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Measuring the Outcomes of a Participatory Research Study: Findings from an Environmental Epidemiological Study in Kaunas City

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Abstract: The achievement of a sustainable urban environment and health for all requires the engagement and greater awareness of local communities on issues of environment and health. This HORIZON2020 CiteS-Health study presents the outcomes of the environmental epidemiological research on the participants' acquisition of new skills and knowledge as well as on health behaviour. We conducted a cross-sectional study of 1062 residents of Kaunas city, Lithuania, from 2019 to 2021. We analysed the associations between the neighbourhood environmental quality scores and health issues, and the self-reported ratings on the acquired knowledge measured using a Likert rating scale. About 42.7% of the participants acknowledged that participation in the research study improved their data collection and interpretation skills, and 58.8% of them stated that the participation improved their knowledge on the links between environmental quality and health. The participants with increased knowledge more often rated their health as "good", had a significantly lower diastolic blood pressure, and regularly visited the natural environment. The high impact of participatory research was associated with a higher scoring of the neighbourhood environmental quality, higher physical activity, and a beneficial effect on health. The study provides scientific evidence that improving the neighbourhood environment would promote increased physical activity, such as reaching green spaces by walking, and might benefit the society.

Keywords: participatory research; neighbourhood environment; health behaviour; outcomes; impact assessment; citizen science

1. Introduction

During the last decades, there has been a significant increase in citizens' activity in environmental health research, with citizens' engagement in the identification of local problems and participation in knowledge production and creation of the indicators of sustainable development goals (SDGs) [1]. Citizens' participation in research could have a positive impact on communities' transformation through pressure on politicians to improve the environmental health and to reduce social health disparities [2,3]. Participatory action research can connect public engagement with scientific research to integrate the knowledge gained with interventions for policy change, setting priorities to improve citizens' health and well-being [4–6]. However, so far, few citizens science studies have investigated the contribution of environmental studies to raising citizens' knowledge on the links between environmental issues and health. Participants' engagement in such research has the potential to increase people's understanding of how the residential environment affects their health and how to integrate the knowledge gained to achieve changes in personal health behaviour as well as to bring benefits to the community [7,8]. To date, the greatest potential of participatory research in the implementation of SDGs has been related to SDG

11 Sustainable Cities and Communities and SDG 3 Good Health and Well-being: improving the quality of the data, creation of indicators, and building partnerships [9].

The participants' active engagement in the research education conforms to SDG 4 Quality Education, target SDG 4.7: "By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and nonviolence, global citizenship". The education goals are based on the discussion between researchers and community participants as well as on the development of practical skills that are advantageous both for the community and the science sector by integrating knowledge in decision making [10–13]. In such a way, participants' education might support complex sustainability transitions in public health and environmental health issues and use scientific understanding to implement changes in behaviour and decision making [3,14,15].

To date, the achievement of the sustainable development goals requires greater perception of environmental issues, responsible action, and health promotion [5]. More attention should be devoted to the most prevalent environment-related diseases, such as cardiovascular diseases and hypertension [16,17]. The public's understanding of the links between environmental quality and human health can motivate personal changes [18,19] and action for improvement of neighbourhood environment quality [20–22]. However, to our knowledge, the participants' learning outcomes from engagement in the environmental epidemiological research have not been studied yet. Learning outcomes include developing interest and identity as well as understanding scientific knowledge and engagement in the practices of science with real data [23].

We conducted a study seeking to determine whether participatory research produced its intended outcomes such as those aimed at improving knowledge, skills, and attitudes toward environmental issues and health and promoting environmental epidemiological study practices. In this environmental epidemiological study, we for the first time, investigated the impact of participation on the knowledge of the links between environmental quality and health among 18–75-year-old citizens of an Eastern European country. The study was initiated as the Kaunas pilot study [24,25]. In this environmental epidemiological study, the researchers, together with the engaged citizens, outlined the participants' environmental concerns and major health problems and placed them at the centre of the participatory research to study how the urban design affects citizens' health and well-being and how it might impact physical activity. This experience-based education has the potential to empower learning through participants' active action in the data collection, defining the environmental health problems, identifying research questions, designing study protocols, and problem-based learning, and it may also offer a pathway for environmental education [26]. In this research, we studied the links between the variables that depend on different SDGs: environmental variables (SDG 11), health and well-being variables (SDG 3), and adult learners' acquired knowledge and skills needed to promote sustainable development (SDG 4.7).

The overall aim of this environmental epidemiological research was to investigate whether the citizens' engagement achieved its intended effect on the participants' acquisition of new skills and knowledge as well as on health behaviours needed to promote SDGs and to improve health (SDG 3, target 3.4: "By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being"). The specific aims were: (1) to identify personal characteristics associated with the acquisition of new skills and knowledge on the links between environmental quality and health; (2) to determine the links between neighbourhood quality and the acquisition of new skills and knowledge; and (3) to determine if there is a real relationship between the participants' acquisition of useful skills and knowledge, their physical activity, and their self-reported health.

This action-based adult education has a potential to identify local environmental problems and to develop the competences for the participants to address environmental

hazards. In addition, it could make important contributions to solving health problems. The study has a potential to increase awareness about the relationship between the quality of the neighbourhood, health-related behaviour, and citizens' health.

2. Materials and Methods

2.1. Study Participants

This citizens' collaborative research was conducted in Kaunas city from 2019 to 2021. Kaunas city is a green area with a good possibility for physical activity in city parks [27]. The study involved 1062 18–75-year-old permanent residents of Kaunas city and consisted of two stages. During the first stage of the engagement, 580 citizens were enrolled using face-to-face interviews. During the second stage, 506 45–64-year-old participants were randomly selected using voting lists and were engaged in the study via an internet survey. Our primary methods of invitation to participate in the environmental epidemiological study included radio, local newspapers and web sites, advertisements at community events, and conferences. Ten citizens responded and participated in the first meeting with researchers devoted to the identification of the environmental concerns in the residential place and main health problems.

Seeking to inform Kaunas citizens on the possibility to engage in the study and to obtain new information, on 8–10 May 2019, we organised open meetings with the engaged citizens, researchers, and the participants of the former conferences. The meetings were attended by 120 participants, including scientists, journalists, NGO representatives, and public health and city planning specialists. During the meetings, we presented primary information about the Urban Environment and Health study, reported the results of previous similar studies as educational material, discussed the participants' concerns, and together with the participants, formulated the research questions and created the questionnaires. On 20 May 2019, during the debates with 21 participants-volunteers, the study data collection protocol and the environmental epidemiological study design were created, and the participatory study evaluation questions were discussed. In autumn of the year 2020, we started an internet survey, and the respondents were invited to answer closed and open questions about the possible research outcomes. On 5–7 May 2021, we organised the Human and Nature Safety 2021 conference to discuss the citizens' suggested measurements of the acquisition of new skills and knowledge. The description of the study design and the protocol, as well as the approval of the research ethics committee, were provided previously [25,28]. The solution of personally relevant problems plays an important role in participants' activity [29] and therefore this environmental epidemiological study using the cross-sectional study design sought to answer the following question asked by the study participants: "Why do citizens in my district suffer from hypertension more often than those in other ones?"

2.2. Variables

In this study, hypertension was defined using the international criteria [30]—the presence of physician-diagnosed hypertension, the reported use of antihypertensive medication, and/or systolic blood pressure of 140 mmHg or higher and/or diastolic blood pressure of 90 mmHg or higher. We validated the study participants' reporting of physician-diagnosed hypertension using responses on blood pressure readings. To ensure that the data are comparable, we compared the prevalence of self-reported physician-diagnosed hypertension with the professionally collected data of a random sample of the inhabitants of Kaunas city [31].

The participants presented information on physical activity during leisure time by answering the following question: "During the last week, what was the mean time per day you spent outdoors by fast walking, bicycling, or gardening?" The measure of physical activity was adapted from the publicised international studies [32]. We validated the consistency of the answers by comparing the above-mentioned time with time spent in a park and with the professionally collected data of a random sample of Kaunas citi-

zens [33]. In this study, the recommended duration of physical activity was defined by the international guidelines [34], i.e., at least 150 min/week of moderate-intensity physical activity outdoors. The participants' health status was assessed by the presence or absence of physician-diagnosed chronic diseases, systolic and diastolic blood pressure, and the body mass index (BMI) calculated using the measures of body weight and body height. General health was measured by asking the participants to answer the question "How would you rate your overall health status at present?" The self-reported health evaluation answers were scored using a five-point Likert rating scale ranging from 1 (great) to 5 (poor). A similar evaluation of general health is used in the international studies [32].

Information collected through formalised questionnaires was relevant to SDGs indicators (see Table 1) and covered sociodemographic and health-related data as follows: age, sex, family status, self-reported health, smoking, physical activity, socioeconomic situation (SES), and residence history (see Tables 2 and 3).

Table 1. Environmental variables potentially relevant to SDGs indicators: proportion of Kaunas citizens' statements by age groups.

Indicator	Total (n, %)	Age Groups (n, %)			
	18–75	18–44	45–64	≥65	
SDG 11.2. Satisfied with public transport services in the district ($p^a = 0.910$)					
No (scores 0–3)	205 (18.9)	70 (19.4)	125 (18.7)	10 (17.2)	
Yes (scores 4–7)	881 (81.1)	290 (80.6)	543 (81.3)	48 (82.8)	
SDG 11.7. Opportunities for walking to reach the city's green spaces or parks ($p^a = 0.599$)					
No (scores 0–3)	243 (22.4)	87 (24.2)	143 (21.4)	13 (22.4)	
Yes (scores 4–7)	843 (77.6)	273 (75.8)	525 (78.6)	45 (77.6)	
SDG 11.6. Air pollution caused problems ($p^a = 0.300$)					
No (scores 0–3)	438 (40.3)	142 (39.4)	267 (40.0)	29 (50.0)	
Yes (scores 4–7)	648 (59.7)	218 (60.6)	401 (60.0)	29 (50.0)	
Suffering from noise in place of residence ($p^a = 0.007$)					
No (scores 0–3)	269 (24.8)	110 (30.6)	148 (22.2)	11 (19.0)	
Yes (scores 4–7)	817 (75.2)	250 (69.4)	520 (77.8)	47 (81.0)	

The seven-point Likert rating scale scores for all citizens statements ranged from 1 to 7: 1 = strongly disagree, and 7 = strongly agree. p^a -value of significance between age groups.

Table 2. Characteristics of the participants by the impact on the knowledge of links between the environmental quality and health.

Participants' Characteristics	Total Number	Low Impact < Mean n (%)	High Impact > Mean n (%)	p
Age groups	1062			0.176 ‡
18–44	345 (32.5)	140 (40.6)	205 (59.4)	
45–64	660 (62.1)	267 (40.5)	393 (59.5)	
≥65	57 (5.4)	16 (28.1)	41 (71.9)	
Sex	1062			0.187 ‡
Men	490	206 (42.0)	286 (58.0)	
Women	572	217 (37.9)	355 (62.1)	
District	1062			0.308 ‡
1	81 (7.6)	27 (33.3)	52 (66.7)	
2	91 (8.6)	36 (39.6)	55 (60.4)	
3	123 (11.6)	42 (34.1)	81 (65.9)	
4	138 (13.0)	61 (44.2)	77 (55.8)	

Table 2. Cont.

Participants' Characteristics	Total Number	Low Impact < Mean n (%)	High Impact > Mean n (%)	p
5	83 (7.8)	29 (34.9)	54 (65.1)	
6	57 (5.4)	22 (38.6)	35 (61.4)	
7	72 (6.8)	27 (37.5)	45 (62.5)	
8	94 (8.9)	32 (34.0)	62 (66.0)	
9	114 (10.7)	55 (48.2)	59 (51.8)	
10	87 (8.2)	40 (46.0)	47 (54.0)	
11	122 (11.5)	52 (42.6)	70 (57.4)	
Family status	1062			0.539 ‡
Married	613 (57.7)	249 (40.6)	364 (59.4)	
Other	449 (42.3)	174 (38.8)	275 (61.2)	
Education status	1062			0.414 ‡
Lower education status	493 (46.4)	203 (41.2)	290 (58.8)	
Higher education status	569 (53.6)	220 (38.7)	349 (61.3)	
Situation at work	1062			0.206 ‡
Full-time	710 (67.0)	293 (41.3)	417 (58.7)	
Other	350 (33.0)	130 (37.1)	220 (62.9)	
Monthly net income	1062			0.550 ‡
<400 Euro	170 (16.0)	64 (37.6)	106 (62.4)	
≥400 Euro	892 (84.0)	359 (40.2)	533 (59.8)	
Current smoking	1058			0.030 ‡
No	792 (74.9)	299 (37.8)	493 (62.2)	
Yes	266 (25.1)	121 (45.5)	145 (54.5)	
Traffic 10,000 cars/day	1062			0.365 ‡
<10,000	762 (71.9)	296 (38.8)	466 (61.2)	
≥10,000	298 (28.1)	125 (41.9)	173 (58.1)	
Duration of living, years (mean (SE))	17.61 (0.43)	16.46 (0.64)	18.48 (0.58)	0.023 †

† p value of Student's *t* test; ‡ p value of the chi-squared test; SE—standard error.

Table 3. Health characteristics in groups of participants by the impact on the knowledge of links between the environmental quality and health.

Health Indices	Low Impact n (%) or Mean (SE)	High Impact n (%) or Mean (SE)	p
Body mass index (BMI)	25.47 (0.22)	25.32 (0.17)	0.592 †
<30	359 (86.5)	558 (88.3)	0.391 ‡
BMI ≥ 30 (obesity)	56 (13.5)	74 (11.7)	
Systolic blood pressure (mmHg)	125.59 (0.66)	124.34 (0.58)	0.166 †
Diastolic blood pressure (mmHg)	84.25 (0.54)	82.59 (0.41)	0.013 †
Chronic disease			0.416 ‡

Table 3. Cont.

Health Indices	Low Impact <i>n</i> (%) or Mean (SE)	High Impact <i>n</i> (%) or Mean (SE)	<i>p</i>
No	298 (70.4)	434 (67.9)	0.489 ‡
Yes	125 (29.6)	205 (32.1)	
Hypertension			0.024 ‡
No	307 (72.6)	450 (70.4)	
Yes	116 (27.4)	189 (29.6)	0.090 ‡
Health status			
Good	344 (81.5)	554 (86.7)	0.003 ‡
Poor	78 (18.5)	85 (13.3)	
Stress level			0.003 ‡
Stress high (score < mean)	231 (54.6)	314 (49.1)	
Stress low (score > mean)	192 (45.4)	325 (50.9)	0.003 ‡
Physical activity			
Low (<150 min/week)	377 (89.1)	526 (82.3)	0.003 ‡
Recommended (>150 min/week)	46 (10.9)	113 (17.7)	

† *p* value of Student's *t* test; ‡ *p* value of the chi-squared test; SE—standard error.

The citizens involved in the study evaluated the environmental quality by using formalised questionnaires developed together with the researchers. The participants rated statements on the residential neighbourhood using a seven-point Likert rating scale to measure mean environmental perceptions (see Table 4). Scores above the mean indicated a higher quality and better neighbourhood conditions. The participants rated states of the built neighbourhood and social well-being, including the opportunities for walking to reach the city's green spaces or parks and problems caused by air pollution and noise exposure. In this study, neighbourhood and social well-being variables were treated as independent variables. Dependent variables included health variables and the participants' acquired knowledge. Physical activity was analysed as a moderating variable that may affect the strength of the relationship. Because of the skewed distribution of variable scores, the mean rating scores were categorised (above mean/below mean).

Table 4. Mean ratings of the perceptions of neighbourhood quality and social well-being by the impact on knowledge of the collaborative research participants.

Statements on Neighbourhood and Social Well-Being	Impact Low < Mean Mean (SE)	Impact High ≥ Mean Mean (SE)	<i>p</i>
The public transport in the district meets my needs	4.98 (0.097)	5.46 (0.073)	0.001
I am satisfied with pathways and cycling routes	4.63 (0.101)	5.17 (0.83)	0.001
There are opportunities for walking to reach the city's green spaces or parks	4.89 (0.104)	5.49 (0.080)	0.001
I regularly visit the natural environment	4.20 (0.104)	4.87 (0.082)	0.001
There is a place in my residential area adapted for exercise and relaxation	4.33 (0.105)	4.53 (0.088)	0.155
Air pollution in my place of residence causes problems	3.99 (0.140)	3.72 (0.123)	0.163
Noise in my place of residence hinders my sleep and/or work at home	4.68 (0.146)	4.80 (0.122)	0.544
There are public spaces and rooms to meet people available in my residential area	3.82 (0.100)	4.25 (0.088)	0.001
I feel safe in my area	5.01 (0.082)	5.23 (0.074)	0.045
I can take part in decision making to improve the environment in which I live	2.99 (0.098)	3.59 (0.091)	0.001
During the last 6 months, I have felt stress, tension, or anxiety	4.07 (0.091)	4.26 (0.079)	0.119

All neighbourhood perception scores ranged from 1 to 7: 1 = strongly disagree, and 7 = strongly agree. Higher scores indicate better neighbourhood conditions.

We measured citizens' engagement in the research on the acquisition of new skills and knowledge to recognise environmental health problems, and evaluated the relationship between the participants' acquired knowledge, physical activity, and self-reported health. The participatory action research approach to learning is based on experience-based education during contacts with researchers at least half a year in duration after inclusion in the study. To measure the study outcomes, the participants were asked to rate statements about the acquisition of new skills and new knowledge (see Table 5). In this study, we tested the participants' responses to different statements, each of which presented a different perception topic. The statements for the assessment of outcomes were evaluated by the participants using a seven-point Likert rating scale of the acquired new skills and knowledge. Scores above the mean indicated a high impact on knowledge and those below the mean indicated a low impact on knowledge.

Table 5. Self-reported outcomes on new skills and knowledge by age groups.

Outcomes on New Skills and Knowledge	18–75	18–44	Age Groups	
	% High Impact (>Mean) ^b		45–64 (Mean Statement Scores)	≥65
Reducing air pollution would improve the health of the citizens ^a	60.3%	5.94	6.18	6.07
Greater physical activity and walks in the park improve my health ^a	60.6%	5.97	6.25	5.79
My opinion and proposals are important for politicians in solving urban environment and health problems ^a	45.5%	3.40	3.46	4.38
I will use the acquired skills in my life and activity ^a	48.4%	3.49	3.52	3.82
The participation in the study improved my data collection and interpretation skills ^a	42.7%	3.24	3.38	3.28
The participation in the study increased my knowledge about links between environmental quality and my health ^a	58.8%	5.94	6.18	6.07
The participation in the study did not meet my expectations ^a	45.1%	4.08	4.16	4.32

^a The scores for all statements ranged from 1 to 7: 1 = strongly disagree, and 7 = strongly agree. Higher scores indicate a better effect on knowledge. ^b The >mean indicates the prevalence of a high impact on the participant's knowledge in %.

The learning outcomes were measured using the recommendations of the citizen science experts [35,36]. We used mean rating scores to evaluate the learning outcomes of this research along three dimensions: the scientific impact, learning and empowerment of the participants, and impact for the wider society. The learning outcomes among the project participants were based on their self-reported scoring of the acquired knowledge. We estimated the scientific impact by evaluating the relevance of the scientific objective to the participants; the participants' awareness of the environmental quality; awareness

of health and environmental health problems in residential settings; and the relevance of the scientific objective for the society. To estimate the learning and empowerment of the participants, we evaluated the impact of new knowledge on a better understanding of the science; on the links between environmental quality, physical activity, and health; on gained practical skills in data collection and interpretation; on project contribution to facilitating personal changes in behaviour; and the contribution to a better understanding of the scientific topic. The project's contribution for the wider society and SDGs was estimated by evaluating the democracy level based on the importance of citizens' opinion for politicians, citizens' higher awareness and knowledge of the natural environment, and scientific evidence of health benefits of physical activity in the green environment.

2.3. Analysis

For the analytic sample, frequency distributions of all participant characteristics were tabulated. The chi-squared test was used to compare the values and the frequencies of the participants' baseline demographic, lifestyle, and health history characteristics as well as perceptions of neighbourhood quality scores, using the impact on the knowledge (low or high). We calculated the means and standard deviations for quantitative variables. Statistical significance was set at p -value < 0.05 . Subsequently, we analysed the personal characteristics influencing the participants' knowledge. To compare qualitative characteristics between groups, we used Fisher's exact test. We applied stratified multinomial regression analysis models to evaluate the relationships between the acquired knowledge, physical activity level, and the self-reported health. In this analysis, dependent variables included health variables and the participants' acquired knowledge, while physical activity was analysed as a moderating variable. The following covariates were included in the models: sex (men, women), smoking status (no, yes), education level (lower education status, higher education status), and age (18–44, 45–64, ≥ 65). Odds ratios (OR) and their 95% confidence intervals (CI) were used to estimate the relationship between the variables. For the inclusion of covariates in the stratified multinomial regression models, we used higher p -value thresholds than 0.05 (e.g., 0.2) [37]. Hence, the variables that changed the adjusted odds ratios (aOR) by 10% or more were also retained for inclusion in the multivariate logistic regression analysis. Data analysis was performed using SPSS version 25.0 package (IBM Corporation, New York, NY, USA).

3. Results

3.1. Participants' Characteristics by Acquisition of New Knowledge

The sample comprised 1062 participants residing in 11 Kaunas districts. In this citizen sample, we analysed some SDG indicators associated with environmental quality, well-being, and public health. The studied indicators comprised SDG target 11.2: "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons"; SDG target 11.6: "By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management"; and SDG target 11.7: "By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities" (Table 1). In this sample of 18–75-year-old participants, 77.6% of the respondents had opportunities for walking to reach the city's green spaces or parks (SDG 11.7). Furthermore, 59.7% participants suffered from air-pollution-caused problems (SDG 11.6), 81.1% were satisfied with public transport services (SDG 11.2), and 75.2% suffered from noise in their place of residence.

However, there was no significant difference in the prevalence of the indicators between the three age groups ($p > 0.05$), except for noise. The prevalence of citizens suffering from noise in their place of residence was higher in the older age groups than among the participants of the younger age groups ($p = 0.007$).

Table 2 presents the characteristics of the analytic sample as well as by the participants' acquisition of new skills and knowledge (low/high impact).

There were no significant differences in the scoring of the acquired knowledge between participants with different social and demographic characteristics. However, the participants with a high impact were more often non-smokers (62.2%) compared to the low-impact group (37.8%, $p = 0.030$), and the duration of their residence in the district was longer ($p = 0.023$).

In this sample of 18–75-year-old participants, the prevalence of people with good or very good perceived health was 84.6%, and 28.7% were categorised as having hypertension. However, there was no significant difference in the prevalence of hypertension between the two impact groups ($p = 0.489$) (Table 3). The participants in the low impact group had a significantly higher mean diastolic blood pressure (84.25 mmHg) compared to those of the high impact group (82.59 mmHg, $p = 0.013$). Health status perceived as “good” was indicated significantly more often in the high-impact group ($p = 0.024$), and participants of this group more often reached the recommended physical activity level ($p = 0.003$). These findings revealed that the high impact of participation in the collaborative research on the acquired knowledge was associated with better self-reported health, higher physical activity, and a lower prevalence of health problems.

3.2. *Links between the Neighbourhood Quality and the Acquisition of New Skills and Knowledge*

The relationships between the perception of the urban built neighbourhood and the quality of the social environment and the participants' acquired knowledge are presented in Table 4.

Compared to the low impact group, the participants of the high impact group provided significantly ($p < 0.001$) better ratings of the built environment, i.e., public transport, accessibility to parks, and other infrastructure. Visiting the natural environment was found to be more common among the higher-impact group participants (4.87 and 4.20, respectively; $p = 0.001$). The rating of the statement “I can take part in decision making to improve the environment in which I live” was positively related with an increased impact on knowledge ($p = 0.001$). Our study results revealed relationships between satisfaction with the neighbourhood environment and acquired new knowledge, which might be associated with personality.

3.3. *Relationship between the Participants' Acquired Knowledge, Physical Activity, and Self-Reported Health*

To evaluate the impact of citizens' engagement in the participatory action research, we estimated the prevalence (measured as %) of the high-impact effect on knowledge in 18–75-age participants and mean ratings of the statement scores by age groups (Table 5). The participants of the age group of 45–64 years provided higher ratings in most of the statements than the participants of the younger or the older age groups did, stating that the participation increased their knowledge and met their expectations. As many as 60.3% of all 1062 participants acknowledged that reducing air pollution would improve the health of the citizens, and a similar proportion of the participants (60.6%) learned that greater physical activity and walks in the park might improve their health. About 42.7% of the participants reported that the participation in the project improved their data collection and interpretation skills, and a half of all the participants intended to use the acquired skills in their life and activity. Even though 58.8% of the participants reported that participation in the project increased their knowledge about the links between environmental quality and their health, 45.1% stated that the participation in the study did not meet their expectations. This discrepancy may be the result of a different formulation of the question, requiring a different scoring than others. The statement, “My opinion and proposals for politicians are important for solving urban environment and health problems” received the lowest evaluation, with only 45.5% of the participants thinking that their voice was heard by politicians.

In the next step, we sought to evaluate the relationships between the acquired knowledge, physical activity, and self-reported health (Table 6). We used multivariable logistic regression models to study if the strength of the associations between knowledge and self-reported health differed depending on the value of the third variable—i.e., the physical activity level. The reference group comprised participants with increased knowledge whose physical activity reached the recommended level (at least 150 min/week). Compared to the reference group, the participants of the group without increased knowledge but with physical activity reaching the recommended level had by 22% increased risk of poor health in the model adjusted for possible confounding variables (OR 1.22, 95% CI 0.38–3.92). This result was not significant. However, among the participants with increased knowledge but low physical activity (i.e., not reaching the recommended level), the adjusted odds ratios for poor health were 2.64, 95% CI 1.34 to 5.18. This association was significant and consistent after controlling for the effect of sex, smoking status, education level, and age, showing that the physical activity level has an impact on health status.

Table 6. Multivariable logistic regression models of associations between the acquired knowledge, physical activity, and self-reported health (stratified multinomial regression models).

Knowledge and Physical Activity (PA)	Self-Reported Health	
	Great ^a	Poor
	aOR (95% CI) ‡	aOR (95% CI) ‡
Referent group: Increased knowledge and PA recommended	1	1
Not increased knowledge and PA recommended	1.38 (0.66–2.91)	1.22 (0.38–3.92)
Increased knowledge and PA low	1.82 (1.14–2.91)	2.64 (1.34–5.18)

^a reference group: great or very good. aOR: adjusted odds ratios. ‡ adjusted for: sex, smoking status, education level, and age.

These findings present evidence that the strength of the relationship between the acquired knowledge and self-reported health was mediated by physical activity. Low levels of physical activity were associated with a significantly increased risk of poor health. The obtained data showed that an improvement in citizens' knowledge about the beneficial effect of physical activity has a potential to improve citizens' health.

4. Discussion

The findings presented in this research suggest that informal adult education through participatory action research is an important measure for the mobilization of citizens to help achieve the SDG 4.7 targets to acquire the knowledge and skills needed to promote sustainable development. Our research findings showed that enhancing education for sustainable development should include several SDGs. This is in line with the Agenda 2030 for sustainable development [38], which states that “SDG 4.7 refers to education in the broader concept, in the context of education for sustainable development” [3,39]. This environmental epidemiological research engaged the citizens in the participatory action research on the association between environmental issues and health and presented evidence on the acquisition of new skills and knowledge. The strengths of our study include an environmental epidemiological approach, a large sample size, and the use of created formalised questionnaires and standardised analytical methods for the assessment of associations. These measures helped us to gain new knowledge on the association between the participants' increased knowledge, self-reported health outcomes, and the mediating effect of the recommended physical activity levels. The findings of this citizen science study revealed a scientific advancement associated with education for sustainable development. In this study, the participants' environmental and health concerns were outlined and were placed at the centre of the participatory research. To answer the participants' substantial questions, the participants rated their perception of environmental quality in

the district, discussed the relevance of the scientific objective to their expectations and the environmental health problems in residential settings, and recognised the relevance of the scientific objective for the society. As many as 58.8% of the study participants indicated an improvement in their science literacy and stated that participation in the study increased their knowledge about the associations between residential neighbourhoods and their health. The participants recognised the link between environmental problems and personal health problems: 75.2% acknowledged that environmental noise in their place of residence hinders sleep. To estimate personal characteristics associated with the acquisition of new skills and knowledge, we compared the groups with a low and a high impact on knowledge. The findings showed that the acquired knowledge did not depend on age, education level, family status, or SES. However, participants with a high impact were more often non-smokers, had a significantly lower mean diastolic blood pressure, rated their health as “good”, and regularly visited the natural environment, compared to those without increased knowledge.

Previous citizen science studies also showed the participants’ abilities to recognise environmental-level problems, but they had little influence on changes in the participants’ behaviour or the socioecological system [20,40]. The participatory action research found that an increase in scientific knowledge increases public awareness and contributes to scientific literacy [41]. Participation in citizen science could contribute to the SDGs by defining local targets, monitoring the progress, and having the potential to implement action [3,39,42,43]. The participants of this study became familiar with the study planning process, starting with the elucidation of environmental problems, the formulation of research questions and hypotheses, data gathering, and the principles of analysis. The citizens participated in the research on standardised environmental quality assessment using a Likert rating scale. The evaluation of the links between environmental quality and health using an epidemiological study approach, such as the cross-sectional design, created the possibility to raise citizens’ knowledge and to improve the participants’ achievements. The use of scientific research principles, formalised questionnaires, study protocols, and the training of the participants creates a potential to generate high-quality data that can be analysed with statistical analysis packages [44].

We acknowledge the limitations of the present study. A cross-sectional design does not reveal causation as there is no direct evidence on the time sequence of the studied outcomes. We only described the existing associations between the perception of environmental quality, the acquired knowledge, physical activity, and health indices. Even though we adjusted multivariable models for covariates, residual confounding in self-reported characteristics cannot be excluded. We did not evaluate the knowledge level as evolving in the study participants but treated it as a continuous learning outcome during the project, producing risks for errors in assessing the impact of learning. We assessed the impact by self-reported ratings on the acquired knowledge measured using a Likert rating scale. We did not measure the exact health status of the participants but used self-reported health status instead. However, to ensure that the data are comparable and could be used in policymaking, we compared the study participants’ reported health data and physical activity data with the professionally collected data of a representative sample of the inhabitants of Kaunas city and found a similar result. In this way, this environmental epidemiological study has a possibility to present evidence-based findings and increase scientific communication through the results of a cross-sectional study [6,28,45].

We analysed if there was a difference in the perceptions of neighbourhoods between citizens for whom the participation in the project had a different impact. The findings showed that the participants of the higher impact group provided significantly better ratings of their residential environment and more often visited the natural environment compared to those in the lower impact group. The participants of the higher impact group more often saw possibilities to be heard by politicians about the problems with the residential environment. These results show that gained knowledge increased awareness and thoughts about the implementation of changes. However, the learning achievements might

be associated with personality [46]. Even though there are significant relationships between the participants' increased knowledge, health behaviour, and health, some variance in perception and approaches to learning remains unexplained.

The participants' learning and empowerment were evaluated based on a self-reported impact on new skills and knowledge by age groups. The participants of all age groups similarly highly rated the statements: "Reducing air pollution would improve the health of the citizens", and "Greater physical activity and walks in the park improve my health", indicating a good understanding of the scientific problem and the links between environmental quality and health. About 60% of the participants stated that their knowledge about the links between the environment and health increased. About 42.7% of the participants gained practical skills on data collection and interpretation, and 48.4% of them would use the acquired skills in their life and activity. However, 45.1% of all the participation stated that participation in the project did not meet their expectations. The participants with unsatisfied expectations, and those without increased knowledge did not differ from those with increased knowledge concerning social or demographic variables but significantly differed concerning health behaviour (smoking and physical activity), implying differences in personality. Nijhuis et al. [46] concluded that students who gained knowledge were well organised, goal-oriented in problem-solving courses, and more inclined to adopt deep learning strategies. Some citizen science studies showed that formal education might improve student's scientific literacy and contribution to addressing the SDGs [47].

The contribution of the study to wider society and SDGs was estimated by the evaluation of the democracy level, higher awareness, and knowledge about the natural environment. Moreover, we assessed specific targets associated with SDG 11 indicators proposals, such as the prevalence citizens satisfied with public transport services in the district (81.1%), opportunities for walking to reach the city's green spaces or parks (77.6%), and others. About 45.5% of the participants thought that their opinion and proposals were important for politicians when solving urban environment and health problems. The participants reported an increased awareness of the impact of environmental quality on health. These data conform with the latest reported achievements, benefits, and challenges of citizen science for the SDGs [48]. The analysis showed that the research could contribute to the achievement of the different SDGs at local, regional, and international levels. There also is the potential of contribution on the level of the individual SDG targets and indicators that might have a positive impact on sustainability. Citizen science projects in Europe could support all SDGs in the future [49].

Our findings of health benefits of the study participants' reaching the recommended physical activity were presented in research articles publicised to the scientific society. In addition, the results of the study were presented to the community and were uploaded on the website. In such way, this study provided facts suggesting that non-formal education through participatory research might contribute to the implementation of SDGs [50].

We sought to estimate if there was a real relationship between the participants' acquisition of useful skills and knowledge, their physical activity, and self-reported health. Physical activity is one of the main modifiable health behaviours associated with cardiovascular diseases and hypertension. Findings of epidemiological studies suggest that physical activity in green spaces may have a positive impact on cardiovascular health by reducing stress levels [31,51,52]. Therefore, increased knowledge and reaching the recommended physical activity level are measures for health promotion.

Our findings of stratified analysis reflect the significance of physical activity for health and a complex interaction of the increased knowledge supported by physical activity that mediates the associations with health. The data are in line with previously reported findings of the links between physical activity, environmental quality, self-rated health [53], and major cardiovascular risk factors besides hypertension [54,55]. The scientific literature contains reports on links between the design of urban environments, neighbourhood greenness, and physical activity [56,57]. In this study, the possibility to reach city parks by walking, as well as increased knowledge, proved to be a sound argument to reach

the recommended physical activity levels. The impact of the gained knowledge was significant ($p = 0.003$), albeit moderate. Even though 60.6% of the study participants agreed that greater physical activity and walks in the park might improve their health, only 17.7% of high-impact participants and 10.9% of those with a low impact on knowledge reached the recommended level of physical activity, which shows a potential for further activity. The participation in the environmental epidemiological project enhanced the understanding of the environmental issues that affect citizens' health and well-being and had a beneficial effect on health behaviour. There is a lack of a standardised assessment of the impact of environmental education, and therefore using the goals to develop targeted outcomes will help to determine if the estimated project goals were met [58]. Judging by the results of our research, this study reached the set goals and made an impact on SDGs by presenting new data potentially relevant to the SDG 3.4, SDG 4.7, SDG 11.2, SDG 11.6, SDG 11.7 indicators. We suggest that greater attention should be paid to defining environmental education targets during study planning and permanent monitoring of the study progress, analysing areas where citizen science could contribute to SDGs. The implications of this research in sustainable cities are that it suggests creating residential neighbourhoods that would provide universal access to a safe green environment and would promote increased physical activity, such as reaching green spaces by walking, which might reduce the health risk via the implementation of the sustainable development goals.

5. Conclusions

The results of this environmental epidemiological study showed that informal adult environmental education through participatory action research is an important measure to empower citizens to identify environmental problems and defining local targets. The study findings showed that citizen science can help achieve various SDG targets through education and changing the participants' attitudes to health-related environmental problems, health behaviours, and citizen engagement in decision making. During this study, inter-sectoral collaboration was established between the public, scientists, stakeholders, and NGOs, and new data for the implementation of SDG 3, SDG 4, and SDG 11 were generated at the city district level for environmental health policy. A perceived high quality of the neighbourhood was found to be associated with better self-rated health, higher acquired knowledge, and higher physical activity levels. These findings emphasise the value of urban planning in promoting healthy behaviour, among them creating opportunities for walking to reach the city's green spaces or parks. In future citizen science studies, the use of new technologies available today, such as the use of sensors, is recommended to increase participation-affected behaviour and the societal promotion of physical activity for the prevention of chronic diseases. The problem-based learning approach empowers citizens to solve environmental health problems through acquired knowledge and provides scientific evidence that improving the neighbourhood environment that would promote increased physical activity might benefit the society. The findings of this participatory research study are helpful in gaining a better comprehension of the relationship between the quality of the neighbourhood and the magnitude of the health-related problems. Therefore, the implementation of the Agenda 2030 for sustainable development goals and targets might be achieved through improving and protecting both the natural environments and the population's health and well-being.

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