.70] and significantly higher odds of singles and single parents (as compared to couples) to perceive higher levels of exposure to dust and soot in Vienna.

7.3 Noise Exposure

In general, noise seems to be a higher burden than air pollution to people living in Austria. Whereas only 13.1 percent of the respondents rated overall air quality as *bad*, the overall noise situation was described as *bad* by 27.3 percent of the study population (Table 3). Significant determinants of the perception of higher levels of noise disturbance are higher age, being a woman, being unemployed, living in an urban environment and having a higher number of flats in the residential building. In the group of young adults below the age of 25, only 23.3 percent rated the general noise situation as *bad* compared to 31.1 percent in the age group containing residents above the age of 64. This finding, however, is not reflected in the evaluation of the personal exposure to noise (see Table 4). Further, people facing unemployment tended to perceive a higher exposure to noise. Indeed, 37.5 percent rated the noise situation as *bad* in comparison to 25.2 percent of the working population in this study. Only a small disparity in rating the exposure to noise as *medium* or *high* can be seen between the lowest and highest income decile (17.9% and 22.0%, respectively).

The relationship between age and the assessment of the overall noise situation is confirmed by the multivariate model, which shows that with each year of life, the odds of respondents evaluating the noise situation as bad increased by 1 percent, though this effect is not reflected in the assessment of personal exposure to noise (Tables 5 and 6, respectively). However, the living environment, as well as housing conditions, are significantly related to noise exposure both in the assessment of the overall situation as well as personal exposure. Especially, living in a building with three or more flats led to significantly higher perceived exposure to noise [OR 1.35, 95% CI 1.05-1.74]. No significant correlation in regard to income, migration background or level of education could be identified in the nationwide analysis. As the residents of Vienna reported the highest levels of exposure to noise (in comparison to the other states of Austria) and because of better comparability to the results from Siedl (2016), a separate model only including residents of Vienna was calculated (see Online Appendix B.4). For the subset of Vienna, the results show a significant, but weak, correlation between income and the exposure to noise disturbance [OR 0.98, 95% CI 0.97-1.00]. However, in Vienna, higher levels of noise disturbance were not associated with gender or the number of flats in the building like in the nationwide model. In contrast to Siedl (2016), who analysed inequality in exposure to noise in Vienna based on a single socioeconomic index variable and could not identify any correlations, the work at hand reveals more differentiated results. Though also very few significant associations between the classical socioeconomic indicators income and highest educational attainment could be found in the model for all of Austria, in Vienna lower income is linked to a higher perception of noise level and on the national level some patterns of double burden in regard to occupational status and housing conditions were discovered.

7.4 Heat Exposure

The increasing number of annual extreme heat days (air temperature > 30°C) within the last decade (ZAMG 2021) is also reflected by the reported levels of heat exposure. 29.5 percent of the respondents felt exposed to high levels and 34.7 to medium levels of heat strain (see Table 4). The elderly (age 64 and above) reported the lowest levels of heat stress. This is rather surprising, as there is broad consensus that older people are the most vulnerable to high temperatures. Further, more women (32.2%) than men (26.8%) perceived high levels of heat exposure. Table 4 also shows that 65.6 percent of the respondents in the lowest income decile reported medium or high levels of heat burden, whereas, in the highest income decile, this number dropped to 60.1 percent.

In the ordinal logistic regression analysis, only very few sociodemographic attributes correlate with perceived heat exposure (see Table 6). The main one is the highest educational achievement, which exhibits a negative correlation with the level of perceived heat exposure [OR 0.91, 95% CI 0.84-0.99]. In addition, perceived heat stress is strongly correlated with population density. Residents of urban areas perceived a significantly higher burden of heat than people living in thinly populated regions [OR 1.19, 95% CI 1.06-1.33]. This finding reflects the tendency that higher temperatures rather occur in cities than in rural areas, known as the urban heat islands effect, caused on the one hand by the high share in soil sealing and relatively low share of green space, and on the other hand by a high concentration of warm exhaust from traffic and other human activity within a small area. No associations between perceived heat exposure and income, age, housing conditions and migration background could be identified. To the best of the author's knowledge, this study is the first one to explicitly scrutinise the relationship between socioeconomic status and heat exposure from an environmental inequality perspective in Austria. However, to identify the above-mentioned urban heat islands and pinpoint geographical hotspots of vulnerability, urban heat maps have been created for the Austrian cities of Vienna (Stadt Wien 2019) as well as for Salzburg, Mödling, and Klagenfurt (See et al. 2020). The created heat vulnerability indices in these projects are based on the age structure of residents in a particular area, but no other sociodemographic characteristics were considered. But, for instance, the findings of the Viennese heat map suggest that especially the districts of Favoriten, Ottakring and Margareten are disproportionately affected by extreme heat. Considering that residents of these districts also exhibit a lower mean income compared to inhabitants of most of the other districts in Vienna (Stadt Wien 2018), an association between heat exposure and socioeconomic status might be suspected, which would be in line with findings from international studies on the relationship of socioeconomic status and heat exposure (e.g. Koman et al. (2019) and Hsu et al. (2021)).

8. Limitations

Based on survey data about perceived environmental conditions, the study at hand contributes to the research on environmental inequality in Austria and was able to highlight sociodemographic disparities in regard to the exposure to adverse environmental impacts. Nevertheless, this study also has its limitations.

First, the pivotal shortcoming of this analysis is the limited availability of income data, as already briefly mentioned in Section 3. In the interviews for the Austrian Microcensus survey, no information about income was gathered. Income data of employees was added later on from wage tax registers. However, no income data is available for other groups like the unemployed, retired, self-employed, etc. Therefore, in the models including income as an explanatory variable, the sample was limited to a subsample of 3,749 employees. Furthermore, information on additional components of income (e.g. earnings from rent, social transfers, etc.) was not available either. To address this limitation an attempt was made to impute missing income information from the EU-SILC survey by statistical matching techniques following the approaches by Wegscheider-Pichler (2014), Puchner (2015), and Baud and Wegscheider-Pichler (2019) as summarised in Online Appendix B.1. However, due to methodological uncertainties and, again, limited data availability, this approach was discarded as, especially in lower income groups, the divergences in income distribution were too high to allow for reliable analysis of the relationship between perceived environmental exposure and income. Despite its limitations and uncertainties, it was decided that income data from o?cial registers for the subgroup of employees represents the more reliable proxy to investigate general tendencies in the relationship between socioeconomic status and exposure to negative environmental impacts – especially if socioeconomic status is not equated with income but is conceptualised as a function of various sociodemographic characteristics. However, in order to not only reveal general tendencies but to also establish robust results regarding the relationship between income and environmental conditions, income data for the whole study population would be necessary, preferably income data on the household level, as household income typically provides a better proxy for socioeconomic status than individual income. Therefore, results of this study need to be treated with caution.

Second, no statements about the small-scale spatial distribution of perceived environmental burdens could be made as the information in the dataset only contained information about the geographical whereabouts of the respondents on the NUTS2 level (corresponding to the nine federal states of Austria). So, for instance, it was not possible to explicitly investigate the perceived environmental exposure in terms of the vicinity to industrial polluters or in regions that are known for higher environmental burdens due to geographical or infrastructural features.

Third, the survey question about the quality and quantity of green space did not assess the personal situation of the respondents, but rather surveyed the overall situation in Austria, and can therefore be only seen as a proxy for one's individual situation in regard to those categories.

Fourth, the effects seen in the regression analyses are rather weak – yet statistically significant – and the explanation of variance (Pseudo-R^2) is also on the lower end. Therefore, the results have to be treated with caution and can only reveal general tendencies on the relationship of perceived environmental conditions. Further studies on subjective environmental quality are needed to confirm the results.

Last, it should be emphasised that the study at hand is based on self-reported data about perceived environmental burdens. This kind of information has its strengths and weaknesses. Opinions about the reliability of self-reported exposure data differ. Some authors identified a significant mismatch between perceived and actual exposure to adverse environmental impacts (e.g. Schwartz (2003) and Graves (2003)), whereas others found that perceived air pollution (Peng et al. 2019) and noise annoyance (Atari et al. 2009) represent a good proxy for actual exposure and Forsberg et al. (1997) concluded that "questionnaire studies have a place in monitoring air pollution" (p.44). However, it is crucial to keep in mind that perceived exposure levels do not necessarily equate to actual exposure levels. Many underlying perception biases (Hunter et al. 2004) and different levels of sensitivity to environmental influences might lead to significant divergences from data about actual exposure. However, at the same time, this is also the advantage of subjective data, as it allows for elucidating individual vulnerabilities and personal adaptation capabilities to adverse environmental effects, which can not be revealed solely by plain pollution data.

9. Conclusion

In light of rising awareness for environmental justice and the very limited body of literature on the situation in Austria, the aim of this study was to analyse socioeconomic disparities in the perception of environmental conditions like overall environmental quality, air pollution, noise disturbance and climate change-related heat stress in Austria and to contrast them with findings from environmental inequality studies based on objectively measured data of exposure. These subjective factors included overall environmental quality, air pollution, noise disturbance and climate change-related heat stress in Austria. Based on survey data on environmental conditions from the Austrian Microcensus 2019, logistic regression models were applied to identify the main sociodemographic determinants of subjective environmental inequality.

The results confirm the existence of certain patterns of environmental inequality in Austria, while also highlighting their complex nature. Robust evidence was found for the influence of income on the assessment of overall environmental quality and the personal exposure to air pollution. However, no correlation between income and exposure to extreme heat could be identified and a relationship between income and levels of noise exposure could only be found in Vienna. In almost all assessed categories of environmental quality, unemployed persons and women were disproportionally affected by negative environmental impacts. Housing conditions are significantly related to the perceived level of noise annoyance. The level of education, however, plays a minor role and only for some types of exposure to environmental burdens could significant associations be identified. Mixed results were found for the influence of migration background on the perception of environmental conditions. Whereas people with migration backgrounds reported significantly higher levels of exposure to dust or soot, they rated overall environmental quality as better compared to people without migration backgrounds.

In summary, the findings verify configurations of double burden and enrich the literature on environmental inequality in Austria by adding the subjective perspective of affected people and highlighting individual vulnerabilities. Building upon the work of Baud and Wegscheider-Pichler (2019), this study extends their research by adding the sociodemographic dimensions of gender and migration background and uses more recent data. Further, the study is the first to assess the role of climate change-related heat stress from an environmental justice perspective in Austria.

The work at hand is also one of the very few environmental inequality studies based on perceived environmental conditions. To date, similar research on subjective environmental inequality has only been published in Germany (Kohlhuber et al. 2006; Mielck et al. 2009), Switzerland (Diekmann and Meyer 2010) and China (Li and De 2021). The work by Kohlhuber et al. (2006), assessing subjective environmental inequality in Germany, is most comparable to the study at hand. They also found lower income, being female and being non-German (this study used nationality instead of migration background) to be associated with a higher burden of air pollution. In contrast to findings in this study, their results suggest a significant relationship between income and perceived levels of noise disturbance. Similar results were obtained by Mielck et al. (2009) for the city of Munich. The analysis of environmental inequality in Switzerland by Diekmann and Meyer (2010) does not only confirm that perceived levels of air pollution are associated with lower income and migration background, but also directly compared subjectively perceived and objectively measured air and noise pollution and found them to be strongly correlated. These results in the international context strengthen the findings of the study at hand.

The evidence for patterns of environmental inequality in Austria, as well as their complex, and sometimes contradictory, nature highlights the need for a) further and more comprehensive research on environmental inequality in Austria and b) the incorporation of concerns of environmental justice in public discourse and policymaking.

In light of almost 1,000 premature deaths due to climate change-related heat stress in Austria between 2017 and 2020 (AGES 2021), the lack of studies addressing the sociospatial distribution of heat stress from an environmental justice perspective can be seen as a major blind spot in the literature on environmental inequality in Austria. Along the lines of various studies on air pollution (Glatter-Götz et al. 2019; Miklin 2019; Brenner 2019; Neier 2021) and as done for other countries (Koman et al. 2019; Su et al. 2012), it would be important to put small-scale measured surface temperatures into perspective with sociodemographic characteristics of residents. Further directions for future research could be to integrate objectively measured pollution data and subjectively perceived exposure into one single study (as done e.g. by Diekmann and Meyer (2010)) to allow for more reliable analysis of the relationship and to get the full picture of environmental inequality in Austria.

In combination with findings from other studies, the results of this analysis can also be seen as a mandate to act for decisionmakers to incorporate considerations of environmental justice into policymaking. However, the development of a just socioecological policy response to environmental inequality is itself an issue of high complexity as inequality can emerge in many different and interrelated dimensions. In addition to the differences in exposure to adverse environmental impacts, it was shown that the contribution to environmental burden (e.g. emissions caused by certain consumption patterns) is also unequally distributed between socioeconomic groups in Austria (Frascati 2020). For instance, the highest income decile emits more than four times as much CO_2 than the lowest income decile. Thus, it can be argued that socioeconomically disadvantaged groups face unjust conditions in a twofold way: they contribute the least to worsening environmental conditions, but often bear the highest burden of adverse environmental effects. Carbon taxation on the individual level (as recently implemented in Austria) is a possible approach to address the inequalities mentioned. However, environmental taxes bear their own risks in regard to inequality, as they are known to often have regressive effects when introduced without further accompanying policy measures.

This example should highlight the complexity when addressing environmental inequality on a policy level. Nevertheless, some general policy recommendations to integrate concerns of environmental justice in Austrian policymaking can be made. First, the need for further research, as mentioned above, also implies the need for data availability. Therefore, public institutions need to gather and provide more comprehensive and small-scale spatial data on air pollution, noise disturbance, high temperatures and other adverse environmental conditions as well as corresponding sociodemographic data to enable further research on environmental inequality in Austria. Second, to follow the claim of procedural justice, the public – and especially the most vulnerable groups with fewer capabilities to adapt to adverse environmental conditions – should be involved in environmental policymaking on all levels by participatory processes. As the results of the study at hand suggest that, for example, people with migration backgrounds and women perceive higher levels of environmental burden, it is important to explicitly involve these groups, especially, because people with migration backgrounds and women often tend to be underrepresented in public discourse anyway. The Austrian Assembly for Climate Action (Klimarat), which involves a hundred citizens, who represent a cross-section of Austrian society in terms of gender, age, level of education, income, and place of residence, can be seen as a best practice example in that regard. Third, all policy measures that could potentially cause adverse environmental impacts should be assessed in terms of their consequences for environmental inequality. A first step in this direction would be to review infrastructure projects as part of environmental impact assessment (Umweltverträglichkeitsprüfung), also with respect to their influence on environmental inequality. Therefore, a standardised assessment methodology should be developed and implemented. Fourth, to address the unequal consumption patterns of households causing different impacts on the environment, environmental policies should follow a polluter-pays principle. However, in the design and implementation of the environmental policies, policy justice in regard to distributional effects of the policies itself needs to be ensured. Fifth, in all categories of adverse environmental impacts tested in this study, urban populations perceived significantly higher levels of exposure. Therefore, measures of adaptation and mitigation should focus on densely populated areas. Policies to significantly limit car traffic in cities would significantly lower noise disturbance as well as reduce air pollution. This would not only ease urban hotspots of environmental pressures, but also encourage active mobility, which in turn has positive impacts on human health. Further, urban planning should ensure access to sufficient recreational green space for everybody by exploring possibilities of unpaving sealed soil. Another starting point could be to integrate considerations of environmental inequality into the development and construction of new public housing projects, which provide lower-income groups with affordable living space and often house a large share of people with migration backgrounds. Both these groups already report higher levels of perceived air pollution and lower income is additionally associated with higher levels of perceived noise disturbance. Thus, the siting of new projects should not be in the vicinity of main roads and industrial polluters and the buildings should feature proper noise insulation to ensure good quality of life also for lower-income groups.

However, following the claim of Walker (2005), the ultimate goal of environmental justice should not be to distribute exposure to air pollution, extreme heat, noise, and other adverse environmental effects as equally as possible, but to reduce emissions, mitigate climate change, limit noise pollution and create an equally liveable future for everybody.

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Abstract

This quantitative study investigates the relationship between perceived environmental conditions (air pollution, noise, extreme heat, access to green space) and socioeconomic status in Austria. Building upon the work of Baud and Wegscheider-Pichler (2019) and integrated into the theoretical framework of environmental justice, it aims to enrich the empirical body of literature on environmental inequality in Austria by adding the subjective perspective of affected individuals in order to highlight individual vulnerabilities and capability to adapt. Data from the Austrian Microcensus 2019, a large-scale population-based survey, is used. In this survey, information on perceived exposure to adverse environmental conditions was collected from a total of 7,021 respondents. To analyse the association between subjective exposure and sociodemographic characteristics, binomial and ordinal logistic regression models are applied. The findings suggest that lower income is associated with a lower perception of overall environmental quality and a higher level of perceived exposure to air pollution. A correlation between income and level of noise disturbance is only present in Vienna, and no relationship between income and perceived heat stress can be identified. However, in almost all categories of adverse environmental impacts, unemployed persons and women feel disproportionally affected, and housing conditions are significantly related to perceived noise annoyance. Mixed results are found regarding the role of migration background. While individuals with migration backgrounds report higher personal exposure to air pollution, they rate the overall environmental quality as better than people without migration backgrounds. In line with other empirical studies, the results confirm that exposure to adverse environmental conditions is distributed unequally across society in Austria. To address these inequalities, concerns of environmental justice should be integrated into public discourse and policymaking.

Keywords: environmental justice; inequality; perceived exposure; air pollution; noise disturbance; heat stress; logistic regression

JEL Codes: Q53; Q54; Q56

Appendix

Appendix A.1: Survey Questions

How would you rate the environmental quality in Austria?
- overall environmental quality: [good/bad]
- air [good/bad]
- noise [good/bad]
- greenspace (quantity and quality) [good/bad]

In the last 12 months, have you been bothered or disturbed by noise in your home during the day or at night?
- during the day [very strongly/strongly/medium/slightly/not at all]
- at night [very strongly/strongly/medium/slightly/not at all]

Are you bothered by odors or exhaust fumes in your home during the day or at night?
- during the day [very strongly/strongly/medium/slightly/not at all]
- at night [very strongly/strongly/medium/slightly/not at all]

What is the extent of your physical strain due to heat during a heat wave?
- during the day [very strongly/strongly/medium/slightly/not at all]
- at night [very strongly/strongly/medium/slightly/not at all]

Are you bothered, either specifically in your home or in general, by dust or soot coming from outside?
- in your home [in summer/in winter/not at all]
- in general [in summer/in winter/not at all]

Note: English translation. Questions were asked in German.