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Associations between Predictors of Indoor Air Quality in Kosovo and Health Symptoms in a Large Representative Survey

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Abstract: Because most human activities take place inside, indoor air quality is essential to human health. Numerous factors contribute to Kosovo's air pollution, including traffic, industrial emissions, aging thermal power plants, home heating, and other hazardous pollutants. The National Institute of Public Health and the WHO conducted a representative household survey to identify the most exposed and susceptible households, targeting two thousand households. Data from this survey were analyzed regarding the relationship between residential air quality predictors and health symptoms in Kosovo inhabitants. Effects from cooking fuel used on headaches, dizziness, and fatigue were somewhat stronger in females and type of heating seemed a little bit more effective in winter. The latter was also true for respiratory problems and heart disease, lending some credence to the causality of the findings. Thus, cooking devices and energy sources for both heating and cooking seem to have an effect on the health of Kosovars. Although the effect estimates were, in general, moderate with adjusted odds ratios in the magnitude of 2 to 3, they only explained a small part of the variation, with pseudo-R^2 often only reaching less than 10% and rarely more than 20%. In order to improve indoor air quality, regular monitoring and supervision systems should be established across the nation.

Keywords: indoor air pollution; households; Kosovo; population health; representative survey

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1. Introduction

1.1. Outdoor and Indoor Air Pollution

The quality of the air in places where people spend the majority of their lives—their homes, schools, workplaces, childcare facilities, public buildings, medical facilities, and other private or public buildings—is crucial to determining their health and overall well-being. Hazardous material emissions from structures, building supplies, and equipment, as well as human activity at home, including cooking and heating with solid fuels, smoking, using ventilation systems, and using furniture, can result in a variety of health issues. Smoking and cooking have been found to be the main indoor causes of air pollution compared to outdoor sources, but the relationship between indoor and outdoor environments is a complex one that involves many other aspects, including ventilation, interior sources, weather, and the materials used in construction and maintenance [1,2].

In houses, solid fuel combustion, especially in less developed countries, occurs in basic stoves that are poorly maintained and designed. This type of combustion puts additional strain on fuel supplies and directly contributes to low energy efficiency [3].

Burning biomass in conventional open-fire stoves or other inefficient, frequently improperly vented stoves releases smoke that is highly polluting and can have detrimental effects on one's health, particularly for women and young children who spend a lot of time with their mothers [4–6].

Almost 3 billion people use wood, coal, and other solid fuels for cooking and heating in their homes globally, while 1.2 billion use simple kerosene. The WHO report from 2015 [7], updated in 2023 [8], states that emissions from coal and wood heating have a major negative impact on public health. In Central Europe, the contribution of residential heating with solid fuels to outdoor $PM_{2.5}$ pollution is highest, reaching 21% in 2010. Taking Europe and North America together, more than 70,000 premature deaths annually are attributable to ambient air pollution from residential heating with wood and coal. While household heating stoves and boilers contribute less than 10% of all outdoor $PM_{2.5}$ globally, its influence is nonetheless felt in houses and places where polluting fuels are used. The persons most affected by the burning of coal and wood live in rural areas of low- and middle-income countries [9,10].

Indoor air pollution (IAP) is the single most significant environmental risk factor in the world, accounting for around 5% of the worldwide illness burden. IAP contributes significantly to mortality caused by outdoor air pollution as a result of emissions into the surrounding environment [10]. Millions of homes worldwide still lack access to electricity and clean energy for lighting, heating, and cooking, despite the fact that these resources are essential to global health and development [11].

According to estimates of the global burden of disease, IAP from dirty fuels for cooking and heating causes about 4 million premature deaths each year [12–14].

Numerous epidemiological research studies conducted over the past decades suggest that there is a link between burning domestic fuels—especially solid fuels—and poor health, especially regarding non-communicable diseases. These diseases are responsible for 60% of DALYs (Life Years Lost due to Disabilities) and 76% of global deaths [15], and many of these diseases are affected by IAP.

Globally, as Rajagopalan and Brook [16] point out, citing Smith [17], indoor air pollution from poor cooking and heating fuels and corresponding health impacts are especially severe in frequently severe in low- and middle-income countries. It is estimated that over half of the world's population is exposed to fine particulate matter ($PM_{2.5}$) in their own homes as a result of utilizing biomass fuels like wood and charcoal for cooking [16].

The effects of exposure to pollutants in the indoor environment can be acute and chronic and vary from person to person. Both the effects of exposure to high IAP on health and their economic consequences are considered a major public health concern. Since dilution is much more limited indoors compared to outdoors, even modest indoor emissions can result in high indoor concentrations [18].

For children, there is substantial evidence that indoor air pollution (IAP) with solid fuels increases the risk of acute lower respiratory tract diseases (ALRI), and this occurs as early as during the mother's pregnancy and may impair cognitive development [18–23].

1.2. Characteristics of Kosovo as the Wider Study Area

Kosovo's climate is largely continental, resulting in warm summers and cold winters with Mediterranean and Alpine influences, with the average temperature within the country ranging from −10 °C in winter to +30 °C in summer. However, due to uneven elevations in some parts of the country, there are variations in temperature and rainfall distribution. December and January are considered the coldest months. July and August are considered the warmest months of the year. The maximum amount of precipitation is reached between October and December. Between November and March, snow can fall in Kosovo, even in the flat parts of the country. The greatest amount of precipitation may fall in the mountainous regions of Kosovo [24].

Kosovo, with a population of 1,859,203 as of 2021, is characterized as very young, where the average age is 30.2 years [25]. It has one of the youngest populations in Europe.

A total of 28% of the population is under 15 years old, and half of the population is 28.2 years old or younger. The average life expectancy in Kosovo is 78.1 years, the lowest in the region; the infant mortality rate is 9.7 deaths per 1000 births. There are still significant data gaps in the health sector [26].

Regarding air pollution, Kosovo does not differ largely from the other countries in the Balkan region. Moreover, the people's behavior and awareness in the country in terms of air pollution is not satisfactory, as is stated in the European Quality of Live Survey [27] and Kosovo Mosaic Survey [28]. Less than 23% of Kosovo's population perceive the ambient air quality as poor, and this percentage is much higher among the Pristina agglomeration population, especially Obiliq, due to the proximity to power plants [29,30].

Kosovo's energy supply is highly constrained due to the limited availability of feasible renewable resources, aging and unreliable lignite-fired generation plants, supply shortages in neighboring countries, and an absence of any natural gas resources or infrastructure to import gas [24].

Approximately 97% of Kosovo's domestic power generation comes from two outdated coal-fired power plants, Kosovo A (commissioned in the 1970s) and Kosovo B (commissioned in the 1980s). The primary energy sources used in Kosovo are coal, oil products (gasoline, diesel, fuel oil, kerosene, and liquefied petroleum gas—LPG), biomass, hydro energy, wind, solar energy, and biofuels. In addition, electricity is considered a primary source of imports and exports [24].

In Kosovo, 1150 deaths per year may be attributed to the current fine $PM_{2.5}$ level. The significant number of premature deaths (758 per year) caused by long-term exposure to $PM_{2.5}$ could be avoided if the World Health Organization Air Quality Guideline (WHO AQG) values are met. In 2019, due to the exceedance of WHO AQG limits, it was estimated that 1127 years of life were lost in adults (aged 30 and over).

Ambient air quality is routinely monitored in many cities around the world, but in Kosovo, regular air quality monitoring only started in 2017. Air quality continues to pose a significant issue to health in Kosovo as the country's ambient concentrations of $PM_{2.5}$ significantly exceed both the national and European Union (EU) and the World Health Organization (WHO) standards [24]. Especially in winter, urban areas face severe smog episodes caused by the increased demand for heat from the residential and commercial sectors, mainly provided by burning solid fuels. While there is a wealth of information about ambient air quality, there is little known regarding IAP in Kosovo [24].

Kosovo's air pollution has several sources, including outdated thermal power plants, household heating, traffic, industrial emissions, and the incineration of waste and other toxic materials. It has been challenging to implement concrete measures to reduce emissions [31].

The Air Quality Strategy is not enforceable with measures to control the use of coal for heating. Air quality plans have not yet been prepared for areas where pollutant levels exceed limit values. Households in Kosovo use various energy sources for different purposes, and the economic concerns result in increased firewood use for heating and cooking [32].

According to the Kosovo Agency of Statistics, 40% of households could not afford to keep warm adequately in 2018, although the situation has improved since then [33]. The energy sector in Kosovo faces significant challenges, including the dependence on old lignite-based electricity generation capacities, which provide inadequate reliability and flexibility and are a primary source of greenhouse gas (GHG) emissions and local pollution [24].

The cooking devices used in Kosovo include electric stoves, liquefied petroleum gas (LPG) or cooking gas stoves, and manufactured stoves. The most used heating devices are electrical heaters, manufactured stoves, heat pumps, and air conditioners. Only three municipalities in urban centers use municipal district heating.

Therefore, following the World Bank [34] and WHO guidelines [35], a survey was conducted to understand energy use and its societal and health impacts by collecting data across Kosovo regarding energy sources and technologies used for cooking and heating to evaluate the baseline situation and enable more efficient planning of activities to prevent and control IAP. The descriptive results of this survey were reported to the Kosovar parliament but are not yet publicly available. In this systematic survey, questions about health and symptoms were also asked. Therefore, this paper sets out to test the hypothesis that heating and cooking with dirtier fuels are associated with a higher prevalence of symptoms mostly related to poor respiratory health.

2. Materials and Methods

2.1. Research Approach

The research approach was a quantitative survey—face-to-face interview through the Tablet-Aided Personal Interview (TAPI) method—and the interview was conducted "in-home" of the respondent. The data were collected through a household questionnaire adapted from the WHO's Clean Household Energy Toolkit (CHEST) resources [35].

The questionnaire consisted of closed and open questions, pre-coded. The survey had four sections: the first section contained questions about the demographic information of the family and the respondents; the second section contained questions about the health status of the family and the health status of family members; and the last two sections contained questions on cooking and home heating.

Before starting the survey, the questionnaire had been piloted by the NIPH team in 20 households in Pristina (11 urban and 9 rural) and revised accordingly.

2.2. Sample Size and Sampling

The total sample size was 2000 households. A number of 2000 households was deemed sufficient for a representative description of all households in Kosovo to provide comparative analysis by main demographic indicators, such as region, type of residence, and so on. A total of 1190 rural and 810 urban households participated in the survey. From these 2000 households, regarding health status, all family members were either interviewed personally, or, especially for the kids, answers regarding their health status were sought through proxy interviews. The data were collected by personal face-to-face interviews using tablets between 3 November and 9 December 2022. In total, health data from 7860 persons were collected. This sample represents nearly 0.5% of the whole population of Kosovo.

The survey's method was multi-staged random probability sampling. The selection of households was conducted via a random route technique, and the designated respondent for the interview was the head of the household or the most knowledgeable person about the health status of all members and energy use in the household.

The sample consisted of a total of 20 out of all 30 municipalities of the country. Within each municipality, starting points were selected randomly. Each starting point was designed to have 10 households, irrespective of the type of residence (urban or rural), with 200 sampling points in total. The residential split for the entire sample was 40% urban vs. 60% rural. The respective number of sampling points, as specified in the sampling plan, was then selected through simple random selection by generating random numbers. The available starting points within each municipality were usually some recognizable social sites or buildings, like a mosque, school, post office, medical center, or coffee shop.

The selection of household was based on the 'random route' method. In urban areas, the first contacted household was the third house/address number from the starting point on the left-hand side of the street/route, and each third one from that household onward. In a block of flats, the selected household was every third apartment, counting from the top floor of each entrance. In rural areas, the selected household was every third inhabitable house/dwelling on both sides of the interviewer's route/track.

A household/respondent was recorded as a non-contact after three failed attempts to accomplish the interview (first visit and two call-backs). The further selection was governed by the rules for selecting a household and a respondent. If a selected household/respondent refused to be interviewed, the next household selected was the neighboring address. The respondent also provided proxy information on the health status of the other household members.

2.3. Data Processing and Analysis

This representative housing survey included a wealth of data. In this study, we are interested in the effects of cooking and heating fuels on the health status of the inhabitants. To that end, the questions described in Appendix A were analyzed.

We used "How many tobacco products (cigarettes) do you or your household members smoke per day?" as a kind of positive control.

We assumed that women would spend more time cooking. Therefore, if there were any health effects due to the cooking fuel used, we expected to find stronger effects in women. To examine this, we also performed analyses stratified by gender. We further analyzed the impact of the duration (hours last day) or frequency (several times a day until rarely) of use last week.

We considered age, gender, socioeconomic status (measured as highest educational level achieved), and residency (urban/rural) as possible confounders in logistic regression models. When a confounding variable had no significant impact on the symptoms rate and upon its removal the point estimate for the exposures of interest did not change by more than 10%, this confounder was removed from the model. The effects of the confounders are only described in the text, while the effects of the exposure indicators of interest are presented in tables. The pseudo-R^2 of each model refers to the final model including also all the remaining confounders.

Descriptive statistics and regression analyses were performed using STATA 17.0 [36].

3. Results

3.1. Descriptive Findings

The survey was performed in November/December 2022. Among the 2000 households, the majority (1168) reported the use of an electrical stove as their primary cooking device. An LPG stove was reported for 78 of the households, solid fuels were used in 738 households, and "other" stoves were used in 16 households.

Likewise, 555 households were heated by central heating and 77 by district heating. Electrical heaters were reported for 152 and manufactured stoves for 831 homes. A heat pump was installed in 13 homes, while 48 relied on air conditioning solely. Other sources of heat were described for 304 homes (20 responses missing).

Smoking was reported from 902 households (2 responses missing), of which 900 provided plausible numbers with an average number of 24.8 cigarettes smoked per day (Std. dev. = 13.7).

Regarding health effects, the frequencies of exposures and the outcomes were not analyzed per household but per person. Table 1 shows the characteristics of the people in total and by gender.

Table 1. Characteristics of the sample population.

Characteristic	Total (n = 7860)	Males (3921)	Females (3939)
Age (mean, ± std. dev.)	40.4 (±20.4)	39.7 (±20.5)	41.1 (±20.5)
Cigarettes/day in household (mean, ± std. dev.)	12.1 (±16.2)	12.4 (±16.2)	11.8 (±16.3)
Urban (n, %)	3074 (39.1%)	1509 (38.5%)	1565 (39.7%)
No education (n, %)	311 (4.0%)	159 (4.1%)	152 (3.9%)
Primary education (n, %)	2383 (30.4%)	1162 (29.7%)	1221 (31.1%)
Lower secondary education (n, %)	816 (10.4%)	431 (11.0%)	385 (9.8%)
Upper secondary education (n, %)	2575 (32.8%)	1286 (32.8%)	1289 (32.8%)
Post-secondary, short-cycle tertiary education (n, %)	597 (7.6%)	304 (7.8%)	293 (7.5%)
Bachelor (n, %)	973 (12.4%)	480 (12.3%)	493 (12.5%)
Master (n, %)	160 (2.0%)	80 (2.0%)	80 (2.0%)
Doctor (n, %)	36 (0.5%)	16 (0.4%)	20 (0.5%)
Missing (n, %)	9 (0.1%)	3 (0.1%)	6 (0.2%)

Table 1. *Cont.*

Characteristic	Total (n = 7860)	Males (3921)	Females (3939)
Electric stove (n, %)	4520 (57.5%)	2253 (57.5%)	2267 (57.6%)
LPG stove (n, %)	300 (3.8%)	149 (3.8%)	151 (3.8%)
Solid fuel stove (n, %)	3005 (38.2%)	1504 (38.4%)	1501 (38.1%)
Other stove (n, %)	20 (0.5%)	15 (0.4%)	20 (0.5%)
Central heating (n, %)	2185 (28.0%)	1085 (27.9%)	1100 (28.2%)
District heating (n, %)	260 (3.3%)	115 (3.0%)	145 (3.7%)
Electrical heater (n, %)	561 (7.2%)	287 (7.4%)	274 (7.0%)
Manufactured stove (n, %)	3408 (43.7%)	1733 (44.6%)	1675 (42.9%)
Heat pump (n, %)	49 (0.6%)	20 (0.5%)	29 (0.7%)
Air conditioner (n, %)	166 (2.1%)	81 (2.1%)	85 (2.2%)
Other heating device (n, %)	1167 (15.0%)	568 (14.6%)	599 (15.3%)
Missing (n, %)	64 (0.8%)	32 (0.8%)	32 (0.8%)
Symptoms reported *			
Irritation of eyes, etc. (n, %)	98 (1.3%)	48 (1.2)	50 (1.3)
Headaches, etc. (n, %)	204 (2.6%)	69 (1.8%)	135 (3.5%)
Difficulty breathing (n, %)	221 (2.8%)	89 (2.3%)	132 (3.4%)
Heart disease (n, %)	368 (4.7%)	150 (3.8%)	218 (5.5%)
Respiratory disease (n, %)	150 (1.9%)	62 (1.6%)	88 (2.2%)

* Answers were "no/sometimes/yes", but "sometimes" was only reported rarely (for the 5 symptoms 17, 69, 52, 10, and 9 times in total. Therefore, this category was left out.

3.2. Irritation of the Eyes, Nose, and Throat

The following possibly confounding variables remained in the final models because they had a significant impact on the rate of irritation of the eyes, nose, and throat, although they did not affect the estimates of the main effects much: higher rates were observed with higher age (about +3% per year) and urban dwelling (nearly twice as frequent as in rural sites). Higher educational achievements led to a higher rate (about +25% per step) in males only. No such effect was seen in females. There was no significant difference in the rates between the genders, and gender did not affect the association between rates and cooking types. The effects of cooking and heating type, as well as of environmental tobacco smoke (ETS) and number of cigarettes per day in the household, are presented in Table 2. Neither cooking duration in hours nor frequency of cooking had a perceivable effect on the symptoms rate.

Table 2. Determinants of the rates of irritation of the eyes, nose, and throat.

Factor	Adjusted Odds Ratio	95% Confidence Interval	*p*-Value
Type of stove			Pseudo-R^2: 0.086
Electric stove	1.06	0.33; 3.46	0.918
LPG stove	(referent)	-	-
Solid fuel stove	1.89	0.57; 6.27	0.299
Other stove	64.62	15.98; 261.28	**<0.001**
Type of heating			Pseudo-R^2: 0.052
Central heating	1.34	0.76; 2.36	0.309
District heating	4.66	2.15; 10.10	<0.001
Electrical heater	2.49	1.44; 5.56	0.003
Manufactured stove	(referent)	-	-
Heat pump	2.50	0.33; 18.95	0.375
Air conditioner	0.73	0.10; 5.43	0.759
Other heating device	2.78	1.61; 4.87	**<0.001**

Table 2. *Cont.*

Factor	Adjusted Odds Ratio	95% Confidence Interval	*p*-Value
In summer			Pseudo-R^2: 0.061
Central heating	0.79	0.35; 1.77	0.565
District heating	3.80	1.38; 10.44	**0.010**
Electrical heater	2.89	1.06; 5.84	**0.036**
Manufactured stove	(referent)	-	-
Heat pump	missing		
Air conditioner	missing		
Other heating device	1.67	0.76; 3.65	0.203
In Winter			Pseudo-R^2: 0.065
Central heating	1.31	0.73; 2.37	0.360
District heating	3.83	1.63; 9.02	**0.002**
Electrical heater	3.90	2.07; 7.35	**<0.001**
Manufactured stove	(referent)	-	**-**
Heat pump	missing		
Air conditioner	missing		
Other heating device	2.77	1.55; 4.93	**0.001**
Cigarettes per day	1.02	1.01; 1.03	**0.001**

3.3. Headaches, Dizziness, and Fatigue

Headaches, etc., were more frequent among females (adjusted odds ratio (aORs) about 2), those with less educational achievements (about 20% change per educational step), and those with increasing age (about 5% change per year). Effects of cooking were somewhat stronger in females (Table 3), and type of heating seemed a little bit more effective in winter. Cooking duration and frequency had again no effect on symptom rates.

Table 3. Determinants of the rates of headaches, dizziness, and fatigue.

Factor	Adjusted Odds Ratio	95% Confidence Interval	*p*-Value
Type of stove			Pseudo-R^2: 0.052
Electric stove	(referent)	-	-
LPG stove	2.03	1.39; 2.56	**0.034**
Solid fuel stove	1.88	1.39; 2.56	**<0.001**
Other stove	26.19	11.69; 58.71	**<0.001**
Males			Pseudo-R^2: 0.029
Electric stove	(referent)	-	-
LPG stove	1.62	0.48; 5.47	0.436
Solid fuel stove	1.67	1.00; 2.80	**0.050**
Other stove	23.66	6.51; 86.00	**<0.001**
Females			Pseudo-R^2: 0.048
Electric stove	(referent)	-	-
LPG stove	2.89	1.04; 5.03	**0.039**
Solid fuel stove	2.01	1.38; 2.95	**<0.001**
Other stove	28.15	10.01; 79.15	**<0.001**
Type of heating			Pseudo-R^2: 0.053
Central heating	1.74	1.18; 2.59	**0.006**
District heating	2.63	1.19; 5.79	**0.016**
Electrical heater	1.64	0.90; 3.01	0.107
Manufactured stove	(referent)	-	-
Heat pump	5.46	1.53; 19.48	**0.009**
Air conditioner	1.67	0.58; 4.78	0.342
Other heating device	4.27	2.92; 6.25	**<0.001**

Table 3. *Cont.*

Factor	Adjusted Odds Ratio	95% Confidence Interval	*p*-Value
In summer			Pseudo-R^2: 0.049
Central heating	1.97	1.33; 2.91	**0.001**
District heating	1.32	0.47; 3.71	0.605
Electrical heater	1.76	0.95; 3.28	0.073
Manufactured stove	(referent)	-	-
Heat pump	3.40	0.80; 14.53	0.193
Air conditioner	1.99	0.57; 4.71	0.357
Other heating device	4.26	2.93; 6.18	**<0.001**
In Winter			Pseudo-R^2: 0.045
Central heating	1.81	1.27; 2.60	**0.001**
District heating	2.73	1.36; 5.45	**0.005**
Electrical heater	2.67	1.65; 4.33	**<0.001**
Manufactured stove	(referent)	-	-
Heat pump	5.79	2.00; 16.81	**0.001**
Air conditioner	1.60	0.57; 4.48	0.370
Other heating device	3.78	2.68; 5.34	**<0.001**
Cigarettes per day	1.01	1.00; 1.02	**0.038**

3.4. *Difficulty Breathing*

Difficulty breathing was more often reported by females (aORs about 1.4), those of older age (+5% per year), and those with lower educational achievements (about 20% change per step). Gender did not have a perceivable moderating effect on the type of cooking stove. Type of heating had a somewhat stronger effect on symptoms in winter. Duration of cooking had no direct effect on symptoms, but the more often cooking was carried out in the last month, the stronger the effects of the type of cooking stove. The effects of the exposures of interest are shown in detail in Table 4.

Table 4. Determinants of the rates of difficulty breathing.

Factor	Adjusted Odds Ratio	95% Confidence Interval	*p*-Value
Type of stove			Pseudo-R^2: 0.144
Electric stove	(referent)	-	-
LPG stove	1.41	0.71; 2.77	0.324
Solid fuel stove	1.40	1.05; 1.87	**0.021**
Other stove	3.84	1.27; 11.61	**0.017**
Type of heating			Pseudo-R^2: 0.154
Central heating	1.27	0.89; 1.82	0.187
District heating	0.64	0.20; 2.09	0.459
Electrical heater	1.52	0.91; 2.56	0.112
Manufactured stove	(referent)	-	-
Heat pump	6.46	2.26; 18.45	**<0.001**
Air conditioner	0.58	0.14; 2.42	0.451
Other heating device	2.26	1.57; 3.26	**<0.001**
In summer			Pseudo-R^2: 0.132
Central heating	1.08	0.72; 1.62	0.718
District heating	0.91	0.32; 2.59	0.858
Electrical heater	0.53	0.24; 1.21	0.132
Manufactured stove	(referent)	-	-
Heat pump	1.14	0.15; 8.82	0.897
Air conditioner	0.65	0.15; 2.72	0.552
Other heating device	1.72	1.13; 2.63	**0.012**

Table 4. *Cont.*

Factor	Adjusted Odds Ratio	95% Confidence Interval	*p*-Value
In Winter			Pseudo-R^2: 0.152
Central heating	1.15	0.82; 1.61	0.416
District heating	0.50	0.15; 1.63	0.252
Electrical heater	1.33	0.80; 2.19	0.267
Manufactured stove	(referent)	-	-
Heat pump	5.38	1.89; 15.32	**0.002**
Air conditioner	0.71	0.22; 2.32	0.573
Other heating device	1.86	1.31; 2.66	**0.001**
Cigarettes per day	1.01	1.01; 1.02	**<0.001**

3.5. Heart Disease

Heart disease was more often reported by females (aORs about 1.4), those of older age (+8% per year), and those with lower educational achievements (about 18% change per step). Female gender strengthened the effect of type of cooking stove, while for both genders combined, none of the stove types reached significance (p always > 0.05). Type of heating had a somewhat stronger effect on symptoms in winter; at least the pseudo-R^2 was a little larger than for the respective summer model. Neither duration nor frequency of cooking had a direct effect on symptoms, and there was also no visible sign of interaction with type of stove. The effects of the exposures of interest are shown in detail in Table 5.

Table 5. Determinants of the rates of heart disease.

Factor	Adjusted Odds Ratio	95% Confidence Interval	*p*-Value
Type of stove			Pseudo-R^2: 0.237
Electric stove	1.08	0.58; 2.04	0.801
LPG stove	(referent)	-	-
Solid fuel stove	1.53	0.81; 2.89	0.190
Other stove	3.11	0.93; 10.40	0.065
Males			Pseudo-R^2: 0.208
Electric stove	1.43	0.49; 4.14	0.551
LPG stove	(referent)	-	-
Solid fuel stove	1.49	0.51; 4.37	0.469
Other stove	1.72	0.16; 18.42	0.654
Females			Pseudo-R^2: 0.258
Electric stove	(referent)	-	-
LPG stove	1.13	0.51; 2.48	0.764
Solid fuel stove	1.78	1.30; 2.42	**<0.001**
Other stove	4.60	1.32; 16.04	**0.017**
Type of heating			Pseudo-R^2: 0.241
Central heating	1.10	0.82; 1.47	0.529
District heating	1.27	0.64; 2.51	0.499
Electrical heater	1.14	0.73; 1.79	0.554
Manufactured stove	(referent)	-	-
Heat pump	3.34	1.10; 10.01	**0.033**
Air conditioner	1.48	0.70; 3.12	0.303
Other heating device	2.03	1.50; 2.75	**<0.001**
In summer			Pseudo-R^2: 0.234
Central heating	1.04	0.76; 1.42	0.819
District heating	0.43	0.15; 1.23	0.115
Electrical heater	0.48	0.25; 0.90	**0.023**
Manufactured stove	(referent)	-	-
Heat pump	1.91	0.52; 7.06	0.334
Air conditioner	1.49	0.68; 3.28	0.316
Other heating device	2.02	1.46; 2.79	**<0.001**

Table 5. *Cont.*

Factor	Adjusted Odds Ratio	95% Confidence Interval	*p*-Value
In Winter			Pseudo-R^2: 0.237
Central heating	1.09	0.81; 1.46	0.566
District heating	0.62	0.26; 1.48	0.280
Electrical heater	1.29	0.83; 2.01	0.248
Manufactured stove	(referent)	-	-
Heat pump	3.49	1.16; 10.54	**0.026**
Air conditioner	1.35	0.62; 2.94	0.456
Other heating device	1.93	1.41; 2.63	**<0.001**
Cigarettes per day	1.00	0.99; 1.01	0.556

3.6. Respiratory Disease

Respiratory disease, mainly asthma, was more often reported by females (aORs about 1.33), those of older age (+5% per year), and those with lower educational achievements (about 20% change per step). Female gender did not alter the effect of type of cooking stove. Type of heating had a somewhat stronger effect on symptoms in winter, at least when considering the model fit (pseudo-R^2). Neither duration nor frequency of cooking had a direct effect on symptoms, and there was also no visible sign of interaction with type of stove. The effects of the exposures of interest are shown in detail in Table 6.

Table 6. Determinants of the rates of respiratory disease.

Factor	Adjusted Odds Ratio	95% Confidence Interval	*p*-Value
Type of stove			Pseudo-R^2: 0.093
Electric stove	1.83	0.57; 5.87	0.309
LPG stove	(referent)	-	-
Solid fuel stove	2.19	0.68; 7.07	0.191
Other stove	2.01	0.21; 21.01	0.533
Type of stove			Pseudo-R^2: 0.106
Central heating	1.08	0.70; 1.68	0.721
District heating	0.93	0.28; 3.06	0.906
Electrical heater	1.49	0.81; 2.75	0.205
Manufactured stove	(referent)	-	-
Heat pump	9.34	3.34; 26.29	**<0.001**
Air conditioner	1.72	0.60; 4.92	0.309
Other heating device	2.06	1.33; 3.18	**0.001**
In summer			Pseudo-R^2: 0.094
Central heating	0.56	0.29; 1.10	0.091
District heating	(missing)		
Electrical heater	0.62	0.21; 1.78	0.370
Manufactured stove	(referent)	-	-
Heat pump	4.90	1.09; 22.06	**0.038**
Air conditioner	0.64	0.09; 4.75	0.659
Other heating device	1.51	0.84; 2.71	0.164
In Winter			Pseudo-R^2: 0.110
Central heating	1.10	0.68; 1.76	0.696
District heating	0.38	0.05; 2.84	0.349
Electrical heater	1.92	1.04; 3.53	**0.036**
Manufactured stove	(referent)	-	-
Heat pump	11.48	4.06; 32.45	**<0.001**
Air conditioner	2.13	0.74; 6.14	0.160
Other heating device	1.78	1.11; 2.89	**0.019**
Cigarettes per day	1.01	1.01; 1.02	**0.003**

3.7. Summary of Regression Results by Exposure

Number of cigarettes smoked per day, causing active and passive exposure, was significantly associated with all outcomes but heart disease. Considering the inherent uncertainties when number of cigarettes is reported, a one to two percent increase in risk per one cigarette per day is deemed a moderately strong effect. Given the cross-sectional nature of this study, reverse causation cannot be dismissed. With chronic diseases like heart disease, we might assume that smoking is reduced because of doctors' advice.

Both among cooking and heating, "other devices" usually gave strong signals indicating higher risk. This was especially true for "other stoves" with adjusted odds ratios as high as about 65 (irritation of the eyes, etc.). Regarding stoves, apart from the "other" category, usually cooking with gas and with electricity fared similarly well. Only for headaches was a significant difference observed, with higher odds for gas. Solid fuel stoves always led to the highest odds ratios (between 1.5 and 2 compared to clean cooking fuel).

Among the heating devices, the order was not so clear cut. Manufactured stoves were usually associated with the lowest risks. Only in some instances were they outperformed by district heating, but never significantly so. In two instances, district heating was even significantly worse than manufactured stoves. Heat pumps and air conditioners were used too rarely for clear conclusions to be drawn.

4. Discussion

In line with our expectations, number of cigarettes smoked was significantly associated with all the analyzed symptoms. This does give some credence to the reported rates of symptoms and to the findings of this study.

We had expected an association between heating and cooking fuels with symptoms in the sense that fuels producing more air pollution locally (solid fuels > oil > gas > electricity and distant heating) would produce more symptoms. Our hypothesis was not fully supported by the data. In contrast, the highest symptom rates were reported for people living in homes with "other" heating and cooking devices. These "other" categories both for cooking and heating devices mostly indicated a poor or missing heating and/or cooking system. It might rather be seen as an indicator of poor socioeconomic conditions, not of a source of local air pollution. This finding, although not expected originally, was far from unexpected. It is noteworthy that this indicator of poor housing conditions had a rather strong impact, while our "official" indicator of socioeconomic status, educational achievement, did not show such consistent effects, with a higher prevalence of irritation of the eyes, nose, and throat in better educated males but (in both genders) leading to less headaches, dizziness, and fatigue on the one hand and difficulty breathing and respiratory but also heart disease on the other hand. The other symptoms were not influenced by educational achievement.

Socioeconomic disparities in lung health are well established [37], but education might not be an optimal predictor of socioeconomic status in Kosovo where political unrest and economic turmoil might have interrupted many "normal" occupational careers.

Disregarding the "other" categories for cooking and heating devices, we still found some differences between the fuel types. These differences were weak, and the effect strengths did not always differ between the genders for cooking fuels and between the seasons for heating fuels. Partly, when we consider more chronic diseases, it is maybe not so surprising that the effects of heating fuels are still seen in summer. Since the survey had been conducted in November, the health status in the last summer was more easily remembered than that in last winter. Therefore, the summer health effects could maybe be estimated with less (non-differential) measurement error.

Also, central district heating, usually considered a very clean source of heat locally, often gave very high odds ratios (for irritation of the eyes, nose, and throat, and for headaches, dizziness, and fatigue) even after controlling for urban/rural region. This might be due to the fact that central district heating is only available in three urban centers. These centers derive the necessary energy for their district heating network from nearby heavily polluting industrial complexes and power plants. Outdoor air quality, therefore, is heavily compromised in these communities, especially in winter time. However, in general, central heating is considered cleaner than the heat production separately in each building. Indeed, we also recently demonstrated that for Kosovo, outdoor air quality has a massive impact on indoor air quality [38]. Thus, when the central source of heat does not comply with national and international emission standards, effects on air quality and health can still be severe.

Also, electrical heaters (again for irritation of the eyes, nose, and throat and for headaches, dizziness, and fatigue) and heat pumps (for headaches, dizziness, and fatigue, for heart disease, and for respiratory disease and difficulties breathing) were associated with higher odds ratios in some cases, even showing stronger effects in winter. This observation is difficult to interpret. But maybe, again, this type of heating acts as a proxy for general housing conditions. Old, poorly isolated houses without a working heating system might have been equipped with an electrical heater which did not require the construction of a chimney or other structures. Given the frequent black-outs in the country, electrical heating might not provide comfortable warmth through the whole winter.

With cooking devices, the results were more in line with a priori expectations. Solid fuel stoves were usually associated with higher odds ratios, and for these symptoms where a gender difference was observed, this effect was usually stronger in females, even though a formal interaction model did not reach significance.

Also, regarding cooking with gas, odds ratios were sometimes (for headaches and for difficulty breathing, although not always) higher than for cooking with electrical stoves. This could be explained by the fact that cooking with gas is a relevant source of indoor nitrogen dioxide. For example, lung function in children, especially girls, living in households with gas cooking was significantly worse than in children from households with electrical stoves [39,40].

Heating and especially cooking with solid fuels are still mostly carried out in developing countries. Many studies performed in these countries have mostly found that acute lower respiratory tract infections, including pneumonia in young children, chronic obstructive pulmonary disease, and lung cancer, have a high correlation with the burning of solid fuels for heating and cooking [41].

A study from rural areas in India found that housewives who regularly cook with traditional biomass fuels are at a greater risk of developing CVD in their reproductive age than their age-matched neighbors who cook with cleaner fuel (LPG) [42].

The survey only asked about some household factors and not others that might also have affected the health of the household dwellers. Other important and unfortunately not assessed housing conditions would be mold and dampness [43–45], the use and type of cleaning products [46], incenses, or candles, and also cohabitation with animals [44].

5. Conclusions

Air pollution is a significant issue in Kosovo, and the burden of disease associated with IAP exposure is a growing concern both in Kosovo and worldwide. Indoor air pollution increases mortality and morbidity from non-communicable cardiovascular and respiratory diseases. Effective interventions encompassing policy and financial commitments are required.

The survey created a knowledge base to address IAP disparities and understand energy use and its societal and health impacts. The survey collected data from 2000 households across Kosovo regarding energy sources and technologies used for cooking and heating to evaluate the baseline situation and enable more efficient planning of activities to prevent and control IAP.

Low-income families should be supported in accessing energy-efficient and environmentally friendly heating and cooking sources. Educational public health programs and campaigns should be developed to raise awareness about the health effects of air pollution, including the adverse health effects of ETS in Kosovar households.

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Appendix A Questions from the Survey That Were Used for the Statistical Analyses

Questions on Exposure	Possible Responses
What does your household use for cooking most of the time, including cooking food, making tea/coffee, boiling drinking water?	Electric stove Liquefied petroleum gas (LPG) Cooking gas stove Manufactured solid fuel stove Others *
What does this household use most of the time for heating?	Individual central heating Central heating (municipal) Electrical heater Manufactured stove Heat pump Air Conditioner Others *

* "Others" was explained in free text. A variety of explanations were provided for that category but, mostly regarding cooking stoves, they turned out to mean, "we do not cook food usually at home" or "our stove is currently out of order". Similarly, regarding heating devices, they could mostly be interpreted as "no functioning heating system available currently".

Questions on Symptoms	Possible Responses
Do you/the person we talk about suffer from. . . Irritation of the eyes, nose, and throat? Headaches, dizziness, and fatigue? Difficulty breathing? Heart disease? Asthma/respiratory disease?	No Sometimes Yes In last spring In last summer * In last fall In last winter *

* Because use of heating fuels will have a stronger effect during the heating season, we analyzed effects of heating on symptoms rate in summer and in winter separately.

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