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Climatic Impacts on Drug Therapy Usage: A Comparative Study of Kurdish Populations in Sulaimani, Iraq, and Stockholm, Sweden

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ABSTRACT

The geographical area is influenced by climate impacts, which, in turn, affect the use of different drug therapies during seasonal weather fluctuations. Thus, this study investigates how geographical climate differences influence drug therapy usage by comparing two Kurdish populations residing in Sulaimani, Iraq, and Stockholm, Sweden. It also highlights significant variations in healthcare practices, demonstrating how environmental conditions shape medication patterns. Data collection was conducted through a structured online survey, covering sociodemographic factors, health behaviors, and medication practices, followed by statistical analysis using Python and SPSS. Geographic Information System (GIS) tools were applied to spatially analyze environmental variables across the two cities, enabling the validation of sampling locations and the statistical determination of optimal limitations for the sample collection dataset. In Stockholm, 73.33% of respondents reported that the cold and humid climate affected their health behavior, whereas in Sulaimani, 50.27% described the climate as moderate but highly variable. The study revealed that the key statistical values such as antibiotic usage were significantly higher in Sulaimani (38.03%) than Stockholm (14.00%, $P < 0.001$), indicating a more treatment-focused approach in Sulaimani versus a preventive focus in Stockholm. Similarly, painkiller usage was significantly higher in Sulaimani, correlating with climate-related seasonal illnesses. Meanwhile, multivitamin usage in Stockholm reached 44.67%, surpassing Sulaimani's 37.77%, reflecting a stronger emphasis on preventive healthcare strategies in colder climates. These findings emphasize that climate, more than cultural differences, significantly influences drug therapy patterns. The study determines that healthcare strategies should integrate climate variability, prioritizing preventive care in colder climates and infection control in warmer regions. Finally, the study concludes with key findings and outlines directions for future research, emphasizing the need for further investigation into climate-adaptive healthcare approaches.

Index Terms: Climate Influence, Drug Therapy, Geographical Area, Medication Usage, Seasonal Weather

1. INTRODUCTION

This geographical area plays a critical role in shaping various aspects of life. For example, climate conditions significantly influence physical and psychological well-being, affecting lifestyle choices [1]–[3]. In this case, the impact of climate on physical health and emotional well-being has been examined in relation to the environments where residents live, taking into account individuals from similar and diverse nationalities and cultural backgrounds [4], [5]. The extensive narrative reviews of current evidence have been conducted, and their implications have been discussed based on these findings.

Moreover, drug therapy usage is one of the modifiable factors influenced by climate and environmental conditions

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across different regions or areas [6]. Climate impacts, such as temperature, humidity, and seasonal transitions, can significantly affect the pharmaceutical drugs of various medications, thereby altering their effectiveness [7], [8]. In addition, sociodemographic factors such as age, income, education level, and access to healthcare, along with cultural beliefs and practices, have a major impact on drug therapy usage during periods of illness [9], [10]. This impact becomes particularly evident during outbreaks of infectious diseases or periods of extreme or rapidly changing weather, especially at the beginning and end of limited seasonal periods. Understanding these complex interactions is essential for improving therapeutic outcomes and creating treatment strategies that are sensitive to both cultural and environmental contexts.

More important than that, a major point is the potential to make comparisons between residents of two or more different regions to illustrate the effects of climate on drug therapy usage in general. Such comparisons can help explain how residents adapt using protective measures, such as vaccines, multivitamins, or other supplements, and how climate conditions influence the use of antibiotics and painkillers in specific areas around the world. Furthermore, sociodemographic factors, including education and access to healthcare, play a significant role in shaping patterns of drug therapy usage [11]. Conducting geographically based investigations is crucial for identifying areas that require focused attention in the future and for optimizing strategies to address the impacts of climate on health outcomes. This approach is especially important in establishing a stronger understanding of the relationship between healthcare practices and geographical effects [12], ultimately contributing to better management and preparation for future climate-related health challenges.

For the purpose of this study, a comparison and discussion were conducted between two important locations: one situated in the Middle East and the other in Europe. This approach aimed to isolate the effects of geography and climate on fluctuations in drug therapy usage. Importantly, the sample focused exclusively on individuals of a single nationality residing in both regions, allowing for a clearer understanding of how environmental differences, rather than cultural or ethnic factors, influenced patterns of medication use. In this investigation, Kurdish populations were chosen to control for ethnicity/culture, enabling isolation of climate-geography effects, including those residing in Sulaimani city in Iraq and Kurdish refugees or residents living in Stockholm, Sweden. The data collection was dedicated to specific queries designed to evaluate how demographic changes, influenced by climate differences, impact healthcare practices. Particular attention was given to analyzing drug therapy usage during periods of seasonal weather fluctuations. In addition, this study focused on different cases based on previous state-of-the-art research and evaluated the data statistically to develop potential solutions and identify limitations encountered in healthcare, particularly in relation to medical therapy within the selected areas. Special attention was given to how changes in climate affect healthcare practices among individuals from Kurdish cultural backgrounds when relocating or living in different environmental conditions.

In response to this issue, the contributions of this research are outlined in the following points: (1) it offers the first comparative analysis of medication use among Kurdish populations living in distinct climatic regions – Sulaimani and Stockholm – revealing how demographic differences influence health behaviors and drug usage patterns. (2) It effectively integrates Geographic Information Systems (GISs) with statistical methods to map environmental conditions and isolate the impact of climate from cultural and geographical influences on medical practices. (3) The findings show that seasonal changes, particularly during autumn and winter, significantly affect illness rates and the consumption of antibiotics, vaccines, and painkillers, with notable differences observed between the two cities. (4) Finally, the study introduces a climate-adaptive healthcare perspective, emphasizing the importance of region-specific public health strategies, improved awareness, and tailored medication approaches in response to varying climate conditions.

The remainder of the paper, including the next section, provides a background review to enhance the state of the art related to the problem at hand. The third section details the methodology and materials, outlining the steps of the method in a step-by-step manner. The fourth section includes a discussion and comparison of the result analysis. The final section is dedicated to the conclusion and suggestions for future research.

2. BACKGROUND REVIEW

Medical geography is an old perspective and a new specialty. Today, much research in the social and behavioral sciences is shaped by its principles, which also influence studies in other fields [13]. This science determines the distribution of human diseases. It also examines the circumstances in which diseases arise. Additionally, it explores how natural environmental factors affect human health. This is especially important following the population explosion known as population rapidity [14]. Studies have described how the environment and seasons affect health, urging practitioners to consider factors such as sun exposure, soil, altitude, climate, and geography [15], [16]. During the 16th–18th centuries, interest in climate and health effects was facilitated by the ability to measure environmental conditions with new instruments [17]. There is a clear gap in defining the relationship between city structure and efforts to reduce social inequalities, particularly through facilities tailored to specific needs during disease outbreaks [18]. The influence of these factors on the creation of a particular type of climate in the regions is evident. Therefore, one of the most important issues affected by climate is public health. Previous studies on this topic have emphasized the relationship between disease prevalence and climate in several cities [19]–[21].

Furthermore, through ecological and biological processes such as altered food supply and disease transmission, climate change may have indirect effects on health. Thus, in the study by Patz *et al*. [22], the impact of climate change on infectious diseases was further explored, including investigations [23] focused on North America [24] and Europe [25]. These important factors of temperature and seasonal variation have influenced drug use. After looking for related research, given the number of studies concerning how climate affects various illnesses, which results in the usage of various medications and therapies. All indices have improved that climatic factors have a large and different impact on disease prevalence and drug use in different parts of the world [15], [26], [27]. Table 1 provides a summary of various studies, outlining the different methods and research objectives used to investigate the selected problem. The inclusion of 2024 studies ensures the representation of the most recent and cutting-edge literature, despite their close temporal proximity to the data collection period.

Nevertheless, the findings of various studies partly correspond with each other. The influence of climate on

TABLE 1: Several studies are exploring the impact of climate on disease progression and medication usage

References	Purpose	Methodology	Key finding*	Year
Hartig *et al*. [28]	Examines if limited access to relaxing landscapes due to bad weather harms mental health and increases medication use.	Analyzes self-reported mental health, outdoor activity, medication use, and weather data.	Cold Swedish winters worsen mental health and boost antidepressant use, especially among women and urban residents.	2007
Talib and Ahmed [29]	Analyzes the link between seasonal climate change and respiratory illnesses in Sulaimani province.	A description and quantitative approach	Health climate features of Sulaimani Province and their impact on respiratory diseases.	2019
Astolphi *et al*. [30]	To examine the effects of weather and climate change on the health and well-being of elderly dementia patients. Recent 2024 studies were included to reflect the latest advancements during data collection.	A scoping review will use PRISMA-ScR and Arksey & O'Malley's framework to examine climate change effects on older adults with dementia, based on selected database findings.	There is little proof to link dementia-related health hazards to climate change; further study and action are required.	2024
Basu and Samet [31]	The study links heat-related deaths to urban heat islands and aging populations, stressing the need for predictive models to guide prevention.	The research methodology includes analyzing exposure and results, choosing a suitable study design, and analyzing the temperature-mortality link with statistical models.	Key findings focus on heat-related mortality, including risk factors like cardiovascular and respiratory conditions, hospital studies, and other temperature-related deaths.	2002
Eng and Mercer [32]	Studied the link between two climate conditions and mortality in two populated areas.	Analyzing metrological data	The effect of seasonal changes varies greatly among nations where extra winter mortality has been reported.	2016
Amuakwa-Mensah *et al*. [33]	The Relationship between Infectious Diseases and Climate Variability	Collecting data and applying statistical analysis	Draws attention to the need for personalized programs for public health.	2017

*While previous studies establish links between climate and disease, as referenced in the table, none have examined medication practices within Kurdish diaspora communities, highlighting the need for this study disease prevalence and subsequent drug therapy use is widely acknowledged in the scientific literature. Although most studies agree on the existence of this effect, the types of diseases influenced by climate vary based on the specific climatic conditions of each region. For example, Dawson *et al*. in 2023 examined the effects of heat and cold exposure on chest pain symptoms [34]. In contrast, a study conducted in Cairo analyzed the impact of climate on human diseases, categorizing them according to seasonal variations [35]. In addition, the effects of extreme weather events on disease spread, such as those observed during Hurricane Katrina in 2005 and the major floods in Pakistan in 2010, have been well documented [36].

In addition to these studies, several other studies have investigated how climate affects therapeutic and disease utilization, focusing on environmental factors in different settings, beyond just climate. The World Health Organization (WHO) reports that there were notable cholera outbreaks in the Kurdistan Region in 2007, 2008, and 2012. A significant outbreak caused by tainted water occurred throughout Iraq in 2007 alone, sickening almost 7000 individuals and leading to 10 recorded fatalities [37].

Neira *et al*. emphasize the impact of environmental factors, including climate, on the development of respiratory diseases in Egypt, identifying both natural and human-made pollution as significant contributors [38]. In 2011, Pfister and Krämer investigated the consequences of climate change, environmental factors, and disease transmission, citing both historical and modern examples [39]. In addition, the effect of climate on diseases can vary among age groups. For example, a study conducted in Melbourne, Australia, shows how climate influences the development of chest pain in young people [21]. Another study explores how high temperatures impact the older population in Europe, particularly regarding medication use and morbidity rates [40]. Investigations emphasize the importance of this issue and its relevance for further research, particularly as climate change is associated with increased chronic disease and, in some cases, higher mortality [41].

Despite these challenges, various locations were selected as research areas to better understand and address the issue, particularly in the context of global development. The study focuses on how to manage and resolve the problem in relation to drug therapy usage, including antibiotics, multivitamins, and preventive vitamin use before the pandemic, within the broader context of climate change. The selected research areas include the city center of Sulaimani and specific districts within Stockholm. In Sulaimani, seasonal changes, prolonged summers, and high temperatures lead to respiratory diseases and seasonal epidemics, increasing the use of painkillers and anti-inflammatory drugs [29]. Furthermore, in Stockholm, the extended cold season and lower temperatures contribute to the spread of influenza, vitamin D deficiency, mental health disorders, and, in some cases, chronic conditions such as heart disease [42]–[44]. These factors are associated with an increased reliance on supplements, painkillers, and psychotropic medications [45]. Thus, studies emphasize the urgent need to adapt healthcare strategies to local climate conditions and to promptly distinguish pandemic-related infections. This approach can improve medication use, enable early identification of emerging diseases, enhance public awareness, and help prevent the spread of illness [46]–[48].

Finally, the literature highlights the long-standing importance of medical geography in linking environmental conditions to human health, including disease distribution and prevalence. Although previous studies emphasized how climate, geography, and seasonal changes affect health, they did not provide direct comparative analyses between specific cities. Our study fills this gap by uniquely comparing drug and antibiotic usage patterns between Sulaimani and Stockholm, revealing how climate differences influence public health behaviors in distinct urban contexts.

3. MATERIALS AND METHODS

In geographical studies, field research is essential because it provides micro-level insights into particular places, which help with larger planning and problem-solving initiatives for development [49]. As outlined in the initial section, the primary objective of this study is to examine the impact of climate change on the use of pharmacological therapies across different geographic contexts. The analysis focuses on how climate change influences public health, particularly through changes in the demand for and types of medications used to treat climate-sensitive illnesses.

Sulaimani, Iraq, and Stockholm, Sweden, are selected as contrasting case study locations due to their differing climates and healthcare systems. In addition, the study focuses on Kurdish residents living in Sulaimani and Kurdish individuals residing in Sweden as refugees or permanent residents. All locations were mapped based on the selected study area, with their identification and design process thoroughly discussed in the corresponding subsection on the study area. This mapping was conducted following specific selection criteria to ensure accuracy and relevance. The comparative method employed, supported by statistical analysis, enables an in-depth examination of how regional environmental factors influence health outcomes and the demand for medication. In addition, all the steps involved in identifying the gap in the problem, as well as the change of the methodological line used to find a solution, are widely illustrated in Fig. 1. This illustration provides a clear and detailed description of the logical progression from problem identification to analytical method selection.

3.1. Problem Approaches Selection

This process involves several critical steps aimed at identifying the most effective approach for addressing the situation under study, following a systematic, step-by-step method. Due to the geographical complexity, it is challenging to directly determine how drug usage patterns vary across different locations. Therefore, this research adopts a scientific approach that relies on healthcare data to clarify the methodology. The analysis is closely linked to geographical variations, climate change, and seasonal weather fluctuations, particularly in the context of pandemics or the spread of various diseases. These approaches are outlined as follows:

- Principal approach: The focus is on describing the climatic conditions that influence disease spread and the use of therapeutic drugs in the two selected study areas. This discussion builds upon the previous sections, which addressed the impact of both natural and human factors on these regions
- Historical approach: The state-of-the-art research relevant to this study's subject, as discussed in the previous sections, highlights the latest advancements and methodologies in understanding the interplay between climatic conditions, disease spread, and therapeutic drug use
- Comparative approach: The study focuses on how different climate conditions relate to the occurrence of diseases and how they affect the use of therapeutic medications in the various study areas. By analyzing their growth and seasonal variability based on data collected from residents, this study delves deeper into the dynamics of these relationships. By highlighting regional variances and temporal trends, this comparative approach provides insights into how climate variations affect pharmaceutical use and health consequences
- Analytical approach: The research is based on questionnaires and email surveys can provide fast and cheap alternatives. The data analytic process begins with defining a clear objective or problem statement. Once the goal is established, a strategy for data collection is devised and implemented. Collected data often contains errors, duplicates, or irrelevant information, so cleaning it involves removing these issues, filling gaps, and organizing the dataset to ensure it's ready for analysis.

3.2. Problem Query Search Strategy

A comprehensive literature search has been conducted to explore the relationship between geographical climate variability and human health. Electronic databases such as PubMed, Scopus, Medline, Elsevier ScienceDirect, Springer Online Journals, Global Health, MDPI, and the Web of Science have been utilized for this investigation. The search has focused on publications from various years, with

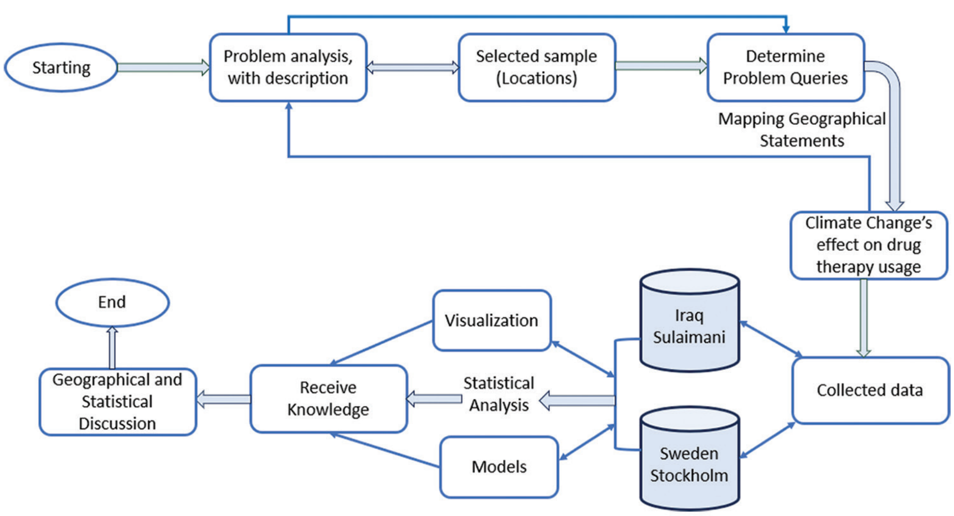

Fig. 1. Methodical flow outlining each step in the problem analysis process.

particular emphasis on the period between 2010 and 2023, using keywords such as "diseases," "climate variability," "meteorological factors," "weather," "climate and diseases," "human health," "health effects," "cardiovascular disease," "seasonal change," and "respiratory disease."

This study efforts to assess the impact of climate on health perceptions and behaviors; however, it does not include direct measures of infection rates or policy outcomes. Therefore, policy-related interpretations, such as prioritizing infection control in warmer regions, are beyond the scope of the data and should be viewed as speculative. To capture newly developed methods not identified in the initial search, we also monitored Google Scholar through daily email alerts. In addition, we reviewed reports and articles from non-biomedical sources, including publications by the World Meteorological Organization and regulatory documents from environmental and health agencies. These sources offered valuable insights into climate variables (e.g., temperature and humidity) and meteorological hazards (e.g., droughts, floods, and heatwaves).

3.3. Study Area Selection

According to the majority of geographers, despite being small, cities are important, complex, and interesting geographical areas. This is especially true for big cities, which exhibit unique urban features and the most intricate functional divisions, making it possible to identify subregions with ease [50]. Based on this approach, our investigation and results focus on a comparative study of two specific areas, which are essential for identifying the impact of geographical climate change on the use of drug therapy among Kurdish populations. The selected study areas, previously identified, are the city of Sulaimani and Stockholm. To accurately represent the study locations, GIS applications were utilized, employing Python programming in combination with the Overpass API to create detailed location maps, as illustrated in this study.

As shown in the map location in Fig. 2, Sulaimani, located in the Northeastern Kurdistan Region of Iraq, the city's coordinates are approximately longitudes 45°12'00"–45°32'00" E and latitudes 35°25'30"–35°40'00" N [51]. However, Sulaimani, known as the cultural capital, offers a stable and appealing environment for development investments. This is further supported by the district's entrepreneurial resources, which are effectively utilized in accordance with the principles of social justice. Sulaimani is renowned for its rich history, modern infrastructure, and esteemed educational institutions. The city center is situated at an elevation of approximately 870 m above sea level. Its landscape is characterized by mountainous terrain, including the Piramagroon, Azmar-Goizha, and Baranan mountains, which constitute over 20% of the city. The lower-lying areas are confined to prominent valleys, such as the Tanjero Valley, which lies at an elevation of around 675 m above sea level

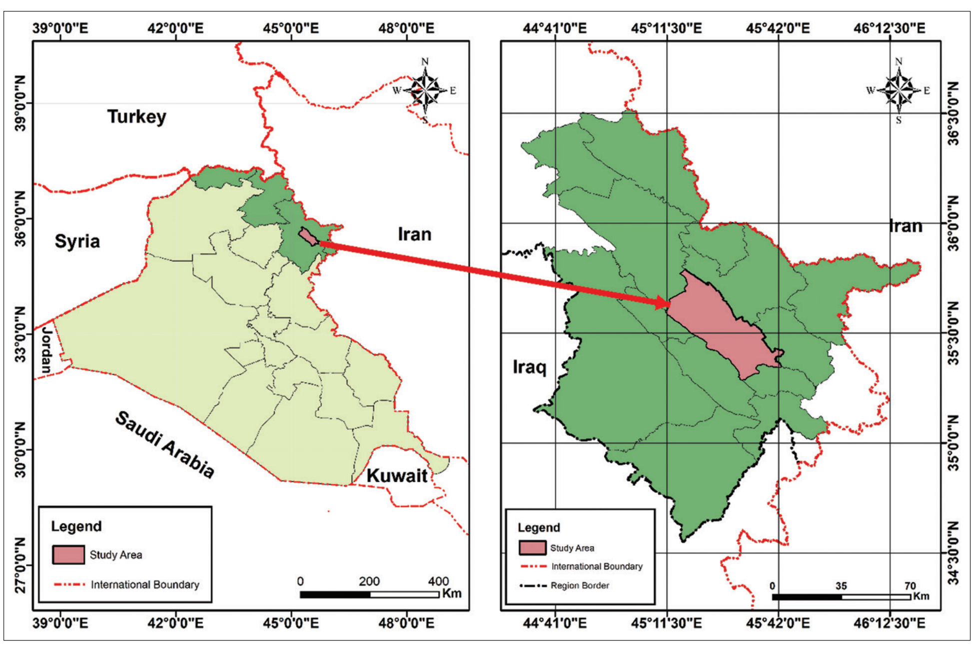

Fig. 2. Location of Sulaimani in the study area as a sample for investigation (Sulaimani: 35°25'–35°40'N, 45°12'–45°32'E.).

(m.a.s.l.). The Earth's astronomical location plays a critical role in determining the amount of solar radiation received at its surface across different seasons. This influences the length of day and night, which varies with the Earth's axial tilt and orbit around the Sun. These variations directly affect seasonal temperature patterns and contribute to fluctuations in daily, monthly, and annual temperature ranges. According to the Köppen climate classification, Sulaimani falls within the Mediterranean climate zone (Csa). This climate is characterized by hot, dry summers and mild, wet winters. The majority of rainfall occurs during the winter months, while summers are generally dry and arid [52]–[56].

On the other hand, this investigation also focuses on Stockholm, Sweden's administrative capital and economic hub, located in the southeastern part of the country, as illustrated in the location map in Fig. 3. Stockholm is one of Europe's fastest-growing cities [57], experiencing rapid development and urban expansion. It serves as a cultural and economic center, attracting people from diverse backgrounds. A significant Kurdish population resides there, contributing to the city's multicultural and dynamic community. It spans across 14 islands in the archipelago where Lake Mälaren meets the Baltic Sea. The city's coordinates are approximately 59.3293° N latitude and 18.0686° E longitude [58]. This city is known for its unique geography, blending urban areas with extensive waterways, green spaces, and historical landmarks. In addition, the city offers something for everyone, from its stunning natural beauty to its vibrant cultural scene and rich history. It falls within the humid continental climate zone (Dfb), which is characterized by cold winters, warm summers, and no distinct dry season, with precipitation distributed throughout the year [59], [60].

The topographic analysis of Sulaimani and Stockholm reveals distinct elevation characteristics. Sulaimani's mixed landscape includes plains (517–750 m), valley-hill zones (750.1–1000 m), and mountainous areas (1000.1–2210 m), leading to significant microclimatic variation that may influence health outcomes and environmental exposure. In contrast, Stockholm features a relatively flat topography, comprising plateaus (0–25 m), plains (25.1–50 m), and small hills (50.1–99 m), scattered with several water bodies. These topographic differences outline each city's air quality, humidity, and temperature, which are factors closely linked to respiratory health and patterns of related drug usage therapies. These features and characteristics are clearly illustrated in the maps shown in Fig. 4, which were generated using open-source GIS tools.

The choice of Sulaimani and Stockholm is meant to highlight the contrast between a mountainous Kurdish city and a flat Scandinavian capital. This comparison helps explore how differences in topography and climate affect seasonal drug use, especially among Kurdish communities. Sulaimani, with its high elevation and sharp seasonal temperature changes,

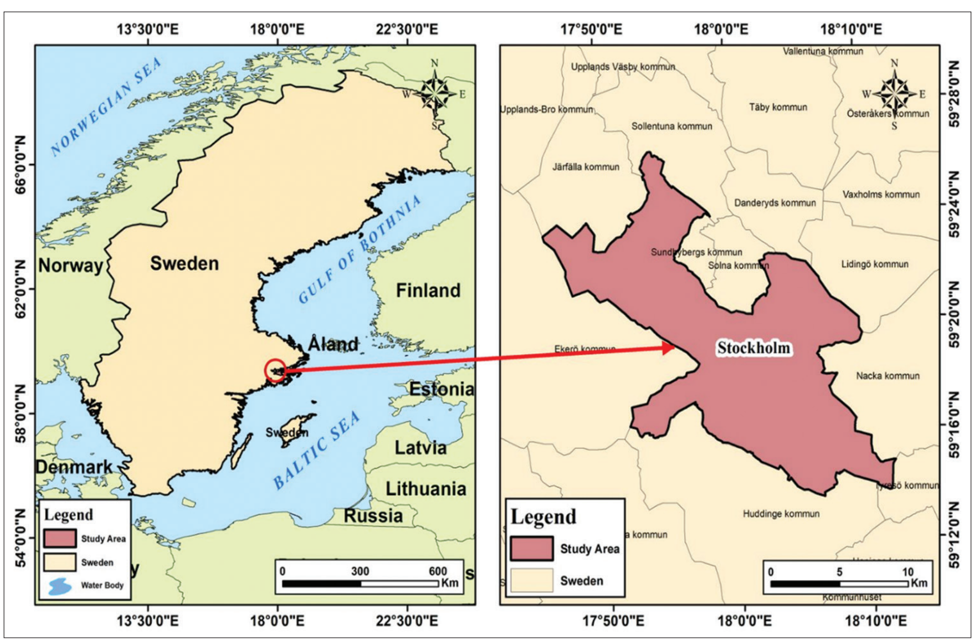

Fig. 3. Location of Stockholm in the study area as a sample for investigation (Stockholm: 59.3293°N, 18.0686°E.).

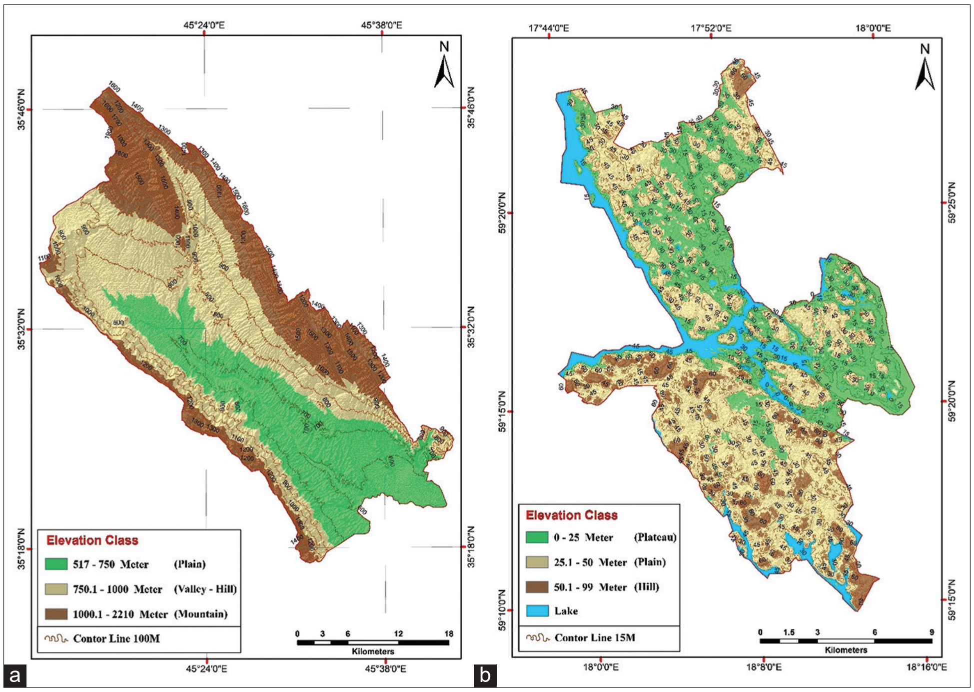

Fig. 4. Comparison of topographic layers between selected city samples, with derived explanatory features. (a) Sulaimani (35°25'–35°40'N, 45°12'–45°32'E.), (b) Stockholm (59.3293°N, 18.0686°E).

may see more respiratory infections during colder months, as reflected in the collected data. This could lead to higher use of antibiotics and other medications, as reported in the survey responses. On the other hand, Stockholm, although generally colder, has a more stable climate, well-developed infrastructure, and better healthcare access, which may contribute to more consistent and lower seasonal changes in drug use. By comparing these two cities, the study aims to better understand how geography and environment shape public health behavior, particularly among Kurdish or immigrant populations adjusting to different urban climates. All observed effects are clearly shown in the data and will be discussed in the following sections.

For a more detailed comparison between these two distinct cities, a significant contrast in temperature and humidity was analyzed using average data. The results for Sulaimani were derived from the city's meteorological station, located at latitude 35°25'–35°40'N and longitude 45°12'–45°32'E. Corresponding data for Stockholm were obtained from the Stockholm Observatory Station (lat. 59.3293°N, long. 18.0686°E), one of Sweden's oldest weather monitoring stations. The analysis focused on monthly seasonal variations over a 10-year period, from 2014 to 2024. Table 2 presents the average comparisons in temperature and humidity between the two cities.

In addition, to provide a more specific and visual understanding of the observed patterns, the data analysis focused on the relationship between seasonal time sequences, defined by specific months, and variations in temperature and humidity. This analysis aimed to improve insights into therapy-related drug usage, particularly how environmental conditions influence the timing and frequency of drug consumption. The selection of this research problem was based on its clear relevance, and the data generated from the two selected meteorological stations supports this focus.

As illustrated in Fig. 5 (Line Chart A and C), the temperature data from Sulaimani show a relatively normal distribution across the years 2014 to 2024, though the frequency patterns vary slightly from year to year. The temperature trend typically starts at its lowest in January and gradually increases, reaching a peak in June and July. However, the recorded normal temperatures in Stockholm are consistently lower than those in Sulaimani. In contrast, Fig. 5 (Line Chart B and D) presents humidity trends. In both cities, humidity generally begins high in January, decreases through the middle of the summer in June and July, and rises again toward December.

A noticeable fluctuation in Sulaimani's humidity occurred in November 2015, reflecting localized climatic instability. Overall, humidity levels in Stockholm are higher and more

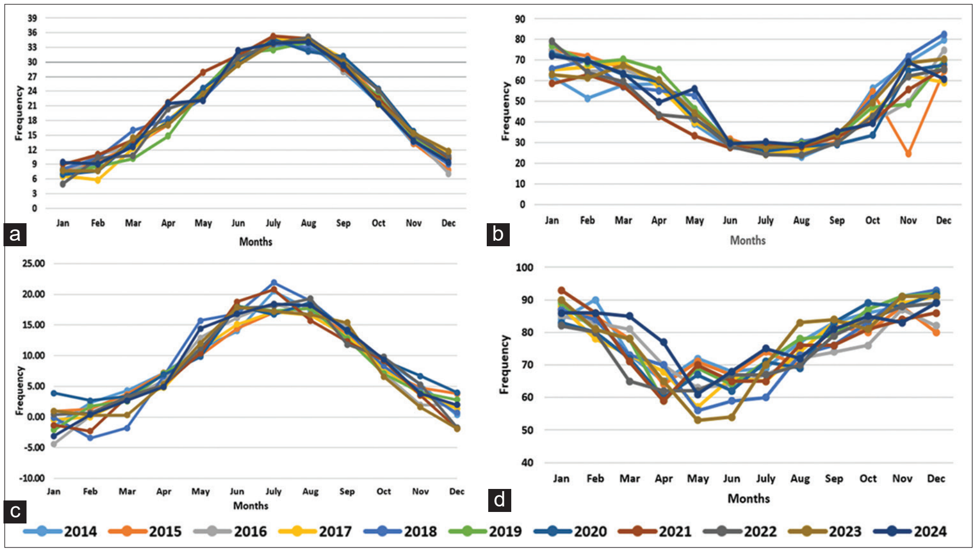

Fig. 5. Comparison of temperature and humidity frequency between Sulaimani and Stockholm from 2014 to 2024. (a) Monthly temperature frequency of Sulaimani, (b) Monthly humidity frequency of Sulaimani, (c) Monthly temperature frequency of Stockholm, (D) Monthly Humidity Frequency of Stockholm

TABLE 2: Comparison of average temperature and humidity between the cities of Sulaimani and Stockholm from 2014 to 2024

Months	Temperature		Humidity	
	Sulaimani	Stockholm	Sulaimani	Stockholm
January	7.445	−0.618	69.627	86.727
February	9.109	0.364	65.582	83.091
March	12.982	2.518	63.291	75.182
April	18.355	6.055	55.427	65.364
May	24.064	11.773	43.718	63.727
June	30.518	16.727	29.700	64.000
July	34.073	18.500	26.636	68.545
August	34.155	17.600	27.009	74.000
September	29.509	13.564	31.909	80.000
October	22.564	8.327	45.355	83.182
November	14.409	4.082	58.748	88.000
December	9.864	1.045	69.191	88.545
Average	20.587	8.328	48.849	76.697

stable compared to those in Sulaimani. This may reflect the more regulated and temperate climate of northern Europe. These seasonal movements in temperature and humidity are important climate variables that influence patterns of drug usage as therapy, particularly in relation to painkillers, antibiotics, and vaccines. The visualized patterns forecast that climate variability may serve as a useful indicator for forecasting therapeutic drug demand.

3.4. Data Collection Using Google Forms

The study examines the impact of climate on disease prevalence and drug therapy usage, focusing on public health in Sulaimani and Stockholm. Data were collected using a structured Google Form questionnaire and organized into several sections based on four specific criteria aligned with the principles of the *Simple Random Sample* model [10], [61]. The Google Form for data collection was launched in November 2024 to systematically gather responses and was completed on January 26, 2025.

Before initiating the main data collection, the survey instrument underwent pilot testing with a small group of 15 participants (10 from Sulaimani and 5 from Stockholm) to assess clarity, cultural relevance, and completion time. Based on the participants' feedback, minor linguistic and structural adjustments were made to improve item comprehension and ensure cross-cultural consistency. To evaluate internal consistency, Cronbach's alpha was calculated for multi-item sections, yielding values between 0.72 and 0.83, which reflect acceptable to good reliability. In addition, the questionnaire was reviewed and validated by three independent experts specializing in public health and climate-health dynamics, confirming the instrument's content validity and contextual appropriateness.

The first section gathered personal sociodemographic information, including age, weight, height, gender, occupation, education, and residence. These foundational data are crucial for contextualizing public health research and ensuring precise analysis of climate-related effects. The second section focused on residential area characteristics, documenting the climate conditions of each city and their perceived impact on disease prevalence and drug use. The third section, subdivided into several parts, explored therapeutic practices for climate-related diseases. It included detailed questions about the use of vaccines, antibiotics, and paracetamol, among other treatments. The final section featured open-ended questions to capture broader perspectives and enrich the study with qualitative insights. This comprehensive approach provides a robust framework for analyzing the interplay between climate, disease, and therapeutic interventions. To further evaluate the problem, an open-ended question was provided to the resident participants, allowing them to express their perspectives and insights regarding the issue.

To address the unequal sample sizes between Stockholm ($n = 150$) and Sulaimani ($n = 376$), we acknowledge that this disparity stems from differences in accessibility and respondent availability, particularly due to the smaller Kurdish refugee population and limited digital access in Stockholm. To reduce the impact of this imbalance, we used Chi-square tests with effect size estimates (Cramér's V) to ensure that observed differences reflect meaningful associations rather than being influenced by sample size alone as discussed in the next subsection. All analyses were conducted using proportional comparisons rather than raw counts to improve interpretability. Both cohorts included Kurdish participants, which helped control for cultural differences and allowed us to focus on climatic and geographic effects. Nonetheless, we recognize that the sample size imbalance may still limit generalizability and reduce statistical power in subgroup analyses.

Participants shared the same ethnicity, but factors such as cultural adaptation, healthcare access, and socioeconomic differences were not fully controlled. Since the study focuses on climate effects, these factors are acknowledged as limitations and discussed accordingly. A specific point regarding online data collection and bias control in online surveys involves addressing sampling limitations caused by relying solely on digital methods, as noted in Section 5. This can lead to underrepresentation of groups such as the elderly or those with limited internet access, affecting the generalizability of findings. To reduce this bias, researchers have used mixed-mode data collection, applied demographic balancing techniques, increased accessibility through multiple formats or languages, and monitored response rates to correct underrepresentation and improve study validity.

3.5. Statistical Analyses

After data collection, the responses have been carefully reviewed to eliminate errors and redundancies, ensuring the accuracy and reliability of the dataset. With the cleaned dataset, statistical analysis techniques can be applied, specifically tailored to extract the desired insights and address the research objectives. After analysis, the results are presented through clear visualizations and detailed reports. Transparency is crucial – present all evidence, highlight any gaps, and avoid selective reporting to maintain credibility. Finally, the process embraces failure as an opportunity for growth. Challenges such as errors or new questions are part of the iterative nature of data analytics, requiring adaptability, creativity, and a willingness to refine the approach while staying aligned with the framework.

In addition to the statistical analysis, the sociodemographic assessment involves the calculation of Body Mass Index (BMI) [62], which is determined using the participants' weight (W) in kilograms and height (H) in meters, as shown in Equation (1).

$$BMI = \frac{W}{H^2} \tag{1}$$

The data were statistically analyzed using two software platforms. The first involved Python 3.9.7 programming language in combination with Anaconda 3.13.3 (Jupyter Notebook 7.4.0). Several Python libraries were employed, including Pandas for data analysis and manipulation and SciPy for performing Chi-square tests. The second platform utilized was IBM SPSS Statistics version 26.0.0.0, which was used to conduct cross-tabulation analyses and calculate P-values to determine statistical significance.

In numerical analysis, a categorical variable is defined as one that has a limited, typically fixed range of possible values and is used to classify data into distinct categories [63]. In this study, beyond constructing the contingency matrix, we also performed a cross-tabulation (X^2) analysis using the Chi-square test of independence. This test, as represented by the formula (2) [10], is crucial for assessing the significance of the association between categorical variables, thereby highlighting the strength and relevance of their correlation with significant values [64]. Despite variations in application, all methods are based on the same fundamental principle: outcomes are determined by comparing observed values with expected values. In this context, (i) and (j) represent a specific cell within the contingency table of the sample (N), defined by its corresponding row (r) and column (c). Here, (O) denotes the observed frequency, while (E) represents the expected frequency under the assumption of independence between the variables.

$$X^2 = \sum_{i=1}^{c} \sum_{j-1}^{r} \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \qquad (2)$$

Where i denotes the row index and j denotes the column index.

4. RESULTS AND DISCUSSION

However, GIS technologies are used to map the coordinates of the research areas and visualize the spatial relationships between location, climate variables, and health indicators. Based on this mapping, certain aspects related to the impact of climate on drug therapy are finalized for the study. The collected data are then subjected to statistical analysis to identify trends and correlations between environmental factors, such as temperature fluctuations and seasonal extremes, and patterns of medication use. This analytical approach aims to assess how climate effects may influence public health practices and treatment strategies, based on data gathered from residents in the two selected study areas.

In addition, the analysis presented in this section enhances our understanding of the geographical factors influencing health and contributes to scientific efforts aimed at addressing development challenges. The findings from this research provide valuable insights to support healthcare planning and policy-making, especially in developing climate resilience and adaptation strategies. This is achieved through the integration of investigative methods, spatial analysis, and statistical evaluation. This study offers a comprehensive visualization of the complex relationships between environmental conditions and health outcomes, with a specific focus on the use of various types of therapeutic drugs in response to climate variability, weather patterns, and social factors across different geographical locations. It centers on two significant regions where Kurdish populations currently reside: Sulaimani and Stockholm.

For this purpose, to provide a more structured statistical comparison, the results were analyzed based on the impact of each modification and the validity of the dataset concerning climatic effects. To achieve this, Cramér's V, as shown in formula 3, a statistical measure used to assess the strength of association between categorical variables, was calculated to evaluate the degree of association between the outcomes from Stockholm and Sulaimani. Cramér's V values range from 0 (indicating no association) to 1 (indicating a perfect association), helping to quantify the strength of observed relationships in the context of categorical data.

$$V = \sqrt{\frac{X^2}{n(k-1)}} \qquad (3)$$

Where n is the total sample size, and k is the smaller value between the number of rows and the number of columns in the contingency table.

All results were derived from a specific sample, collected randomly according to the principles of the *Simple Random Sample* model. Data collection took place in two selected locations, including 376 individuals from Sulaimani and 150 individuals from Stockholm, representing various demographic groups. This approach was intended to predict outcomes and finalize conclusions related to the research problem. The collected data were then illustrated and visualized to better understand and address key aspects of the issue, particularly those that initially appeared insignificant.

4.1. Effects of Sociodemographic Variables

Geographically, one of the key features of this study is the mathematical and statistical analysis of sociodemographic variables to identify significant aspects related to the selected demographic locations. As outlined in the methodological section, the sociodemographic variables considered include gender, age groups, BMI, education level, and employment status. To improve the accuracy of data visualization, BMI values were classified into four range levels based on the arithmetic results.

Every variable was divided into distinct groups, as Table 3 illustrates. Age was separated into five groups, for example: 18–25, 26–35, 36–45, 46–55, and 56 and over. Age distribution differed significantly between the two populations ($\chi^2 = 38.9$, $p < 0.001$). In both Sulaimani and Stockholm, the 36–45 age group represented the largest share, with 35.64% and 40.67%, respectively. Younger participants 18–25 were much fewer in Stockholm, 8% compared to Sulaimani, 25.8%. Overall, the majority of participants in both cities were under 40 years old, with Stockholm showing a stronger concentration in this age range. In addition, female participation was higher in both locations, particularly in Sulaimani. In addition, education levels differed significantly between the two groups ($\chi^2 = 84.6$, $P < 0.001$), with bachelor's degrees most common in Sulaimani and high school or diploma levels more frequent in Stockholm. Employment status also showed a significant

TABLE 3: Statistical and arithmetic comparison of sociodemographic features

Features	Categories	Iraq-Sulaimani (376)		Sweden-Stockholm (150)		Statistics	
		Count	Percentage	Count	Percentage	χ^2	*P*-value
Gender	Male	172	45.74	80	53.33	2.47E+00	1.16E-01
	Female	204	54.26	70	46.67		
Age Group	18–25	97	25.80	12	8.00	3.89E+01	7.42E-08
	26–35	105	27.93	35	23.33		
	36–45	134	35.64	61	40.67		
	46–55	30	7.98	30	20.00		
	56 or above	10	2.66	12	8.00		
BMI*	Low range	55	14.63	13	8.67	3.83E+00	2.80E-01
	Lower mid-range	270	71.81	112	74.67		
	Upper mid-range	44	11.70	22	14.67		
	High range	7	1.86	3	2.00		
Education Degree	Basic	3	0.80	7	4.67	8.46E+01	9.06E-17
	High school	35	9.31	48	32.00		
	Diploma	51	13.56	40	26.67		
	Bachelor's degree	216	57.45	40	26.67		
	Master's degree	42	11.17	14	9.33		
	Doctorate	29	7.71	1	0.67		
Employment Status	Student	94	25.00	21	14.00	6.12E+01	1.66E-12
	Employee	204	54.26	53	35.33		
	Entrepreneur (Businessman)	46	12.23	63	42.00		
	Unemployed	29	7.71	10	6.67		
	Retired	3	0.80	3	2.00		

*BMI categories were defined as follows: Low range (BMI≤22), Lower mid-range (BMI >22 and ≤30), upper mid-range (BMI >30 and ≤37), and high range (BMI >37)

difference (χ^2 = 61.2, P < 0.001), with more employees in Sulaimani and more entrepreneurs in Stockholm.

According to Table 3, a Chi-square analysis was conducted to compare the sociodemographic variables between groups. Gender distribution did not significantly differ (χ^2 = 2.47, P = 0.116, Cramér's V = 0.08), indicating a small and non-significant effect. Age group differences were statistically significant (χ^2 = 38.9, P < 0.001, Cramér's V = 0.29), showing a moderate effect size. BMI categories also showed no significant variation (χ^2 = 3.83, P = 0.280, Cramér's V = 0.07, small effect). In contrast, education levels varied markedly between groups (χ^2 = 84.6, P < 0.001, Cramér's V = 0.43), reflecting a large effect size. Similarly, employment status was significantly different (χ^2 = 61.2, P < 0.001, Cramér's V = 0.38), indicating a moderate to large effect.

4.2. Impact of Demographic Factors on Weather-related Descriptions

Several key inquiries and impacts were identified related to how individuals living in specific locations are influenced, particularly regarding the use of drug therapy and healthcare behaviors within a sociological context. Although there are some differences between cases, similar impacts can emerge globally, especially during widespread events like pandemics. Thus, geography, linked with demographic factors, can significantly affect lifestyle changes and cultural shifts. To explore these influences, the study gathered targeted responses from participants based on two specific questions, as presented in Table 4.

The weather description is shown in the second main part. The study emphasizes how the environment and weather have a major influence on public health in Stockholm and Sulaimani. The majority of respondents in Stockholm classified the weather as cold and humid, 73.33%, but the Sulaimani varied climate, 50.27% revealed a wider range of opinions as a median. Autumn and winter saw a rise in illnesses, especially seasonal respiratory infections. In both places, participants noted that seasonal variations affected the spread of sickness, with colder months showing higher rates of illness. Strangely, in Sulaimani, 50.27% of participants indicated that city weather had no impact on their health, whereas in Stockholm, 73.33% of respondents reported a moderate effect. In Sulaimani, seasonal variation was the most frequently reported factor affecting public health, 57.18%, followed by cold waves, 16.22%, reported by 66 participants. Similarly, in Stockholm, seasonal variation remained the leading factor, 48.00%, reported by 215 participants, while cold waves showed a comparatively higher impact, 29.33%,

TABLE 4: Comparison of weather-related health impact factors between two selected cities

Queries	Categories	Iraq-Sulaimani (376)		Sweden-Stockholm (150)		Statistics	
		Count	Percentage	Count	Percentage	χ^2	*P*-value
Weather description	Humid (Moist) and cold	27	7.18	110	73.33	267.9559	8.80E-57
	Dry and cold	96	25.53	34	22.67		
	Medium	189	50.27	6	4.00		
	Dry and hot	50	13.30	0	0.00		
	Humid and hot	14	3.72	0	0.00		
Impact of city weather on health	No effect	189	50.27	6	4.00	47.20219	1.38E-09
	Too little	96	25.53	34	22.67		
	Somewhat	27	7.18	110	73.33		
	A lot	50	13.30	0	0.00		
	Too much	14	3.72	0	0.00		
Major weather factors affecting public health	The dry period	46	12.23	0	0.00	44.93217	1.50E-08
	Seasonal variation	215	57.18	72	48.00		
	Cold waves	61	16.22	44	29.33		
	Heat waves	30	7.98	8	5.33		
	Types of precipitation (rain, snow, hail, etc.)	23	6.12	23	15.33		
	Natural disaster (flood, storm, etc.)	1	0.27	3	2.00		
Observed how weather patterns and seasonal changes influence disease spread in their cities	No noticeable effect	18	4.79	9	6.00	23.07625	1.22E-04
	Minimal impact	11	2.93	15	10.00		
	Moderate impact	122	32.45	66	44.00		
	Significant impact	174	46.28	45	30.00		
	Significantly effective	51	13.56	15	10.00		
The peak season for illness and medication depends on weather and disease prevalence.	Spring	5	1.33	6	4.00	9.499586	2.33E-02
	Summer	13	3.46	6	4.00		
	Autumn	260	69.15	85	56.67		
	Winter	98	26.06	53	35.33		
Weather-sensitive diseases include seasonal respiratory infections.	Sensitization	26	6.91	21	14.00	16.27837	2.67E-03
	Seasonal epidemics (Infectious diseases)	327	86.97	110	73.33		
	Skin diseases (Dermatosis)	11	2.93	9	6.00		
	Chronic diseases (Non-communicable diseases)	1	0.27	3	2.00		
	Sudden diseases (Acute diseases)	11	2.93	7	4.67		
The area's location and climate influence medicine usage.	No effect	25	6.65	28	18.67	28.78596	9.00E-06
	Slight effect	44	11.70	31	20.67		
	Moderate effect	220	58.51	70	46.67		
	Significant effect	75	19.95	17	11.33		
	Strong effect	12	3.19	4	2.67		

reported by 44 individuals. In Sulaimani city, 46.28% of participants, or 174 individuals, reported that weather patterns and seasonal changes had a significant impact on disease spread, while 32.45%, or 122 participants, observed a moderate impact. In Stockholm, 44.00% of participants, or 66 individuals, noted a moderate impact, and 30.00%, or 45 participants, reported a significant effect. The key findings from the data on climate impact showed that in Sulaimani, 86.97% of participants, or 327 individuals, identified seasonal epidemics (infectious diseases) as the primary weather-sensitive disease. In Stockholm, 73.33% of participants, or 110 individuals, reported the same, with a significant percentage also recognizing seasonal respiratory infections. 220 participants reported a moderate effect of the area's location and climate on medicine usage in Sulaimani, while 70 participants indicated a similar moderate effect in Stockholm. In Sulaimani, 69.15% of participants identified autumn as the peak season for illness and medication, while 56.67% of participants in Stockholm reported the same. In addition, this trend is emphasized and visualized in Fig. 6. Conversely, spring and summer had the lowest reactions and are least linked to pharmaceutical use in both regions. These patterns indicate that illness and higher medicine use are more closely associated with the colder and transitional

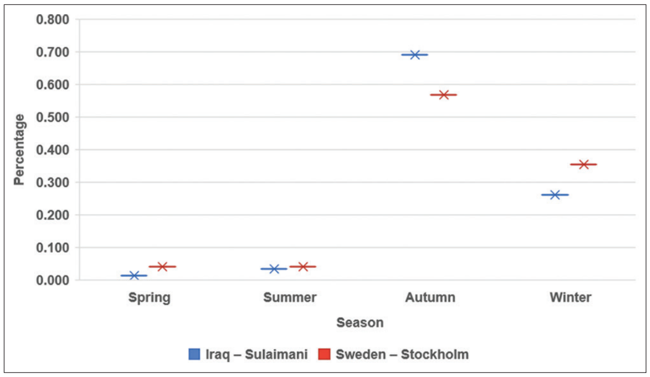

Fig. 6. The depiction of peak illness seasons and medication usage is influenced by weather and disease prevalence.

seasons. The two nations' different climates could be the cause of the differences: Stockholm's longer and colder winters could make people more open to seasonal illnesses for a longer length of time, while Sulaimani's fluctuating autumnal temperatures could cause greater health problems. The current pattern demonstrates how seasonal variations and local weather affect public health practices and attitudes toward medication.

The analysis of all queries exposed significant differences between the two locations based on the Chi-square test (χ^2) and P-values. In several cases, such as weather description, the impact of city weather on health, and the main weather factors affecting public health, the P-values were extremely low (e.g., $P < 0.001$), representing statistically significant differences between Sulaimani and Stockholm. For example, the weather description showed a clear distinction in the conditions reported, with a significant difference in the outcome of the weather on health. As well, χ^2 for factors like the impact of city weather on health and major weather factors affecting public health were also high, further supporting the statistical significance of the findings. These results highlight the substantial impact of location-specific factors on health, climate, and medication use, with clear differences experiential in the two cities.

According to Table 4, a comparative analysis was conducted to examine categorical differences between Stockholm and Sulaimani in terms of weather perception, health impact, and seasonal illness patterns. Chi-square tests revealed significant associations across all variables. Notably, the description of weather differed strongly between the two cities ($\chi^2 = 267.96$, $P < 0.001$, Cramér's V = 0.72), indicating a very large effect size. Similarly, perceptions regarding the impact of city weather on health ($\chi^2 = 47.20$, $P < 0.001$, Cramér's V = 0.38) and seasonal variation ($\chi^2 = 44.93$, $P < 0.001$, Cramér's V = 0.37) showed moderate to large effect sizes, suggesting substantial perceptual differences. Observations related to disease spread across seasons also varied significantly ($\chi^2 = 23.08$, $P < 0.001$, Cramér's V = 0.27), reflecting a moderate effect size. These findings underscore both statistical and practical differences in weather-related health perceptions and experiences between the two regions.

4.3. Therapeutic Role in Seasonal Illness Prevention

This section evaluates the use of three primary therapies, vaccines, antibiotics, and painkillers, across different locations during illness and examines how seasonal climate variations influence their application and effectiveness.

4.3.1. Assessing vaccine usage for preventing seasonal weather-related illnesses

Vaccines are a primary prophylactic intervention designed to sustain antibody-mediated immunity during emergent outbreaks and seasonal pandemic shifts. Sociocultural and demographic factors modulate vaccine uptake, as populations respond variably to climate influences and weather fluctuations at the start of each season. Such immunization programs protect against influenza and other pandemic threats; for instance, widespread obligatory vaccination was applied during the COVID-19 pandemic. Table 5 presents vaccination uptake rates alongside participants' responses on treatment utilization across fluctuating climatic conditions.

Notably, 76 participants in Sulaimani and 34 participants in Stockholm reported using vaccines to protect against seasonal weather-related illnesses. The results show a remarkably close vaccination rate in both selected cities, with approximately between 20% and 23% of participants reporting vaccine use. In addition, most participants reported a moderate influence of location and climate on vaccine usage, with 36 individuals in Sulaimani and 13 in Stockholm. In Sulaimani, 52.63% of participants (40 persons) used the vaccine for prevention, while 38.16% (29 persons) reported using it for both prevention and treatment. In Stockholm, 70.59% of participants (24 persons) used it for prevention, with 20.59% (7 persons) using it for both purposes. For vaccine use, 52.63% in Sulaimani and 70.59% in Stockholm reported using it for prevention, while 38.16% and 20.59%, respectively, used it for both prevention and treatment. Regarding the impact of climate and disease exposure on vaccine use, 52.63% in Sulaimani and 41.18% in Stockholm indicated a moderate influence. Predictably, autumn was identified as the most ideal season for using vaccines, reported by 69.74% in Sulaimani and 50.00% in Stock.

TABLE 5: Seasonal vaccination patterns and environmental health impacts in two selected cities

Queries	Categories	Iraq-Sulaimani (376)		Sweden-Stockholm (150)		Statistics	
		Count	Percentage	Count	Percentage	χ^2	*P*-value
Using vaccines helps protect against seasonal weather-related illnesses.	No	300	79.79	116	77.33	3.90E-01	5.32E-01
	Yes	76	20.21	34	22.67		
Location and climate influence vaccine usage.	No effect	13	17.11	8	23.53	5.85E+00	2.11E-01
	Slightly	9	11.84	9	26.47		
	Moderate	36	47.37	13	38.24		
	Significantly	17	22.37	4	11.76		
	Strongly	1	1.32	0	0.00		
The use of the vaccine was for prevention or treatment.	Prevention	40	52.63	24	70.59	3.99E+00	2.63E-01
	Treatment	6	7.89	2	5.88		
	Both of them	29	38.16	7	20.59		
	None of them	1	1.32	1	2.94		
The type of climate and disease exposure in the area has impacted vaccine use.	No effect	6	7.89	6	17.65	7.66E+00	1.05E-01
	Slightly	13	17.11	11	32.35		
	Moderate	40	52.63	14	41.18		
	Significantly	16	21.05	3	8.82		
	Strongly	1	1.32	0	0.00		
The most ideal season, weather, and climate for using the vaccine.	Spring	9	11.84	3	8.82	6.85E+00	7.68E-02
	Summer	2	2.63	1	2.94		
	Autumn	53	69.74	17	50.00		
	Winter	12	15.79	13	38.24		

One of the statistical issues observed is that all *P*-values indicate significance ($P < 0.05$), while the Chi-square, as illustrated by χ^2 values, is very low. However, this outcome is mainly due to the small number of participants using vaccines, making the statistical results difficult to control. However, it can be discussed that addressing these issues depends on improving vaccine implementation during climate fluctuations. Perceiving Table 5, an analysis of vaccine-related variables between groups revealed no statistically significant differences. Vaccine usage rates were comparable across locations ($\chi^2 = 0.39$, $P = 0.532$, Cramér's V = 0.04), indicating a very small effect size and suggesting minimal influence of geography on vaccination behavior. Similarly, perceptions of location and climate influence on vaccine decisions ($\chi^2 = 5.85$, $P = 0.211$, Cramér's V = 0.18) and the reported purpose for vaccine use ($\chi^2 = 3.99$, $P = 0.263$, Cramér's V = 0.20) showed small to small–moderate effect sizes, but these differences were not statistically significant. Overall, the findings suggest that vaccine-related attitudes and behaviors were largely consistent between the two populations, with only minor variations that lack statistical support.

4.3.2. Assessing antibiotics usage for preventing seasonal weather-related illnesses

One technique of protection during fluctuating weather and seasonal illnesses is the use of antibiotics as a therapeutic approach. In addition, antibiotics are often used as a seasonal therapy to treat secondary bacterial infections that may follow epidemiologic illnesses during seasonal changes. Their use typically grows during periods of heightened respiratory infections, such as in autumn and winter. However, inappropriate use against viral infections remains a significant public health concern. For this purpose, the study investigated the use of antibiotic therapy during infectious illnesses associated with seasonal weather changes.

According to Table 6, in Sulaimani, 143 participants, mean of 38.03%, used antibiotics for protection, while only 21 participants, mean of 14.00%, did so in Stockholm. This highlights the influence of demographic factors and culture on the participants, even though both groups are from the same Kurdish nation. Regarding the influence of location and climate on antibiotic use, 48.25% of participants in Sulaimani reported a moderate effect, while 24.48% noted a significant effect. In Stockholm, 38.10% observed a moderate impact, and 19.05% saw a significant effect. When asked about the purpose of antibiotic use, 73.43% of participants in Sulaimani used antibiotics for treatment, while 33.33% in Stockholm used them for both prevention and treatment. Regarding the impact of climate and disease exposure, 51.05% of participants in Sulaimani and 38.10% in Stockholm reported a moderate effect. Finally, when identifying the most ideal season for antibiotic use, 58.74% of Sulaimani participants selected autumn, and 37.06% chose winter, while in Stockholm, 57.14% chose autumn and 33.33% chose winter. This result indicates that seasonal weather is highly related to the impact of climate on the use of drug therapy for treating infections.

TABLE 6: Antibiotic patterns and environmental health impacts in two selected cities

Queries	Categories	Iraq-Sulaimani (376)		Sweden-Stockholm (150)		Statistics	
		Count	Percentage	Count	Percentage	χ^2	*P*-value
Using antibiotics helps protect against seasonal weather-related illnesses.	No	233	61.97	129	86.00	2.89E+01	7.78E-08
	Yes	143	38.03	21	14.00		
Location and climate influence antibiotics usage	No effect	15	10.49	5	23.81	4.20E+00	3.79E-01
	Slightly	20	13.99	4	19.05		
	Moderate	69	48.25	8	38.10		
	Significantly	35	24.48	4	19.05		
	Strongly	4	2.80	0	0.00		
The use of the antibiotics was for prevention or treatment	Prevention	11	7.69	5	23.81	1.17E+01	8.55E-03
	Treatment	105	73.43	8	38.10		
	Both of them	25	17.48	7	33.33%		
	None of them	2	1.40	1	4.76		
The type of climate and disease exposure in the area has impacted antibiotics use.	No effect	5	3.50	3	14.29	7.00E+00	1.36E-01
	Slightly	20	13.99	5	23.81		
	Moderate	73	51.05	8	38.10		
	Significantly	40	27.97	5	23.81		
	Strongly	5	3.50	0	0.00		
The most ideal season, weather, and climate for using the antibiotics.	Spring	2	1.40	1	4.76	1.44E+00	6.96E-01
	Summer	4	2.80	1	4.76		
	Autumn	84	58.74	12	57.14		
	Winter	53	37.06	7	33.33		

The use of antibiotics to protect against seasonal weather-related illnesses was found to be statistically non-significant, as the *P*-value was >0.05. However, in Sulaimani, individuals who reported antibiotic use demonstrated a stronger association, reflected by a favorable χ^2 value, leading to the rejection of the null hypothesis. Observing Table 6, significant differences were observed in antibiotic-related practices between the two study locations. Antibiotic usage was notably higher in Sulaimani compared to Stockholm ($\chi^2 = 28.9$, $P < 0.001$, Cramér's V = 0.27), indicating a moderate effect size and suggesting a meaningful influence of geographical context on treatment behavior. Similarly, the reported purpose of antibiotic use also differed significantly between groups ($\chi^2 = 11.7$, p = 0.0085, Cramér's V = 0.26), reflecting another moderate association. These findings imply that antibiotic consumption patterns and motivations vary substantially across the two cities, likely reflecting differences in health beliefs, access, or prescribing practices.

4.3.3. Assessing painkillers usage for preventing seasonal weather-related illnesses

The use of painkillers as a therapeutic approach was assessed for managing seasonal weather-related illnesses, highlighting painkillers as one of the protective therapies during seasonal weather fluctuations. Furthermore, painkiller therapy usage varies notably across different geographical regions, reflecting both environmental influences and cultural healthcare practices. In regions with harsher seasonal changes, such as colder winters or speedy temperature fluctuations, the use of painkillers tends to increase as individuals manage weather-related illnesses, including respiratory infections and musculoskeletal pain.

In Sulaimani, 55.05% of participants, or 207 individuals, reported using painkillers to protect against these issues, while in Stockholm, 42.00%, or 63 individuals, reported the same as stated in Table 7. Participants in both Sulaimani and Stockholm reported that climate and location moderately influenced their usage of painkillers, with 103 participants (49.76%) in Sulaimani and 29 participants (46.03%) in Stockholm admitting a moderate effect. Most individuals primarily used painkillers for treatment, with 139 participants (67.15%) in Sulaimani and 44 participants (69.84%) in Stockholm indicating this resolution, while a smaller proportion used them for both prevention and treatment, reported by 53 participants (25.60%) in Sulaimani and 15 participants (23.81%) in Stockholm. Climate and disease exposure were also noted to moderately affect painkiller usage, with 93 participants (44.93%) in Sulaimani and 32 participants (50.79%) in Stockholm reporting moderate influence. Regarding the ideal season for using painkillers, autumn was the most commonly identified season by 109 participants (52.66%) in Sulaimani and 30 participants (47.62%) in Stockholm, followed closely by winter, selected by 89 participants (43.00%) in Sulaimani and 30 participants (47.62%) in Stockholm, reflecting the seasonal rise in weather-related illnesses.

TABLE 7: Painkillers patterns and environmental health impacts in two selected cities

Queries	Categories	Iraq-Sulaimani (376)		Sweden-Stockholm (150)		Statistics	
		Count	Percentage	Count	Percentage	χ^2	*P*-value
Using painkillers helps protect against seasonal weather-related illnesses.	No	169	44.95	87	58.00	7.31E+00	6.85E-03
	Yes	207	55.05	63	42.00		
Location and climate influence painkiller usage.	No effect	26	12.56	12	19.05	9.57E+00	4.83E-02
	Slightly	48	23.19	16	25.40		
	Moderate	103	49.76	29	46.03		
	Significantly	0	0.00	0	0.00		
	Strongly	30	14.49	6	9.52		
The use of the painkillers was for prevention or treatment.	Prevention	10	4.83	4	6.35	1.85E+00	6.04E-01
	Treatment	139	67.15	44	69.84		
	Both of them	53	25.60	15	23.81		
	None of them	5	2.4	0	0.00		
The type of climate and disease exposure in the area has impacted painkillers use.	No effect	9	4.35	7	11.11	8.19E+00	8.47E-02
	Slightly	37	17.87	12	19.05		
	Moderate	93	44.93	32	50.79		
	Significantly	61	29.47	12	19.05		
	Strongly	7	3.38	0	0.00		
The most ideal season, weather, and climate for using the painkillers.	Spring	1	0.48	2	3.17	4.37E+00	2.24E-01
	Summer	8	3.86	1	1.59		
	Autumn	109	52.66	30	47.62		
	Winter	89	43.00	30	47.62		

Statistical analysis showed that the use of painkillers in relation to seasonal weather illnesses has been significantly influenced by climate and location ($P = 0.0483$). The majority used painkillers mostly for treatment purposes, with moderate climatic impact detected in both cities. The preference for using painkillers during the autumn and winter seasons further supports the seasonal pattern of weather-related illnesses.

4.3.4. Comparison discussion of usage frequency for vaccines, antibiotics, and painkillers

The differences in treatment usage frequency between Sulaimani and Stockholm highlight the impact of location and climate on health behaviors, and the collected data provide important insights for analysis. Fig. 7 presents a comparison of vaccine, antibiotic, and painkiller usage among participants from both cities, reflecting seasonal medication preferences. In both locations, autumn emerged as the most common season for medication use; however, a larger proportion of participants in Sulaimani (approximately 70%) reported taking medications during this period compared to about 55% in Stockholm. In Sulaimani, vaccine usage was notably low, with nearly 300 participants, indicating that they did not use vaccines, while only around 70 participants reported vaccine usage. Conversely, the use of antibiotics and painkillers was considerably higher in Sulaimani, with approximately 140 participants using antibiotics and slightly over 200 using painkillers. In Stockholm, vaccine usage was also limited, but proportionally, more participants used vaccines than antibiotics. Painkiller use was more prevalent than antibiotic use in Stockholm, with around 60 participants using painkillers compared to fewer than 30 for antibiotics. Overall, medication usage was higher in Sulaimani, particularly for antibiotics and painkillers, whereas Stockholm exhibited a lower but relatively more balanced pattern of medication use across the different treatments.

4.4. Impact of Health Priorities on Climate-driven Drugs

This section provides a crucial evaluation of the results related to the overall impact of climate on drug therapy usage in various ways. Furthermore, it focuses on responses that explored general opinions about weather-related health issues. In both locations, most participants assigned some degree of importance to addressing these challenges. According to Table 8, the key findings for each query are analyzed and discussed separately below, focusing on general opinions and practices related to weather-induced health challenges:

- Priority in addressing health problems was evident in both locations, where most participants emphasized the need to tackle weather-related health issues. In Sulaimani, 60.9% of respondents indicated that they assigned to some extent or to a great extent a priority to finding solutions, compared to 48% in Stockholm. Notably, a higher percentage of participants in Stockholm, 12.67%, reported never prioritizing such solutions, compared to only 4.26% in Sulaimani

TABLE 8: Compares responses on health priorities related to climate-driven drugs in these two regions

Queries	Categories	Iraq-Sulaimani (376)		Sweden-Stockholm (150)		Statistics	
		Count	Percentage	Count	Percentage	χ^2	*P*-value
The level of priority in seeking solutions to health problems caused by the weather is high.	Never	16	4.26	19	12.67	7.12E+00	6.81E-02
	Little	131	34.84	59	39.33		
	To some extent	163	43.35	51	34.00		
	To a great extent	66	17.55	21	14.00		
In general, the treatment or medication most often used is due to the local climate	Vaccine	23	6.12	14	9.33	2.86E+01	2.75E-06
	Antibiotics	118	31.38	12	8.00		
	Painkillers (Analgesics)	138	36.70	64	42.67		
	Multivitamins (Dietary supplements)	97	25.80	60	40.00		
Any public health policies or guidelines related to the climate in your city	No policy	100	26.60	15	10.00	5.93E+01	8.22E-13
	To some extent	104	27.66	42	28.00		
	In good shape	8	2.13	49	32.67		
	Unaware	164	43.62	44	29.33		
Describe the accessibility and permissibility of obtaining medicines for prevention and treatment in the area	Easy	240	63.83	52	34.67	8.99E+01	2.35E-19
	Relatively (Somewhat) easy	122	32.45	50	33.33		
	Difficult	10	2.66	28	18.67		
	Very difficult	4	1.06	20	13.33		
Types of drugs that are helpful and necessary for treating health problems related to the climate in the city include	Vaccine	76	20.21	30	20.00	1.67E+01	8.00E-04
	Antibiotics	88	23.40	13	8.67		
	Painkillers (Analgesics)	70	18.62	40	26.67		
	Multivitamins (Dietary supplements)	142	37.77	67	44.67		

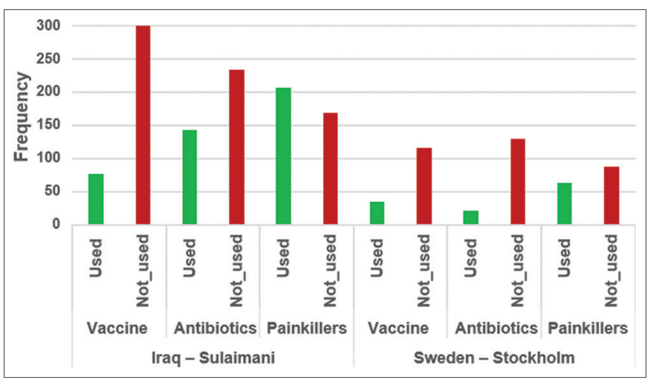

Fig. 7. The differences in frequency of treatment usage based on the impact of different locations.

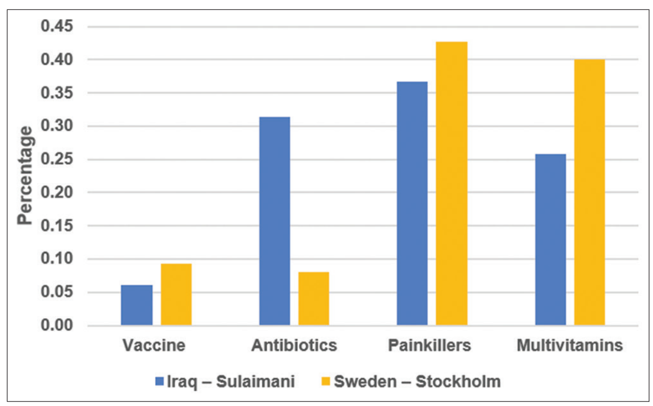

Fig. 8. The percentage of the treatment or medication most often used due to the local climate.

- Common treatments for climate-related health issues showed that painkillers, specifically analgesics, were the most commonly reported treatment in both cities, particularly in Stockholm with 42.67% and in Sulaimani with 36.7%. Multivitamins were the next most preferred treatment, with a higher usage in Stockholm at 40% compared to 25.8% in Sulaimani. The use of antibiotics was significantly higher in Sulaimani, reaching 31.38%, compared to only 8% in Stockholm. The comparison discussion, as indicated by the percentage values, is clearly illustrated in Fig. 8
- Public health policies related to climate showed considerable variation in awareness and approval between the two locations. In Sulaimani, 164 participants, representing 43.62%, reported being uninformed of any climate-related health policies, compared to 44 participants or 29.33% in Stockholm. In contrast, 49% in Stockholm, accounting for 32.67%, indicated that climate-related policies were in respectable, whereas only 8 participants or 2.13% stated the same in Sulaimani

- Accessibility of medicines showed notable differences between the two cities. In Sulaimani, 240 participants, or 63.83%, reported that obtaining medicines was easy, compared to 52 participants or 34.67% in Stockholm. Meanwhile, 48 applicants in Stockholm, representing 32%, described access as difficult or very difficult, compared to only 14 participants or 3.72% in Sulaimani
- The perceived necessity of different drug types revealed that multivitamins were the most commonly cited medications for climate-related health issues, with 142 contestants or 37.77% in Sulaimani and 67 participants or 44.67% in Stockholm. Antibiotics were reported more frequently in Sulaimani by 88 participants or 23.4%, compared to 13 contributors or 8.67% in Stockholm. The identification of this issue is highly valuable, as demonstrated in Fig. 9.

The discussion of *P*-values as discussed by statistical models, as presented in the table, highlights the statistical significance of the observed differences across various factors. The low *P*-values indicate a high level of confidence in the results, suggesting that the differences observed between the locations are not due to chance. This strengthens the reliability of the conclusions drawn from the data.

Finally, two open-ended questions were included to further explore the topic. The majority of participants reported making lifestyle or health habit changes to protect themselves against illnesses caused by adverse weather conditions. Many emphasized the importance of public education on the negative health effects of climate change, particularly through the expertise of medical professionals. Notably, in Stockholm, some respondents linked weather-related factors to mental health issues. Others highlighted that those environmental factors, such as air and water pollution, also contribute to health problems, in addition to weather-related factors. Overall, participants expressed a preference for prevention over treatment when addressing weather-induced health concerns.

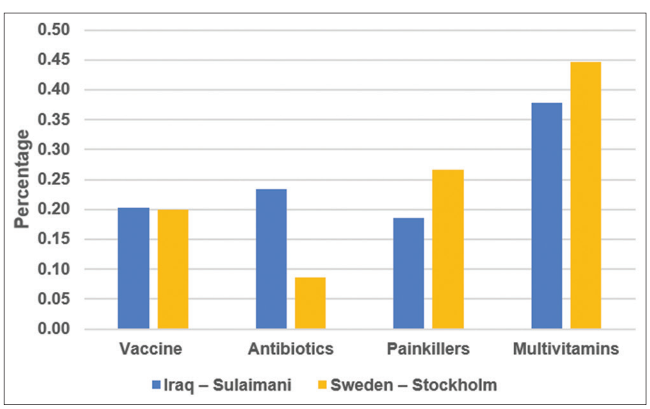

Fig. 9. The impact of using various types of drugs that are essential for treating climate-related health issues in the city includes.

5. CONCLUSION AND FUTURE WORK

This study highlights the influence of climate and geography on drug therapy practices among Kurdish residents in Sulaimani and Stockholm, including Kurdish refugees living in Stockholm. It also considers the impact of sociodemographic factors on the study outcomes and related healthcare challenges. While Stockholm shows a stronger emphasis on preventive care, evidenced by higher use of multivitamins and vaccinations, Sulaimani exhibits significantly greater antibiotic use, indicating a more treatment-oriented approach. Painkillers emerged as the most commonly used drugs in both locations, though their usage was notably higher in Stockholm, suggesting that seasonal health issues are a major concern regardless of geographic setting. According to the research, Sulaimani relies more on rapid treatment, while Stockholm's health strategies go toward prevention, showing how environmental pressures and healthcare systems adapt differently. The comparative ratio findings reveal that colder climates encourage a stronger focus on defensive health behaviors, while more variable climates drive higher rates of reactive treatments. Statistical model analysis helped isolate these trends by minimizing cultural bias; however, some effects were still clearly impacted.

Overall, the results suggest that integrating geographical and climate-sensitive strategies into healthcare planning is essential for improving medical outcomes. Future research should extend the scope to different cultural groups and regions, leading to broader validation. Understanding these regional dynamics can lead to more personalized, resilient healthcare systems that better respond to environmental and demographic shifts. The study suggests that healthcare systems in warmer, more variable climates in Sulaimani should need to emphasize infection control due to higher treatment-driven medication use, whereas colder climates might prioritize preventive care. However, these recommendations require validation in broader contexts, accounting for regional healthcare infrastructure and cultural practices.

Naturally, the study has certain limitations that should be addressed in future data collection efforts, particularly in Sulaimani. Online recruitment in this city may underrepresent individuals with limited or no internet access, potentially affecting the inclusiveness and representativeness of the sample. While participants shared the same ethnic background, potential confounders such as cultural adaptation, healthcare access, and socioeconomic differences across regions were not fully controlled. These factors are acknowledged as limitations and may influence the interpretation of some findings. One challenge was the difficulty in selecting and identifying the necessary Kurdish residents for data collection in Stockholm. In addition, obtaining data on the weather impact over the past 10 years proved challenging, making it hard to analyze and integrate this information for improving the comparative study. Future studies could utilize Internet of Things-based (IoT-based) environmental sensors in combination with medication-tracking applications to monitor real-time interactions between climate conditions and drug usage [65], [66]. In addition, machine learning algorithms in artificial intelligence can be applied to analyze the data [67]. The data could also be classified and optimized using parameter-tuning algorithms, particularly those related to genetic algorithms and real-world bioinformatic algorithms [68], [69]. Finally, the most critical and apparent limitation is the lack of cross-cultural generalizability; extending the findings beyond Kurdish populations will require validation in more diverse ethnic and cultural groups.

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