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Unseen Peril: Air Pollution And Its Impact On Geriatric Health In Hyderabad

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Abstract:

Introduction: The rapid urbanization of Hyderabad, driven by its transformation into an information technology hub, has led to significant physical changes and deteriorating air quality due to increased vehicular traffic and industrial activities. This poses a serious health risk, particularly to the growing elderly population, which is especially vulnerable to the adverse effects of air pollution. With Telangana state surpassing the United Nations' "aging" threshold, understanding the interplay between urban air pollution and the health of senior citizens in Hyderabad is crucial for developing targeted mitigation strategies.

Methodology: This study employed a stratified random sampling technique to collect primary data via questionnaires from 200 participants aged 60 and above across four distinct areas within Hyderabad: Ashok Nagar (residential), Abids (commercial), Katedan (industrial), and Patancheru (urban sprawl). These areas were selected to represent diverse exposure environments. A pilot study involving 40 participants was conducted in the Nacharam industrial area. Measures for key variables were adopted from previous studies. Data analysis was performed using SPSS, including descriptive statistics (frequencies and percentages) and inferential statistics (Chi-square and likelihood ratio tests) to assess differences in perceptions and experiences of air pollution across demographic variables (gender, age groups, education levels) at a significance level of $p < 0.05$.

Results: Gender and age impact transportation and air pollution perception, while education strongly shapes awareness, mitigation, and economic views, especially for seniors. Health and industrial area effects also show demographic links, illustrating the complex social-environmental interaction.

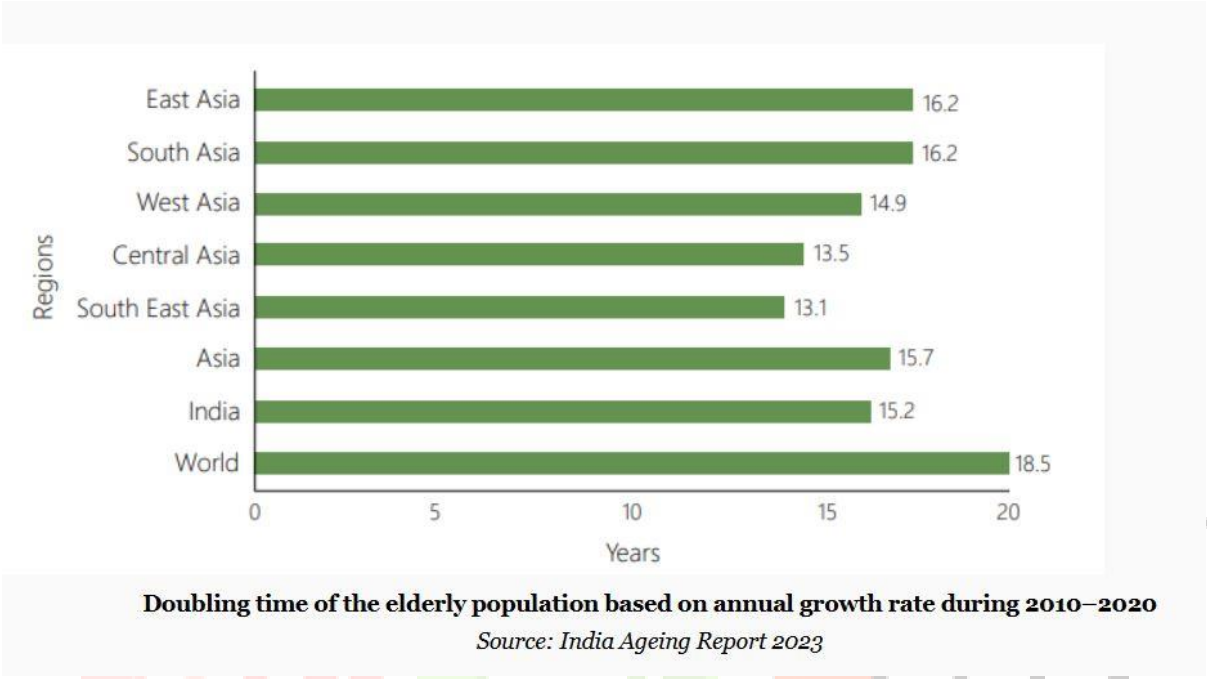
Conclusion: The study explores the link between senior citizens' perceptions/behaviours related to air pollution and their demographics, finding that transport preferences are influenced by age and gender, whereas education level plays a key role in dietary/lifestyle adjustments, perceptions of air quality in public transit, and economic beliefs.

Key words: Population Ageing, Geriatrics, Air pollution, Silver economy

1. Introduction:

India is undergoing a significant demographic shift as its elderly population grows at an unprecedented rate. According to the United Nations, there are currently around 153 million individuals aged 60 and above in India, a number expected to nearly double to 347 million by 2050. By mid-century, older adults will constitute approximately 20% of the country's total population. This phenomenon, known as population aging, is largely driven by two factors: increased life expectancy due to improvements in healthcare and living standards, and declining fertility rates (United Nations, 2023). In many developing countries, the population is still relatively young but is ageing faster than it did in developed countries.

Figure 1.1 Doubling time of the elderly population:



Doubling time of the elderly population based on annual growth rate during 2010–2020

Source: India Ageing Report 2023

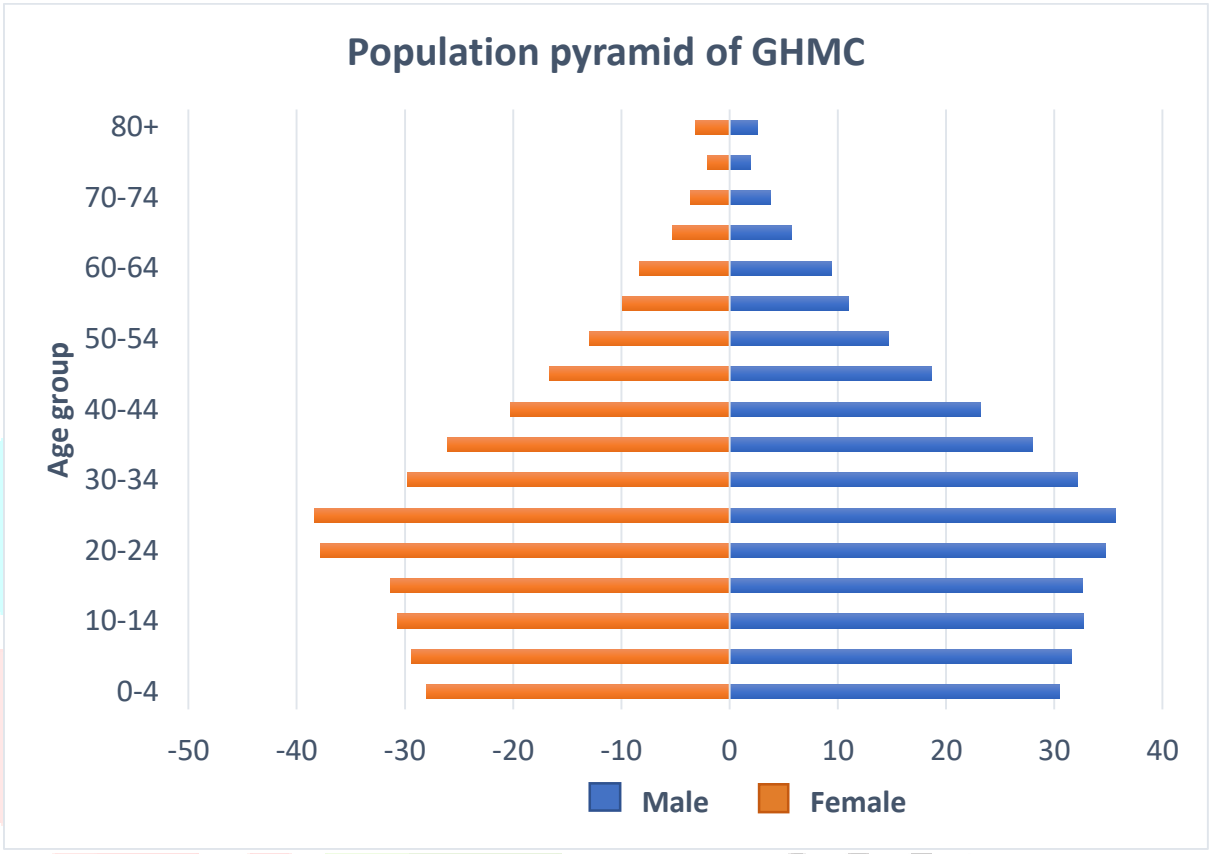
This image 1.1 presents a horizontal bar graph comparing the doubling time of the elderly population (in years) across different regions and countries, based on their annual growth rate during the period 2010-2020. India has a doubling time of 15.2 years, which is faster than the Asian average (15.7 years) and the global average (18.5 years), suggesting a relatively rapid increase in the country's elderly population.

According to the **Telangana Statistical Abstract (ATLAS) 2024**, Hyderabad surpasses Delhi with a population density of 18,161 people per square kilometre, putting immense pressure on the city's infrastructure. (Telangana State Development Planning Society, 2024).

Hyderabad's rapid urban expansion presents a complex interplay of opportunities and challenges. While this growth has undeniably fuelled economic dynamism, it simultaneously exerts significant pressure on the city's infrastructure, public services, and housing capacity. The increasing demand for resources, driven by substantial in-migration, is approaching critical levels. Hyderabad's attractiveness as a hub for professionals, students, and entrepreneurs is attributable to its burgeoning technology sector, coupled with its rich cultural and historical heritage. However, this growth trajectory coincides with a noteworthy demographic shift in Telangana. While the state's proportion of the national population is projected to experience a slight decline between 2011 and 2031, a more significant trend is the aging of the population. By 2031, Telangana is anticipated to have a smaller proportion of young people (under 39 years of age) and a substantial increase in

the number of older residents (over 40), particularly those aged 80 and above, whose numbers are projected to surge by 80%. This demographic transformation signifies a considerable and rapid aging of the population in the coming decades, with potential implications for healthcare, social services, economic development (Planning Department, Government of Telangana, 2023).

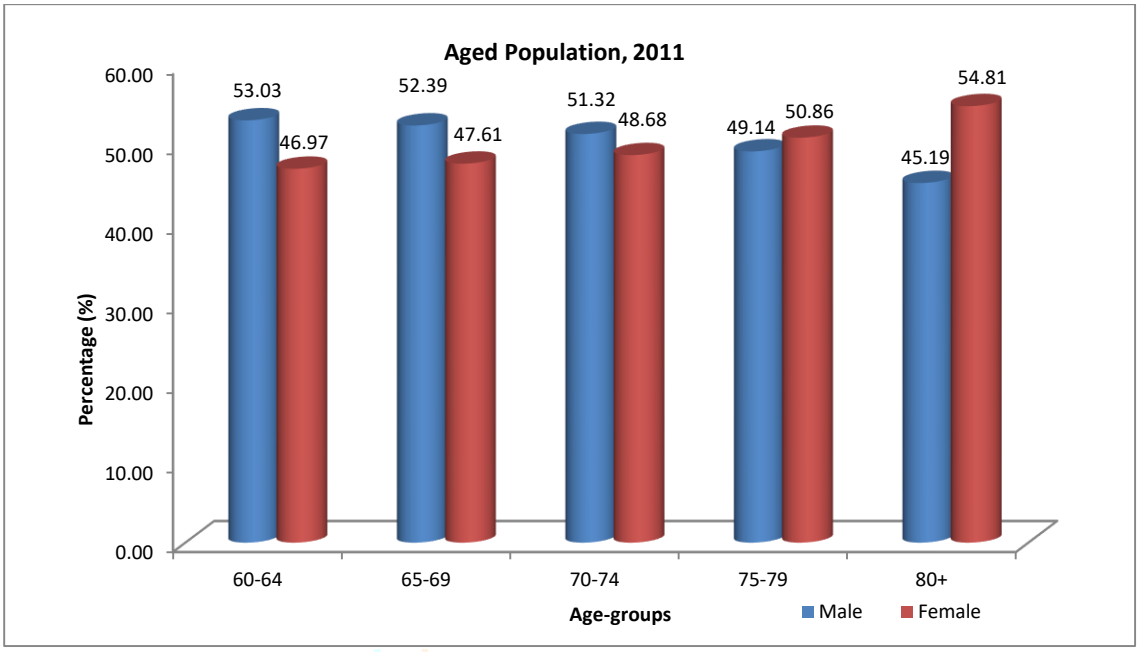
1.2 POPULATION IN FIVE YEAR AGE-GROUP BY RESIDENCE AND SEX - 2011



Source: Census of INDIA 2011

The 2011 population pyramid of the Greater Hyderabad Municipal Corporation (GHMC) shows a distinct **narrow top**, indicating a relatively small proportion of senior citizens (60+) at that time. However, when considering the demographic future of GHMC, it's crucial to note the **significant cohort represented by the 40-50 age group** in 2011. By 2050, these individuals will have reached their late 70s and 80s, becoming a substantial part of the senior citizen population. Therefore, it is highly likely that the **top of the population pyramid will widen considerably by 2050**, reflecting a much larger proportion of elderly individuals in GHMC. This aligns with the global trend of population aging, where increased life expectancy and declining fertility rates lead to a growing proportion of older individuals, as highlighted in reports by the United Nations, Department of Economic and Social Affairs, Population Division (2019) in their 'World Population Prospects 2019' [United Nations, 2019] This demographic change necessitates proactive planning and policy adjustments to address the needs of an increasingly elderly population.

1.3 Aged Population Distribution by Age and Gender, 2011



Source: Census of INDIA 2011

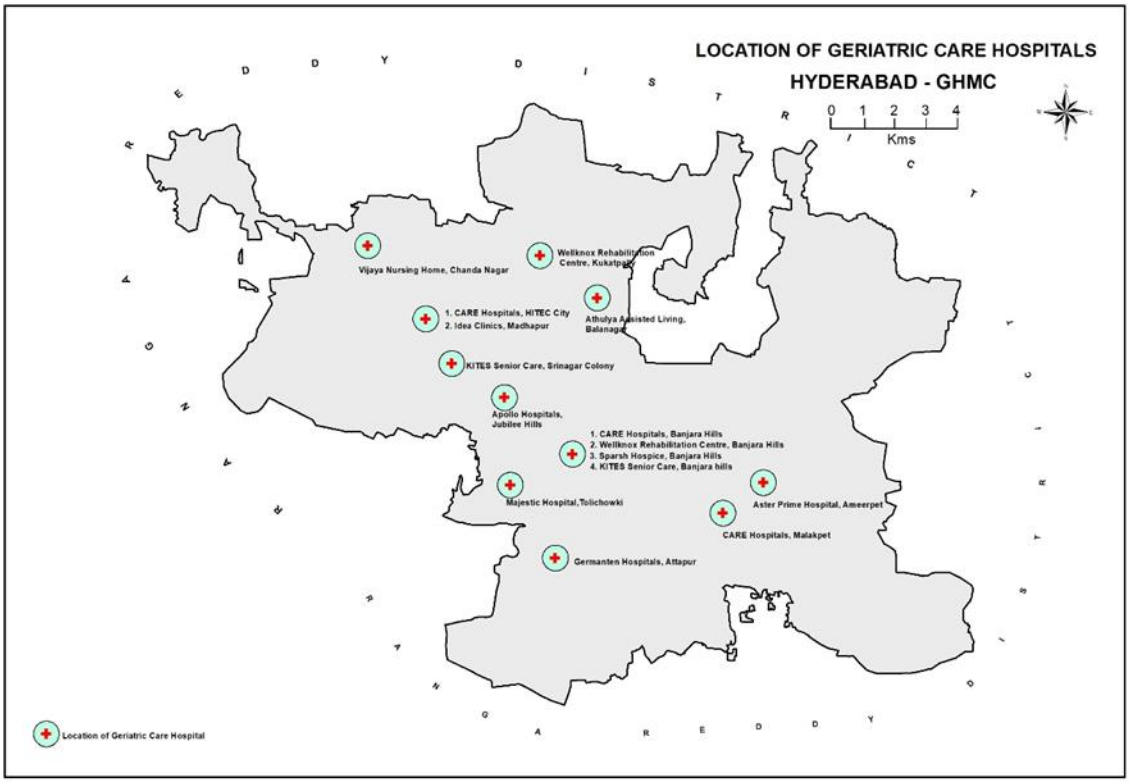
The bar graph depicts the aged population distribution in 2011, segmented by age groups (60-64 to 80+) and gender. Notably, it reveals a shift in gender dominance with age: males slightly outnumber females in the younger age brackets (60-64 and 65-69), but this trend reverses as age increases. From the 70-74 age group onwards, females progressively constitute a larger percentage of the population, culminating in a significant majority in the 80+ age group. This suggests a higher life expectancy for females compared to males within this population, highlighting important demographic trends with potential implications for social and healthcare planning.

Significance of Hyderabad in Geriatric Care

Private Geriatric Care Hospitals in Hyderabad (GHMC):

The map 1.4 depicts the geographical distribution of private hospitals within the Greater Hyderabad Municipal Corporation (GHMC) that offer geriatric care services. Here's a breakdown of the key observations:

1.4 Map showing the location of Hospitals with geriatric care

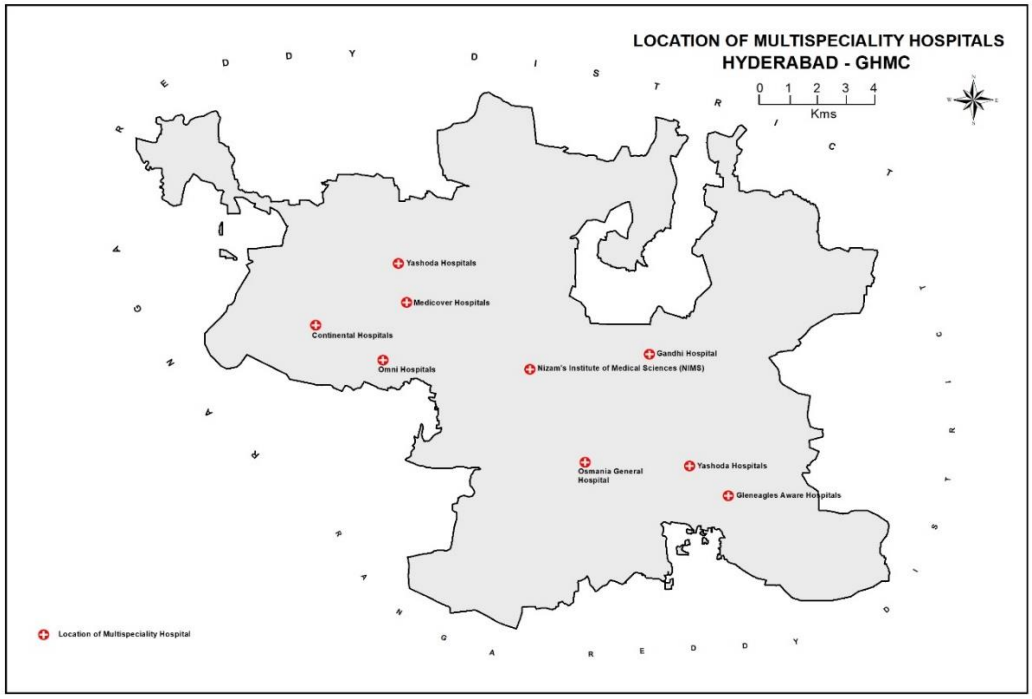


Concentration in Western and Central regions: Particularly in regions like Banjara Hills, Jubilee Hills, HITEC City, and Madhapur, the map clearly shows the geriatric care hospitals located in the western and central sections of Hyderabad. This implies that these rather wealthy and developed areas have more availability of specialist senior care services. Restricted Coverage in Eastern and Southern Areas: By comparison, GHMC's eastern and southern regions have noticeably less registered geriatric care facilities. This difference draws attention to a possible imbalance in access to specific senior care for citizens living in different areas of the city.

Prominent Hospital Chains: Geriatric care is acknowledged in several well-known private hospital chains including Apollo Hospitals and CARE Hospitals. This shows that experienced medical professionals are meeting the rising demand for treatments with a senior concentration. Emphasizing the many variety of private geriatric care alternatives accessible, the map also contains specialized rehabilitation institutes (Wellknox) and assisted living facilities (Athulya). Possible problems with accessibility: The unequal spread of these facilities can cause accessibility issues for senior residents living in places with inadequate coverage. Reaching timely and suitable treatment could be seriously hampered by distance and travel time. Implications: This map emphasizes the need of knowing the geographical dispersion of providers for geriatric care. Although private hospitals are quite important in offering specialist treatment, the concentration in particular areas raises questions regarding fair access for every older adult in the GHMC. To guarantee thorough geriatric care coverage all throughout the city and to resolve possible inequalities, more investigation

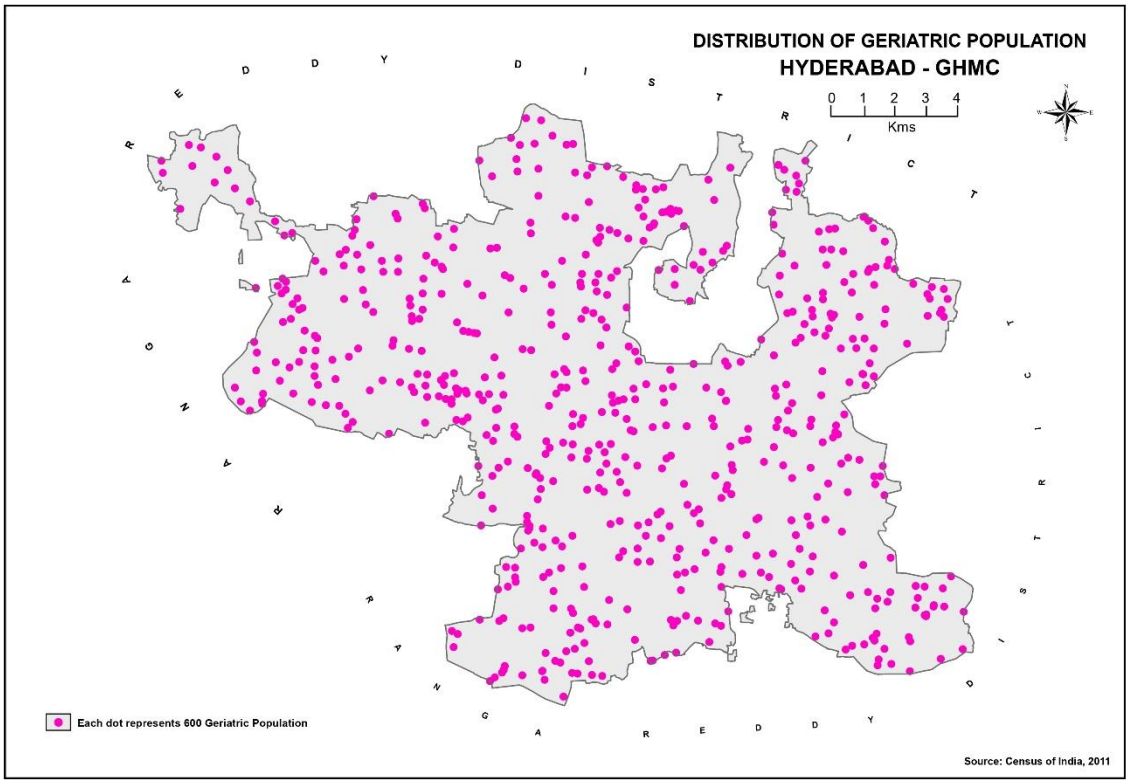
of elements including socioeconomic demography, transportation infrastructure, and public healthcare projects is required.

1.5 Map showing the location of multispeciality hospitals & Government hospitals



The map 1.5 illustrates the distribution of multispeciality hospitals within the Greater Hyderabad Municipal Corporation (GHMC), revealing a concentration in the western and central areas, while highlighting the presence of only four government hospitals: Gandhi Hospital, Nizam's Institute of Medical Sciences (NIMS), Osmania General Hospital. Alongside these, private multispeciality hospitals like Yashoda, Medicover, Continental, Omni, and Gleneagles Aware are also depicted. The observed disparity in access, with fewer government hospitals and a concentration of both government and private facilities in wealthier areas, suggests a potential need for more government-run multispeciality hospitals, particularly in underserved regions, to ensure equitable healthcare access for all residents of the rapidly growing GHMC.

1.6 Dot map showing the distribution of geriatric population in Hyderabad-GHMC



The dot map illustrates the uneven distribution of the geriatric population within the Greater Hyderabad Municipal Corporation (GHMC) area. Each dot represents roughly 600 senior citizens, and the varying density of dots across the map indicates areas of higher and lower concentrations of elderly residents. This visual representation allows for the identification of population clusters and disparities in geriatric population distribution within the city, based on the 2011 Census of India.

2. Literature review:

2.1 Global Impact of Air Pollution on Health:

A strong body of evidence links air pollution to increased risks of respiratory and cardiovascular diseases, as well as lung cancer (Pope & Dockery, 2006). This includes risks for non-smokers. Moreover, emerging research suggests a correlation between air pollution exposure and type 2 diabetes, potentially due to impaired glucose metabolism (Pope & Dockery, 2006). Air pollution may also contribute to poorer cancer survival and other adverse health outcomes.

2.2 Air Pollution and Health in India and Hyderabad:

In India, studies consistently link air pollution, particularly PM2.5, to increased cancer risk, including lung cancer in non-smokers (Kumar et al., 2019). Further contributing to different forms of cancer are industrial pollutants (Kumar et al., 2019). Studies specifically in Hyderabad show a possible correlation between high air pollution levels and growing lung cancer cases in non- smokers (Kumar et al., 2019). The interaction on health between population aging and air pollution: Particularly sensitive to the negative health consequences of air pollution is the elderly population (Pope & Dockery, 2006). Older persons are more vulnerable to the negative effects of air pollutants, including the aggravation of respiratory and cardiovascular diseases, an increased risk of developing cancer and diabetes, and maybe poorer general health outcomes due to age-related physiological changes and pre-existing chronic conditions (Brook et al., 2010). The combined weight

of an aging population and rising air pollution levels is probably going to tax healthcare systems heavily and raise demand for long-term care facilities (World Health Organization, 2018). Healthcare resources will be more used as the number of elderly persons suffering from chronic diseases aggravated by air pollution increases. This calls for the creation and execution of combined policies addressing the issues of air pollution as well as the particular healthcare and social support needs of the aging population (World Health Organization, 2018).

3. Objectives:

- Analyze the varied impact of air pollution on Hyderabad's senior citizens across different urban environments, considering demographic influences on their perceptions and behaviours.
- Evaluate the effectiveness of current mitigation strategies and propose targeted preventive measures, informed by seniors' experiences and transportation choices, to improve their health and quality of life.
- Assess the significant role of education in shaping seniors' awareness, lifestyle adaptations, and economic perceptions related to air pollution and its effects.

4. Methodology:

The primary data in the form of Questionnaire has been collected form four different locations of GHMC, Hyderabad. It presents an intriguing approach by sampling from four distinct areas, each representing different facets of urban life. The survey was conducted both in offline and online (Google form). A stratified random sampling technique, was employed to collect primary data on the impact of air pollution on the geriatric population. Four distinct areas within Hyderabad were selected as strata to represent diverse land use types and potential pollution sources:

1. Ashok Nagar: Representing a residential area.
2. Abids: Representing a commercial area.
3. Katedan: Representing an old industrial area.
4. Patancheru: Representing an urban sprawl area.

Main Study:

To ensure representation across varying exposure environments, a stratified random sampling approach was employed. Four distinct strata were defined, and within each, 50 geriatric individuals aged 60 years and above were selected via simple random sampling. This resulted in a total sample size of 200 (n=200), allowing for comparative analysis of air pollution impacts across the different strata.

Pilot Study:

A pilot study was conducted in the Nacharam industrial area, involving the collection of 40 samples (n=40).

- **Residential Area - Ashok Nagar**: This area likely represents the living conditions, environmental factors, and possibly socio-economic status of residents. Sampling from a residential area provides insights into the daily exposures and health risks faced by individuals in their living spaces.
- **Commercial zones** are hive centers of economic activity, usually distinguished by heavy traffic, vehicle-related pollution, and concentration of companies. Sampling from Abids allows the study to evaluate possible health effects for workers and visitors as well as the influence of commercial activity on air and noise pollution.
- **Old Industrial Area:** Katedhan: Because of prior manufacturing operations, industrial areas—especially older ones—may contain residual pollutants. Sampling from Katedhan lets researchers investigate how industrialization still affects public health and the environment. This could involve air pollution from surrounding factories as well as poisoning of water and soil supplies.
- **Urban Sprawl & Industrial Area:** Patancheru most certainly reflects a mix of industrial growth and fast urbanisation. While industrial activity can aggravate pollution levels, urban growth sometimes results in more strain on infrastructure and natural resources. Sampling from Patancheru will enable the study to investigate how industry and urban growth interact to affect the environment and human health.

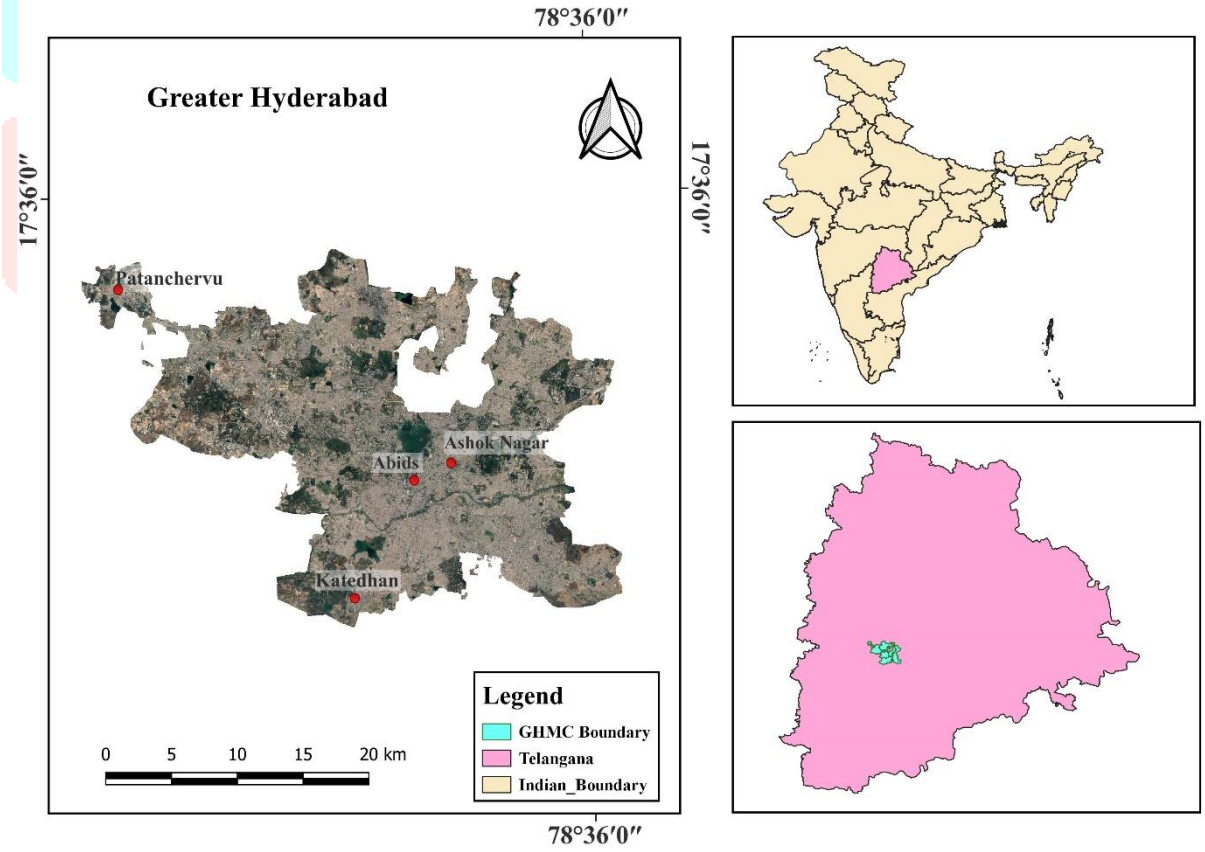


Figure 1.7: Study area Map

The questionnaire has 9 sections: Awareness of air quality: Perceived health impacts: Experiences living near industrial areas: Knowledge of pollution mitigation: Transportation perception: The perceived economic influence of air pollution. The questionnaire also included socio-demographic questions (Age, Gender, Education level, Occupation, Economic status). A 29-item questionnaire was developed to assess the impact

of air pollution on senior citizens and to gather information on related issues. The questionnaire was designed to collect and record data on the participants' experiences, perceptions, and knowledge concerning air pollution. As geriatrics are the target audience, data collection required significant time and care. To ensure understanding and accurate responses, each question was read aloud and thoroughly explained to participants before their responses were recorded. Consequently, the completion of each questionnaire took approximately 30 minutes to one hour. This extended timeframe is consistent with best practices for surveys involving older populations, who may require more time to process and respond to questions.

4.1 Statistical analysis:

Following data encoding, the questionnaire responses were analysed using the Statistical Package for the Social Sciences (SPSS). Initial analysis involved the calculation of descriptive statistics, specifically frequencies and percentages, to provide an overview of the data distribution. Subsequently, inferential statistical analyses were conducted to determine potential differences in responses across key demographic variables. Chi-square analysis and likelihood ratio tests were employed to examine these differences between male and female participants, across four distinct age groups, and among varying educational levels. A significance level of $p < .05$ was utilized as the criterion for statistical significance in all analyses, which is a standard threshold in social science research (Cohen, 1988). This approach allowed for a comprehensive assessment of both the overall response patterns and the specific impacts of demographic factors on perceptions and experiences related to air pollution among the geriatric population.

Analysis and observations:

Table 1: General demographic information of the participants n=240.

Factors		Percentage (%)
Gender	Male	Female
	70.4	29.6
Age	51-60	29.2
	61-70	44.2
	71-80	20.4
	Above 80	6.3
Education Level	School Level	27.5
	Plus 2 level	24.2
	Graduation	23.3
	PG & Above	11.3
	Others	13.8
Job/Occupation	House wife	6.7
	Private Job (Working/retired)	26.7
	Govt job (Working/retired)	22.5
	Working in industry (W/R)	15.8

	Business (Working/Retired)	15
	Others	13.3
Economic status	Up to Rs.10000 per month	18.8
	Rs.10001-Rs.25000 per month	26.7
	Rs.25001-Rs.50000 per month	24
	Rs.50001-Rs.75000 per month	19.2
	Rs.75001-Rs.100000 per month	8.3
	Rs.100001-Rs.150000 per month	3

1. Mode of Transport Used in the Last 50 Years

- **Public Transport:** There is a statistically significant association between the mode of public transport used over the past 50 years and both gender (χ^2 (5) = 13.501, p = .019) and age (χ^2 (15) = 45.976, p < .001). However, there is no significant association with education (χ^2(20) = 13.619, p = .849). Age was significantly associated with the use of trains (χ^2 (12) = 44.949, p < .001), buses (χ^2 (12) = 22.521, p = .032), and cars/autos (χ^2 (12) = 42.219, p < .001). Rickshaw use was significantly associated with both gender (χ^2 (4) = 6.301, p = .178) and age (χ^2 (12) = 10.431, p = .578). The 'Any other' category showed a significant association with gender (χ^2 (4) = 3.034, p = .552) and age (χ^2 (12) = 11.794, p = .462). The linear-by-linear association test was statistically significant for the overall mode of transport (p = .009) and rickshaw use (p = .031). This is consistent with Aoki's (2003) empirical analysis, which found that older adults were more likely to choose transport modes offering greater comfort and convenience, even if they were more expensive.
- **Private Transport:** There is a statistically significant association between geriatric status and overall private transport usage over the past 50 years (χ^2 = 16.017, p = .007). Walking and age (χ^2(12) = 26.078, p = .010), two-wheeler usage and gender (χ^2(4) = 8.343, p = .080), four-wheeler usage and education level (χ^2(16) = 34.321, p = .005), and 'any other' transport usage and education level (χ^2(16) = 36.377, p = .003) showed significant associations. However, bicycle usage showed no significant associations, and walking did not show a significant association with gender (χ^2(4) = 5.526, p = .237). The significant association between education level and both four-wheelers use and the "Any other" category suggests that socioeconomic factors may play a role in accessing and choosing certain private transport modes within this senior citizen population. This is supported by studies that have found a link between socioeconomic status and transportation choices, particularly in terms of car ownership and access to private vehicles (Cervero & Kockelman, 1997).

2. Awareness of Air Quality

- **Perceived Air Quality:** No statistically significant associations were found between perceived air quality and gender ($\chi^2(5) = 6.611$, $p = .251$), age ($\chi^2(15) = 11.276$, $p = .733$), or education level ($\chi^2(20) = 16.715$, $p = .671$). A significant majority (54%) perceived the air quality negatively, describing it as 'Poor'. This may indicate that the experience of air pollution is relatively homogenous within this population, regardless of individual characteristics. Field observations revealed a discrepancy between the perception of air and water pollution. While many participants reported poor water quality due to visible foam in the "nalas" (drains), they often rated the air quality as better, despite living in metropolitan polluted areas.
- **Impact of Traffic Congestion:** A statistically significant association was found between perceived traffic congestion impact and gender ($\chi^2(5) = 11.327$, $p = .045$). No significant associations were found with age ($\chi^2(15) = 18.188$, $p = .253$) or education level ($\chi^2(20) = 15.217$, $p = .764$). This may indicate that men and women have varying experiences or awareness of traffic-related air pollution, potentially due to differences in travel patterns, exposure to traffic, or sensitivity to pollutants (Clougherty et al., 2010).
- **Public Awareness and Concern:** The analyses revealed no statistically significant associations between agreement levels and gender ($\chi^2(5) = 7.990$, $p = .157$), age ($\chi^2(15) = 20.603$, $p = .150$), or education level ($\chi^2(20) = 26.712$, $p = .144$). These findings suggest a homogenous perception across demographic groups regarding the adequacy of public air pollution awareness, potentially indicating shared concerns. This lack of demographic difference does not necessarily imply satisfaction; it could reflect widespread dissatisfaction or a perceived lack of individual influence on policy.

3. Impact of Air Pollution

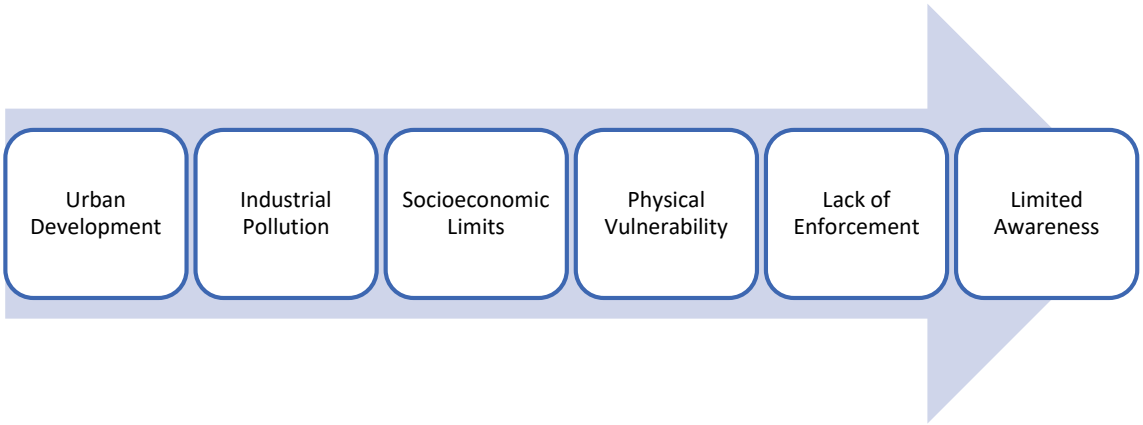
- **Perceived impact:** There were no statistically significant associations between gender and perceived impact, ($\chi^2(5, N = 240) = 2.415$, $p = .789$), age and perceived impact, ($\chi^2(15, N = 240) = 12.746$, $p = .622$), or education level and perceived impact, ($\chi^2(20, N = 240) = 21.721$, $p = .356$). The findings revealed that gender, age, and education level did not significantly predict these perceptions. This lack of significant association does not suggest that air pollution has no impact. Rather, it implies that other factors may play a more substantial role in shaping these perceptions. Potential factors influencing senior citizens' perceptions may include pre-existing health conditions, proximity to pollution sources, and individual sensitivity or awareness (Jerrett et al., 2005).
- **Impact on Maternal Health:** The results indicated no statistically significant associations between gender and concern, $\chi^2(4, N = 240) = 1.024$, $p = .906$; age and concern, $\chi^2(12, N = 240) = 15.997$, $p = .191$; or education level and concern, $\chi^2(16, N = 240) = 11.302$, $p = .790$. Consistent results were obtained using the likelihood ratio chi-square test: gender, $\chi^2(4, N = 240) = 1.285$, $p = .864$; age, $\chi^2(12, N = 240) = 15.172$, $p = .232$; education, $\chi^2(16, N = 240) = 11.151$, $p = .800$. In India, senior citizens often influence family healthcare choices and are actively involved in supporting pregnant daughters-

in-law and new-born grandchildren. Furthermore, national health policies like the National Health Mission (NHM) and Pradhan Mantri Surakshit Matritva Abhiyan (PMSMA), which focus on maternal and child health, indirectly involve senior citizens as family caregivers and supporters. The Senior Citizens Act, 2007, reinforces the societal responsibility to care for seniors, validating their concerns about family well-being. Additionally, growing environmental awareness, as reflected in the National Clean Air Programme (NCAP), has led to increased concerns about air pollution's impact on vulnerable populations, including pregnant women and children.

- **Impact on Gender Roles:** The results indicated no statistically significant associations between gender and perceived impact, ($\chi^2(4, N = 240) = 4.239$, $p = .375$); age and perceived impact, ($\chi^2(12, N = 240) = 8.177$, $p = .771$); or education level and perceived impact, ($\chi^2(16, N = 240) = 18.273$, $p = .308$). This suggests that demographic factors alone do not explain senior citizens' views on air pollution's impact on gender roles. While demographic associations were absent, air pollution's known health impacts could indirectly affect roles and responsibilities (Pope & Dockery, 2006).

4. Measures to Reduce Air Pollution Exposure

- **Air pollution reduction**: There was no statistically significant association between gender and reported air pollution reduction behaviors, $\chi^2(5) = 3.615$, $p = .606$, or between age and reported behaviors, $\chi^2(15) = 20.923$, $p = .139$. However, a potential association was observed between education level and reported air pollution reduction behaviors, as evidenced by a significant likelihood ratio chi-square, $\chi^2(20) = 33.729$, $p = .028$, although the standard chi-square test was not significant, $\chi^2(20) = 30.171$, $p = .067$. As study found no significant link between age or gender and seniors' actions to reduce air pollution exposure in a metropolitan area, but suggested higher education may correlate with increased protective measures. However, urban environmental challenges, socioeconomic disparities, and age-related vulnerabilities limit seniors' control over exposure, despite potential motivation. The education link implies better-educated seniors might navigate these constraints more effectively
- **Factors Limiting Control over Air Pollution:**



- **Government Prioritization:** The analyses revealed no statistically significant associations between opinions and gender ($\chi^2(5) = 5.215$, $p = .390$) or age ($\chi^2(15) = 17.327$, $p = .300$). However, a statistically significant association was observed between opinions and education level using the Chi-Square test ($\chi^2(20) = 32.407$, $p = .039$), but not with the Likelihood Ratio Chi-Square test ($\chi^2(20) = 26.130$, $p = .162$). This study found uniform perception across genders and age groups regarding the need for local government action on air pollution, potentially reflecting its perception as a universal concern. A potential link between higher education and perceived need for government action, possibly due to increased environmental awareness was observed.
- **Effectiveness of Measures:** The analyses revealed no statistically significant associations between perceived effectiveness and gender ($\chi^2(5) = 2.904$, $p = .715$), age ($\chi^2(15) = 11.068$, $p = .748$), or education level ($\chi^2(20) = 24.916$, $p = .205$). This suggests a shared understanding or experience among senior citizens, regardless of gender, age, or education. The importance of public perception in shaping environmental policy and its implementation should not be underestimated (Agresti, 2007).

5. Health Hazards

- **Experienced Symptoms:** The analyses revealed no statistically significant associations between reported symptoms and gender ($\chi^2(5) = 7.476$, $p = .188$), age ($\chi^2(15) = 18.236$, $p = .250$), or education level ($\chi^2(20) = 20.028$, $p = .456$). Homogenous reporting on air pollution's impact among seniors may reflect shared exposure and health consequences, given their vulnerability. However, the often invisible and cumulative nature of air pollution can hinder direct symptom attribution, particularly for older adults who may attribute symptoms to age-related decline.
- **Impact on Healthcare Costs and Quality of Life:** The analyses revealed no statistically significant associations between opinions and gender ($\chi^2(5) = 5.689$, $p = .338$). However, a statistically significant association was observed between opinions and age using the Chi-Square test ($\chi^2(15) = 29.551$, $p = .014$), while the Likelihood Ratio test indicated a trend towards significance ($\chi^2(15) = 24.583$, $p = .056$). For education, the Chi-square test showed a trend toward significance ($\chi^2(20) = 30.422$, $p = .063$), while the Likelihood Ratio test showed a statistically significant association ($\chi^2(20) = 31.314$, $p = .051$). Air pollution has been shown to increase healthcare utilization and costs, while also diminishing quality of life through exacerbation of chronic conditions (Anderson et al., 2012).

6. Effects of Living at Industrial Area

- **Impact on Quality of Life:** The analyses revealed no statistically significant associations between perceived impact and gender ($\chi^2(5) = 4.184$, $p = .523$), age ($\chi^2(15) = 21.874$, $p = .111$), or education level ($\chi^2(20) = 17.477$, $p = .622$). Proximity to industrial areas negatively impacts older adults' quality of life due to increased air and noise pollution, and the urban heat island effect, leading to health issues (Jerrett et al., 2009).

- **Perceived Changes in Air Quality:** No statistically significant association was found between gender and perceived changes in air quality ($\chi^2(5) = 5.269$, $p = .384$). A statistically significant association was observed between age and perceived changes in air quality ($\chi^2(15) = 25.574$, $p = .043$). A statistically significant association was found between education level and perceived changes in air quality ($\chi^2(20) = 43.547$, $p = .002$). This suggests that geriatric participants with different education levels reported varying perceptions of air quality changes. Studies have shown that education plays a significant role in shaping environmental awareness and perception.

- **Considered relocating due to concerns about air pollution:** Chi-Square tests revealed no statistically significant associations between gender ($\chi^2(5) = 8.834$, $p = .116$; Likelihood Ratio $\chi^2(5) = 8.351$, $p = .138$), age ($\chi^2(15) = 11.973$, $p = .681$; Likelihood Ratio $\chi^2(15) = 14.071$, $p = .520$), or education ($\chi^2(20) = 16.638$, $p = .676$; Likelihood Ratio $\chi^2(20) = 19.381$, $p = .497$). The lack of statistically significant associations between gender, age, education, and considering relocation due to air pollution concerns is likely attributable to the prevalence of homeowners and geriatric individuals dependent on families within the surveyed population. Furthermore, research indicates that homeownership creates stability and reduces mobility (Jensen-Battaglia et al., 2024).

7. Dietary/Lifestyle Changes

- Chi-Square and Likelihood Ratio Chi-Square tests revealed no statistically significant associations between senior citizens' consideration of alternative dietary practices or lifestyle changes to minimize air pollution exposure and gender ($\chi^2(5) = 7.346$, $p = .196$; Likelihood Ratio $\chi^2(5) = 7.167$, $p = .209$) or age ($\chi^2(15) = 8.679$, $p = .894$; Likelihood Ratio $\chi^2(15) = 9.536$, $p = .848$). However, a statistically significant association was found between education level and consideration of such changes ($\chi^2(20) = 38.923$, $p = .007$; Likelihood Ratio $\chi^2(20) = 42.867$, $p = .002$). The finding of a significant association between education level and the consideration of alternative dietary practices or lifestyle changes to minimize air pollution exposure suggests that higher education levels may be correlated with increased awareness and proactive behaviors related to environmental health lifestyle changes, such as modifying outdoor activities during peak pollution hours, can also play a role in minimizing exposure (WHO, 2016). Research has shown that dietary interventions, such as increasing antioxidant intake, can potentially reduce the oxidative stress induced by air pollutants.

8. Perception on Public Transportation

- **Perceptions of air quality inside public transit vehicles:** Chi-Square and Likelihood Ratio Chi-Square tests revealed no statistically significant associations between senior citizens' perceptions of air quality inside public transit vehicles compared to outdoor environments and gender ($\chi^2(5) = 4.652$, $p = .460$; Likelihood Ratio $\chi^2(5) = 4.895$, $p = .429$). While age approached a level of statistical significance ($\chi^2(15) = 23.008$, $p = .084$; Likelihood Ratio $\chi^2(15) = 23.842$, $p = .068$), it did not reach the threshold of .05.

However, a statistically significant association was found between education level and perceptions of air quality in public transit ($\chi^2(20) = 51.382$, $p < .001$; Likelihood Ratio $\chi^2(20) = 51.931$, $p < .001$). This is consistent with studies that show that increased education is correlated with increased health literacy, and therefore increased perception of the health risks of air pollution (Nutbeam, 2000).

- **Advancements in transportation technology:** Chi-Square and Likelihood Ratio Chi-Square tests revealed no statistically significant associations between senior citizens' perceptions of how advancements in transportation technology could impact air pollution levels and health outcomes and gender ($\chi^2(5) = 4.676$, $p = .457$; Likelihood Ratio $\chi^2(5) = 4.677$, $p = .457$) or age ($\chi^2(15) = 19.075$, $p = .210$; Likelihood Ratio $\chi^2(15) = 18.745$, $p = .226$). However, a statistically significant association was found between education level and perceptions of the impact of transportation technology advancements ($\chi^2(20) = 46.575$, $p = .001$; Likelihood Ratio $\chi^2(20) = 38.503$, $p = .008$). Higher education correlates with increased awareness of electric vehicle benefits for air pollution reduction and senior health (IEA, 2023). This may stem from greater access to scientific information. Electric vehicle adoption reduces urban air pollution, improving respiratory health (Pope & Dockery, 2006), crucial for vulnerable seniors. In Hyderabad, where vehicular emissions are significant (Telangana SPCB, 2021), education on clean transportation is vital. Future research should explore factors influencing this correlation, evaluate intervention effectiveness for older adults, and assess localized impacts in Hyderabad.

9. Economic Influence

- **Increased healthcare expenses**: Chi-Square and Likelihood Ratio Chi-Square tests revealed no statistically significant associations between senior citizens' reported increased healthcare expenses due to air pollution-related health issues and gender ($\chi^2(4) = 7.432$, $p = .115$; Likelihood Ratio $\chi^2(4) = 7.369$, $p = .118$). A weak to moderate statistically significant association was found between age and increased health care costs ($\chi^2(12) = 18.812$, $p = .093$; Likelihood Ratio $\chi^2(12) = 22.638$, $p = .031$). A statistically significant association was found between education level and reported increased healthcare expenses ($\chi^2(16) = 43.494$, $p < .001$; Likelihood Ratio $\chi^2(16) = 39.687$, $p = .001$). These findings suggest that while gender does not significantly influence seniors' reported healthcare expenses, age has a weak to moderate influence, and educational attainment has a strong influence. In Hyderabad, the costs of home health care and assisted living facilities further illustrate these financial challenges (Helpee, n.d)
- **Disparities in exposure**: Chi-Square and Likelihood Ratio Chi-Square tests revealed a marginal association between senior citizens' beliefs about disparities in air pollution exposure and gender ($\chi^2(4) = 9.300$, $p = .054$; Likelihood Ratio $\chi^2(4) = 9.117$, $p = .058$), approaching but not reaching the .05 significance level.

No statistically significant association was found between age and beliefs about disparities ($\chi^2(12) = 15.374$, $p = .222$; Likelihood Ratio $\chi^2(12) = 14.341$, $p = .279$).

A statistically significant association was found between education level and beliefs about disparities ($\chi^2(16) = 31.022$, $p = .013$; Likelihood Ratio $\chi^2(16) = 29.403$, $p = .021$). It is well established that disparities in exposure to air pollution among senior citizens based on income and location are significant, with lower-income and urban residents often facing higher pollution levels (Tessum et al., 2019). In Hyderabad, a rapidly growing metropolitan city, these disparities are particularly pronounced due to increased urbanization and industrial activity (Telangana SPCB, 2021).

Economic benefits of investing in preventative measures:

Chi-Square and Likelihood Ratio Chi-Square tests revealed no statistically significant associations between senior citizens' beliefs about the economic benefits of investing in preventative measures to reduce air pollution-related health issues and gender ($\chi^2(5) = 7.798$, $p = .168$; Likelihood Ratio $\chi^2(5) = 8.114$, $p = .150$) or education ($\chi^2(20) = 19.175$, $p = .510$; Likelihood Ratio $\chi^2(20) = 20.695$, $p = .415$).

A statistically significant association was found between age and beliefs about economic benefits ($\chi^2(15) = 27.996$, $p = .022$; Likelihood Ratio $\chi^2(15) = 23.183$, $p = .080$). Studies have shown that promoting active transportation, like walking and cycling, reduces air pollution and increases physical activity, leading to improved health outcomes and reduced healthcare costs (Rissel et al., 2010).

Effects of air pollution on the housing market: Chi-Square and Likelihood Ratio Chi-Square tests revealed no statistically significant associations between senior citizens' observed effects of air pollution on the housing market and gender ($\chi^2(5) = 3.442$, $p = .632$; Likelihood Ratio $\chi^2(5) = 3.413$, $p = .637$) or education ($\chi^2(20) = 15.014$, $p = .776$; Likelihood Ratio $\chi^2(20) = 16.590$, $p = .679$).

A statistically significant association was found between age and observed effects ($\chi^2(15) = 39.326$, $p = .001$; Likelihood Ratio $\chi^2(15) = 36.047$, $p = .002$). Older seniors show increased awareness of air pollution's impact on Hyderabad's housing market (HMDA, 2023). In Hyderabad's booming marketplace this creates inequity, forcing vulnerable seniors into polluted areas. Age-related awareness highlights the need for equitable urban planning.

- **Economic implications of targeted air pollution mitigation policies**: Chi-Square and Likelihood Ratio Chi-Square tests revealed no statistically significant associations between senior citizens' beliefs about the economic implications of targeted air pollution mitigation policies and gender ($\chi^2(5) = 5.791$, $p = .327$; Likelihood Ratio $\chi^2(5) = 6.337$, $p = .275$) or education ($\chi^2(20) = 24.987$, $p = .202$; Likelihood Ratio $\chi^2(20) = 26.992$, $p = .135$). A statistically significant association was found between age and beliefs about economic implications ($\chi^2(15) = 28.669$, $p = .018$; Likelihood Ratio $\chi^2(15) = 31.607$, $p = .007$). Age, but not gender or education, correlates with seniors' awareness of air pollution policy's

economic impact. In Hyderabad's polluted urban area (Telangana SPCB, 2021), senior-focused policies reduce healthcare burdens and green infrastructure improves well-being (Tzoulas et al., 2007). Age-related awareness highlights the need for senior perspectives in policy decisions.

Conclusion:

Transportation Choices and Demographics:

Gender and age significantly influence public transport preferences among the geriatric population in Hyderabad, while education level does not appear to be a major factor. Age is a consistent predictor of transport mode choice, with older individuals more likely to use buses and trains, and younger individuals more likely to use cars/autos. Gender also plays a role, particularly in the choice of rickshaws and two-wheelers. Geriatric status has a statistically significant association with overall private transport usage. Education level is significantly associated with four-wheeler and 'any other' private transport usage. Older adults often rely on public transportation due to physical limitations and reduced driving ability. (Dickerson et al., 2007).

Perceptions of Air Quality: A significant majority of the surveyed senior citizens perceive the air quality in their area negatively. Perceptions of air quality do not differ significantly across gender, age, or education levels. There is a discrepancy between the perception of air and water pollution, with water pollution being perceived as worse due to its visibility. (Semenza et al., 2008). Perceptions of traffic congestion's impact on air quality differ significantly by gender, but not by age or education level. Public awareness and concern about air pollution are perceived similarly across gender, age, and education levels (Landrigan et al., 2018).

Impact of Air Pollution:

Perceptions of air pollution's impact on quality of life are not significantly associated with gender, age, or education level. Concern about the impact of air pollution on maternal health or pregnancy outcomes is relatively uniform across the senior groups studied. Perceptions of how air pollution affects women's/men's roles and responsibilities in caregiving or occupational settings are not significantly associated with gender, age, or education. (Pope & Dockery, 2006).

Actions to Reduce Air Pollution Exposure:

Gender and age are not significantly associated with reported actions to reduce air pollution exposure. Education level shows a potential association with reported air pollution reduction behaviours, with higher education potentially correlating with increased adoption of protective measures. (Bourdrel et al., 2017).

Opinions on Government Prioritization and Effectiveness of Measures:

Opinions on whether the local government should prioritize addressing air pollution do not differ significantly across gender and age groups. Education level shows a potential association with opinions on government prioritization, with higher education potentially correlating with a greater perceived need for government action. Perceptions of the effectiveness of air quality improvement measures do not differ significantly across gender, age, and education groups.

Health Impacts and Economic Considerations:

Reported experiences of respiratory or cardiovascular symptoms linked to air pollution do not differ significantly across gender, age, and education levels. Age and education level show a potential association with perceptions of the impact of air pollution interventions on healthcare costs and quality of life, with older age groups and higher education levels perceiving a greater impact. Lower educational attainment may correlate with heightened vulnerability to the financial burdens of air pollution-related health problems. More educated seniors are more likely to acknowledge disparities in air pollution exposure. Older seniors are more likely to acknowledge the economic benefits of investing in preventative measures to reduce air pollution-related health issues. (Brauer et al., 2016).

Effects of Living Near Industrial Areas:

Perceptions of living near industrial areas affecting overall quality of life do not differ significantly across gender, age, and education levels. Age and education level show a statistically significant association with perceived changes in air quality since living in the locality, with different education levels reporting varying perceptions. Demographic factors do not significantly influence the decision to consider relocating due to concerns about air pollution from nearby industrial sources.

Dietary/Lifestyle Changes and Urban Environment Design: Education level, but not gender or age, is significantly associated with consideration of alternative dietary practices or lifestyle changes to minimize air pollution exposure, with higher education correlating with increased awareness and proactive behaviours. Variations in gender, age, and education do not significantly influence how senior citizens perceive the impact of urban environment design and infrastructure on their air pollution exposure during transportation. (Tzoulas et al., 2007).

Recommendations

- **Transportation Planning:**
  - Urban planning and transportation policies should consider the distinct transportation preferences and needs of different age groups and genders within the geriatric population.
  - Ensure accessible and comfortable public transportation options for older adults to encourage its use and reduce reliance on private vehicles, which contribute to air pollution. (Litman, 2020).
- **Air Quality Management:**
  - Implement targeted interventions to improve air quality, particularly in areas with high traffic congestion and industrial activity. (WHO, 2016).
  - Public health initiatives should raise awareness about air pollution and its health impacts, especially among vulnerable populations like the elderly. (Landrigan et al., 2018).
  - Consider the influence of visibility on pollution perception when communicating air quality information to the public. (Semenza et al., 2008).

- **Health and Social Support:**
  - Healthcare providers should be aware of the potential impact of air pollution on the health of senior citizens and consider it in their diagnoses and treatment plans. (Pope & Dockery, 2006).
  - Provide support and resources to help seniors, especially those with lower educational attainment, adopt proactive strategies to minimize air pollution exposure, such as dietary modifications and lifestyle changes. (Bourdrel et al., 2017).
  - Address the disproportionate impact of air pollution on seniors with lower educational attainment through targeted education campaigns and enhanced access to affordable healthcare. (Morello-Frosch et al., 2002).
- **Urban Planning and Development:**
  - Incorporate green spaces and pedestrian-friendly designs into urban environments to mitigate air pollution and promote healthier lifestyles for older adults. (Tzoulas et al., 2007).
  - Urban planning decisions should consider the health impacts of industrial zoning and traffic patterns on the quality of life of senior citizens. (Brauer et al., 2016).
  - Prioritize green infrastructure and reduce traffic congestion in urban design to lower air pollution exposure for seniors. (Nowak et al., 2006).

Need for focus on silver economy:

Several countries have successfully tapped into the potential of the silver economy, recognizing the needs and opportunities presented by their aging populations. Japan, often cited as a leader in this area, has developed innovative technologies and services in sectors such as robotics for elderly care and accessible housing, driven by its rapidly aging society. European nations have also made significant strides, focusing on areas like age-friendly tourism and leisure and particular monetary goods to cater to their growing older demographics. These examples illustrate the importance of proactive policies and business strategies that address the diverse needs of older adults, enhancing their quality of life while also stimulating economic growth.

India, with its rapidly growing elderly population, is also beginning to recognize the importance of the silver economy. The Indian government has initiated policies and programs, such as the National Programme for the Health Care of the Elderly (NPHCE) under the Ministry of Health & Family Welfare (Ministry of Health & Family Welfare, n.d.), to address the healthcare needs of seniors. However, there is a need for a more comprehensive approach that encompasses various sectors. My study area, Hyderabad, can be a key player in this. Given the study's findings on transportation preferences among the elderly in Hyderabad, there's a clear opportunity to develop age-friendly transportation systems and services. Furthermore, the concerns about air quality among the elderly in Hyderabad highlight the need for solutions that promote healthy aging, such as specialized healthcare facilities, air purification technologies for homes, and age-friendly urban planning that prioritizes clean air and accessibility. By addressing these needs, Hyderabad can not only improve the quality of life for its senior citizens but also position itself as a hub for silver economy innovation and investment. By the focus on following: Increased availability and affordability of air purifiers and air quality monitors for

seniors in Hyderabad. Developing culturally sensitive and user-friendly designs for air pollution control devices that cater to the needs of the local elderly population. Promoting awareness among seniors and healthcare providers in Hyderabad about the benefits of air pollution mitigation equipment. Encouraging government policies and initiatives that support the adoption of air pollution control measures in senior living facilities and homes in Hyderabad.

Further Research:

- Future research should explore the reasons behind observed associations and investigate the impact of different transport modes on air pollution exposure and health outcomes in the geriatric population.
- Research should consider the complex interplay of factors influencing transportation choices in older adults, including environmental factors, social networks, and access to transportation infrastructure.
- Future studies could incorporate objective air quality data alongside qualitative interviews to gain a more comprehensive understanding of how senior citizens perceive and experience air pollution.
- Qualitative research, such as interviews and focus groups, is needed to understand the specific concerns and inform targeted interventions related to air pollution and its impact on senior citizens.
- Future research should examine variables such as pre-existing health conditions, proximity to pollution sources, access to real-time air quality information, and social amplification of risk.

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