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THE MULTIDIMENSIONAL NATURE OF ATTITUDES TOWARDS PREVENTIVE VACCINATIONS – A CROSS-SECTIONAL SURVEY AMONG POLES AGED 15–39 YEARS

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Abstract
Objectives: Vaccination skepticism and vaccination refusal both constitute global public health concerns. Systematic monitoring of public attitudes towards vaccination is crucial for maintaining a high vaccination coverage rate. The study aimed to identify and characterize homogenous social groups distinguished by attitudes toward preventive vaccinations. **Material and Methods:** Between October and November of 2021, a nationwide representative cross-sectional survey was conducted on a representative sample of 1560 inhabitants of Poland aged 15–39 years. The study questionnaire included 60 questions on public attitudes towards vaccines, vaccination, and the COVID-19 pandemic. Factor analysis was applied to identify the main dimensions of vaccination attitudes. **Results:** Factor analysis included 22 variables and yielded 3 factors or dimensions that accounted for 48.5% of the model's variability. Young adults were assigned into 6 homogeneous groups based on these factors: 1) general trust in vaccination, 2) vaccine safety concerns, 3) trust in fake medical news regarding COVID-19 vaccination, and denying the COVID-19 pandemic. Groups I–IV differed by sociodemographic factors and vaccination coverage rates. Nearly 60% of the respondents expressed concern regarding various aspects of vaccination. **Conclusions:** Most of Poland's young adults lack clearly defined attitudes towards vaccination. Attitudes towards vaccination can be divided into 6 heterogeneous groups. Int J Occup Med Environ Health. 2023;36(2):214–28

Key words:
Poland, vaccination, factor analysis, vaccines, vaccine hesitancy, vaccine trust

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INTRODUCTION

Vaccination is one of the most effective public health interventions for preventing mortality and morbidity globally [1,2]. According to estimations, vaccination prevents more than 2 million deaths yearly [3]. In 2012, 194 member states of the World Health Organization (WHO) developed a Global Vaccine Action Plan to provide equitable vaccine access [4]. Most countries have developed national childhood immunization schedules [4,5], yet these schedules differ across nations (e.g., in terms of eligible populations or funding sources). However, their common goal is to reach herd immunity [5], in which case the percentage of vaccine coverage rates for most childhood infectious diseases should reach at least 90–95% [6]. Nevertheless, the minimum vaccination coverage rate for herd immunity varies across individual infectious diseases [6,7]. In general, vaccinations fall into 3 groups:

– childhood vaccinations,
– routine vaccines for adults (ex., influenza), and
– travel vaccinations [2–4].

Diphtheria-pertussis-tetanus (DPT) vaccine coverage often serves as an indicator of immunization program performance [8,9]. Between 2010 and 2018, global coverage of the third dose of the DPT vaccine (complete cycle) increased from 84% to 86% [8]. Still, this value is below the global target for national coverage of the DPT vaccine (complete cycle), estimated at ≥90% of children [8]. Vaccination coverage rates depend on access to immunization and healthcare services. In 2019 the WHO indicated vaccine hesitancy as a global threat to public health and immunization programs [7].

The WHO defines vaccine hesitancy as a "delay in acceptance or refusal of vaccines despite the availability of vaccination services" [10]. Identifying factors that influence vaccine hesitancy is of the highest importance for public health specialists. Multiple international tools serve as means of measuring public attitudes towards vaccination, including the *Vaccine Hesitancy Scale* [11], *Vaccination Confidence Scale* [12], and *Vaccine Confidence Index* [13]. However, it is essential to mention that individuals who are hesitant towards vaccines constitute a heterogeneous group that differs across various factors [14,15].

The COVID-19 pandemic has evoked a public debate concerning infectious disease prevention and the role of vaccinations in public health [16]. The introduction of the COVID-19 vaccine sparked discussions on conspiracy theories and an array of disinformation, spread mainly through social media [17,18]. Moreover, the COVID-19 pandemic has harmed routine vaccinations of children and adolescents [19]. Numerous studies reported a decline or delay in vaccination, simultaneous with the COVID-19 pandemic [19]. However, the long-term impact of the COVID-19 pandemic requires further investigation, specifically concerning public attitudes towards vaccination.

Vaccine skepticism and vaccination refusal both constitute global public health concerns. International organizations, such as the WHO and the European Centre for Disease Prevention and Control (ECDC), are currently developing policy papers and guidelines to maintain high vaccination rates across the member states. The ECDC persistently monitors vaccination schedules and coverage rates across the member states [20]. In recent years, the EU has reported measles outbreaks, despite providing free-of-charge access to measles vaccination [21,22]. Estimations claim that >80% of the EU's reported measles cases occurred among unvaccinated individuals [21]. National data on vaccination indicated that vaccine uptake declined in numerous EU countries over the last 5 years [21,22]. Furthermore, vaccination coverage rates vary across the EU's member states. For example, the infant DPT vaccination coverage rate ranges from 89.1% in Romania to 98.2% in Sweden [23]. Finally, significant gaps persist in vaccination coverage rates among adults. In 2016, the influenza vaccination coverage rate ranged from 4.3% in Poland to 66.1% in Belgium [23].

Poland is one example of an EU country that imposes mandatory childhood vaccinations, similar to most post-communist countries [24,25]. Poland's national immunization schedule is being published annually by the Chief Sanitary Inspectorate – a governmental agency tasked with public health and infectious disease prevention [26]. As of 2022, Poland has listed 11 mandatory, government-funded vaccinations [25]. Moreover, additional non-government-funded vaccinations (e.g., against influenza, human papillomavirus, or hepatitis A) are recommended for selected populations [25,26]. Interestingly, the number of vaccination refusals (mandatory childhood vaccinations) has doubled over the past 5 years, from 23 147 incidents in 2016 to 50 575 incidents in 2020 [27]. Further, despite public health efforts to encourage the inhabitants of Poland to vaccinate against influenza (e.g., reimbursement for selected populations or availability of vaccination in Pharmacies), Poland indicates one of the lowest influenza vaccination coverage rates in the EU [28]. The ECDC database indicates that Poland ranks significantly below the EU average (59.1% vs. 72.6%) in cumulative COVID-19 vaccine uptake of the complete primary course [29].

In 2018, Poland's anti-vaccination movement submitted a public bill to the Polish Parliament, proposing the abolition of mandatory childhood vaccination [24]. This event initiated a public debate on vaccination and vaccines in Poland. With the onset of the COVID-19 pandemic, the media have become overflown with conspiracy theories and misinformation about vaccination, posing serious public health ramifications [17,18]. A decreased vaccine uptake in Poland may pose a severe threat to public health in the EU, potentially resulting in a public health crisis [30]. Such consequences are significant in the context of the war in Ukraine and its resultant migration of over 3 million refugees from Ukraine – a country characterized by a significantly lower vaccination coverage rate than that of EU member states [30].

Previous data indicate that public attitudes towards vaccination differ across sociodemographic factors, like biological sex, age, ethnicity, educational level, income class, and religious belief [31–33]. However, most data on public attitudes towards vaccination in Poland focuses primarily on selective local populations [34,35]. Few studies are being conducted on nationwide, representative populations. Furthermore, lacking data on young adults' attitudes towards vaccinations poses a potential threat, as this group is most likely to be soon faced with the decision to vaccinate their future children.

This study aimed to analyze public attitudes towards vaccinations as well as to identify and characterize homogenous social groups distinguished by attitudes towards preventive vaccinations among Poland's inhabitants aged 15–39 years. The presented characteristics may provide scientific evidence to better target vaccine hesitancy and anti-vaccination attitudes in Poland as well as to plan educational campaigns based on personalized communication.

MATERIAL AND METHODS

Study design

Between October and November of 2021, a nationwide, cross-sectional survey was conducted on a representative sample of Poland's inhabitants aged 15–39 years.

Settings

The research utilized computer-assisted personal interviewing (CAPI) – a face-to-face data collection method in which the interviewer record answers on a computer or mobile device. A specialized survey company collected data. One-fourth (25%) of the questionnaire interviews were subject to telephone or direct quality control.

Participants

The sample consisted of 1560 inhabitants of Poland aged 15–39 years. The reproductive age in Poland is defined for

women as the range 15–49 years of age. Having children is associated with frequent decisions about immunization. For the purposes of the study, the age was limited to 39 years. Due to the fact that the number of vaccinations decreases with the age of the child, and thus the number of decisions made by parents in this matter. Random sampling with the cluster sampling technique was applied to ensure the sample's representativeness. Six interviews were carried out for each of the 260 clusters (census areas). Address-based sampling was applied; addresses were selected from the TERYT database – an official register of Poland's territorial division, published and updated by the Central Statistical Office of Poland [36].

Variables

The research utilized an original 60-item questionnaire, which was constructed contingent on the literature review [22–24,31–35]. Thirteen of its items were adapted from the Public Opinion Research Center (a public research agency that conducts national cross-sectional surveys on the public's attitudes towards vaccination and vaccines in Poland). These items were adapted to facilitate comparability between current and previously published data. The items were implemented upon obtaining official approval.

The questionnaire included 4 parts:

- attitudes towards the COVID-19 pandemic and COVID-19 vaccine (I);
- general attitudes towards vaccines and vaccination (II);
- attitudes towards mandatory childhood vaccination (III); and
- questions on sociodemographic characteristics (IV).

Each interview lasted for 30 min on average. Twenty-two questions targeted attitudes towards vaccination and inquired about mandatory preventive vaccinations, vaccinations against COVID-19, and the COVID-19 pandemic.

Measurements

The participants' responses were assessed using a 5-point Likert scale, where the value of 1 represented "it is difficult to say," while the value of 5 reflected strong agreement. In terms of multivariate analyses, the response "it is difficult to say" had been recoded into the value of the range "3" on a 5-point scale.

Statistical analysis

Data were analyzed using the IBM SPSS program, v. 28.0.1 (IBM Corp, Armonk, NY, USA).

Descriptive statistics were performed in order to characterize the studied sample. The χ^2 test was implemented to determine the significance of between-group differences. Statistical significance was based on the criterion of $p < 0.05$.

Factor analysis was applied to identify the main dimensions of vaccine attitudes. The study utilized the maximum likelihood factor analysis algorithm with orthogonal rotation (Varimax), which yielded 3 factors that had accounted for 48.5% of the model's variability. Pearson linear correlation coefficients were used to determine the relationship between the factors and individual variables. Further, cluster analysis was conducted using the k-means clustering method. A regression method was applied using the centroid algorithm (k-means), with the number of clusters equal to 6. Finally, 6 groups distinguished by attitudes towards vaccination were identified.

Ethics

The study was approved by the Ethical Review Board from the Medical University of Warsaw (no. AKBE/134/2021). All research were performed in accordance with the relevant guidelines and regulations. The informed consent (oral) was obtained from all participants and/or their legal guardians.

Participants were briefed about the research orally or in writing, receiving information about its purpose, provider, and source of financing. The participants were also

notified about personal data protection and the possibility of withdrawing from the study at any stage.

Information about the personal data administrator and contact details were provided.

RESULTS

Characteristics of the study sample

The analysis was conducted on data obtained from 1560 individuals (52.8% females) aged 15 through 39 years (M±SD = 29.01±0.19, Me 30.5).

The sample included females (N = 823), whose mean age reached 29.46 years (SD = 0.26, Me 31), and males (N = 737), whose mean age amounted to 29.5 years (SD = 0.27, Me 29). The sample was composed of inhabitants of both urban and rural areas, with 57.3% of the sample residing in cities of various sizes and 42.7% of the participants residing in the countryside. More than half of the respondents (53.2%) had secondary education. Among the respondents, 46.6% were married and 38.5% had children. In terms of employment, more than three-quarters (76.5%) of the respondents had either a full or half-time job. Self-assessment of religiosity indicated that 75.3% of respondents described themselves as believers or very believers. Religiousness was measured through self-report, revealing that 75.3% of the respondents consider themselves to be either religious or very religious. Table 1 presents the demographic characteristics of the sample.

Factor analysis

Factor analysis included 22 variables and yielded 3 factors (dimensions), which accounted for 48.5% of the model's variability. Table 2 presents findings on the association between individual factors and attitudes towards vaccination and the COVID-19 pandemic. The strongest correlation was found between general trust in vaccination (Factor 1) and the belief that vaccination is the most effective way to protect children from serious diseases (correlation coefficient r = 0.728). Factor 1 was also strongly related to the beliefs that:

- due to immunization of children, many dangerous diseases were eradicated (r = 0.675);
- childhood vaccines are safe (r = 0.674);
- overall, immunization of children does more good than harm (r = 0.662);
- medical experts in the media who encourage vaccination are credible to me (r = 0.649).

Factor 2 was related to the following claims:

- childhood vaccines may cause severe developmental disorders in children, e.g., autism (r = 0.670);
- vaccinations weaken the child's natural immunity (r = 0.654);
- instead of vaccination, it is better to let the child develop an infectious disease because it is nothing terrible – a few days of suffering from measles, smallpox or rubella and children already have natural immunity for life (r = 0.633);
- childhood vaccines may cause serious side effects and complications (r = 0.622).

Factor 3 was strongly related to the claims that:

- mass vaccination against COVID-19 is a medical experiment that should not be allowed (r = 0.674);
- COVID-19 vaccines may contain hazardous substances or other components (r = 0.622);
- the media exaggerate the risk of coronavirus infection (r = 0.622).

These findings allowed for the following interpretation of factors:

- general trust in vaccination (factor 1);
- vaccine safety concerns (factor 2);
- denying the COVID-19 pandemic and trust in medical fake news regarding COVID-19 vaccination (factor 3).

The proposed division into groups of public attitudes towards vaccination

Cluster analysis of the 3 factors allowed for assigning the participants into 6 groups distinguished by vaccination attitudes (Table 3).

Table 1. Sample characteristics in the study aimed to identify and characterize homogenous social groups distinguished by attitudes toward preventive vaccinations, October 7–November 28, 2021, Poland

Variable	Participants (N = 1560)	
	n	%
Biological sex		
male	737	47.2
female	823	52.8
Age		
15–19 years	209	13.4
20–24 years	302	19.4
25–29 years	230	14.7
30–34 years	310	19.9
35–39 years	509	32.6
Place of residence		
rural	666	42.7
city		
≤19 999 residents	192	12.3
20 000–49 999 residents	168	10.8
50 000–99 999 residents	126	8.1
100 000–499 999 residents	240	15.4
≥500 000 residents	168	10.8
Educational level		
primary	183	11.8
vocational	253	16.3
secondary	823	53.2
higher	289	18.7
Marital status		
single	789	51.0
married	722	46.6
divorced, separated, widowed	37	2.4
Having children		
yes	600	38.5
no	960	61.5
Do you currently work?		
yes		
full-time	1073	69.2
part-time	114	7.4
no	364	23.5
Self-assessment of religiousness		
totally unbeliever	103	6.6
rather unbeliever	179	11.5
a believer	1106	70.9
deeply believer	68	4.4
refusal to answer	104	6.7

Figures 1a-c present the center positions (centroid) of each of the 3 dimensions (factors 1–3).

Most of the participants were assigned to group II (N = 464, 29.7%), composed of individuals who presented a positive attitude to vaccination in general (average of 0.55 for factor 1), showed no concerns about vaccine safety (average of –0.074 for factor 2) and were skeptical of fake medical news regarding COVID-19 vaccination (M = –0.57 for factor 3), and did not deny the pandemic. Group III was the smallest in size (N = 160, 10.3% of the total sample) and consisted of individuals who held opposite attitudes to those exhibited by the members of group II (M = –1.51 for factor 1, 0.92 for factor 2, and 0.61 for factor 3).

Statistically significant differences were found between groups I–VI in terms of biological sex ($p < 0.001$), age ($p < 0.001$), place of residence ($p < 0.001$), educational level ($p < 0.05$), marital status ($p < 0.001$), having children ($p < 0.001$), level of religiosity ($p < 0.001$), weekly time spent on the internet ($p < 0.01$).

In contrast to the total sample average, group II (N = 464) included more females (56.3% vs. 52.8% of the total sample), and persons aged 35–39 years (39.2% vs. 32.6%). More of the group II participants were married (55.7% vs. 46.6% of the total sample) and had children (50.4% vs. 38.5%). Moreover, a larger part of its participants (83.8%) described themselves as either religious, or very religious, compared to all the respondents (75.3%).

Table 2. Pearson's linear correlation between the identified factors (dimensions) and attitudes towards vaccine claims and the COVID-19 pandemic (factor analysis), October 7–November 28, 2021, Poland

Statement	Pearson correlation coefficients		
	factor 1	factor 2	factor 3
Vaccines are the most effective way to protect children against serious diseases	0.728		
Due to immunization of children, many dangerous diseases were eradicated	0.675		
Childhood vaccines are safe	0.674	–0.311	
Overall, immunization of children does more good than harm	0.662		
Medical experts in the media who encourage vaccination are credible to me	0.649		
Getting vaccinated is in line with my religious beliefs	0.538		
The person who gets vaccinated protects not only himself but also others	0.529		–0.478
Parents of vaccinated children are adequately informed about the side effects of vaccines	0.526		
Childhood vaccines may cause severe developmental disorders in children, e.g., autism		0.670	
Vaccinations weaken the child's natural immunity		0.653	
Instead of vaccination, it is better to let the child develop an infectious disease, because it is nothing terrible – a few days of suffering from measles, smallpox or rubella and children already have a natural immunity for life		0.633	
Childhood vaccines may cause serious side effects and complications		0.622	
In the first years of life, children receive too many vaccinations		0.595	
Vaccinations are promoted not because they are really needed, but because it is in the interest of pharmaceutical companies		0.570	0.346
Mass vaccination against COVID-19 is a medical experiment that should not be allowed		0.414	0.674
COVID-19 vaccines may contain hazardous substances or other components		0.460	0.622
The media exaggerate the risk of coronavirus infection			0.602
COVID-19 vaccines cause changes in genes and lead to mutations		0.475	0.594
Patients do not die from COVID-19, but from comorbidities			0.593
COVID-19 vaccines are a success of modern medicine	0.453		–0.513
(Index) for how many groups should vaccination against COVID-19 be mandatory			–0.455
The SARS-CoV-2 coronavirus was man-made		0.307	0.381

Correlations in the range –0.3–0.3 are not presented due to the low level of the relationship.
Factor 1 – general trust in vaccination; factor 2 – vaccine safety concerns; factor 3 – denying the COVID-19 pandemic and trust in medical fake-news.
All presented correlations are significant at the level of $p < 0.001$.

Table 3. Division of attitudes towards vaccination into groups based on the findings from cluster analysis, October 7–November 28, 2021, Poland

Group	Characteristics of the group	Attitudes towards vaccination		
		factor 1	factor 2	factor 3
I	neutral attitudes towards vaccinations (in general), rather believe in vaccination safety, strongly denying the COVID-19 pandemic	±	−	+++
II	general trust in vaccination, lack of concerns about the vaccine safety, awareness of health risk related to COVID-19 pandemic	++	−−	−−
III	strongly negative attitudes towards vaccinations (in general), concerns about vaccine safety and deny the health risk of COVID-19 pandemic	−−−	++	++
IV	neutral attitudes towards vaccinations (in general), concerns about vaccine safety, awareness of health risk related to COVID-19 pandemic	±	++	−−
V	strongly negative attitudes towards vaccinations (in general), lack of concerns about the vaccine safety, rather believe in the health risk related to COVID-19 pandemic	−−−	−−	−
VI	general trust in vaccination, strong concerns about vaccine safety, rather negate the health risk related to COVID-19 pandemic	++	+++	+

Factor 1 – general trust in vaccination; factor 2 – vaccine safety concerns; factor 3 – denying the COVID-19 pandemic and trust in medical fake-news.
Centroid: +++ [1.00–∞]; ++ [0.50–0.99]; + [0.25–(–0.49)]; ± [(–0.24)–0.24]; − [(–0.25)–(–0.49)]; −− [(–0.50)–(–0.99)]; −−− [(–1.00)–(–∞)]

Group III included about one-third of participants aged 20–24 years (31.9% vs. 19.4%), and nearly two-thirds males (65.0% vs. 47.2%).

Almost two-thirds of participants assigned to group III were male (65.0% vs. 47.2% among all respondents). Nearly one-third (31.9% vs. 19.4%) of those assigned to group III were aged 20–24 years, while 26.9% had children (vs. 38.5% among all respondents) and 64.4% were single (vs. 51.0% among all respondents). More than a quarter of respondents assigned to group III (28.1% vs. 18.1%) described themselves as either completely or somewhat non-believers. Detailed characteristics of groups I–VI are presented in Table 4.

Attitudes towards mandatory childhood vaccinations, COVID-19 vaccination coverage rate, and flu vaccination coverage rate in groups I–VI

Respondents were asked about their attitudes towards mandatory childhood vaccinations. Out of all respondents, 51.5% declared that childhood vaccinations should be mandatory. More than two-thirds of the respondents indicated that all childhood vaccinations should be voluntary, administered only upon parental consent. Attitudes towards mandatory childhood vaccinations differed ($p < 0.001$) between the groups (Figure 2). The highest prevalence of respondents who declared support for mandatory childhood vaccination (78%) was observed in group II and the lowest in group III (8.8%).

COVID-19 vaccination coverage rate also differed between the groups ($p < 0.001$). More than half of all respondents (52%) declared that they were vaccinated against COVID-19. The highest COVID-19 vaccination coverage rate was observed in group II (84.7%) while the lowest was found in group III (6.9%). Moreover, the flu vaccination coverage rate also differed between the groups I–VI ($p < 0.001$). Being vaccinated against the flu within the past 5 years was reported by 24.6% of group II respondents, and only 1.3% of group III respondents.

DISCUSSION

To the best of the authors' knowledge, this article presents the most comprehensive characteristic of attitudes

Table 4. Sociodemographic characteristics of groups I–VI, October 7–November 28, 2021, Poland

Variable	Participants (N = 1560) [%]						
	group I (N =308)	group II (N = 464)	group III (N = 160)	group IV (N = 289)	group V (N = 169)	group VI (N = 170)	p
Biological sex							<0.001
male	44	44	65	44	50	47	
female	56	56	35	56	50	53	
Age							<0.001
15–19 years	13	10	11	18	18	12	
20–24 years	20	15	32	19	18	20	
25–29 years	17	14	15	15	15	12	
30–34 years	19	21	18	22	20	16	
35–39 years	31	39	24	27	28	40	
Place of residence							<0.001
rural	53	41	45	43	36	32	
city							
≤19 999 residents	9	11	12	13	12	21	
20 000–49 999 residents	14	8	8	10	12	15	
50 000–99 999 residents	5	9	6	11	14	2	
100 000–499 999 residents	12	14	18	17	18	19	
≥500 000 residents	8	17	12	6	8	11	
Educational level							<0.05
primary	14	9	6	16	15	11	
vocational	16	16	20	14	21	15	
secondary	52	57	57	48	46	56	
higher	18	18	16	22	18	18	
Marital status							<0.001
single	53	42	64	55	57	46	
married	45	56	34	42	42	50	
divorced, separated, widowed	3	2	1	3	2	4	
Having children							<0.001
yes	39	50	27	33	22	42	
no	61	50	73	67	78	58	
Do you currently work?							0.105
yes							
full-time	64	73	67	70	68	70	
part-time	8	6	13	6	8	7	
no	28	22	20	24	23	23	

Table 4. Sociodemographic characteristics of groups I–VI, October 7–November 28, 2021, Poland – cont.

Variable	Participants (N = 1560) [%]						
	group I (N =308)	group II (N = 464)	group III (N = 160)	group IV (N = 289)	group V (N = 169)	group VI (N = 170)	p
Self-assessment of the level of religiosity							<0.001
totally unbeliever	4	3	10	6	14	13	
rather unbeliever	12	9	18	13	15	4	
a believer	74	77	59	73	60	67	
deeply believer	3	7	3	2	3	7	
refusal to answer	7	4	10	7	8	9	
Time spent on the Internet							<0.01
0–7 h/week	27	39	28	29	31	40	
8–21 h/week	45	36	46	36	36	37	
22–35 h/week	10	11	9	10	9	11	
≥36 h/week	10	8	13	16	12	8	
difficult to tell	7	6	4	9	11	4	

Groups as in Table 3.

towards vaccination among Poland's inhabitants aged 15–39 years. Factor analysis, which consisted of 22 variables, yielded 3 factors, which accounted for 48.5% of the model's variability and could be used to characterize attitudes towards vaccination. The factors were as follows:

- general trust in vaccination;
- vaccine safety concerns;
- denying the COVID-19 pandemic, trust in fake medical news regarding COVID-19 vaccination.

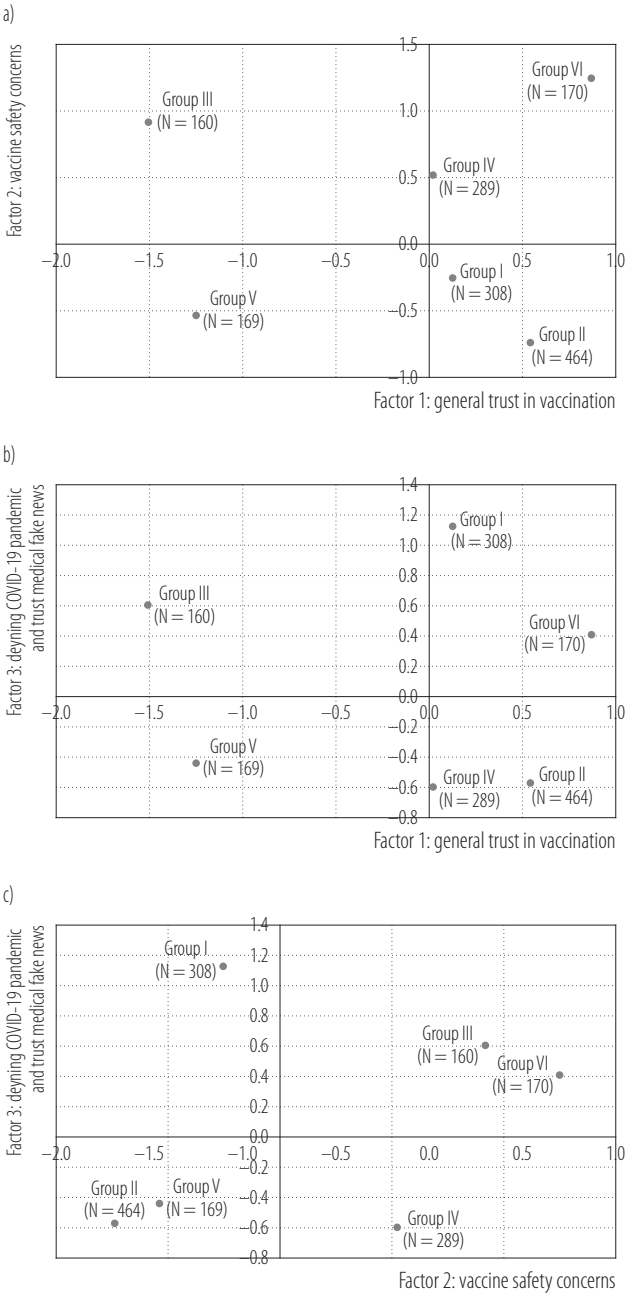
Respondents were assigned to 6 homogenous groups contingent on the mentioned factors. Group I–VI varied regarding sociodemographic factors and vaccination coverage rates. The findings support the heterogeneity of attitudes towards vaccination, with 60% of respondents reporting concerns regarding various aspects of vaccination.

Systematic monitoring of public attitudes towards vaccination is crucial to maintaining a high vaccination coverage rate. Existing data indicate that these public attitudes differ by biological sex, age, ethnicity, educational level, income class, and religious belief [31–33]. Regardless, factors associated with attitudes towards vaccination differ across countries [37], while data on public attitudes towards vaccination in Poland remains inconsistent. In 2016, Duplaga [38] studied a representative sample of Poland's adult inhabitants and reported that individuals who had higher education, were married, as opposed to single, and were currently employed were more likely to declare trust in vaccine safety and effectiveness. Braczkowska et al. [39] showed that perceived risk of adverse vaccine reaction (AVR), contraindications and perception of the qualification procedure for vaccination as substandard were significant factors associated with the rating of children's vaccination as unsafe. Furman et al. [24] studied a corresponding sample in the year 2019, reporting no influence ($p > 0.05$) of biological sex, marital status, educational level, occupational status, or place of residence

on attitudes towards vaccination. The discrepancies between these findings indicate that single sociodemographic variables (e.g., educational level) are insufficient for characterizing public attitudes towards vaccination. Findings from the current study showed that based on 3 factors, adults in Poland may be assigned into 6 different groups that reflect heterogeneous attitudes towards vaccination in Polish society. The research provided detailed sociodemographic characteristics of social groups, distinguished by attitudes towards vaccination. Group III, which consisted of individuals who presented strongly negative attitudes towards vaccinations in general, concerns about vaccine safety, and denial of the COVID-19 pandemic health risk, was dominated by young, single, childless males. It can be hypothesized that this group is at the highest risk of refusal to vaccinate their future offspring (e.g., after starting a family). Compared groups differed in demographic and other factors and such differences were significant to declared opinions. The presented data enables a more precise identification of vaccine-hesitant and anti-vaccine individuals by pointing to a set of sociodemographic features rather than focusing on individual sociodemographic variables as was done in previous studies [24,34,35].

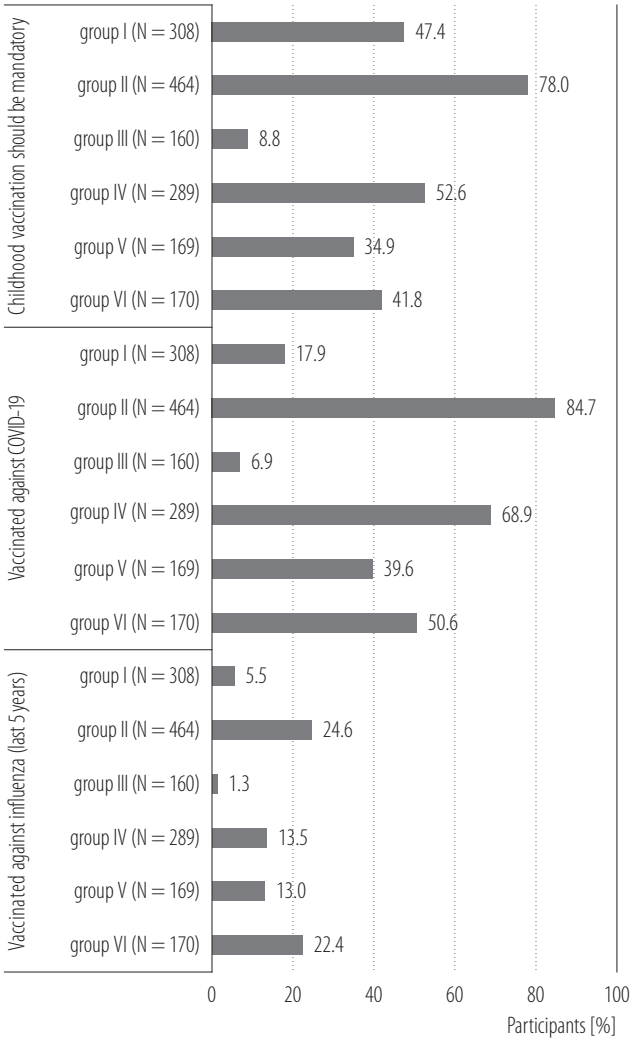
Data reflected that some of the analyzed groups were characterized by radical views regarding vaccination. For example, group III presented strongly negative attitudes towards vaccination in general, group VI presented strong concerns about vaccine safety, while group I indicated strong denial of the COVID-19 pandemic and a high level of acceptance towards pandemic-related fake news. However, neither firm pro-vaccine attitudes nor complete trust in vaccine safety was found to be characteristic of any of the analyzed groups. Moderate attitudes predominated. Future research should aim to verify whether individual attitudes are permanent or may be subject to change.

The findings of this study showed that the distinguished groups might vary by conflicting attitudes toward differ-



Groups as in Table 3.

Figure 1. Location of focal points (centroid) for 6 groups on dimensions: a) general trust in vaccination (factor 1) and vaccine safety concerns (factor 2) based on cluster analysis, b) general trust in vaccination (factor 1) and denying the COVID-19 pandemic and trust in medical fake-news regarding COVID-19 vaccination (factor 3) based on cluster analysis, c) vaccine safety concerns (factor 2) and denying the COVID-19 pandemic and trust in medical fake-news regarding COVID-19 vaccination (factor 3) based on cluster analysis



Groups as in Table 3.

Figure 2. Attitudes towards mandatory childhood vaccinations, COVID-19 vaccination coverage, and influenza vaccination coverage rates in groups I–VI

ent vaccine-related issues. Group VI, which accounted for 10.9% of the sample, indicated general trust in vaccination but showed strong concerns about vaccine safety and low belief in COVID-19 pandemic health risks. A similar trend was observed in group V, which composed 10.8% of the sample, and presented strongly negative attitudes towards vaccination in general, yet lack of vaccine safety concerns and awareness of the health risks associated with the COVID-19 pandemic. Heterogeneity of attitudes towards vaccination was previously described in the literature. Dubé et al. showed that vaccine-hesitant individuals refuse certain vaccines (e.g., against influenza) but agree to others [40].

The authors' findings emphasize the need for personalized educational campaigns, which are addressed to particular social groups that express concern about specific vaccine-related issues.

The findings confirm that attitudes towards vaccination and the COVID-19 pandemic affect vaccine uptake. Group II consisted of pro-vaccine individuals, out of which 84.7% were vaccinated against COVID-19, as opposed to group III, which indicated strong vaccine hesitancy and included 6.9% of vaccinated individuals. A similar phenomenon was observed among particular groups regarding their influenza vaccination coverage rates.

Several practical implications for vaccination policies arise from these findings. The study shows that public attitudes towards vaccination among Poland's inhabitants aged 15–39 years are heterogeneous and may be divided into 6 homogenous groups. Most of the respondents (60%) lack clearly defined attitudes toward vaccination, perhaps sparking the need for novel approaches and educational activities that would target strengthening vaccination confidence. Moreover, the study's socio-demographic characteristics of particular groups may be used by public health authorities to identify individuals at higher risk of vaccine refusal. Different views on different types of vaccination (e.g., strong positive attitudes towards vaccinations in general and negative attitudes towards pandemics and COVID-19 vaccine) indicate the need for adapting public policies to different social views and needs.

The current study is critical in the context of Poland's massive influx of migrants coming from regions with low vaccination coverage rates due to the war in Ukraine [30,41].

The main limitation of this research arises from its cross-sectional methodology and self-report nature.

Both attitudes towards vaccination and vaccine uptake data were self-declared, while no verification occurred. Nevertheless, the methodology that was applied in this study allowed for a broad understanding of the respondents' views and opinions, which would not be possible if the focus was solely on medical registers. Additionally, cluster analysis with a 6-group division was applied. Models with 3–7 groups were tested during the data analysis. The researchers decided to apply the 6 group model based on assessing the centroid position in each model. The decision was, in fact, arbitrary. Despite its mentioned limitations, this study provides a pioneering model, which presents the division of vaccine-hesitant and anti-vaccine individuals in Poland into heterogeneous groups.

CONCLUSIONS

Most of Poland's inhabitants aged 15–39 years lack clearly defined attitudes towards vaccination. Public attitudes towards vaccination in Poland can be divided into 6 homogeneous groups, that may pose a basis for further educational activities and personalized communication. Only one-third of Poland's inhabitants, aged 15–39 years, presented strong support for vaccines and vaccination, while one-tenth expressed clearly negative attitudes towards vaccination. Attitudes towards vaccination are clearly linked with vaccination uptake in subsequent groups. Raising vaccine confidence among individuals who lack clearly defined attitudes toward vaccination is crucial to maintaining herd immunity. Public health campaigns on vaccination should be based on personalized statements adapted to the needs of individual groups.

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