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PUBLIC ATTITUDES TOWARD PERSONAL AND POPULATION INTERVENTIONS TO REDUCE AIR POLLUTION EXPOSURE: A 2025 NATIONWIDE CROSS-SECTIONAL SURVEY IN POLAND

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Highlights

- More than three-quarters of respondents perceived air pollution as a serious issue.
- Fewer than half respondents reported using personal protective measures.
- Interventions targeting industry received a high level of support.
- Measures targeting individuals, such as limiting private vehicle use, received less support.
- There is an ongoing need for targeted educational and financial support measures.

Abstract

Objectives: The air in Poland is among the most polluted in Europe. This study aimed to assess public attitudes towards personal and population measures for reducing air pollution exposure. **Material and Methods:** A cross-sectional study was conducted in May 2025 using a computer-assisted web interview (CAWI) questionnaire on a representative sample of 1092 adults in Poland, selected through quota sampling. **Results:** Air pollution in Poland was considered a significant issue requiring action from public authorities by 76.4% of participants. Women (aOR: 1.47, 95% CI: 1.11–1.96, $p = 0.008$), participants aged ≥60 years (aOR: 2.49, 95% CI: 1.59–3.91, $p < 0.001$), and residents of cities with populations of 20 000–499 999 ($p < 0.05$) were more likely to hold this view. The most common protective measures applied in the last 12 months included keeping windows closed during poor air quality episodes (44.2%) and avoiding time outdoors (36.5%). The imposition of fines for burning prohibited materials in domestic furnaces was supported by 70.2% of participants. Support was more likely among participants aged ≥60 years (aOR: 1.57, 95% CI: 1.03–2.41, $p = 0.04$), those with higher education (aOR: 1.55, 95% CI: 1.18–2.04, $p = 0.002$), urban residents ($p < 0.05$), and those with good household economic status (aOR: 1.53, 95% CI: 1.02–2.29, $p = 0.04$). **Conclusions:** A gap exists between the perception of air pollution as a significant issue and the willingness to apply appropriate mitigation measures. Public knowledge of the effectiveness of air pollution interventions remains insufficient. Int J Occup Med Environ Health. 2026;39(5):523–42

Key words:
Poland, air pollution, attitude, perception, surveys and questionnaires, environmental hazards preventions

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INTRODUCTION

Ambient air pollution exposure is a global public health concern, with 99% of the global population living in areas that do not meet current air quality standards [1]. Polish cities have had the worst air quality across the EU [2] and the highest estimated particular matter 2.5 ($PM_{2.5}$) mortality burden in Europe alongside Italian and Czech agglomerations [3].

As a consequence, in the last 2 decades, environmental health has grown in significance as an element of public health policies nationally and across the world. Public health agencies and public authorities work jointly on local and global measures to reduce air pollution exposure and minimize its negative health and socio-economic consequences. In 2021, the WHO proposed stringent global air quality requirements [4]. In 2024, the EU introduced the updated version of the air quality directive, which will become binding in 2030 [5]. The document introduces stricter requirements for air pollutants' concentration limits, forcing EU member countries to act rapidly on the matter. It is estimated to decrease the number of premature deaths due to air pollution by as much as 55% and provide significant savings in health care and socio-economic costs [6].

Reducing exposure to air pollutants can be achieved in many ways, through both personal and population interventions. The most common personal interventions include wearing protective masks, actively tracking local air pollution levels, limiting time spent outside and outdoor physical activity, and closing windows during episodes of increased pollution [7]. Other measures, such as the use of air purifiers, changes in means of transport, and relocation, are less frequently applied [8,9]. All of them allow for a limited reduction in exposure to air pollution; however, they require a high level of health literacy, engagement, and motivation from the individual involved, and are thus much more likely to be adopted by the more educated and privileged citizens.

It is considered much more effective to take action against air pollution on local, national, and international levels. Among the most efficient population interventions, most require introducing legislative action and control measures that aim to eliminate the main pollution sources rather than reduce exposure [10]. These include limitations and taxation of emissions from the industry and switching to cleaner, renewable energy sources, alteration of the city and transport infrastructure (e.g., designing bypasses, improving public bus and train transport, limiting road traffic), incentives and subsidies to upgrade domestic heating systems, and prohibition of illegal waste burning [10,11].

Poland is still among the most polluted European countries [12], although a significant improvement in air quality has been observed over the last 10 years [2]. This has mainly been due to legislative reforms introduced at the international, national, and municipal levels. One of the pivotal actions was the introduction of the Clean Air Program in 2018 [13], which encouraged the replacement of domestic heating systems and renovation by providing subsidies for citizens living in single-family houses. The program gained significant popularity and resulted in the renovation of more than 400 000 households [13].

However, investigating the social perception of air pollution and its control measures has only recently become a subject of interest for public health professionals in Poland. This study aimed to characterize public attitudes towards personal and population interventions to reduce air pollution exposure in a representative sample of adults in Poland.

MATERIAL AND METHODS

Study design and sample

This survey was carried out June 6–10, 2025 in Poland using a computer-assisted web interview (CAWI) method through the Nationwide Research Panel Ariadna site [14].

A sample of 1092 participants was recruited from >100 000 registered users. The Nationwide Research Panel Ariadna is an online research panel of individuals who voluntarily register to participate in survey research. Panel

members are recruited through multiple online channels, and the panel is continuously monitored and updated to maintain an active pool of respondents. For individual studies, eligible panel members are invited to participate according to predefined sampling criteria. To ensure that the sample was representative of the general Polish population, as described in the annual report on the demographic characteristics from the Statistics Poland [15], quota sampling was used. Quotas were based on age, sex, and place of residence. Respondents were required to answer all survey questions; therefore, there were no missing data.

The study adhered to the principles of the Declaration of Helsinki. Participation was voluntary and anonymous, and informed consent was collected. The study protocol was approved by the Ethics Committee at the Centre of Postgraduate Medical Education, Warsaw, Poland (decision No. 42/2025, May 14, 2025).

Measures

The study questionnaire contained 10 questions on knowledge of air-polluting substances, sources of air pollution in Poland, susceptible populations, health risks of exposure to air pollution, social perceptions of air pollution, and knowledge and support for air pollution mitigation strategies.

The questions were based on a literature review [16–18]. Three questions were multiple-choice, and 2 were single-choice agreement questions incorporating the 5-point Likert scale with possible answers of "definitely yes," "rather yes," "rather no," "definitely no," and "hard to say." To facilitate the analysis, the responses of "definitely yes" and "rather yes" were combined.

In addition, all participants provided information on their marital status, household size, residence, number of children, education level, occupational status, and economic status.

Statistical analysis

The survey results by categorical variables were presented in tables using response counts and proportions. The χ^2 test of independence was used to test the relationship between the sociodemographic characteristics of the participants and the questionnaire answers. Sociodemographic and socioeconomic variables were included to assess population-level differences in attitudes toward air pollution interventions and were analyzed consistently across study outcomes. The sociodemographic factors associated with the odds of a given response were identified using logistic regression. Univariable regression was used to select statistically significant factors for inclusion in a multivariable model. The results of logistic regression analyses were presented using odds ratios (OR), 95% confidence intervals (95% CI), and p-values, where values ≤0.05 were considered statistically significant. IBM SPSS v. 29 (Armonk, NY, USA) was used for all analyses.

RESULTS

Sociodemographic characteristics of the study population

The study included 611 women (56%) and 481 men (44%). Nearly one-third (30.4%) of participants were aged ≥60 years. The majority (64.6%) of participants resided in urban areas. Detailed characteristics of the study population are presented in Table 1.

Public attitudes towards methods of preventing air pollution exposure

The most commonly used protection method against air pollution among respondents in the past 12 months was keeping windows closed or avoiding ventilation during poor air quality episodes (44.2%), followed by avoiding time outdoors when air quality was poor (36.5%) and checking local air quality information (29.4%). Only 5.7% of participants reported relocating to avoid air pollution (Table 2). Most participants considered green zones (63.6%) and industrial chimney filters (60.3%) to be effective measures for improving air quality. More than half (53.9%) considered increasing the use of renew-

Table 1. Characteristics of the study population comprising a representative sample of Polish adults, Poland, 2025

Variable	Participants (N = 1092)	
	n	%
Gender		
female	611	56.0
male	481	44.0
Age group		
18–29 years	157	14.4
30–39 years	197	18.0
40–49 years	216	19.8
50–59 years	190	17.4
≥60 years	332	30.4
Having higher education		
yes	526	48.2
no	566	51.8
Currently married		
yes	586	53.7
no	506	46.3
Place of residence		
rural area	387	35.4
city		
<20 000 residents	143	13.1
20 000–99 999 residents	228	20.9
100 000–499 999 residents	186	17.0
≥500 000 residents	148	13.6
Having children <18 years old		
yes	280	25.6
no	812	74.4
Number of household members		
1 (living alone)	160	14.7
2	438	40.1
≥3	494	45.2
Occupational status		
active	663	60.7
passive	429	39.3
Self-reported household economic status		
good	554	50.7
moderate	396	36.3
bad	142	13.0

able energy sources and replacing non-ecological heating sources as effective. Only 9.8% of participants thought that introducing paid parking zones would improve air quality (Table 2). The most supported legal measures for reducing air pollution were imposing taxes on companies and facilities emitting pollutants (53.7%), mandatory replacement of old domestic heating systems (52.6%), and imposing strict emission limits on industrial facilities (48.5%). Only 9.9% of participants supported banning the production of internal combustion engine vehicles (Table 2). The majority of participants (38.9% "definitely yes" and 31.3% "rather yes") supported authorizing local and state law enforcement to impose fines for burning prohibited materials in domestic furnaces or fireplaces (Table 2). Over three-quarters of participants (37.6% "definitely yes" and 38.8% "rather yes") agreed that air pollution is a serious issue that should be prioritized by public authorities (Table 2).

Socio-economic differences in the use of methods to protect against air pollution exposure

Avoiding time outdoors when air quality was poor was more common ($p < 0.05$) among women, participants with higher education, and those living in larger cities (≥20 000 residents) (Table 3). Monitoring local air quality information was also more common ($p < 0.05$) among participants with higher education and those living in larger cities, as was the use of air purifiers at home (Table 3). Using air purifiers was also more frequently reported ($p < 0.05$) by participants with children <18 years old, those living in larger households (2 members, ≥3 members), and those who were occupationally active. In addition, these groups, along with younger participants (18–29 years, 30–30 years, 40–49 years), were more likely ($p < 0.05$) to report wearing protective masks during episodes of poor air quality (Table 3). Relocating to avoid air pollution was a strategy observed more often ($p < 0.05$) among younger participants (18–29 years, 30–39 years),

Table 2. Public attitudes toward air pollution exposure prevention methods among Polish adults, Poland, 2025

Variable	Participants (N = 1092)	
	n	%
In the past 12 months, have you used any of the following methods to protect yourself against air pollution exposure? (select all that apply)		
checking information about the current level of air pollution in your area	321	29.4
using an air purifier at home	206	18.9
wearing a protective mask during episodes of poor air quality	109	10.0
avoiding spending time outdoors when air quality is poor	399	36.5
limiting physical activity when air quality is poor	271	24.8
keeping windows closed or avoiding ventilation during episodes of poor air quality	483	44.2
relocating due to poor air quality	62	5.7
Which of the following measures do you consider effective in improving air quality? (select all that apply)		
replacing non-ecological heat sources (e.g., domestic coal-fired boilers)	552	50.5
banning the use of solid fuels (e.g., coal, wood, pellet) for building heating	325	29.8
increasing the use of renewable energy sources	589	53.9
replacing internal combustion engine vehicles with hybrid or electric vehicles	250	22.9
establishing low-emission zones in cities (areas accessible only to low-emission vehicles)	297	27.2
introducing paid parking zones	107	9.8
constructing bypass roads	390	35.7
improving accessibility to public transport (e.g., railway systems)	476	43.6
installing industrial chimney filters	659	60.3
creating green zones	695	63.6
implementing educational campaigns on the causes and consequences of air pollution	405	37.1
Do you support the following legal regulations aimed at reducing air pollution? If yes, which ones? (select all that apply)		
mandatory replacement of old domestic heating systems with newer, more environmentally friendly models	574	52.6
banning entry of old vehicles into cities	233	21.3
restricting car traffic in urban areas	300	27.5
introducing strict emission limits for industrial facilities	530	48.5
banning the production of internal combustion engine vehicles	108	9.9
closing coal mines in Poland	252	23.1
imposing taxes on companies and facilities that emit pollutants	586	53.7
Do you believe that municipal police or law enforcement should be authorized to impose financial penalties for burning prohibited materials in domestic furnaces or fireplaces?		
definitely yes	425	38.9
rather yes	342	31.3
rather no	78	7.1
definitely no	83	7.6
I do not know	164	15.0

Table 2. Public attitudes toward air pollution exposure prevention methods among Polish adults, Poland, 2025 – cont.

Variable	Participants (N = 1092)	
	n	%
In your opinion, is air pollution a serious issue that should be prioritized by public authorities?		
definitely yes	411	37.6
rather yes	424	38.8
rather no	110	10.1
definitely no	40	3.7
I do not know	107	9.8

participants with children <18 years, and those living in larger households (Table 3).

There were no significant differences in the use of protective methods against air pollution exposure by marital status or household economic status (Table 3).

Socio-economic differences in perceived effectiveness of air quality improvement measures

Recognition of green zones as effective measures for improving air quality was higher ($p < 0.05$) in the oldest age group (≥60 years), participants without children <18 years old, those living in smaller households (1 member [living alone], 2 members), those occupationally inactive, and women (Table 4). Female participants were also more likely ($p < 0.05$) to recognize the importance of educational campaigns for improving air quality, as were participants with higher education and those living in large cities (100 000–499 999 residents) (Table 4). Moreover, participants from large cities more often ($p < 0.05$) indicated establishing low-emission zones in cities and banning the use of solid fuels for heating as effective (Table 4).

The use of renewable energy sources and replacing non-ecological heat sources were more often ($p < 0.05$) recognized as effective air quality improvement measures by the oldest participants (≥60 years), participants with higher education, those living in larger cities (≥20 000 residents), those without children <18 years, and those with good household economic status (Table 4).

Socio-economic differences in support for legal regulations to reduce air pollution

Penalty taxes and emission limits were more often ($p < 0.05$) endorsed by women, the oldest participants (≥60 years), participants with higher education, those without children <18 years, and those living in smaller households (1 member [living alone], 2 members) (Table 5). These groups were also more supportive ($p < 0.05$) of closing coal mines in Poland. The mandatory replacement of old domestic heating systems was also more often supported by these groups (apart from women, since no significant gender differences were observed), as well as participants with good household economic status, and those living in larger cities (≥20 000). Participants living in larger cities were also more likely ($p = 0.04$) to support banning the entry of old vehicles into cities (Table 5).

Banning the production of internal combustion engine vehicles was favored ($p < 0.05$) by participants without higher education, those with children <18 years, and occupationally active participants (Table 5).

There were no significant differences in public support for legal measures against air pollution by marital status.

Table 3. Socio-economic differences in public attitudes toward air pollution exposure prevention methods among Polish adults, Poland, 2025

Variable	Participants using in the past 12 months any method to protect themselves against air pollution exposure													
	total (N = 1092) [n]	checking information about the current level of air pollution in your area		using an air purifier at home		wearing a protective mask during episodes of poor air quality		avoiding spending time outdoors when air quality is poor		limiting physical activity when air quality is poor		keeping windows closed or avoiding ventilation during episodes of poor air quality		relocating due to poor air quality	
		%	p	%	p	%	p	%	p	%	p	%	p	%	p
Gender			0.07		0.7		0.2		<0.001		0.03		<0.001		0.1
female	611	31.6		19.3		8.8		43.7		27.3		48.8		4.7	
male	481	26.6		18.3		11.4		27.4		21.6		38.5		6.9	
Age group			0.1		0.07		0.04		0.1		0.4		0.6		<0.001
18–29 years	157	28.0		21.7		13.4		33.8		21.7		46.5		10.2	
30–39 years	197	32.0		23.9		12.7		38.6		28.9		43.7		10.2	
40–49 years	216	27.8		20.8		12.0		29.6		22.7		41.7		4.6	
50–59 years	190	23.2		15.3		6.3		37.4		22.6		41.1		4.2	
≥60 years	332	33.1		15.5		7.5		40.7		26.5		47.0		2.4	
Having higher education			0.004		0.02		0.5		0.03		0.006		0.003		0.9
yes	526	33.5		21.9		9.3		39.9		28.5		48.9		5.7	
no	566	25.6		16.1		10.6		33.4		21.4		39.9		5.7	
Currently married			0.7		0.4		0.4		0.3		0.5		0.8		0.7
yes	586	29.9		19.8		10.8		35.0		25.6		43.9		5.5	
no	506	28.9		17.8		9.1		38.3		23.9		44.7		5.9	
Place of residence			0.002		0.04		0.6		0.01		0.1		0.3		0.4
rural area	387	23.3		15.5		9.0		31.0		21.7		41.3		4.4	
city															
<20 000 residents	143	25.9		14.7		13.3		32.2		20.3		42.7		4.9	
20 000–99 999 residents	228	31.6		22.4		9.6		43.0		27.6		48.2		7.0	
100 000–499 999 residents	186	38.2		19.9		10.8		40.3		28.5		48.4		5.4	
≥500 000 residents	148	34.5		25.0		8.8		40.5		28.4		41.9		8.1	

Table 3. Socio-economic differences in public attitudes toward air pollution exposure prevention methods among Polish adults (N = 1092), Poland, 2025 – cont.

Variable	Participants using in the past 12 months any method to protect themselves against air pollution exposure														
	total (N = 1092) [n]	checking information about the current level of air pollution in your area		using an air purifier at home		wearing a protective mask during episodes of poor air quality		avoiding spending time outdoors when air quality is poor		limiting physical activity when air quality is poor		keeping windows closed or avoiding ventilation during episodes of poor air quality		relocating due to poor air quality	
		%	p	%	p	%	p	%	p	%	p	%	p	%	p
Having children <18 years old			0.7		0.01		0.04		0.1		0.9		0.3		0.002
yes	280	30.4		23.9		13.2		32.5		25.0		41.4		9.3	
no	812	29.1		17.1		8.9		37.9		24.8		45.2		4.4	
Number of household members			0.3		0.04		0.008		0.3		0.1		0.4		0.01
1 (living alone)	160	26.9		13.1		4.4		33.1		18.1		40.0		1.9	
2	438	27.6		17.8		9.1		39.3		25.8		44.1		4.8	
≥3	494	31.8		21.7		12.6		35.2		26.1		45.7		7.7	
Occupational status			0.5		<0.001		0.008		0.09		0.9		0.9		<0.001
active	663	30.2		22.9		11.9		34.5		24.9		44.0		7.5	
passive	429	28.2		12.6		7.0		39.6		24.7		44.5		2.8	
Self-reported household economic status			0.2		0.07		0.8		0.8		0.4		0.1		0.1
good	554	31.2		21.5		10.3		37.4		26.0		46.9		7.0	
moderate	396	29.0		16.7		10.1		35.4		24.7		42.9		4.0	
bad	142	23.2		14.8		8.5		36.6		20.4		37.3		4.9	

[a] Positive answers – yes.

Table 4. Socio-economic differences in public attitudes toward the effectiveness of selected measures to improve air quality among Polish adults, Poland, 2025

Variable	total (N = 1092) [n]	Participants considering measures effective in improving air quality[a]																					
		1		2		3		4		5		6		7		8		9		10		11	
		%	p	%	p	%	p	%	p	%	p	%	p	%	p	%	p	%	p	%	p	%	p
Gender			0.9		0.7		0.2		0.9		0.02		0.6		0.4		0.7		0.9		<0.001		<0.001
female	611	50.5		30.3		55.5		22.7		30.0		9.3		34.5		44.0		60.4		70.5		42.2	
male	481	50.7		29.1		52.0		23.1		23.7		10.4		37.2		43.0		60.3		54.9		30.6	
Age group			<0.001		<0.001		<0.001		0.09		0.003		0.8		<0.001		0.09		<0.001		<0.001		0.1
18–29 years	157	41.4		20.4		46.5		21.0		24.2		11.5		19.7		41.4		48.4		50.3		33.8	
30–39 years	197	48.2		25.4		48.7		18.3		25.9		9.6		30.5		42.6		52.8		57.9		37.1	
40–49 years	216	42.1		27.8		50.0		19.9		19.0		8.3		26.9		37.0		53.2		57.9		31.0	
50–59 years	190	52.1		30.0		53.2		24.7		28.4		11.6		39.5		50.0		63.2		68.4		43.2	
≥60 years	332	60.8		38.0		63.6		27.4		34.0		9.0		50.0		45.8		73.5		74.4		39.2	
Having higher education			<0.001		0.2		0.002		0.7		0.2		0.4		0.3		<0.001		<0.001		0.2		<0.001
yes	526	59.3		31.7		58.7		22.4		28.9		10.6		37.3		49.2		65.8		65.4		42.6	
no	566	42.4		27.9		49.5		23.3		25.6		9.0		34.3		38.3		55.3		62.0		32.0	
Currently married			0.3		0.5		0.9		0.3		0.9		0.7		<0.001		0.5		0.2		0.8		0.1
yes	586	49.1		28.8		53.9		21.7		27.3		10.1		40.4		42.7		62.3		63.3		35.0	
no	506	52.2		30.8		54.0		24.3		27.1		9.5		30.2		44.7		58.1		64.0		39.5	
Place of residence			<0.001		0.008		0.01		0.02		0.006		0.7		0.7		0.1		0.3		0.07		0.03
rural area	387	41.3		24.5		50.1		18.1		23.8		9.0		33.3		40.1		57.1		58.1		32.8	
city																							
<20 000 residents	143	47.6		25.2		46.9		20.3		18.9		8.4		36.4		39.2		65.7		69.2		37.1	
20 000–99 999 residents	228	53.9		33.3		59.6		29.4		29.4		9.6		38.2		44.3		64.0		65.8		36.0	
100 000–499 999 residents	186	62.9		37.6		61.8		24.7		34.9		10.2		34.9		47.8		59.1		67.7		46.8	
≥500 000 residents	148	56.8		32.4		52.0		25.7		31.1		12.8		38.5		50.7		59.5		64.2		37.8	

Table 4. Socio-economic differences in public attitudes toward the effectiveness of selected measures to improve air quality among Polish adults (N = 1092), Poland, 2025 – cont.

Variable	total (N = 1092) [n]	Participants considering measures effective in improving air quality[a]																					
		1		2		3		4		5		6		7		8		9		10		11	
		%	p	%	p	%	p	%	p	%	p	%	p	%	p	%	p	%	p	%	p	%	p
Having children <18 years old			<0.001		0.01		0.02		0.2		0.04		0.9		0.3		0.03		0.007		<0.001		0.3
yes	280	41.1		23.6		47.9		20.0		22.5		10.0		33.2		37.9		53.6		53.9		34.6	
no	812	53.8		31.9		56.0		23.9		28.8		9.7		36.6		45.6		62.7		67.0		37.9	
Number of household members			0.003		0.09		0.8		0.7		0.2		0.6		0.6		0.8		0.07		0.004		0.2
1 (living alone)	160	56.9		36.3		54.4		24.4		28.7		8.1		32.5		45.6		61.9		65.0		38.1	
2	438	54.6		30.4		53.0		23.5		29.5		9.4		37.0		42.5		63.9		68.9		34.0	
≥3	494	44.9		27.1		54.7		21.9		24.7		10.7		35.6		43.9		56.7		58.5		39.5	
Occupational status			0.2		0.2		0.07		0.3		0.5		0.3		0.03		0.9		0.03		0.04		0.8
active	663	48.9		28.4		51.7		21.7		26.5		10.6		33.2		43.7		57.8		61.2		37.4	
passive	429	53.1		31.9		57.3		24.7		28.2		8.6		39.6		43.4		64.3		67.4		36.6	
Self-reported household economic status	554		0.002		0.1		0.02		0.5		0.5		0.3		0.8		0.8		0.6		0.7		0.3
good		55.8		32.5		57.8		24.4		28.3		10.5		35.7		44.6		61.7		64.6		39.0	
moderate	396	46.0		26.8		51.3		21.2		27.0		10.1		36.6		42.2		59.1		63.4		36.4	
bad	142	43.0		27.5		46.5		21.8		23.2		6.3		33.1		43.7		58.5		60.6		31.7	

1 – replacing non-ecological heat sources; 2 – banning the use of solid fuels for building heating; 3 – increasing the use of renewable energy sources; 4 – replacing internal combustion engine vehicles with hybrid or electric vehicles; 5 – establishing low emission zones in cities; 6 – introducing paid parking zones; 7 – constructing bypass roads; 8 – improving accessibility to public transportation; 9 – installing industrial chimney filters; 10 – creating green zones; 11 – implementing educational campaigns on the causes and consequences of air pollution.

[a] Positive answers – yes.

Table 5. Socio-economic differences in public support for legal regulations aimed at reducing air pollution among Polish adults, Poland, 2025

Variable	total (N = 1092) [n]	Participants supporting the legal regulations aimed at reducing air pollution[a]													
		mandatory replacement of old domestic heating systems with newer, more environmentally friendly models		banning entry of old vehicles into cities		restricting car traffic in urban areas		introducing strict emission limits for industrial facilities		banning the production of internal combustion engine vehicles		closing coal mines in Poland		imposing taxes on companies and facilities that emit pollutants	
		%	p	%	p	%	p	%	p	%	p	%	p	%	p
Gender			0.6		0.06		0.2		<0.001		0.6		0.9		0.01
female	611	51.9		23.4		29.0		53.7		10.3		23.1		57.0	
male	481	53.4		18.7		25.6		42.0		9.4		23.1		49.5	
Age group			<0.001		0.6		0.007		<0.001		0.8		<0.001		0.008
18–29 years	157	45.2		19.7		19.1		35.7		12.1		15.3		46.5	
30–39 years	197	47.7		20.8		24.4		44.7		9.6		15.2		51.3	
40–49 years	216	46.3		19.0		24.5		41.2		10.6		20.4		51.9	
50–59 years	190	46.8		20.5		33.7		52.6		10.0		22.1		50.0	
≥60 years	332	66.3		24.4		31.6		59.3		8.4		33.7		61.7	
Having higher education			<0.001		0.2		0.2		<0.001		0.04		0.005		0.004
yes	526	58.0		23.0		29.5		54.4		8.0		26.8		58.2	
no	56	47.5		19.8		25.6		43.1		11.7		19.6		49.5	
Currently married			0.7		0.9		0.9		0.7		0.1		0.3		0.2
yes	586	53.1		21.5		27.5		48.0		8.5		24.4		55.5	
no	506	52.0		21.1		27.5		49.2		11.5		21.5		51.6	
Place of residence			<0.001		0.04		0.6		0.3		0.05		0.06		0.02
rural area	387	43.2		17.6		25.1		46.3		8.8		18.9		48.3	
city															
<20 000 residents	143	48.3		18.9		28.0		45.5		5.6		21.7		55.9	
20 000–99 999 residents	228	61.0		24.1		31.1		54.8		11.8		23.7		59.2	
100 000–499 999 residents	186	64.0		28.0		27.4		49.5		14.5		27.4		59.7	
≥500 000 residents	148	54.1		20.9		27.7		46.6		8.1		29.1		49.3	

Table 5. Socio-economic differences in public support for legal regulations aimed at reducing air pollution among Polish adults (N = 1092), Poland, 2025 – cont.

Variable	total (N = 1092) [n]	Participants supporting the legal regulations aimed at reducing air pollution[a]													
		mandatory replacement of old domestic heating systems with newer, more environmentally friendly models		banning entry of old vehicles into cities		restricting car traffic in urban areas		introducing strict emission limits for industrial facilities		banning the production of internal combustion engine vehicles		closing coal mines in Poland		imposing taxes on companies and facilities that emit pollutants	
		%	p	%	p	%	p	%	p	%	p	%	p	%	p
Having children < 18 years old			0.01		0.5		0.7		0.01		0.03		<0.001		0.003
yes	280	46.1		22.9		26.4		41.8		13.2		15.4		46.1	
no	812	54.8		20.8		27.8		50.9		8.7		25.7		56.3	
Number of household members			0.03		0.7		0.3		0.002		0.1		0.02		0.04
1 (living alone)	160	56.9		18.8		32.5		51.9		11.3		26.9		53.1	
2	438	55.9		21.9		27.2		53.9		7.5		26.3		58.2	
≥3	494	48.2		21.7		26.1		42.7		11.5		19.0		49.8	
Occupational status			0.2		0.3		0.01		0.2		0.02		0.06		0.9
active	663	50.8		22.5		30.2		46.9		11.6		21.1		53.8	
passive	429	55.2		19.6		23.3		51.0		7.2		26.1		53.4	
Self-reported household economic status			<0.001		0.1		0.5		0.4		0.9		0.07		0.7
good	554	60.6		22.9		26.0		50.4		10.1		26.0		54.7	
moderate	396	45.5		21.5		29.3		45.7		9.3		20.2		52.0	
bad	142	40.8		14.8		28.2		49.3		10.6		19.7		54.2	

[a] Positive answers – yes.

Factors associated with attitudes towards fines for domestic burning of banned materials

In the multivariable logistic regression model (Table 6), age ≥60 (aOR: 1.57, 95% CI: 1.03–2.41, p = 0.04), having higher education (aOR: 1.55, 95% CI: 1.18–2.04, p = 0.002), living in urban areas (p < 0.05), and good household economic status (aOR: 1.53, 95% CI: 1.02–2.29, p = 0.04) were significantly associated with support for financial penalties for burning prohibited materials in domestic furnaces or fireplaces. There were no significant differences in support for fines for burning prohibited materials in households by gender, marital status, having children <18 years old, or occupational status (Table 6).

Factors associated with the perception of air pollution as a priority issue for public authorities

In the multivariable logistic regression model (Table 6), female gender (aOR: 1.47, 95% CI: 1.11–1.96, p = 0.008), age ≥60 years (aOR: 2.49, 95% CI: 1.59–3.91, p < 0.001), and living in cities with 20 000–499 999 residents (p < 0.05) were significantly associated with perceiving air pollution as a serious issue that should be prioritized by public authorities.

There were no significant differences in public perception of air pollution as a serious issue by education level, marital status, having children <18 years old, household size, and occupational status (Table 6).

DISCUSSION

Public attitudes toward air pollution and methods of preventing and reducing it, is currently not a common subject of public health research in Poland, and there is a lack of comprehensive international studies to enable comparison of results.

Air pollution is a tremendous problem not only for environmental protection but also for environmental and public health in Poland, generating excess hospitalizations and outpatient visits every year [19–21] and significantly increasing the incidence of numerous chronic diseases: cardiovascular disease, lung disease, cancer, diabetes, rheumatic diseases, and many others [22]. Therefore, an analysis of public awareness and perceptions of air pollution is necessary. The perception of air pollution and its relationship with pro-environmental behavior is a complex issue that has long been of interest to sociological sciences but has received less attention from a public health perspective.

Over the past decade, efforts to improve air quality have intensified in Poland, partly due to pressure from external international institutions such as the EU and the WHO. The numerous subsidy programs introduced for the replacement of domestic heating sources and thermomodernization at the individual and municipal level [23] attracted a large group of beneficiaries [15] and coincided with a visible improvement in air quality in Poland [2].

In this study, over three-quarters of respondents (76.4%) considered air pollution to be a serious problem that should be a priority for public authorities, while 13.7% held the opposite view. These results seem to be comparable to those from a Portuguese study [16], where air pollution was deemed a „major concern" for 27.4% of the respondents and a „moderate concern" for 36.9%, adding up to a total of 64.3% of positive responses. According to a report from Public Opinion Research Centre (Centrum Badania Opinii Społecznej – CBOS) [24], 44% of Poles considered poor air quality a serious problem in their neighborhood, of which 17% labelled it as a very serious problem, while 19% of respondents did not think it an issue.

The authors' study found that the most common personal protective measures taken by respondents over the past year included closing windows or avoiding ventilation during episodes of poor air quality (44.2%) and avoiding spending time outdoors (36.5%). The least frequently used methods were using an air purifier (18.9%), wearing face masks (10%), and changing residence (5.7%). The results

Table 6. Factors associated with support for financial penalties for burning prohibited materials in domestic furnaces or fireplaces and perceptions of air pollution as a serious issue that should be prioritized by public authorities among Polish adults (N = 1092), Poland, 2025

Variable	Municipal police or law enforcement should be authorized to impose financial penalties for burning prohibited materials in domestic furnaces or fireplaces[a]							Air pollution is a serious issue that should be prioritized by public authorities[a]						
	participants (N = 1092)		p	univariable logistic regression		multivariable logistic regression		participants (N = 1092)		p	univariable logistic regression		multivariable logistic regression	
	n	%		OR (95% CI)	p	aOR (95% CI)	p	n	%		OR (95% CI)	p	aOR (95% CI)	p
Gender			0.8							0.01				
female	611	70.5		1.03 (0.80–1.34)	0.8			611	79.4		1.44 (1.09–1.91)	0.01	1.47 (1.11–1.96)	0.008
male	481	69.9		ref.				481	72.8		ref.		ref.	
Age group			0.1							0.001				
18–29 years	157	66.2		ref.		ref.		157	67.5		ref.		ref.	
30–39 years	197	67.0		1.04 (0.66–1.61)	0.9	0.97 (0.61–1.53)	0.9	197	73.6		1.34 (0.85–2.13)	0.2	1.35 (0.85–2.15)	0.2
40–49 years	216	70.4		1.21 (0.78–1.88)	0.4	1.15 (0.73–1.82)	0.5	216	75.0		1.44 (0.92–2.27)	0.1	1.43 (0.90–2.27)	0.1
50–59 years	190	67.9		1.08 (0.69–1.69)	0.7	1.18 (0.74–1.88)	0.5	190	75.8		1.51 (0.94–2.41)	0.09	1.51 (0.94–2.44)	0.09
≥60 years	332	75.3		1.55 (1.03–2.35)	0.04	1.57 (1.03–2.41)	0.04	332	83.7		2.48 (1.59–3.86)	<0.001	2.49 (1.59–3.91)	<0.001
Having higher education			<0.001							0.2				
yes	526	75.9		1.69 (1.30–2.20)	<0.001	1.55 (1.18–2.04)	0.002	526	78.3		1.22 (0.92–1.62)	0.2		
no	566	65.0		ref.		ref.		566	74.7		ref.			
Currently married			0.2							0.3				
yes	586	71.8		1.18 (0.91–1.53)	0.2			586	77.8		1.18 (0.89–1.56)	0.3		
no	506	68.4		ref.				506	74.9		ref.			
Place of residence			<0.001							<0.001				
rural area	387	62.0		ref.		ref.		387	71.3		ref.		ref.	
city														
<20 000 residents	143	72.0		1.58 (1.04–2.40)	0.03	1.54 (1.01–2.35)	0.04	143	69.9		0.94 (0.62–1.42)	0.8	0.92 (0.60–1.41)	0.7
20 000–99 999 residents	228	72.8		1.64 (1.15–2.34)	0.007	1.55 (1.08–2.22)	0.02	228	84.2		2.15 (1.41–3.26)	<0.001	2.16 (1.41–3.29)	<0.001
100 000–499 999 residents	186	80.1		2.47 (1.63–3.73)	<0.001	2.26 (1.49–3.45)	<0.001	186	82.8		1.94 (1.25–3.01)	0.003	1.93 (1.23–3.01)	0.004
≥500 000 residents	148	73.6		1.71 (1.13–2.60)	0.01	1.61 (1.05–2.47)	0.03	148	76.4		1.30 (0.84–2.01)	0.2	1.32 (0.85–2.06)	0.2
Having children <18 years old			0.4							0.9				
yes	280	68.2		0.88 (0.66–1.18)	0.4			280	76.8		1.02 (0.74–1.41)	0.9		
no	812	70.9		ref.				812	76.4		ref.			

Number of household members			0.8					0.3				
1 (living alone)	160	70.0	1.04 (0.70–1.53)	0.9		160	76.9		1.14 (0.75–1.73)	0.5		
2	438	71.5	1.11 (0.84–1.48)	0.5		438	78.5		1.25 (0.92–1.70)	0.1		
≥3	494	69.2	ref.			494	74.5		ref.			
Occupational status			0.1					0.9				
active	663	71.9	1.23 (0.94–1.60)	0.1		663	76.5		1.01 (0.75–1.33)	0.9		
passive	429	67.6	ref.			429	76.5		ref.			
Self-reported household economic status			0.01					0.03				
good	554	74.2	1.71 (1.16–2.53)	0.007	1.53 (1.02–2.29)	0.04	554	79.8		1.39 (0.91–2.13)	0.1	
moderate	396	67.4	1.23 (0.83–1.84)	0.3	1.13 (0.75–1.71)	0.6	396	72.7		0.94 (0.61–1.45)	0.8	
bad	142	62.7	ref.		ref.		142	73.9		ref.		

[a] "Rather yes" or "definitely yes" answers.

of another study from 2019, conducted on a representative sample of the Polish population, regarding the perception of smog [24], are consistent with the authors' observations: among the general population, the most common actions during episodes of poor air quality are closing the windows (32%) and avoiding going outdoors (20%). Only 2% of respondents report wearing a smog or dust mask. A complete 58% of respondents do not take any action to protect themselves from smog. These responses confirm that fewer than half of Polish residents take any measures to reduce their exposure to air pollution, despite the fact that >70% consider it a serious problem that should be a priority for the country's public authorities. This highlights a significant discrepancy between the perception of air pollution and engagement in health-promoting behaviors.

When interpreting the results of this study, it is important to consider the local context. Studies conducted on the Polish population [24,25] clearly indicate that the belief that air quality in one's immediate area is poor has a very strong positive impact on personal action and support for legal regulations to protect against poor air quality. In assessing the effectiveness of methods to improve air quality, respondents in this study indicated the creation of green zones as the most useful (63.6%). These results are highly similar to those reported in a Portuguese study performed in 2020 [16], where 64% of participants supported creating green spaces as „maximum priority" for air pollution management. The next most frequently mentioned responses in the authors' survey were installing chimney filters in factories (60.3%) and increasing the use of renewable energy sources (53.9%). Continuing, half (50.5%) of participants pointed to replacing old, non-ecological domestic heating sources. Meanwhile, introducing paid parking zones (9.8%), replacing combustion engine cars with hybrid or electric vehicles (22.9%), and designating low-emission zones in cities (27.2%) were considered the least effective.

In another Polish survey conducted in 2020 [26] which examined the public support for various air pollution reduction measures in people's neighborhood, the 2 most cited answers were "providing subsidies for an ecological source of home heating after replacing the furnace" (35%) and "replacing existing heating with more eco-friendly sources, assistance with replacement" (22%), amounting to a total of 57%, which is comparable to the results of the authors' study. In the same study, "subsidies to renewable energy" received 20% support, significantly less than in the authors' analysis. It is, however, necessary to remember that both studies are based on significantly different questionnaires and were performed 5 years apart, in 2020 and 2025, which has been, mainly due to major international events, a very turbulent time for residents of Poland due to the COVID-19 pandemic and the war in Ukraine, which may have influenced the results [27].

It is also important to note the resulting gap in knowledge about the sources of air pollution, which was evident in the results of the authors' previous analysis [28] and other publications [18]. Currently, the most significant and dominant source of air pollution in Poland is domestic combustion heating systems [29,30], followed by industry and transport. Therefore, support for replacing non-ecological heating sources to improve air quality, at a level of only slightly >50%, presents a challenge and a significant scope for public health action. It is crucial to raise awareness among the public that this method positively impacts the health and longevity of Polish citizens.

Regarding the legal regulations supporting air quality improvement, respondents showed the greatest support for: imposing taxes on businesses and entities emitting air pollutants (53.7%), obligatory replacement of old boiler models with more environmentally friendly ones (as high as 52.6%) and introducing restrictive emission limits for industrial plants (48.5%). Significantly less frequently mentioned were a ban on the production of combustion engines (only 9.9%), a ban on older cars entering cities (21.3%), and the closure of coal mines in Poland (23.1%). Again, support for the mandatory replacement of unsustainable boilers with new ones was supported by just over half of the respondents, indicating low public awareness of the real causes of poor air quality in Poland. The particularly low level of support for a ban on combustion engines and restrictions on car traffic in cities suggests that public transport in Poland is still not functional enough to satisfy its users. This finding is supported by the literature, which demonstrates that >40% of rural residents in Poland have very limited access to larger regional centers by public transport [31]. This underscores the massive scale of transport exclusion in Poland and indicates one of the key directions for public policy [31]: improving the accessibility of public transport outside big agglomerations, particularly rail and bus transport.

The survey also found high public support for imposing fines for burning prohibited materials in domestic furnaces or fireplaces by the local and state law enforcement (70.2% combined). In a logistic regression analysis, support for imposing fines for burning prohibited materials in domestic heating sources was associated with older age, having higher education, living in a city ($p < 0.05$), and a good economic status. This seems to confirm the research findings indicating that older people in Poland have the greatest knowledge of air pollution [25,26] and that the main barrier to modifying one's domestic heating system is financial situation [26,32]. The results of a questionnaire survey conducted by the Polish Economic Institute are consistent in this regard, indicating 65% support for imposing fines for air pollution [25]. Public support for issuing fines and for inspections by municipal guards increased in correlation with the perception of air pollution in the respondent's area of residence [25].

Logistic regression analysis showed that the sociodemographic factors associated with the perception of air pollution as a serious issue that should be a priority for public

authorities were female gender, older age, and residing in medium-sized cities ($p < 0.05$). This is consistent with the results of a section of this survey presented in an-other article [28], confirming that people ≥60 years of age have the greatest knowledge about the sources of air pollution in Poland.

According to international literature, exposure to air pollution is higher among groups with low socio-economic status, ethnic minorities, and residents of small towns [33,34]. Socioeconomic inequalities also constitute a significant barrier to access to resources, technologies, and knowledge that could enable effective protection against air pollution. In Poland, the primary sources of pollution, so-called low emissions, primarily affect smaller towns. Meanwhile, the largest number of air quality measurement stations is located in large urban areas [35], which limits access to air quality information for people living in peripheral regions. Low-income individuals are more likely to live in buildings without central heating and to use old heating equipment that emits significant amounts of pollutants. In the Polish context, these are primarily single-family homes and tenement buildings. Limitations in government programs mean that low-income individuals may also struggle to obtain funding to replace their heating source. Furthermore, energy poverty in Poland affects 12% of the population, or >4 million people. Those affected may be more likely to burn unauthorized materials, including domestic waste, in furnaces, thus saving on fuel costs [36]. They may also be less aware of the health consequences of such activities. They are also more likely to perform physical labor, often in conditions harmful to their health, without adequate protection.

The authors' findings have practical implications for public health policy. The identified sociodemographic differences may help target educational activities toward population groups less likely to adopt protective behaviors or support air pollution mitigation measures. Moreover, the relatively low support for some interventions suggests that their implementation should be accompanied by clear communication about their rationale and expected health benefits. There is a need for ongoing, regular monitoring of awareness levels and public perception of air pollution in Poland to develop appropriate, long-term strategies for public health professionals. Health and environmental education are also required, particularly for younger age groups and populations most vulnerable to air pollution, especially in southern Poland. It is also necessary to maintain and expand subsidy programs for replacing non-ecological heating sources. Improving access to public transport should also be a key goal of state policy.

This is a cross-sectional study, which presents limitations typical of its design. Participation in the survey was voluntary. Therefore, there is a risk of self-inclusion bias. As the questionnaire refers to respondents' actions over the past year, recall bias is also probable. Respondents' exact geographic location was not collected, precluding linkage with local air quality measurements. This should be considered when interpreting the findings, as local air quality may influence public attitudes and protective behaviors. Furthermore, due to the chosen method of data collection (CAWI), the risk of under-representation of those digitally excluded should be taken into account; it is estimated that approximately. 4.1% of Polish households lack internet access [36]. Lastly, due to financial constraints, the number of questions in the research questionnaire was limited.

CONCLUSIONS

The study identified substantial differences in the adoption of personal protective behaviors and public support for air pollution mitigation measures across sociodemographic groups in Poland. These findings may help identify population groups requiring targeted educational interventions and measures for which greater public com-

munication and engagement are needed. In particular, public health communication should address gaps in the adoption of protective behaviors and improve understanding of the rationale and expected health benefits of less widely supported air pollution mitigation measures. These findings may support the development of more targeted educational and policy interventions aimed at reducing air pollution exposure in Poland.

AUTHOR CONTRIBUTIONS

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