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ASSESSING THE RELATIONSHIP BETWEEN AIR POLLUTANTS AND PUBLIC HEALTH SENSITIVITY IN LOW-POLLUTION ENVIRONMENTS: A MULTI-CITY STUDY FROM FINLAND

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Abstract. *In this study, the sensitivity of the public health and activity indexes to changes in air pollutant concentration is evaluated in Finland, a country with a nationally low level of air pollution. The comparison was done for four cities: Helsinki, Tampere, Oulu, and Rovaniemi. The cities are chosen to be a representation of two distinct environments: 1) the more urban cities in slightly warmer environments in the South of Finland (Helsinki and Tampere), and 2) the less urban cities of the North, located in or near the Arctic Circle (Oulu and Rovaniemi). The weekly air pollutant concentration for particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and carbon monoxide (CO), as well as the health and activity parameters in several categories were the main two indicators used to make conclusions in this study, using the simultaneously collected meteorological variables as contextual support. AccuWeather was used as the main source of information, from which the data was derived in the period of autumn 2024, late spring, summer, and the beginning of autumn 2025. The findings in this study revealed that even though air pollution in Finland is still considered ideal and of a lower level compared to many developed nations, some level of difference is observed in air pollutant concentrations and consequently health symptoms between cities in the south and those in the north. The health indicators, such as asthma, sinus pressure, and migraines, are more common in regions with a high level of air pollutant concentration, whereas the common cold and the flu are more common in northern regions, likely for the reason of the colder climate conditions. The findings in this study confirmed that even in regions of lower air pollution, even a minor variation in concentration or climate can affect people's well-being.*

Keywords*: air pollutants, health effects, allergens, low-pollution environments, urbanization, regional difference, Finland*

INTRODUCTION

Respiratory allergies and related illnesses have become an increasing concern for public health globally in the 21st century. Over the past decades, more people have been experiencing allergic responses, and these not only have medical burdens but also environmental, economic, and social ones as well (ARDUSSO & CALDAS, 2018; BERGER et al., 2021; D'AMATO et al., 2015; WHO, 2016). One of the biggest causes connected to this rise is associated with air pollution and climate change. Therefore, both natural and anthropogenic influences are responsible for the development and worsening of allergic reactions, other health difficulties, or both, among populations worldwide (BOWATTE et al., 2017; De SARIO et al, 2012, JULIAN et al., 2020; DENG et al., 2020).

Industrial activity, urbanization, traffic, burning of waste, and other human activities, along with climate-related changes, have altered ambient air composition. Particulate matter (such as $PM_{2.5}$; PM_{10}), nitrogen dioxide (NO_2), ozone (O_3), and other pollutants are known to aggravate respiratory conditions, including allergic rhinitis, asthma, and other vital functions of the human organism, such as the cardiovascular system (ANDERSON, 2009; ARDUSSO, L. R., & FERNÁNDEZ-CALDAS, 2018; BERGER et al., 2021; BOWATTE et al. 2017; DENG et al., 2020; D'AMATO et al., 2015; EEA, 2025; HAAHTELA et al. 2021; HEALY et al., 2024, WHO, 2016).

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These pollutants interact with meteorological conditions (temperature, humidity, wind, precipitation), which affect their dispersion and concentration in the air, thereby affecting the exposure levels of people (De DARIO et al., 2013; D'AMATO et al., 2015). Understanding how even minor fluctuations in pollutant concentrations can influence health and activity is particularly important in regions with relatively good baseline air quality (CHEN et al., 2024).

Finland is often considered in this sense as a sustainable country with good overall air quality. Nonetheless, fine particulate matter, nitrogen dioxide, and ozone still pose measurable health risks, especially for vulnerable groups, and traffic emissions in urban areas still remain sources of concern. For example, a recent Finnish study found that exposure to air pollutants, even at low concentrations, below the WHO's 2021 air quality guidelines, was associated with cardiometabolic health risks (DARREN R. HEALY, et al., 2024). The European Environment Agency reports that Finland's air quality is "very good," but that fine particulate matter ($PM_{2.5}$) still contributes to thousands of premature deaths and many healthy life-years lost annually (EEA, interactive chart, 2025). These findings indicate that low pollution does not necessarily mean no risk at all.

This study seeks to examine the sensitivity of public health and activity indicators to weekly fluctuations in air pollutant concentrations in four Finnish cities (Helsinki, Tampere, Oulu, and Rovaniemi). Using AccuWeather data collected every Monday throughout the following seasons: autumn (2024), late spring, summer, and beginning of autumn (2025), the focus of this study is the comparison of cities and overall analysis of how current pollutant levels relate to the health & activities indexes, with meteorological variables serving as supporting context.

The main research question guiding this work is: How do weekly variations in air pollutant concentrations, no matter how small, influence public health and activity indexes in Finnish cities within a low-pollution environment?

MATERIAL AND METHODS

Study Design

Data collection began as part of a semester project at John Wesley Theological College in Budapest in autumn 2024. The data collection was further carried out as a base for this study and a thesis project, from the end of May 2025 until the end of September 2025, making the total period for this study autumn of 2024, late spring, summer, and early autumn of 2025. The data analysis is subject to possibly being carried out even further.

Two categories of data were used as the basis for this study: 1) air quality and current pollutants, and 2) health and activities. The source of this information and data is AccuWeather, one of the most accurate sources of Weather Forecasts and health warnings in the world (https://accuweather.com/).

The 1st category of data includes: the amount of particulate matter (PM2.5 and PM10), carbon dioxide (NO2), ozone (O3), sulfur dioxide (SO2), and carbon monoxide (CO), as individual air quality for every one of these elements, and the overall air quality for that day in Helsinki, Oulu, Tampere, and Rovaniemi.

The 2nd category of data includes: 'Allergies', 'Health', 'Outdoor Activities', 'Travel and Commute', 'Home Garden', and 'Pests'. 'Allergies' measured gave us the status of tree pollen, ragweed pollen, mold, grass pollen, and dust and dander. In the 'Health' category, the risk of arthritis, sinus pressure, common cold, flu, migraine, and asthma was measured and collected. The air quality for the 'Outdoor Activities' category includes fishing, running, golf, biking and cycling, beach and pool, stargazing, and hiking. Next up, the 'Travel and Commute' section includes air and travel, and driving parameters. The ’Home Garden’ category includes the degree of circumstances for lawn mowing, composting, and outdoor entertaining. Lastly, the ’Pests’ category measures the presence of mosquitoes, indoor pests, and outdoor pests.

Data analysis

After collecting the data, the frequency of each value for each parameter in both categories (Current Pollutants and Health and Activities) was calculated separately using statistical formulas for calculating the frequency. The next step was to make the tables showing the change and comparison of different frequencies in all categories across the four cities. Using critical thinking and knowledge about the locations and general information of the four Finnish cities, conclusions were made.

Lastly, using the meteorological data collected as well, discussions were made about how big an influence things like temperature, humidity, or UV index had on the prevalence and behaviour of pollutants, the worsening of different health-related symptoms, or the ability to engage in outdoor activities.

RESULTS AND DISCUSSIONS

Classification of Air Pollutants and Their Effects on Human Health

Due to a skyrocketing industrial, technological, and economic growth worldwide, a massive amount of harmful emissions has been cycling in our environment, therefore accounting for the decrease in air quality and for air pollution becoming a global problem (ÅSTRÖM et al., 2021; FOWLER D. et al., 2020; ULLSTEIN B. & De MATTOS, 2019; SOFIA et al., 2020; UNEP, 2021).

Since 2016, the World Health Organization (WHO) has drawn attention to air pollution as the largest global environmental health risk. More than that, in 2022, a report published by WHO showed that only 10% of the population in the places studied in their report are exposed to the recommended annual mean levels of $PM_{2.5}$ and PM_{10}, and only 23% at NO_2 levels (WHO, 2016, 2023). Other studies on this topic also agree that air pollution is connected to the longer-lasting periods of allergens and, therefore, the increase in overall allergic rhinitis and other reactions (ANDERSON, 2009).

Results of how big an effect air pollution has on human health differ by pollutant considered and study area, suggesting that the conclusions should be made by considering local and specific conditions (De SARIO, M., et al, 2013). Different types of pollutants have different properties and different effects on human health. The properties include the size of the pollutant, the concentration, the time of exposure to it, solubility, and how it reacts with other pollutants (ARDUSSO, L.R., et al. 2018). They are inflammatory and irritating, and they can trigger different responses, allergic responses, or other health diseases.

Besides the direct health hazards from pollutants (KINOSHITA, H., et al, 2020; MARCHWINSKA-WYRWAL, E., et al, 2011; USEPA 2024), the climate and meteorological conditions have a role in the behavior of pollutants and allergic responses to allergens. For example, it has been proven by many studies that air pollution can intensify the response to allergens in the nasal cavity by increasing the sensitivity and the ability of airborne pollen allergens to be absorbed and used by the human body (ARDUSSO, L. R., et al, 2018). According to Ardusso, L. R., et al, air pollution can affect respiratory allergic diseases in many ways, by increasing the allergenic effect of pollen and plant material particles, which enables them to enter the lower respiratory tract and cause inflammation of the respiratory tract. In addition, it may act as an immune system stimulant by increasing the production of IgE (immunoglobulin E) antibodies, causing more severe allergic reactions.

Finally, it is critical to mention the vulnerable groups most affected by the impacts of air pollution on their respiratory tract. This vulnerable group consists of children, older people, pregnant women, and people with predispositions to asthma and other respiratory or cardiovascular diseases.

DATA COLLECTION RESULTS

AQI frequency for pollutants

The data that was collected on the four previously mentioned cities in Finland: Helsinki, Oulu, Tampere, and Rovaniemi, confirmed the low-pollution levels and showed that most of the data for the pollutants are controlled, and that in almost all cases, the most frequent air quality index is 'Excellent'. The other most frequent AQI was 'Fair'. It is important to note that in the case of SO_2 and CO, the AQI was 'Excellent' every time, without exception. The AQI 'Poor' only occurred in two cities, Helsinki and Tampere, for $PM_{2.5}$ and NO_2; however, these frequencies are very low, 3.33% for $PM_{2.5}$ in both cities and for NO_2 in Tampere. The only time that the AQI 'Poor' frequency was higher than 3.33% is in Helsinki for NO_2, being 6.67%, as shown in Table 1.

Roveniemi, being the least urban city, showed the best results, with the highest 'Excellent' overall AQI frequencies across all cities, even having 100% 'Excellent' values for NO_2 and PM_{10}, and 93.33% 'Excellent' value for $PM_{2.5}$. The only instance where the situation was different is for O_3, when there was a higher overall AQI frequency for 'Moderate' values (66.67%) than for 'Excellent' values (33.33%).

The second-best air quality results were measured in Oulu, revealing a clear regional contrast between northern and southern Finland. The northern cities of Oulu and Rovaniemi demonstrated better AQI results compared to the more urbanized and densely populated southern cities of Helsinki and Tampere, where pollution levels were higher, as shown in Table 1.

Health and Activities Frequency Data

The data collected for the Allergies parameter in the Health and Activities part of this study showed a consistent 'Low' score for the whole time of measurement, in 4 out of 5 different types of allergens, for Tree pollen, Ragweed pollen, Mold, and Grass pollen. The only allergen that had variations in the score was Dust and dander, while still having the highest frequency of 'Low' scores. The 'Very High' score of 4% is only present in Rovaniemi across all measurements in this study.

Overall, the values show a very similar situation across all cities, except for the only 'Very High' value in Rovaniemi exclusively, as shown in Table 2.

The data collected for different health conditions, including arthritis, sinus pressure, common cold, flu, migraine, and asthma. Overall, the results indicate that the prevalence of these conditions tends to vary between low and moderate frequency levels in most cases, suggesting that the general health status across the cities remains relatively stable. Arthritis is the only parameter that had 'Extreme' values, and they are present in all cities.

Helsinki showed relatively balanced frequencies across most conditions, with 'Low' and 'Moderate' levels being the most common. Notably, migraine and asthma had the highest reported frequencies, with migraines reaching up to 80% in the 'Low' category and asthma showing 60% in the same range.

Oulu displayed a similar trend, where arthritis and sinus pressure frequencies were distributed mainly between 'Low' and 'High' levels. The highest occurrences were seen for asthma (76% 'Low') and migraine (72% 'Low').

Table 1

Frequency of the air quality indexes divided by cities and pollutants

AQI (Frequency%)		Excellent (0 - 19)	Fair (20 - 49)	Poor (50 - 99)
PM2.5	Helsinki	43.33	53.33	3.33
	Oulu	83.33	16.67	
	Tampere	63.33	33.33	3.33
	Rovaniemi	93.33	6.67	
PM10	Helsinki	80.00	20.00	
	Oulu	86.67	13.33	
	Tampere	76.67	23.33	
	Rovaniemi	100.00		
NO2	Helsinki	60.00	36.67	6.67
	Oulu	96.67	3.33	
	Tampere	43.33	53.33	3.33
	Rovaniemi	100.00		
O3	Helsinki	63.33	36.67	
	Oulu	56.67	43.33	
	Tampere	73.33	26.67	
	Rovaniemi	33.33	66.67	
SO2	Helsinki	100.00		
	Oulu	100.00		
	Tampere	100.00		
	Rovaniemi	100.00		
CO	Helsinki	100.00		
	Oulu	100.00		
	Tampere	100.00		
	Rovaniemi	100.00		

Table 2

Frequency of the scores for the 'Dust and dander' allergen

Frequency (%)		Dust and dender
Helsinki	Low	60.00
	Moderate	20.00
	High	20.00
	Very High	
Oulu	Low	64.00
	Moderate	20.00
	High	16.00
	Very High	
Tampere	Low	52.00
	Moderate	32.00
	High	16.00
	Very High	
Rovaniemi	Low	48.00
	Moderate	28.00
	High	20.00
	Very High	4.00

In Tampere, 'Low' frequency values were also dominant for most conditions, particularly for the flu (88%) and migraine (80%). The relatively high 'Low' percentages indicate that although these conditions occur, they are generally not severe or persistent.

Rovaniemi showed slightly more variation in the frequencies. While most conditions still appeared within the 'Low' and 'Moderate' categories, there were notable 'Extreme' frequency values for arthritis, same to those in the other cities. A difference observed is in the flu parameter, which had higher values, same to those in Oulu, showing the influence of the colder climate in the North.

Overall, the data demonstrate that across all four cities, most health conditions occur with low to moderate frequency, as summarized in Table 3. The more urbanized cities (Helsinki and Tampere) tend to have slightly higher reported frequencies for stress-related conditions like migraines, while the northern cities (Oulu and Rovaniemi) show more common cold and flu symptoms, explaining the influence of the colder climate in the North.

Table 3

Frequency of the scores for the Health parameters

Frequency (%)		Arthritis	Sinus Pressure	Common Cold	Flu	Migrane	Asthma
Helsinki	Low	32.00	16.00	56.00	64.00	80.00	60.00
	Moderate	32.00	20.00	28.00	36.00	16.00	20.00
	High	20.00	60.00	16.00		4.00	20.00
	Very High	12.00	4.00				
	Extreme	4.00					
Oulu	Low	28.00	20.00	44.00	64.00	72.00	76.00
	Moderate	28.00	20.00	28.00	28.00	28.00	16.00
	High	20.00	48.00	20.00	4.00		8.00
	Very High	8.00	12.00	8.00	4.00		
	Extreme	16.00					
Tampere	Low	28.00	32.00	68.00	88.00	80.00	60.00
	Moderate	32.00	20.00	24.00	12.00	16.00	28.00
	High	20.00	44.00	8.00		4.00	12.00
	Very High	16.00	4.00				
	Extreme	4.00					
Rovaniemi	Low	28.00	20.00	28.00	48.00	80.00	68.00
	Moderate	32.00	16.00	40.00	40.00	20.00	24.00
	High	20.00	36.00	24.00	8.00		8.00
	Very High	4.00	28.00	8.00	4.00		
	Extreme	16.00					

The data collected on recreational activity frequencies shows clear regional variations in outdoor lifestyle patterns and preferences. Overall, the frequency of ‘Ideal’ and ‘Great’ conditions for outdoor activities tends to be moderate across all cities, with ‘Good’ and ‘Fair’ being the most commonly reported categories. ‘Poor’ conditions are notably high for stargazing in all cities (48-56%), likely due to light pollution. Additionally, beach and pool show consistent high frequencies of ‘Poor’ values, and missing ‘Ideal’ values for Helsinki, Oulu, and Rovaniemi, agreeing with the cold climate conditions across all of Finland.

Helsinki shows a relatively balanced distribution across activities, with ‘Good’ conditions dominating in activities such as biking and cycling (40%) and hiking (36%). However,

Oulu demonstrates more evenly distributed activity frequencies, with ‘Good’ and ‘Fair’ ratings most common across all categories. Hiking and biking maintain favourable ‘Ideal’ and ‘Great’ conditions at around 28%.

In Tampere, the overall pattern reflects lower ‘Ideal’ frequencies, with most activities falling within the ‘Good’ and ‘Fair’ ranges. Fishing and golf in particular show substantial ‘Good’ frequencies (32–36%).

Rovaniemi maintains consistent, frequent ‘Ideal’ values for running (24%), biking (28%), and hiking (24%).

Overall, as depicted in Table 4, outdoor activities are often not highly favourable in Finland, with some parameters such as hiking and running having better average values, such as ‘Good’, explaining again the colder climate conditions, less suitable for warm-weather activities such as beach and pool.

Table 4

Frequency of the scores for the Outdoor Activities parameters

Frequency (%)		Fishing	Running	Golf	Biking and Cycling	Beach and Pool	Stargazing	Hiking
Helsinki	Ideal	12.00	28.00	16.00	28.00		8.00	24.00
	Great	4.00	12.00	24.00	12.00	12.00	16.00	16.00
	Good	32.00	36.00	20.00	40.00	28.00	12.00	36.00
	Fair	32.00	12.00	24.00	12.00	8.00	12.00	12.00
	Poor	20.00	12.00	16.00	8.00	52.00	52.00	12.00
Oulu	Ideal	16.00	24.00	24.00	28.00		8.00	28.00
	Great	12.00	24.00	12.00	20.00	16.00	20.00	12.00
	Good	28.00	16.00	20.00	20.00	16.00	8.00	24.00
	Fair	12.00	12.00	12.00	12.00	12.00	16.00	8.00
	Poor	32.00	24.00	32.00	20.00	56.00	48.00	28.00
Tampere	Ideal	4.00	28.00	20.00	28.00	4.00	8.00	28.00
	Great	12.00	16.00	12.00	24.00	12.00	12.00	12.00
	Good	32.00	28.00	36.00	28.00	24.00	16.00	28.00
	Fair	28.00	24.00	16.00	16.00	20.00	8.00	28.00
	Poor	24.00	4.00	16.00	4.00	40.00	56.00	4.00
Rovaniemi	Ideal	12.00	24.00	12.00	28.00		4.00	24.00
	Great	12.00	12.00	16.00	8.00	12.00	4.00	12.00
	Good	20.00	24.00	16.00	16.00	12.00	36.00	16.00
	Fair	12.00	12.00	24.00	24.00	8.00		16.00
	Poor	44.00	28.00	32.00	24.00	68.00	56.00	32.00

The data collected on frequencies for the travel part shows the highest ‘Ideal’ scores for every city, the highest being 92 in Helsinki for air and travel. The lowest frequency for the ‘Ideal’ score is 44% for driving in Rovaniemi. Scores for air and travel never fall below ‘Good’, and for Driving, they never fall below ‘Fair’. The highest score for ‘Fair’ of 20% frequency was recorded in Helsinki, then 16% in Tampere, followed by 12% in Rovaniemi, and the lowest score of 8% in Oulu, as shown in Table 5.

The data collected on the frequencies of three outdoor household activities, lawn mowing, composting, and outdoor entertaining, reveal distinct regional trends influenced by climate and urbanization levels. Overall, ‘Good’ and ‘Fair’ conditions appear most frequently across the dataset, while ‘Ideal’ and ‘Great’ frequencies are less common, particularly in the northernmost regions. ‘Ideal’ scores never appear for composting in all cities and for outdoor entertaining in Helsinki. The score of ‘Fair’ does not appear for lawn mowing in Oulu and Rovaniemi, the northern regions.

In Helsinki, the results show relatively convenient conditions for outdoor entertaining. Lawn mowing also shows steady participation, with 24% ‘Ideal’ and 28% ‘Good’, although composting conditions are more variable, as ‘Fair’ frequency as 44% dominate.

Oulu displays a similar balance between ‘Good’ and ‘Fair’ conditions, particularly for composting (40% ‘Fair’) and lawn mowing (28% ‘Ideal’). However, ‘Poor’ conditions are quite high for outdoor entertaining (40%) and lawn mowing (40%), indicating more climatic or environmental limitations compared to Helsinki.

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Table 5

Frequency of the scores for the Travel parameters

Frequency (%)		Air and Travel	Driving
Helsinki	Ideal	92.00	56.00
	Great	8.00	12.00
	Good	20.00	12.00
	Fair		20.00
	Poor		
Oulu	Ideal	84.00	52.00
	Great	12.00	20.00
	Good	4.00	20.00
	Fair		8.00
	Poor		
Tampere	Ideal	88.00	56.00
	Great	8.00	24.00
	Good	4.00	4.00
	Fair		16.00
	Poor		
Rovaniemi	Ideal	72.00	44.00
	Great	16.00	24.00
	Good	12.00	20.00
	Fair		12.00
	Poor		

In Tampere, conditions appear somewhat more stable, with the ‘Good’ category being the most frequent across all three activities (24-32%). This suggests a balanced environment for both household maintenance and social outdoor activities. Nevertheless, ‘Poor’ conditions (28%) remain significant for composting, showing moderate variability.

Rovaniemi, the northernmost city, shows the greatest limitations for outdoor activities overall. ‘Poor’ frequencies dominate across all three categories, 52% for lawn mowing, 48% for composting, and 48% for outdoor entertaining, while ‘Ideal’ and ‘Great’ conditions are scarce. This pattern reflects the colder climate and shorter warm seasons typical of the Arctic region, making outdoor maintenance and leisure less practical for much of the year.

The analysis carried out highlights a clear divide between the north and the south. The southern cities of Helsinki and Tampere exhibit more favourable conditions for outdoor household activities, while northern cities like Oulu and especially Rovaniemi experience harsher conditions that limit both domestic and recreational outdoor engagement, as summarized in Table 6.

The data collected on the frequencies of different pest activity levels, mosquitoes, indoor pests, and outdoor pests (Table 7), reveal notable variations that reflect both climatic and geographical influences. In general, the ‘Low’ and ‘Moderate’ categories are most common in the northern cities, while ‘High’ and ‘Very High’ frequencies appear more often in southern and more urbanized areas. ‘Low’ scores are missing from indoor pests in all cities except Oulu.

In Helsinki, pest activity levels are distributed relatively evenly across the scale. Mosquito presence is mostly ‘Low’ (64%), with only 24% classified as ‘High’. Indoor pests, however, show higher frequencies, with 40% ‘High’ and 32% ‘Very High’, suggesting that urban density and building structures may contribute to higher indoor pest activity. Outdoor pests show the ‘Extreme’ value as the highest frequency of 28%.

Table 6

Frequency of the scores for the Home Garden parameters

Frequency (%)		Lawn Mowing	Composting	Outdoor Entertaining
Helsinki	Ideal	24.00		
	Great	16.00	16.00	28.00
	Good	28.00	16.00	32.00
	Fair	12.00	44.00	20.00
	Poor	20.00	24.00	20.00
Oulu	Ideal	28.00		8.00
	Great	12.00	12.00	20.00
	Good	20.00	16.00	20.00
	Fair		40.00	12.00
	Poor	40.00	32.00	40.00
Tampere	Ideal	28.00		4.00
	Great	12.00	12.00	28.00
	Good	24.00	28.00	32.00
	Fair	12.00	32.00	12.00
	Poor	24.00	28.00	24.00
Rovaniemi	Ideal	24.00		8.00
	Great	8.00		16.00
	Good	16.00	32.00	16.00
	Fair		20.00	12.00
	Poor	52.00	48.00	48.00

Table 7

Frequency of the scores for the Pests parameters

Frequency (%)		Mosquitos	Indoor Pests	Outdoor Pests
Helsinki	Low	64.00		12.00
	Moderate	12.00	16.00	24.00
	High	24.00	40.00	20.00
	Very High		32.00	16.00
	Extreme		12.00	28.00
Oulu	Low	72.00	28.00	20.00
	Moderate	20.00	40.00	28.00
	High	8.00	32.00	20.00
	Very High			12.00
	Extreme			20.00
Tampere	Low	68.00		12.00
	Moderate	16.00	4.00	20.00
	High	16.00	52.00	24.00
	Very High		40.00	12.00
	Extreme		4.00	32.00
Rovaniemi	Low	84.00		32.00
	Moderate	8.00	16.00	20.00
	High	8.00	72.00	28.00
	Very High		12.00	
	Extreme			20.00

In Oulu, mosquitoes and indoor pests' values do not exceed 'High' scores, contrary to the outdoor pests, which present 'Very High' and Extreme' values. There is a distinct pattern of generally lower mosquito presence (72% 'Low') but higher variability in indoor pest activity, where 'Moderate' and 'High' frequencies dominate, reaching 40% and 32% frequency. Outdoor pests exhibit a more even spread, with 'Moderate' and 'High' levels each accounting for 20%.

In Tampere, the data indicate increased pest presence compared to Oulu and Rovaniemi. Mosquito levels remain mostly 'Low' (68%), but indoor pests show high frequencies in the 'High' (52%) and 'Very High' (40%) categories, which is one of the most concentrated patterns of pest activity among all cities. Outdoor pests are also notable, with 32% 'Extreme' and 24% 'High', suggesting warmer and more humid conditions that favour pest increase.

Finally, Rovaniemi demonstrates the lowest mosquito activity (84% 'Low'), consistent with its colder climate. However, indoor and outdoor pests show significant presence, with 72% 'High' indoor pest frequency and 28% 'High' outdoor pests. These results imply that, despite low mosquito populations, pest issues within and around buildings remain relevant in Arctic environments due to sheltering behaviours of insects and rodents.

Therefore, as a result of the analysis carried out (Table 7), we can mention a strong climatic gradient, where southern cities like Helsinki and Tampere experience higher overall pest activity, especially indoors, while northern cities like Oulu and Rovaniemi maintain lower mosquito levels but still face notable indoor pest challenges.

How meteorological data connects

Over the course of the investigation period, meteorological data shows how the change of seasons influences pollutants' concentrations and health symptoms, through temperature, UV index, humidity, and cloud ceiling, ultimately revealing how humans react to these circumstances.

Temperatures showed a small increase over average forecasts, the lowest being in November 2024 and the highest being in July 2025. The coldest city is Rovaniemi, because of its northernmost location in Finland. The hottest city out of the measured four can be ruled off as a tie between Helsinki and Tampere, which is reasonable because of their close proximity.

Low temperatures should also be considered as concerns for respiratory health, because they can increase daily mortality and hospitalisations for respiratory causes by 3-4%, for people over the age of 75 (De SARIO M., et al 2013). This puts the two northern cities from this study, Oulu and Rovaniemi, at higher risk during cold winter months, and is something to spread awareness about. Several other studies confirmed that air pollution interacts with heat, and this could be another explanation for why Finland has consistently low-pollution values (DENG et al., 2020; D'AMATO et al., 2015).

The UV index is mostly Low throughout all the time of measurements, except in late spring (May) and summer, where they are Moderate at most, only reaching an index of 5 a few times in each city. In the autumn seasons and late summer, the UV index most of the time fluctuates from 0 to 3, reflecting the nature of the seasons and the small number of sunny days. This is because Finland is split into the north temperate zone, in which Helsinki and Tampere fall, and the Arctic Circle, where Rovaniemi falls, with Oulu being in very close proximity to it, around 170 km.

Humidity can be connected to the increase in the effect of suspended particles (De SARIO M., et al. 2013; FREITAS et al., 2010; ZENDER-SWIERCZ et al., 2024). In the APHEA2 project done in 29 EU cities, a significant observed effect of PM_{10} mortality increased when humidity decreased; however, it is important to remember that humidity is closely related to temperature, so these findings may also be referred to in the temperature sense as well (De SARIO, et al. 2013).

The results of this investigation showed that the highest values were present in the fall of each year (end of September, October, beginning of November) and the lowest at the end of spring, in May. Rovaniemi showed to be the overall most humid city and Tampere the least humid.

In autumn, cloud ceiling can be expected to fall low, sometimes even to zero, and cause fog, which is what was observed in this study as well. Fog and other air masses can also have an interaction with air pollutants, making favourable conditions for particulate matters (BISWAS et al., 2008; De SARIO., et al., 2013; MOHAN & PAYRA, 2009).

CONCLUSIONS

This study shows that even in nations like Finland, which are known for having excellent air quality, even slight changes in pollutant concentrations can have noticeable impacts on everyday life and public health. The results demonstrate a quantifiable correlation between air pollutants, specifically $PM_{2.5}$, PM_{10}, and NO_2, and health markers like migraine frequency, sinus pressure, and asthma. Regional differences were noticeable even though the overall pollutant levels in the four cities under study, Helsinki, Tampere, Oulu, and Rovaniemi, remained within the ‘Excellent’ to ‘Fair’ range. In contrast to the northern cities, which are characterized by colder climates and lower urban densities, which showed fewer symptoms related to air quality but a higher prevalence of cold and flu-related conditions, the more urbanized southern cities showed slightly higher concentrations of pollutants and associated health sensitivities.

Meteorological factors such as temperature, humidity, and UV index played a key role in shaping these differences. In the north, colder temperatures and higher humidity are likely to have contributed to the higher risk of increased health symptoms, while urban density and traffic emissions were the main influencing factors in the south.

Overall, this study shows that low pollution does not equate to zero risk, and even in environments with great air quality, such as Finland, small changes in the levels of pollutants can affect the health and activity of the population. In order to maintain public health resilience, it remains crucial to have continuous air quality monitoring, public awareness campaigns, public health assessments, and innovative environmental policies across all regions.

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