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The Effect of Environmental Science Communication on Perceived Neighborhood Environmental Quality, Physical Activity, and Health Risk

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Abstract

Environmental science communication integrated into environmental epidemiological research is a measure to raise community awareness of neighborhood environment-related health issues and impact health behavior. However, little data exists on the effect of communication practice on the participants in collaborative epidemiological research. We aimed to evaluate environmental science communication's effect on study participants' ecological knowledge, physical activity, and health, and examine the relationship between urban-built and perceived neighborhood environments' quality and health risk. This was an environmental epidemiological collaborative study, using a cross-sectional study design, individual-level data, evidence-based environmental science communication, and geographic information systems methodology, which included 714 population-based 45-64-year-old citizens. We measured residential traffic flows and perceived neighborhood environmental quality. Health outcomes were measured by physician-diagnosed chronic disease and self-rated health. Multivariate logistic regression analysis was used to estimate the associations between combined environmental factors, perceived environmental quality, physical activity, and the risk of poor health. Environmental science communication improved participants' ecological knowledge. There were significant differences in rating of the acquired knowledge, individual environmental quality perceptions, stress level, and self-rated health risk. Perceived poor environmental quality was independently associated with stress level and self-rated poor health risks. High ecological education impact was associated with significantly lower stress level and poor health risk (adjusted odds ratios 0.61 and 0.72, accordingly). We found a significant indirect association between physical activity in parks, stress level and health risk. Environmental science communication had the potential to increase public health benefits to society by influencing ecological awareness and health behavior. The perceived ambient air pollution might be used as an indicator of poor environmental quality that impacts citizens' health risk and should guide policies aimed at improving health and air quality in cities.

Keywords: *Urban environment, science communication, perceived environmental quality, health risk, physical activity, collaborative epidemiological research.*

Introduction

Current research through public engagement in open science can support policy for the implementation of sustainable development goals [1–3]. Environmental science communication through problem-based education might enhance public awareness of how the residential environment affects their health and to motivate participation in local environmental decision-making [4–6]. In this research, environmental communication means the distribution of information among the study participants and the implementation of communication practices that are related to the environment. Currently, science communication in practice means the entire science communication chain – scientists, participants, stakeholders, social media, and policymakers [2] and requires significant changes in teaching [7]. The communication practice of the Social Cognitive theory suggests changes by informing, enabling, motivating, and investigating personal behavior considering the environmental impact [8]. However, to date, the science communication practice in environmental epidemiological research has not been studied extensively [9,10]. The communication needs to engage study participants in environmental education, with using problem-based learning and evaluating the impact of the research results on the study participants, the community, science, and sustainability [9,11]. The created Concept Mapping model encourages considering the participants' actual themes, environmental behavior, and outcomes assessment [12]. A framework of indicators has been presented to measure the environmental behavior by environmental lifestyle behavior, participation in environmental policymaking, and social cohesion [13].

In this epidemiological study, environmental science communications as an integrated process of research were used to encourage participants' pro-environmental health behaviors. Our evaluation of science communication includes the Concept Mapping model [12], the principles of evidence-based science communication [7], and the Theory of Planned Behavior [14]. The concept assumes that the environment influences individuals' personality, meanwhile behavior depends on subjective norms, knowledge, and perceived behavioral control to influence the decision to behavior change. Figure 1 shows our conceptual framework and hypothesized pathways linking environmental issues and health outcomes, controlling for the influence of socioeconomic status (SES) variables.

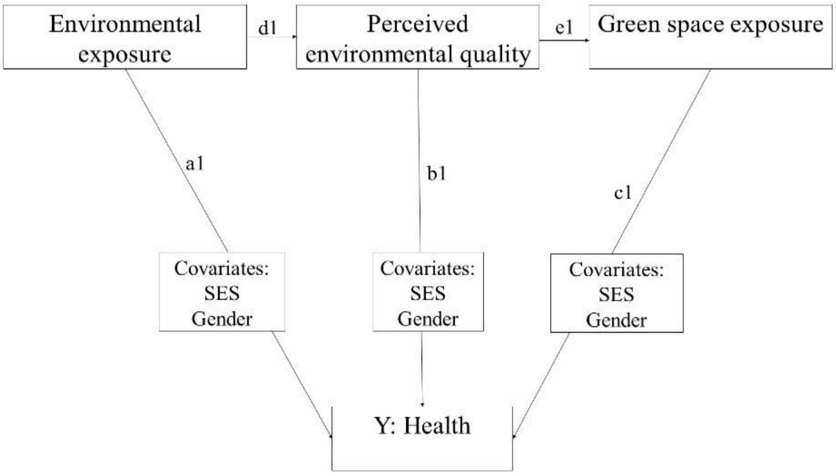

Figure 1: Conceptual framework showing hypothesized pathways linking environmental issues to health outcomes. The arrows represent hypothetical patterns of influence.

Our study of hypothetical associations was focused on the reported previous epidemiological findings that residents' physical health and well-being may depend on the urban environments including green spaces, and participants' physical activity associated with perceived local environmental quality [15–17]. The conceptual framework includes environmental domains that impact health depending on the traffic-related environmental exposure levels [18,19], SES, sex, and health behavior [20–22], and green spaces effect [23–26]. However, little is known about personal outcomes resulting from science communication, and the impact of environmental behavior changes on the participants' health remains uncertain [4,27]. There is some evidence that urban green space is beneficial for the health and well-being of urban residents through increased physical activity, societal cohesion, reduced stress, and better general health [28–30]. Potential pathways linking green space exposure to health mainly comprise psychological stress-relieving and increased physical activity levels among residents of urbanized settings [24,26].

This environmental epidemiological study has been initiated as the Pilot study of the Horizon proposal Citizen Science for Urban Environment and Health 2019-2022 [31]. In this study, we for the first time investigated the environmental science communication as part of the whole environmental epidemiological research and evaluated ecological education impact on the general health among 45–64-year-old participants of an Eastern European country. General health is treated as environmental exposure and the health behavior outcome and is measured by questionnaire. A questionnaire measures a subjective indicator of self-rated health status that integrates biological, mental, social, and functional aspects of a person, including environmental health behaviors [21]. Self-rated general health is treated as a valid predictor of residents' morbidity and mortality [32,33], and might depend on satisfaction with residential environmental conditions, well-being, and participants' physical health [34,35].

In this study, we placed participants' concerns at the heart of environmental epidemiological research to foster problem-based learning of the environment's impact on health outcomes. Building on the 45–64-year-old participants' concerns for neighborhood environmental quality and residents' health, this study tested two hypotheses: H1) environmental science communication improves participants knowledge and significantly impacts environmental quality perception, H2) perceived poor environmental quality and low physical activity are independent variables that impact stress and self-rated poor health risks. This epidemiological study, while using science communication, explores hypothesized pathways of how built and perceived neighborhood environments affect health behavior and multi-dimensional health issues. Such complex knowledge serves policy makers and public health practitioners in designing intervention programmes.

Materials and Methods

Study Design

The present study extends previous work of the Citizen Science for Urban Environment and Health Kaunas Pilot study by providing new empirical evidence on how environmental science communication and perceived air pollution in residential settings is related to physical activity and poor health risk, especially of heavy-traffic flow streets residents. This epidemiological-collaborative study used science communication and statistical analysis methods for the evaluation of complex research outcomes using a systematic approach. The basic principles of engaged participants included individual rights and the right to make informed decisions described in the Declaration of Helsinki [36]. The informed consent was signed before entering the research and was approved by the local Ethics Committee. The epidemiological study description have been provided previously [37].

The current study data was collected through an online survey carried out in 2022. The survey sample of 1000 was drawn from voting lists of 45–64-year-old Kaunas residents and 714 agreed to participate in the study (71.2% response rate). Environmental science communication strategy included study participants providing a tutorial during annual scientific-practical conferences Human and Nature Safety, discussions, mapping, and videos, and sharing scientific results. During the dialogues with stakeholders and politicians, scientific research results, practical recommendations, and findings for intervention programmes were discussed.

This collaborative research builds on the environmental epidemiological approach and cross-sectional study design. Participants were involved in scientific hypothesis formulation, discussion of study protocol, and activities of environmental data collection, measuring and rating the neighborhood environmental quality, and scoring personal health. To raise participants' environmental awareness, we organized annual meetings and conferences and used education material built on evidence-based real Kaunas environmental epidemiological cohort studies [38], and randomized clinical trial results [39,40]. Through communication and ecological education, we seek to motivate participants' activities in the study [41]. Our publicized results of the collaborative Kaunas Pilot study demonstrated data potentially relevant to sustainable development goals (SDGs): air pollution caused problems (SDG 11.6), ensure healthy lives and promote well-being for all (SDG 3), and education for sustainable development (SDG 4.7) (37).

This study analyzes data of 714 population-based samples of 45-64-year-old citizens permanently residing in 11 Kaunas City districts. We seek to answer the participants' formulated question: "What impact does the perceived poor neighborhood environment quality have on residents' health?" We evaluated individual-impact outcomes as a problem-based ecological education result during the study. We aimed to show that environmental science communication through promoting ecological knowledge impacts environmental health behavior and has a positive impact on general health. To measure self-rated research outcomes, we encouraged participants to take what they have learned during problem-based education and their activities and evaluate the strategies for themselves. This comprised using health behavioral changes, also a good acknowledgment of self-rated health issues, and an evaluation of neighborhood environmental quality effect on their personal health.

Measurement of Environmental Science Communication Outcomes

In this study, we used the recommendations of the experts' for evaluation of science communication and environmental education outcomes [13,42,43]. The outcomes were estimated by the testing of the hypothesized pathways using quantitative and qualitative methods to better understand complex mechanisms [44,45].

To measure research outcomes, 660 participants independent of their health status, using formalized questionnaires rated ecological education outcomes about the acquisition of new skills, new knowledge, and behavior changes. The participants rated statements using a Likert rating scale ranging from 1 (strongly disagree) to 7 (strongly agree). The statements were: reducing air pollution would improve the health of the citizens; greater physical activity and walks in the park improve my health; my opinion and proposals for politicians are important for solving urban environment and health problems; I will use the acquired skills in my life and activity; participation in the study improved my data collection and interpretation skills; participation in the study increased my knowledge about the links between environmental quality and my health; participation in the study did not meet my expectations. Higher scores indicated higher impact.

Measurement of Environmental Quality

Two measures were used to estimate environmental quality: road traffic flow and perceived environment quality scores. We used geographic information systems (GIS) and ArcGIS 10.4 software to link traffic flow and perceived environment quality scores to each participant's home address. In the analysis, participants living on the street with more than 10,000 cars per day were referred to as highly exposed to traffic emissions, remaining participants were referred to as low exposed to traffic emissions.

The perceived environmental quality was estimated by rating questions comprising neighbourhood quality and social well-being: Does the public transport in the district meet your needs? Are you satisfied with the pathways and cycling routes? Are there opportunities for walking to reach the city's green spaces or parks? Can you take part in the decision-making to improve the environment in which you live? Do you feel safe in your area? During the last 6 months, have you felt stress, tension, or anxiety? Does air pollution in your place of residence cause health problems? Does the noise in your place of residence hinder your sleep and/or work at home? Do you regularly visit the park? The perceived environmental quality was rated using a seven-point Likert rating scale ranging from 1 (strongly disagree) to 7 (strongly agree). Higher scores indicated better environmental quality satisfaction.

Measurement of Health Status

The participants' subjective health status was assessed by the self-rated health score of the question "How would you rate your overall health status at present on a scale from 1 (poor) to 5 (very good)?" A similar measure of health status, a five-point Likert rating scale is used in international studies [32,46,47]. We treated health status below the mean as "poor", and above the mean as "good". Self-rated poor health was validated by the presence of physician-diagnosed chronic non-communicable diseases (cardiovascular disease, hypertension, obesity). To measure stress level, participants scored the question: "During the last 6 months, have you felt stress, tension, or anxiety?" Scores below the mean indicated lower stress levels.

To measure the health behavior variable of physical activity, both subjective measurement and objective measurement tools were used. The measure was indicated by two subjective variables: self-reported leisure-time recommended physical activity duration and frequency of visits to a park. To measure objectively physical activity levels, we used 7-day wearing certified sensors Fitbit Alta data. We validated subjectively acknowledged physical activity levels by the sensor's estimated physical activity. For this measure, we used the data of the first 50 participants who agreed to wear the sensor during everyday activities. In this study, the recommended duration of physical activity was defined by international guidelines [48], i.e., at least 150 min/week of moderate-intensity physical activity outdoors. The participants presented information on physical activity during leisure time by answering the following question: "During the last week, what was the meantime per day you spent outdoors walking fast, bicycling, or gardening?" The measure of physical activity was adapted from publicized international studies [46]. We classified spent outdoors physical activity by time: recommended - at least 150 min/week of moderate-intensity and fewer min/week. Another estimate was acquired by answering the question: "Do you regularly visit the natural environment/park?'' The answers were classified as regular visits (three or more times per week) and irregular visits (two or less times per week). We validated the consistency of the answers by comparing the above-mentioned leisure time physical activity levels of recommended time activity level and regular visits in a park with the 7-day sensors Fitbit Alta devices data of calculated activities in METS. Self-reported moderate-intensity data and regular visits to the park showed good concordance to activities ranging between 3 - 6 METS showing good validity of acknowledged physical activity spent outdoors.

Key Concepts and Hypotheses Testing

The key hypothesized pathways testing of this study comprises a holistic approach of long-term traffic-related environmental exposure associated with perceived poor environmental quality and environment-related major chronic non-communicable diseases, such as cardiovascular disease, hypertension, and obesity, which are main determinants of self-rated poor health. The collected personal data for hypotheses testing comprised participants perceived environmental quality, residence history, demographic, and SES, physician-diagnosed chronic diseases, physical activity level, visits to a park, stress, and self-rated general health. In analysis, all data were dichotomized. Individual level SES was estimated by the participant's education level and the situation at work. The impact of confounding variables SES, age, gender, smoking status, and others in testing hypotheses of the associations of environmental exposures and health outcomes was controlled by using mathematical modeling.

Statistical Analysis

Descriptive statistics

Testing H1, first, we analyzed participants' baseline characteristics associated with different personal and environmental factors distribution according to health status. The baseline covariates were examined using the chi-squared test to compare the values and the frequencies of the participants' characteristics by good and poor health status. Then, we evaluated the prevalence of acquired of new skills and knowledge outcomes among males and females and estimated the links between health indices and ecological education outcomes. We used mean ratings of the perceived neighborhood quality scores to analyze links with the self-rated good and poor health. In tables, quantitative variables we reported as mean values and standard deviations and choose a p-value < 0.05 as the significance level. Qualitative characteristics were analyzed by Fisher's exact test.

Modeling of environment-health associations effects

Testing H2, we applied univariate and multivariate (adjusted) logistic regression models to produce odds ratios (OR) and measure the strengths of the associations and their 95% confidence intervals (CI). In the models, we evaluated the strengths of the relationships between the perceived neighborhood quality factors, physical activity, and ecological education impact on stress and poor health risk. In a sensitivity analysis, univariate odds ratio (OR) and adjusted odds ratios (aOR) of multivariate models were used to estimate the strengths of the relationship between the variables. In such a way we calculate the risk that a poor health effect will result from exposure, controlling for co-variates by statistical modeling. The multivariate models were adjusted for co-variates: sex, education level, age, smoking status, and income. In this analysis, independent variables included perceived environmental quality indicators, ecological education outcomes and physical activity. Dependent variables were poor health and stress. In the multivariate logistic regression models, we applied higher than 0.05 p-value thresholds (such as <0.2) for the inclusion of predictor variables from bivariate statistics to prevent the exclusion of relevant factors (49). For this reason, we also retained the variables that changed the adjusted odds ratios by 10% or more for inclusion in the multivariate logistic regression analysis. Statistical analysis was performed using the SPSS version 25.0 package (IBM Corporation, New York, NY, USA).

Results

Results of testing H1. Hypothesis testing started with the elucidation of the sociodemographic and environment-related variables which are associated with health status and are treated as risk factors for poor health (Table 1). Findings showed that high traffic flow did not have a significant effect on self-rated poor health. Poor health risk was significantly associated with physicians diagnosed chronic diseases, perceived air pollution, irregular visits to the park, and higher levels of stress. These variables can be treated as risk factors for poor health. Poor health participants reported participation in the study impact as "high" more rarely than good-health participants did (14.8% and 85.2%, respectively, p = 0.015).

Table 1: Sample characteristics by health status among 45-64-year-old participants. (N=714).

Characteristics	Total number N (%)	Good health, N (%)	Poor health, N (%)	p
Sex				0.850‡
Men	325 (45.5)	260 (80.0)	65 (20.0)	
Women	389 (54.5)	314 (80.7)	75 (19.3)	
Family status				0.666‡
Married	458 (64.1)	366 (79.9)	92 (20.1)	
Other	256 (35.9)	208 (81.3)	48 (18.8)	
Education status				0.703‡
Higher educated	408 (57.1)	330 (80.9)	78 (19.1)	
Lower educated	306 (42.9)	244 (79.7)	62 (20.3)	
Situation at work				0.048‡
Full-time	517 (72.4)	425 (82.2)	92 (17.8)	
Other	197 (27.6)	149 (75.6)	48 (24.4)	
Current smoking				0.878‡
No	573 (80.3)	460 (80.3)	113 (19.7)	
Yes	141 (19.7)	114 (80.9)	27 (19.1)	
Visits to the park				0.004‡

Regular	443 (62.0)	371 (83.7)	72 (16.3)	
Irregular **Traffic 10,000 cars/day**	271 (38.8)	203 (74.9)	68 (25.1)	0.212‡
< 10,000	505 (70.7)	412 (81.6)	93 (18.4)	
≥ 10,000	209 (29.3)	162 (77.5)	47 (22.5)	
Hypertension				0.003*‡
No	512 (71.7)	443 (86.5)	69 (13.5)	
Yes	202 (28.3)	131 (64.9)	71 (35.1)	
Body mass index		25.96 (4.03)	27.32 (5.75)	0.009*†
Healthy (18.5-24.99)	297 (42.1)	238 (80.1)	59 (19.9)	0.013*‡
Overweight (25-29.99)	304 (43.1)	254 (83.6)	50 (16.4)	
Obesity (>=30)	104 (14.8)	73 (70.2)	31 (29.8)	
Physical activity				0.421‡
Low (<150 min/week)	569 (79.7)	454 (79.8)	115 (20.2)	
Recommended (>150 min/week)	145 (20.3)	120 (82.8)	25 (17.2)	
Participation impact				0.015*‡
High (>mean score) Low (<mean score)	267 (40.5) 393 (59.5)	335 (85.2) 208 (77.9)	58 (14.8) 59 (22.1)	
Stress level				0.000*‡
High (score <mean)	360 (50.4)	267 (74.2)	93 (25.8)	
Low (score >mean)	354 (49.6)	307 (86.7)	47 (13.3)	
Perceived air pollution				0.000*‡
No (score >mean)	338 (50.6)	300 (88.8)	38 (11.2)	
Yes (score <mean)	330 (49.4)	249 (75.5)	81 (24.5)	

† p-value of Student's t test; ‡ p-value of the chi-squared test; SD – standard deviation; *p<0.05.

Table 2 presents the self-reported prevalence (%) of high impact outcomes of 45-64 years participants (acquired new skills and knowledge of learning and empowerment). The results indicate that the high-impact ecological education outcomes are similar for males and females. Most of all participants acknowledged the high impact of acquired new knowledge on a better understanding links between environmental quality and health problems, and that greater physical activity and walks in the park might improve their health. However, 31.2% of the participants stated that participation in the study did not fully meted their expectations.

Table 2: Self-reported collaborative study of 45-64 years participants acquired new skills and knowledge by sex.

Outcomes of new skills and knowledge	**Total sample**	**Sex**		
	% high impact (>mean)[b]	**Male**	**Female**	**p**
Reducing air pollution would improve the health of the citizens[a]	68.0%	6.09	6.05	0.757
Greater physical activity and walks in the park improve my health[a]	80.4%	6.18	613	0.618
My opinion and proposals for politicians are important for solving urban environment and health problems[a]	67.2%	3.30	3.61	0.617
I will use the acquired skills in my life and activity[a]	66.9%	3.39	3.64	0.071
Participation in the study improved my data collection and interpretation skills[a]	68.8%	3.23	3.51	0.148
Participation in the study increased my knowledge about the links between environmental quality and my health[a]	62.7%	6.15	6.20	0.627
Participation in the study did not meet my expectations[a]	31.2%	4.12	4.19	0.621

[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 %.

Next, we studied whether exists links between self-reported health-associated indices and education impact level (Table 3). The findings indicate that the high-impact participants more often rated their health as "good" and 64.4% of them regularly visited parks. High-impact participants also more often than low-impact participants worried that air pollution in the place of residence impacts their health (p = 0.010), and their stress level was lower than that of low-impact participants. Visiting the park regularly was found to be more common among the high-impact group participants (p = 0.054), but they do not suggest that the knowledge acquired during the study alone influenced the changes in personal health behaviors. Recommended leisure time moderated physical activity (>150 min/week) was low in both groups reaching only 19.6% of high-impact participants, and 12.4% of low-impact participants (p = 0.014). The findings show a big potential to increase physical activity, especially for 80.4% of participants who recognized that greater physical activity and walks in the park might improve their health.

Table 3: Health issues of the 45-65 years participants by the ecological education impact level.

Health Indices	Low Impact, N (%)	High Impact, N (%)	p
Health status			0.015*‡
Good	208 (77.9)	335 (85.2)	
Poor	59 (22.1)	58 (14.8)	
Stress level			0.038*‡
Stress high (score <mean)	147 (55.1)	184 (46.8)	
Stress low (score >mean)	120 (44.9)	209 (53.2)	
Physical activity			0.014*‡
Low (<150 min/week)	234 (87.6)	316 (80.4)	
Recommended (>150 min/week)	33 (12.4)	77 (19.6)	
Visits to the park			0.054‡
Regular	152 (56.9)	253 (64.4)	
Irregular	115 (43.1)	140 (35.6)	
Perceived air pollution			0.010*‡
No (score >mean)	151 (56.6)	182 (46.3)	
Yes (score <mean)	116 (43.4)	211 (53.7)	
Perceived noise			0.177‡
No (score >mean)	188 (70.4)	257 (65.4)	
Yes (score <mean)	79 (29.6)	136 (34.6)	
‡ p-value of the chi-squared test; *p<0.05.			

Next, we studied whether there are differences in good health and poor health participants' perception of environmental quality (Table 4). We estimated mean environmental perceptions along three dimensions: satisfaction with the built environment, perceived environmental exposure, and social cohesion. Health status perceived as "good" was significantly more often associated with higher scores of satisfactions with the built environment, higher perceived environmental exposure, and better rating of social cohesion compared to the "poor" health group. Our findings show that problem-based education improves science literacy and ecological knowledge and significantly impacts environmental quality perception, which is associated with self-rated health status. However, we found a significant gap between participants knowing that more physical activity and walking in the park can improve their health and the recommended level of physical activity that they have achieved.

Table 4: Mean ratings of the perceived neighbourhood quality and social well-being in 45-64-year-old participants by health status.

Questions Neighbourhood quality and social well-being	Good health Mean (SD)	Poor health Mean (SD)	p
Satisfaction with the built environment			
1. Does the public transport in the district meet your needs?	5.31 (1.78)	4.84 (2.22)	0.022
2. Are you satisfied with pathways and cycling routes?	5.08 (2.01)	4.34 (2.35)	0.001
3. Are there opportunities for walking to reach the city's green spaces or parks?	5.53 (1.97)	4.78 (2.25)	0.000
Environmental exposure			
4. Does air pollution in your place of residence cause problems?	4.21 (2.04)	3.26 (2.15)	0.000
5. Does the noise in your place of residence hinder your sleep and/or work at home?	5.11 (1.88)	4.39 (2.30)	0.001
6. Do you regularly visit the park?	4.95 (1.98)	4.26 (2.15)	0.001
Social cohesion			
7. Do you feel safe in your area?	5.30 (1.61)	4.69 (2.05)	0.001
8. Can you take part in the decision-making to improve the environment in which you live?	3.50 (2.11)	3.00 (2.28)	0.019
9. During the last 6 months, have you felt stress, tension, or anxiety?	4.32 (1.80)	3.54 (2.00)	0.000
All neighbourhood perception scores ranged from 1 to 7: 1 = strongly disagree, and 7 = strongly agree. Higher scores indicate better neighbourhood conditions.			

Results of testing H2. During evaluation of the relationships between perceived environmental quality, ecological education impact, physical activity level, and self-rated poor health and stress we conducted univariate and multivariate logistic regression analysis controlling for co-variates that may impact the strength of the associations (Table 5). All multivariate results were adjusted for co-variates: sex, education level, age, smoking status, and income, and the strength of the association was determined as odds ratios and their 95% confidence intervals (CI). Traffic flow tends to increase the odds ratios of poor health risk and stress; however, the associations were not significant. Perceived poor environmental quality was associated with significantly increased the odds ratios for poor health risk and stress. The odds of poor health risk among those participants who perceived high ambient air pollution were 2.58 (1.69-3.94) times higher compared to those of individuals who gave higher scores to ambient air quality. The odds of poor health risks and stress among regular visitors to the park were significantly lower compared to those of irregular visitors to green spaces (adjusted OR 0.56 (0.38-0.82) and 0.69 (0.51-0.95)). Consistent associations in univariate and multivariate models demonstrate that regular visits to the park were independently associated with health risk in the studied population and that regular physical activity in green spaces might significantly decrease the risk for poor health and stress.

Table 5: Multivariate logistic regression models of perceived neighborhood quality and physical activity on poor health, and stress in 45-64-year-old participants.

Independent variables	Dependent variable models			
	Poor health		Stress (<mean)	
	Univariate OR (95% CI)	Multivariate OR* (95% CI)	Univariate OR (95% CI)	Multivariate OR* (95% CI)
Quality of pathways and cycling routes				
<mean score	1.93** (1.32-2.81)	1.95** (1.34-2.85)	1.67** (1.22-2.29)	1.68** (1.22-2.30)
Green spaces by walking				
<mean score	1.97** (1.36-2.87)	2.01** (1.38-2.92)	1.67** (1.24-2.27)	1.69** (1.25-2.29)
Available relaxation area				
<mean score	1.56** (1.08-2.26)	1.58** (1.09-2.31)	1.02 (0.76-1.37)	1.04 (0.77-1.40)
Perceived air pollution				
<mean score	2.57** (1.69-3.91)	2.58** (1.69-3.94)	1.72** (1.27-2.34)	1.70** (1.25-2.31)
Safety in the district				
<mean score	1.45 (0.99-2.11)	1.47** (1.01-2.14)	2.04** (1.51-2.75)	2.07** (1.53-2.79)
Traffic 10,000 cars/day				
Yes (vs No)	1.29 (0.87-1.91)	1.29 (0.86-1.92)	1.16 (0.84-1.61)	1.18 (0.85-1.64)
Visits to the park				
Regular (vs Irregular)	0.58** (0.40-0.84)	0.56** (0.38-0.82)	0.73** (0.54-0.98)	0.69** (0.51-0.95)
Physical activity				
Recommended (vs Low)	0.82 (0.51-1.33)	0.81 (0.50-1.31)	0.70 (0.48-1.02)	0.70 (0.48-1.01)
Ecological education impact level				
Hight (vs Low)	0.62** (0.41-0.92)	0.61** (0.41-0.92)	0.73** (0.53-0.99)	0.72** (0.53-0.98)
OR, odds ratios; *adjusted for: sex, education level, age, smoking status, and income; Neighbourhood quality scales ranged from 1 to 7. For all scales, the referent group is the mean score or above; **p<0.05.				

These data provide evidence that perceived air pollution is a risk factor of self-rated poor health, and that physical activity in green spaces should be used as an effective measure for a decrease of poor health risk.

Discussion

This is one of the first study of environmental science communication as an integrated process in environmental research that examines the complicated relationships among environmental quality and ecological education impact on participants ‘environmental quality perception, health behavior and self-rated health. The complex research, using a cross-sectional study design and mathematical modeling, assessed the relationship between urban-built, perceived neighborhood environments, and self-rated health controlling the impact of confounding variables. This epidemiological study provided evidence that science communication using ecological education and evidence-based data had a positive impact on participants' ecological literacy, health behavior, and health. The research results are used in environmental policy and public health practitioners in designing intervention programmes to improve the health of the residents.

Our framework for science communication methods comprised organizing scientific-practical conferences, engaging participants in discussions, data acquisition, and presenting a research data that inform policy and promote decision-making at local, national, and global scales. The impact of science communication on most participants was found to be significant, with improved intentions to use the skills learnt in their lives and the ability of policy makers to influence environmental and health issues. The high-impact communication outcome was associated with a better perception of environmental quality, regular physical activity in parks, and better self-rated health. About half of participants recognized that residential air pollution causes health problems, and as many as 80.4% of participants stated that greater physical activity in the green environment might improve their health. The findings show that problem-based education through the improvement of science literacy significantly impacts environmental quality perception. In this population sample, the high impact participants more often had a significantly lower stress level, rated their health as “good”, and regularly visited the park, compared to low impact participants. However, the recommended physical activity level is low in both groups and there is a big potential to increase physical activity by walking in the parks. The data suggests that personality, subjective attitudes, priority, and low levels of motivation may be contributing factors to low levels of physical activity. This is in line with the previous studies' findings on the participants' gains in ecological knowledge and abilities to recognize environmental-level problems, however, little influence on changes in the participants' behavior or their activities to impact the situation [4,27].

Strengths and limitations of the study

The study strengths include a population sample, a traditional epidemiological analytical study approach, the use of formalized questionnaires, and standardized multivariable analytical methods for the assessment of associations. Neighborhood traffic flow was determined using validated GIS-based measures, and physical activity measures included certified sensors for validating self-reported physical activity in green environments. These measures and outlined participants' environmental and health concerns helped us to gain new knowledge about the neighborhood and health, about the associations between the participants' increased knowledge, self-rated health status, and the positive effect of regular physical activity in city parks on participants health. The findings revealed an advancement of environmental science communication associated with problem-based ecological education. The quantitative and qualitative measurements and use of scientific research principles generated high-quality data [50].

A key study limitation was the cross-sectional design, which ruled out the possibility of determining causality but confirmed the hypothesized associations between environmental issues and health risk. Also, usage of self-reported characteristics cannot exclude the residual confounding. Self-rated outcome impact appreciated as an education outcome during the study, had the potential to produce random errors in assessing the study outcomes. We used self-rated health status; however, to ensure that the data could be used in policy making, we compared self-rated "poor" health cases with the physician-diagnosed major chronic diseases of every study participant and found good concordance. Even though the acknowledged limitations can produce random errors, this study has the potential to present evidence-based findings which might enhance public understanding of links between the environmental quality and health issues through the results of the epidemiological study.

Obtained important findings

Testing scientific hypotheses, we have confirmed the hypothesized pathways linking environmental quality to health issues. Science communication and the use of problem-based education improved science literacy and ecological knowledge and significantly impacted environmental quality perception. The findings showed that residential road traffic had an impact on the perception of air pollution. These data are in line with environmental studies that acknowledged traffic-related environmental exposure levels determine health impact levels [19]. Our findings showed that the participants with perceived air pollution more often had increased risks of stress and self-rated poor health. Self-rated poor health was associated with the presence of major environment-related chronic non-communicable cardiovascular diseases and was the result of complex environmental exposures, stress, and health behavior, including low physical activity in the natural environment. This hypothesized pathway is supported by the representative population cohort study findings showing that cardiovascular risk factors are significantly lower among park users for physical activity than among non-users [38]. This study's findings showed that perceived poor environmental quality and low physical activity are independent variables that impact stress and self-rated poor health risks. The stress risk among regular visitors to the park was 31% lower compared to that of irregular visitors to the park, and the odds for poor health risk decreased by 44%. Consistent associations in mathematical models controlling for confounding variables demonstrate that regular visits to the park were independently associated with health risk outcomes in the studied population. The findings suggest that there is a good opportunity to increase recommended physical activity levels in a natural environment which might significantly decrease the risk of poor health and stress by reaching moderate physical activity levels during walking. This hypothesized pathway is supported by the randomized control trial of citizens suffering from cardiovascular problems [40]. This controlled field study presented evidence that moderate physical activity in a city park has a positive effect on participants' stress hormone cortisol levels and hemodynamic parameters. Investigating the impact of perceived environmental quality on adults' health and life satisfaction, it has been found that a better perceived neighborhood environment promotes physical activity [51], influences attitudes, and might reduce the intention-behavior gap [52].

Data from our environmental epidemiological study and previously reported findings confirm the possible pathophysiological pathways and the beneficial effects of exposure to the natural environment. Exposure to green spaces has been shown to reduce stress, anxiety and cortisol levels, and has a restorative effect on health [26,53].

The obtained data present evidence that regular physical activity in green spaces is an effective measure to reduce poor health risk. The perceived high air pollution in the place of residence should be a target of health policy to improve the situation, which comprises both measures: increasing physical activity in the park and controlling traffic-related emissions. Stronger green space-health effects in city parks might be explained in part by the pathways underlying these associations (i.e., lower air pollution, less noise, reducing chronic stressors, manifest in homeostasis) and the modification effects of physical activity on health [24,54]. In general, green space might yield a wide range of health positive effects on both short-term and long-term health outcomes, suggesting how important it is to support decisions on urban green space accessibility and how beneficial for health walking in green environments can be [53].

Conclusion

In this research, science communication was part of the whole environmental epidemiological research of participants health risk evaluation. The findings show that science communication using problem-based ecological education improves participants' natural science literacy, and significantly impacts environmental quality perception associated with health issues. These outcomes are important for health behavior and physical activity in green environment, but their effect size for achieving the recommended level of physical activity is small at the studied population sample level. Exists a big gap between the knowledge of physical activity benefits personal health and real physical activity, which might be a result of subjective attitudes that impact personal behavior changes, and personality. The new findings from the current study point to the important role of environmental quality perception and regular physical activity in parks in decreasing the effect of perceived air pollution on chronic stress and poor health risk. This study provides scientific evidence for health policy that perceived ambient air pollution should be treated as an indicator of poor environmental quality increasing citizens health risk. Improving the urban environment and the accessibility of parks by walking can reduce the citizen's health risks, stress levels, and the prevalence of environment-related chronic non-communicable diseases. Future research should use science communication to promote scientific advancement for sustainable development by interaction with diverse audiences to awareness raising. Understanding nature's impact pathways could expand the appropriate use of the green environment to improve psychological and physical health.

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Conflict of interest

The authors declare no conflict of interests.

Author contributions

R.G.: conceptualization and writing; S.A.: methodology and formal analysis; A.R.: acquisition and revision of data. All authors have read and agreed to the published version of the manuscript.

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References

1. Dickinson JL, Shirk J, Bonter D, Bonney R, Crain RL, Martin J, et al. The current state of citizen science as a tool for ecological research and public engagement. Front Ecol Environ [Internet]. 2012 Aug 1 [cited 2021 Dec 8];10(6):291–7. Available from: https://esajournals.onlinelibrary.wiley.com/doi/full/10.1890/110236
2. Hecker S, Haklay M, Bowler DE, Makuch Z, Vogel J, Bonn A. Innovation in open science, society and policy – setting the agenda for citizen science. Citizen Science. 2019. 1–184 p.
3. West S, Pateman R. How could citizen science support the Sustainable Development Goals? 2017;(2017):1–8. Available from: https://www.sei-international.org/mediamanager/documents/Publications/SEI-2017-PB-citizen-science-sdgs.pdf
4. Bonney R, Phillips TB, Ballard HL, Enck JW. Can citizen science enhance public understanding of science? Public Underst Sci [Internet]. 2016 Oct 1 [cited 2021 Apr 5];25(1):2–16. Available from: http://journals.sagepub.com/doi/10.1177/0963662515607406
5. Den Broeder L, Devilee J, Van Oers H, Schuit AJ, Wagemakers A. Citizen Science for public health. Health Promot Int [Internet]. 2018 Jun 1 [cited 2020 Mar 17];33(3):505–14. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28011657
6. Wake SJ, Birdsall S. Lookout for learning: Exploring the links between drama and environmental education pedagogies. Aust J Environ Educ [Internet]. 2020 Nov 1 [cited 2021 Apr 5];36(3):234–45. Available from: https://www.cambridge.org/core/journals/australian-journal-of-environmental-education/article/abs/lookout-for-learning-exploring-the-links-between-drama-and-environmental-education-pedagogies/3AE25996130B7C2B2E4C7849760051C4
7. Jensen EA, Gerber A. Evidence-Based Science Communication. Front Commun. 2019 Jan;4:78.
8. Bandura A. Social Cognitive Theory of Mass Communication. Media Psychol. 2009;3(3):265–99.
9. Kirsop-Taylor N, Appiah D, Steadman A, Huggett M. Reflections on integrating the political into environmental education through problem-based learning and political ecology. J Environ Educ [Internet]. 2020 [cited 2021 Apr 5];52(1):1–13. Available from: https://www.tandfonline.com/doi/abs/10.1080/00958964.2020.1825919
10. Pandya R, Dibner KA. Learning through citizen science: Enhancing opportunities by design. Learning Through Citizen Science: Enhancing Opportunities by Design. National Academies Press; 2019. 1–183 p.
11. Constant N, Roberts L. Narratives as a mode of research evaluation in citizen science: understanding broader science communication impacts. J Sci Commun [Internet]. 2017 Sep 18 [cited 2023 Feb 6];16(4):A03. Available from: https://jcom.sissa.it/archive/16/04/JCOM_1604_2017_A03
12. Bickman L, editor. The SAGE handbook of applied social research methods /. 2nd ed. Los Angeles : SAGE,; 2009. 435–474 p.
13. Olesk A, Renser B, Bell L, Fornetti A, Franks S, Mannino I, et al. Quality indicators for science communication: results from a collaborative concept mapping exercise. J Sci Commun. 2021 May;20(3):A06.
14. Brookes E. The Theory of Planned Behavior - Simply Psychology [Internet]. 2021 [cited 2023 Feb 6]. Available from: https://www.simplypsychology.org/theory-of-planned-behavior.html
15. Nieuwenhuijsen MJ, Kruize H, Gidlow C, Andrusaityte S, Antó JM, Basagaña X, et al. Positive health effects of the natural outdoor environment in t pical populations in different regions in E urope (PHENOTYPE): a study programme protocol. BMJ Open [Internet]. 2014 Apr;4(4):e004951. Available from: http://bmjopen.bmj.com/lookup/doi/10.1136/bmjopen-2014-004951.
16. Ruijsbroek A, Droomers M, Groenewegen PP, Hardyns W, Stronks K. Social safety, self-rated general health and physical activity: Changes in area crime, area safety feelings and the role of social cohesion. Heal Place. 2015 Jan 1;31:39–45.
17. WHO Regional Office for Europe. Urban green spaces and health - a review of evidence (2016) [Internet]. Copenhagen: World Health Organization; 2016 Apr [cited 2023 Jan 15]. Available from: https://www.euro.who.int/en/health-topics/environment-and-health/urban-health/publications/2016/urban-green-spaces-and-health-a-review-of-evidence-2016.

18. Foraster M, Künzli N, Aguilera I, Rivera M, Agis D, Vila J, et al. High blood pressure and long-term exposure to indoor noise and air pollution from road traffic. Environ Health Perspect [Internet]. 2014 Nov 1 [cited 2021 Sep 17];122(11):1193–200. Available from: https://pubmed.ncbi.nlm.nih.gov/25003348/.
19. Zock JP, Verheij R, Helbich M, Volker B, Spreeuwenberg P, Strak M, et al. The impact of social capital, land use, air pollution and noise on individual morbidity in Dutch neighbourhoods. Environ Int. 2018 Dec 1;121:453–60.
20. Addressing socioeconomic and gender inequities in the WHO European Region Social and gender inequalities in environment and health [Internet]. Copenhagen; 2010 [cited 2023 Jan 25]. Available from: http://www.euro.who.int/parma2010.
21. Balaj M, McNamara CL, Eikemo TA, Bambra C. The social determinants of inequalities in self-reported health in Europe: findings from the European social survey (2014) special module on the social determinants of health. Eur J Public Health [Internet]. 2017 Feb 1 [cited 2022 Apr 15];27(suppl_1):107–14. Available from: https://academic.oup.com/eurpub/article/27/suppl_1/107/3045939.
22. Rompel S, Schneider A, Peters A, Kraus U. Sex/Gender-Differences in the Health Effects of Environmental Noise Exposure on Hypertension and Ischemic Heart Disease—A Systematic Review. Int J Environ Res Public Health [Internet]. 2021 Sep 18 [cited 2022 Apr 15];18(18):9856. Available from: https://www.mdpi.com/1660-4601/18/18/9856/htm.
23. Nieuwenhuijsen MJ. Influence of urban and transport planning and the city environment on cardiovascular disease. Nat Rev Cardiol [Internet]. 2018 Jul 13 [cited 2020 Mar 17];15(7):432–8. Available from: http://www.nature.com/articles/s41569-018-0003-2
24. Browning MHEM, Rigolon A, McAnirlin O, Yoon H (Violet). Where greenspace matters most: A systematic review of urbanicity, greenspace, and physical health. Landsc Urban Plan. 2022 Jan 1;217:104233.
25. Jin Z, Wang J, Liu X. Attention and Emotion Recovery Effects of Urban Parks during COVID-19—Psychological Symptoms as Moderators. Forests. 2022;13(12):1–19.
26. Markevych I, Schoierer J, Hartig T, Chudnovsky A, Hystad P, Dzhambov AM, et al. Exploring pathways linking greenspace to health: Theoretical and methodological guidance. Environ Res [Internet]. 2017 Oct 1 [cited 2020 Jul 20];158:301–17. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0013935117303067
27. Jordan RC, Gray SA, Howe D V., Brooks WR, Ehrenfeld JG. Knowledge Gain and Behavioral Change in Citizen-Science Programs. Conserv Biol [Internet]. 2011 Dec [cited 2021 Apr 5];25(6):1148–54. Available from: https://pubmed.ncbi.nlm.nih.gov/21967292/
28. Hartig T, Mitchell R, de Vries S, Frumkin H. Nature and Health. Annu Rev Public Health [Internet]. 2014 Mar 18;35(1):207–28. Available from: http://www.annualreviews.org/doi/10.1146/annurev-publhealth-032013-182443
29. Mandelbaum J. Advancing health equity by integrating intersectionality into epidemiological research: Applications and challenges [Internet]. Vol. 74, Journal of Epidemiology and Community Health. BMJ Publishing Group; 2020 [cited 2021 Oct 27]. p. 761–2. Available from: https://jech.bmj.com/content/74/9/761
30. Hunter RF, Cleland C, Cleary A, Droomers M, Wheeler BW, Sinnett D, et al. Environmental, health, wellbeing, social and equity effects of urban green space interventions: A meta-narrative evidence synthesis. Environ Int [Internet]. 2019 Sep 1 [cited 2023 Feb 6];130. Available from: https://pubmed.ncbi.nlm.nih.gov/31228780/
31. Cities Health – Cities Health [Internet]. [cited 2023 Nov 2]. Available from: http://citieshealth.vdu.lt/
32. Wuorela M, Lavonius S, Salminen M, Vahlberg T, Viitanen M, Viikari L. Self-rated health and objective health status as predictors of all-cause mortality among older people: A prospective study with a 5-, 10-, and 27-year follow-up. BMC Geriatr. 2020 Mar;20(1):1–7.
33. Baćak V, Ólafsdóttir S. Gender and validity of self-rated health in nineteen European countries. Scand J Public Health [Internet]. 2017 Aug 1 [cited 2022 Apr 15];45(6):647–53. Available from: https://journals.sagepub.com/doi/10.1177/1403494817717405
34. Deci EL, Ryan RM, Gagné M, Leone DR, Usunov J, Kornazheva BP. Need Satisfaction, Motivation, and Well-Being in the Work Organizations of a Former Eastern Bloc Country: A Cross-Cultural Study of Self-Determination. Personal Soc Psychol Bull. 2001 Aug 2;27(8):930–42.
35. Di Domenico SI, Fournier MA. Socioeconomic Status, Income Inequality, and Health Complaints: A Basic Psychological Needs Perspective. Soc Indic Res. 2014 Dec 18;119(3):1679–97.
36. Association WM. World Medical Association declaration of Helsinki: Ethical principles for medical research involving human subjects [Internet]. Vol. 310, JAMA - Journal of the American Medical Association. American Medical Association; 2013. p. 2191–4. Available from: www.jama.com.
37. Grazuleviciene R, Andrusaityte S, Rapalavicius A. Measuring the Outcomes of a Participatory Research Study: Findings from an Environmental Epidemiological Study in Kaunas City. Sustainability [Internet]. 2021 Aug 20 [cited 2022 Apr 15];13(16):9368. Available from: https://www.mdpi.com/2071-1050/13/16/9368/htm
38. Tamosiunas A, Grazuleviciene R, Luksiene D, Dedele A, Reklaitiene R, Baceviciene M, et al. Accessibility and use of urban green spaces, and cardiovascular health: findings from a Kaunas cohort study. Environ Heal [Internet]. 2014 Dec 19 [cited 2021 Sep 17];13(1):20. Available from: https://pubmed.ncbi.nlm.nih.gov/24645935/
39. Grazuleviciene R, Vencloviene J, Kubilius R, Grizas V, Dedele A, Grazulevicius T, et al. The Effect of Park and Urban Environments on Coronary Artery Disease Patients: A Randomized Trial. Biomed Res Int [Internet]. 2015 [cited 2020 Mar 17];2015:403012. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26161399
40. Grazuleviciene R, Vencloviene J, Kubilius R, Grizas V, Danileviciute A, Dedele A, et al. Tracking Restoration of Park and Urban Street Settings in Coronary Artery Disease Patients. Int J Environ Res Public Health [Internet]. 2016 May 31;13(6):1–9. Available from: http://www.mdpi.com/1660-4601/13/6/550
41. Grazuleviciene R, Andrusaityte S, Dedele A. Citizens education through participatory research learning: A Kaunas pilot study. In: Citizens education through participatory research learning: a Kaunas pilot study

[Internet]. 2019 [cited 2023 Feb 6]. p. 8391–6. Available from: https://library.iated.org/authors/Regina_Grazuleviciene

42. Kieslinger B, Schäfer T, Heigl F, Dörler D, Richter A, Bonn A. The Challenge of Evaluation: An Open Framework for Evaluating Citizen Science Activities. 2017 [cited 2021 Apr 5]; Available from: https://osf.io/preprints/socarxiv/enzc9/
43. Phillips T, Ferguson M, Minarchek M, Porticella N, Bonney R. Program Development and Evaluation Evaluating learning outcomes from citizen science [Internet]. 2014 [cited 2021 Jul 2]. Available from: www.citizenscience.org
44. Bonell C, Fletcher A, Morton M, Lorenc T, Moore L. Realist randomised controlled trials: A new approach to evaluating complex public health interventions. Soc Sci Med. 2012 Dec 1;75(12):2299–306.
45. Moore GF, Audrey S, Barker M, Bond L, Bonell C, Hardeman W, et al. Process evaluation of complex interventions: Medical Research Council guidance. BMJ [Internet]. 2015 Mar 19;350(mar19 6):h1258–h1258. Available from: https://www.bmj.com/lookup/doi/10.1136/bmj.h1258
46. van Herzele A, de Vries S. Linking green space to health: A comparative study of two urban neighbourhoods in Ghent, Belgium. Popul Environ [Internet]. 2012 Nov 2 [cited 2021 Dec 2];34(2):171–93. Available from: https://link.springer.com/article/10.1007/s11111-011-0153-1
47. Stanojevic Jerkovic O, Sauliune S, Šumskas L, Birt CA, Kersnik J. Determinants of self-rated health in elderly populations in urban areas in Slovenia, Lithuania and UK: findings of the EURO-URHIS 2 survey. Eur J Public Health. 2017 May;27(suppl_2):74–9.
48. Kahlmeier S, Wijnhoven TMA, Alpiger P, Schweizer C, Breda J, Martin BW. National physical activity recommendations: systematic overview and analysis of the situation in European countries. BMC Public Health [Internet]. 2015 Dec 12;15(1):133. Available from: http://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-015-1412-3
49. Hosmer DW, Lemeshow S, Sturdivant RX. Applied Logistic Regression [Internet]. Wiley: Hoboken, NJ, USA: Wiley; 2013 [cited 2020 Mar 17]. 528 p. (Wiley Series in Probability and Statistics). Available from: https://onlinelibrary.wiley.com/doi/book/10.1002/9781118548387
50. Welvaert M, Caley P. Citizen surveillance for environmental monitoring: combining the efforts of citizen science and crowdsourcing in a quantitative data framework [Internet]. Vol. 5, SpringerPlus. SpringerOpen; 2016 [cited 2021 Apr 5]. p. 1890. Available from: http://springerplus.springeropen.com/articles/10.1186/s40064-016-3583-5
51. Liu J, Yang L, Xiao L, Tao Z. Perceived Neighborhood Environment Impacts on Health Behavior, Multi-Dimensional Health, and Life Satisfaction. Front Public Heal. 2022 Mar 14;10:474.
52. Rhodes RE, Brown SG, McIntyre CA. Integrating the Perceived Neighborhood Environment and the Theory of Planned Behavior When Predicting Walking in a Canadian Adult Sample. http://dx.doi.org/104278/0890-1171-212110 [Internet]. 2016 Aug 25 [cited 2023 Feb 6];21(2):110–8. Available from: https://journals.sagepub.com/doi/10.4278/0890-1171-21.2.110
53. World Health Organization WHO. Green and blue spaces and mental health: new evidence and perspectives for action [Internet]. 2021 [cited 2023 Feb 6]. Available from: https://apps.who.int/iris/handle/10665/342931
54. Tsunetsugu Y, Park BJ, Ishii H, Hirano H, Kagawa T, Miyazaki Y. Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest) in an old-growth broadleaf forest in Yamagata Prefecture, Japan. J Physiol Anthropol. 2007;26(2):135–42.

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