Intersectionality of Age And Air Pollution On The Use of Medical Care: National Data From Taiwan

Hung-Chieh Chang (✉ chcjessica@ntu.edu.tw)

National Taiwan University

Li-Ling Hsu

National Taiwan University

Wei-Liang Shih

National Taiwan University

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Abstract

This study uses an intersectionality lens to understand the inequality of medical use at the intersection of age and air pollution. Using national databases from Taiwan, the results show that the increase of the level of air pollution and age is related to higher percentage of high medical use. Through stratified analysis, we found that there is no significant difference in medical use among different age groups in low AQI (Air Quality Index) areas. Yet, in areas with increasing amounts of polluted air, the elderly have a significantly higher percentage in frequent medical use. Our results show that the elderly people are more susceptible to air pollution, and suggest that, to protect their health and reduce the use of medical care, not only is there a need to reduce air pollution, but also maintain the annual average AQI level to under the value of 50.

1. Introduction

The World Health Organization (WHO) listed air pollution and climate change among the top threats to global health (WHO, 2019^[1]). A recent study estimated that a global total of 10.2 million premature deaths annually are attributable to the fossil-fuel component of PM2.5 (Vohra, et al., 2021^[2]). Many studies have reported a strong relation between air pollution and illness as a foundation for policy recommendations to protect people's health. Studies showed air pollution contributed to an increase of outpatient visits of eighteen diseases, from physical diseases such as COPD, asthma, diabetes, and heart disease, to mental diseases such as anxiety, and accidents (Chau and Wang, 2020^[3]; Filleul et al., 2004^[4]).

Air pollution disproportionately affects people in various socioeconomic groups. In the area of social determinants of health, research has found that social characteristics, such as age, gender, income inequality, and education, are related to the inequality of health and mortality (Berkman, Kawachi and Glymour, 2014^[5]; Marmot and Wilkinson, 2005^[6]). Air pollution also disproportionately affects different age groups. The elderly is more susceptible to air pollution (Simoni et al., 2015^[7]). For the elderly, long-term studies have shown that air pollution causes additional increases in mortality, and these increases are even greater among socially disadvantaged elders (Costa et al., 2017^[8]; Bateson and Schwartz, 2004^[9]; Qiu et al., 2015^[10]; Cakmak et al., 2011^[11]; Deryugina et al., 2019^[12]). It has also been shown that air pollution increases disease morbidity and hospitalizations for cardiovascular disease, chronic kidney disease and respiratory diseases in the elderly (Chuang et al., 2011^[13]; Chen et al., 2018^[14]; Schikowski, et al., 2010^[15]). Hence, air pollution increases the burden of health care. Previous studies have shown a strong relationship between air pollution and medical care may include only the elderly, and therefore it is difficult to know whether their health status is different from other groups (Fuchs and Frank, 2002^[16]; Birnbaum et al., 2020^[17]).

Taylor (2000)^[18] suggested treating the environmental injustice of air pollution as a social issue, because it involves policy making and implementation thereby creating an analytical framework to address disadvantages. This study used the concept of intersectionality, which was first introduced in the social sciences to criticize the single axes of social disadvantages, and provide an analytical framework to understand multiple oppressions, discrimination and disadvantages encountered by black women (Crenshaw, 1989^[19]). This concept has been flourishing in social sciences, and recently Bowleg (2021)^[20] proposed that the intersectionality framework could be useful to public health, allowing public health researchers to enhance their understanding of multiple oppressions and disadvantages in health inequity (Alvarez, 2021^[21]; Bauer, 2014^[22]; Bowleg, 2008^[23]). Hence, this study tests the

concept of intersectionality to understand how multiple intersections (air pollution and ageing) impact the use of medical care, instead of solely axis (i.e., age or air pollution).

Less use of medical care is beneficial to the governmental health insurance, as well as an individual's finances. With national databases from Taiwan, this study investigates the potential benefit from pollution reduction from a health policy perspective, which is the decrease in the use of medical care.

2. Materials And Methods

2.1. Study Design and Participants

This study conducted a secondary data analysis of data combined from two data sources: the first one is the 2019 Taiwan Social Change Survey (TSCS). This survey is a repeated cross-sectional study with a national representative sample of nationals over 18 years old from 1985. The study used the 2019 survey data that contains the dimensions of Social Inequality, and Technology and Risk (Fu, 2020^[24]). This study included 1,933 respondents that completed the survey. The second data source is the annual Air Quality Index (AQI) data in 2019 from the Taiwan Environmental Protection Administration. This study identified the residential cities of the respondents of the TSCS, and merged them with the city-level air pollution data to understand their overall hazard exposure to multiple air pollutants.

2.2 Measurements

The dependent variable is medical use, of which a binary variable of 'low medical use' is defined as 0-10 medical visits in the past year, and 'high medical use' when individuals had medical visits over ten times in the past year, which means a respondent visited the hospital almost once every month, and are therefore classified as frequent users of medical care. This study categorized age into three groups: Aged 18-35 years representing young adults, aged 36-65 group representing middle age, and individuals aged over 66 are elderly. In order to measure the overall exposure to air pollution, this study uses the indicator of the annual average of AQI of the residential city. The level of annual AQI was classified into three categories: AQI low ($AQI < 50$), AQI middle ($50 \leq AQI < 60$), AQI high ($AQI \geq 60$). The controlled variables were gender (male and female), and monthly income (Under NTD20,000; 20,001-40,000; 40,001-60,000; over 60,001).

2.3 Statistical Analysis

The descriptive statistics of key measures in this study are presented with percentages. Stratified analysis and logistic regression are used to understand the interaction of age and air pollution on medical use. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to present the association between medical use and level of air pollution, age, gender, and monthly income. All analyses were conducted using SAS statistical software (version 9.3; SAS Institute Inc., Cary, NC, USA), and the statistical significance level was set at 0.05.

3. Results

Table 1 shows that nearly 22% of respondents reported high medical use due to illness in the past year. Only 9.6% of the subjects live in a low AQI area, which is annual AQI under 50. This figure is similar to the WHO data which indicates that less than 10% people live in areas where air quality meets the WHO's standard. In this sample, there are slightly more male respondents than females, and about one-third of them have a monthly income of NTD20,001-40,000. More than half of the individuals are aged 36 to 65.

Table 1

Description of independent variables and their association with medical use by using multivariable analyses

Variable		Bivariate Analysis				Multivariable Analysis*			
		n	(%)	Medical use (%)		P-value	OR	95%CI	P-value
				Low use	High use				
Medical Use	low medical use	1491	78.02						
	high medical use	420	21.98						
Air Pollution	AQI low	191	9.96	82.63	17.37	.011	1.00		
	AQI middle	850	44.34	79.83	20.17		1.40	[0.92,2.19]	.128
	AQI high	876	45.70	74.83	25.17		1.73	[1.14,2.69]	.012
Age	18-35	555	28.71	87.32	12.68	<.001	1.00		
	36-65	1013	52.41	79.94	20.06		1.81	[1.35,2.46]	<.001
	Over 66	365	18.88	57.95	42.05		3.99	[2.83,5.66]	<.001
Gender	Male	1010	52.25	80.20	19.80	.016	1.00	(Reference)	
	Female	923	47.75	75.63	24.37		1.17	[0.93,1.49]	.181
Monthly Income	≤20,000	655	35.12	67.96	32.04	<.001	1.00		
	20,001-40,000	593	31.80	82.31	17.69		0.61	[0.46,0.81]	<.001
	40,001-60,000	360	19.30	83.29	16.71		0.60	[0.42,0.85]	.004
	≥60,001	257	13.78	85.99	14.01		0.49	[0.32,0.73]	<.001
* Multivariable analysis included level of air pollution, age, gender, and monthly income									

Individuals living in areas with a high level of air pollution have significantly greater chance to report high medical use ($P=0.011$). The percentage of higher medical use increased significantly with age ($P<0.001$). Over 42% of individuals aged over 65 years reported high medical use, while only 12.6% of individuals aged 18-35 reported high medical use. Also, females were more likely to report high medical use than males ($P=0.016$). Individuals with low monthly income also showed a higher percentage in high medical use ($P<0.001$).

In the multivariable analysis, the result shows that the odds ratio of individuals living in high AQI areas had a significantly higher odds ratio than those living in low AQI areas to become frequent users of medical care, after controlling for other factors ($OR=1.73$, $CI=[1.14,2.69]$, $P=0.012$). The odds ratio of being a frequent medical care user increased with age. Compared to the 18-35 age group, the 35-65 age group's odds ratio was 1.81 ($CI=[1.86, 2.46]$, $P<0.001$), and odds ratio of the over 65 age group was 3.99 ($CI=[2.83, 5.66]$, $P<0.001$).

We further used a stratified analysis to understand the interaction of age and air pollution on medical use (Figure 1). In the low AQI areas, the percentage of people aged over 66 years reported high medical user was 22.5%, which was higher than that of the 18-35 age group, but there was no statistical significance ($\chi^2=2.2$, $P=0.034$). In the middle AQI area, the percentage of high medical use among people aged over 66 increased to 43.3%. The disparity between the youngest and oldest group was widened to 4.4 times (43.3%/9.8%) with statistical significance ($P\text{-value}<0.001$). In the high AQI area, the percentage of high medical use increased in all ages. When we compared the elderly's percentage of high medical user in different AQI areas, the percentage doubled, from 22.5% in low AQI areas to 43.3% in middle AQI areas and 45.7% in high AQI areas. The percentage of high medical users doubled when the air quality deteriorates, which indicates the susceptible of elderly people.

Table 2 shows the intersectional vulnerability of environmental injustice and ageing on medical use. After controlling for other variables, there is no significant difference in medical use among different age groups in the low AQI areas, but there is significant difference in middle and high AQI areas. In the middle AQI areas, individuals aged over 65 years were 5.86 times more likely to report high medical use ($P<0.001$). In the high AQI areas, the odds ratio between these groups were 3.56 ($p<0.001$). It seems counterintuitive that the odds ratio is not as high as that in middle AQI areas. Yet, Figure 1 shows that all age groups were affected by serious air pollution in the high AQI areas, and 16.8% of the 18-35 age group reported high medical use.

Table 2
Stratified analyses of the association between medical use and age, gender, and monthly income for different levels of air pollution areas

AQI low				AQI middle			AQI high		
Variable	OR	95%CI	P-value	OR	95%CI	P-value	OR	95%CI	P-value
Age									
18-35	1.00			1.00			1.00		
36-65	1.89	[0.70,5.75]	0.231	2.21	[1.38,3.64]	0.001	1.54	[1.02,2.36]	0.041
Over 66	1.04	[0.30,3.72]	0.950	5.86	[3.42,10.29]	<0.001	3.56	[2.20,5.81]	<0.001
Monthly Income									
≤20,000	1.00			1.00			1.00		
20,001-40,000	0.20	[0.06,0.57]	0.004	0.63	[0.39,1.01]	0.055	0.68	[0.46,1.00]	0.053
40,001-60,000	0.26	[0.04,1.10]	0.100	0.74	[0.44,1.23]	0.247	0.55	[0.33,0.89]	0.018
≥60,001	0.57	[0.16,1.82]	0.356	0.57	[0.31,1.01]	0.060	0.34	[0.16,0.68]	0.004
Gender									
Male	1.00			1.00			1.00		
Female	1.15	[0.51,2.56]	0.729	1.26	[0.87,1.83]	0.216	1.10	[0.79,1.54]	0.580

4. Discussion

This study used an intersectionality lens to investigate of inequality of medical use at multiple intersections (e.g., age and air pollution) instead of solely by a single axis (i.e., age or air pollution). An intersectional perspective allows us to understand susceptibility of certain group that might have been overlooked in the past. The results show that both air pollution and age contributed to higher use of medical care. Yet, there is no significance difference on percentage of high medical user in all ages in low AQI areas (annual AQI<50). This shows that good air quality can prevent individuals in all groups from seeking medical care, especially the elderly. Yet, when the air pollution increased, the elderly became more susceptible than other age groups. Comparing to the low AQI areas, the percentage of individuals aged over 66 reported as frequent medical users doubled in the middle AQI areas. The percentage remains high in the high AQI areas among individuals aged over 66. This result is consistent to previous study that shows strong relationship between air pollution and medical use among elderly (Fuchs and Frank, 2002^[16]).

These results demonstrate the intersectional effect of air pollution and ageing on high medical use. From the perspective of reducing the burden of health care, this study therefore suggests that not only is there a need to reduce air pollution, but also maintain the annual average AQI level to under the value of 50 could be more effective in reducing the burden of medical use for the elderly. Air Quality Index is an comprehensive index based on multiple air pollutants, which reflect the overall hazard exposure than individual air pollutant. Yet, unlike the Air Quality Guideline set up by the World Health Organization (2021)^[25] that contains instant and annual standard of individual air pollutants, the Air Quality Index lacks guidelines for annual standard. It could be beneficial to set up an annual guideline of the Air Quality Index. It needs more research on its relation to health.

The limitation in this study is that we found that monthly income is also significantly related to the frequency of medical use. This paper did not examine the intersectionality of age, income, and air pollution on medical use, which requires development and improvement of statistical methods for future research.

Declarations

The authors declared that all methods were performed in accordance with the relevant guidelines and regulations of the BMC Public Health

Ethics approval and consent to participate

This study conducted a secondary data analysis from public accessed data. One is the Air Quality Annual Report, and the other is the archive of the Taiwan Social Change Survey (Round 7, Year 5), which has been approved by the IRB on Humanities & Social Science Research, Academia Sinica (Reference No: AS-IRB-HS-17030). The authors confirm that all research was performed in accordance with relevant guidelines.

Consent for publication

NOT APPLICABLE

Availability of data and materials

This study used two open data.

1. The 2019 Taiwan Social Change Survey (Round 7, Year 5): Social Inequality is available from the Social Research Data Archive. Link: https://srda.sinica.edu.tw/browsingbydatatype_result.php?

category=surveymethod&type=1&csid=2

2. The air pollution data is accessed from the Air Quality Annual Report of R.O.C. (Taiwan),2019.The authors key- in the data of air pollution to our dataset. Link: <https://www.epa.gov.tw/DisplayFile.aspx?FileID=6DF52F28D8A44EC3>

Competing interests:

The authors declare that they have no conflict of interest

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Authors' contributions:

Chang wrote the main manuscript. Hsu prepared Table 1-2 and Figure 1. Shih reviewed and gave statistical suggestions. All authors reviewed the manuscript.

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Figures

Figure 1

Percentage of high medical user of different age groups in different AQI areas