

# Dynamic Land-Use Change and Health Risks of Urbanization in Border Area: Case Study of Border Logistics Hub in Thailand

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**Abstract**— According to the changed policy, the city of "Chiang Khong" is a logistics city. The transformation of border towns to be more urbanized in Northern Thailand in 2012, affected the environment, pollution, and population health. The research aimed to study the relationship between health risk and land use change, industry area, urban population, and pollution with dependent variables, namely the rate of patients from respiratory disease and mortality rate. The study selected Moran's I to analyze the industry build-up density pattern in Chiang Khong and Generalized Additive Models to analyze the non-linear relationship between dependents and independent factors. The results showed that Concentration rates of industrial build-up areas were clustered, and the results of the correlation analysis revealed that the amount of Nitrogen Dioxide (No<sub>2</sub>) and the percentage of urban change were discovered as a non-linear association. total mortality and Industrial Area, PM<sub>2.5</sub>, and Nitrogen Dioxide revealed non-linear solid associations with the number of respiration cases. Nitrogen Dioxide has 93.30% of the deviance explanation, Pm 2.5 has 87.6 and Industrial Area has 81% of the deviance explanation. Therefore, Increases in the rate of urbanization and development of land area have also been linked to increases in respiration cases.

**Keywords**— land use change, border logistics city, pollution, respiration.

## I. INTRODUCTION

Border trading has long been a part of the way of life for the people who live along Thailand's borders. Border trade is expanding and is one of Thailand's most important economic activities. Particularly in the Chiang Khong District, Chiang Rai in Thailand is one of the border towns located with Lao PDR. Previously, the cargo was transported across the border by local ships [1], but this is

no longer the case because China has pushed through trade routes transportation by land. After all, the policy concentrates on international commodities transit between Thailand, Lao PDR, and China, known as the North-South Corridor (NSEC) projects were formed to connect trade between the three countries via the route "R3A" [2].

Route R3A connects Bangkok to Kunming City, Yunnan Province, China, via Lao PDR. Thailand has a total distance of around 1,240 kilometers from Bangkok city to Kunming City through Thai-Laos Friendship Bridge which is the first cross-country transportation link between Thailand-Lao PDR-China. The route affected to local population, local business, tourism, and land used sector. Many investors had come to take advantage of the area of Chiang Khong. Some of them are built as logistics business and some came to buy for speculation. Land use has changed as a result. The city of Chiang Khong was served by a wide variety of transportation and underwent industrialization, which had an impact on the local population and environment directly. Moreover, Thai government's strategy focus on infrastructure development in Chiang Khong district in 2012, and it was planned officially to set Chiang Khong's role as a logistics center city by 2020.[2] In addition, the railway connecting the Thai railway with the Chinese railway in the border area is scheduled to be successful in 2027.

However, urbanization is being accompanied by an increase in morbidity and death from respiratory diseases linked to environmental pollution [1,2]. Urbanization in Thailand was transformed from local forests to more urban. Within the urban territorial system, there are various natural and socioeconomic elements such as land use, industry, and population. These transformations inevitably have an impact on public health. In this light, understanding the relationship between urban land growth, urbanization, and environmental health challenges in Thailand is critical [3].

There has been a study of problems with urbanization affecting health [4,5], declared that the transition from rural to urban make more construction and they cause pollution called PM10 and PM2.5, which directly affect the respiratory tract and lungs [4,5]. PM10 and PM 2.5 are arisen from factory pollution, construction, smoke from large trucks and pollution from rocks, clay, and dust from trucks being transported. [6]

Urbanization is a dynamic spatial process that occurs between persons and the environment. The change from rural to urban has an impact on the health hazards posed by environmental diseases. As a result, this research aims to study recognition of the correlation between shifting land use, pollution, and population's health difficulties. Once the results of this research have been proven, the government can design policies and guidelines for urban planning, pollution reduction, public health management, and assisting the city in becoming a sustainable logistical center.

## II. METHODOLOGY

### A. Study Area

Chiang Khong District (Fig. 1) was in northern Chiang Rai Province. It is frequently utilized as a city of cultural and nature. There is the tourism route to Luang Prabang, Lao PDR by local boat due to its advantageous location immediately over the Mekong River by Huay Xai, Lao PDR [1].

Chiang Khong used to be a little border commerce town and a way to get to Luang Prabang, Laos, but after cooperating to develop the R3A route, businesspeople and investors have come to buy land and start their enterprises. Such changes have an impact on people's livelihoods, including business, industry, hotels, and transportation.

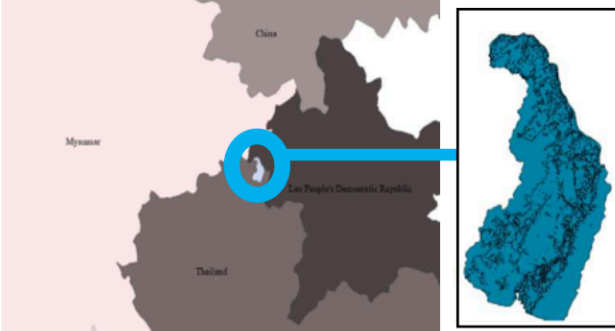


Fig. 1. Study region "Chiang Khong"

### B. Data Management

The study set a period starting from 2012 as the year the cross-border trade by the bridge was enabled and ending 2019 because if it is more than a year, COVID-19 is recorded as a respiratory disease.

The data were gathered on multiple sources: remote-sensing images 2012 – 2019 (Landsat 7 and 8) were downloaded from U.S. Geological Survey Earth Explorer and Land Use Land Change maps were cross checked by Land Development Station in Thailand. The pollution emissions as PM 10, PM 2.5 and No2 obtained from

Pollution Control Department of Thailand. Population in Chiang Khong data were obtained from The Bureau of Registration Administration of Thailand. The population mortality and respiratory case data obtained from Health Data Center of Thailand. The POI data were obtained from Google Earth and Department of Business Development of Thailand. Construction land in 2012 – 2019 Land use Land Changed were analyzed by ArcGIS software version 10.8.1 and Generalized Additive Model was analyzed by R Language software.

### C. Moran's I Scatterplot

Moran's I Scatterplot shows the spatial autocorrelation of the emergence of industry, business, hotel, and transportation [7] which is a statistic used to evaluate how the spatial relationship of the near versus distant has distinct effects, demonstrating that the distribution of values depends on the spatial distribution of objects [8] and statistics typically used to measure as:

$$MI = \frac{N \sum_{i=1}^N \sum_{j=1}^N (\omega_{ij}(y_i - \bar{y})(y_j - \bar{y}))}{(\sum_{i \neq j} \sum \omega_{ij})(\sum_{i=1}^N (y_i - \bar{y})^2)}, \quad (1)$$

where  $MI$  is the Moran correlation,  $y$  is independent variable,  $\bar{y}$  is the mean of independent variable, take  $\omega_{ij}$  as the weight from pollution emission rate,  $i$  and  $j$  is the number of independent variables [8] which is the number of industries in Chiang Khong.

### D. Generalized Additive Model (GAM)

The data were evaluated in the complex linear and non-linear datasets of the connection, the Generalize Additive Model was employed in this study to determine the association between the dependent variable (health) and independent variables (industrial, LULC, pollution). As a result, I chose this instrument to complement the relationship. we constructed the following Generalized Additive Model (GAM):

$$g(\mu) = \sum_{m=1}^M f_m(S^{(m)}) \quad (2)$$

Where  $(\mu) = M(Y, S^{(1)}, S^{(2)}, \dots, S^{(M)})$  is expectation of  $Y$  is a dependent variable (number of respiratory disease cases and number of mortality),  $S^{(m)}$ ,  $f_m()$  is a single variable function for the independent variable (for example, the industrial rate, urbanization population rate, pollution rate) generally uses nonparametric methods for fitting [9].

In Figure 2, this study included the urbanization rate; industrial area, and urban population rate as LU, the POL included the PM 2.5, PM 10, and NO2 with the highest in 24 hrs. average,  $Y$  variable included total mortality (2012–2019), and the number of Respiratory cases (2012–2019) in Chiang Khong as dependent variables into the GAMs.

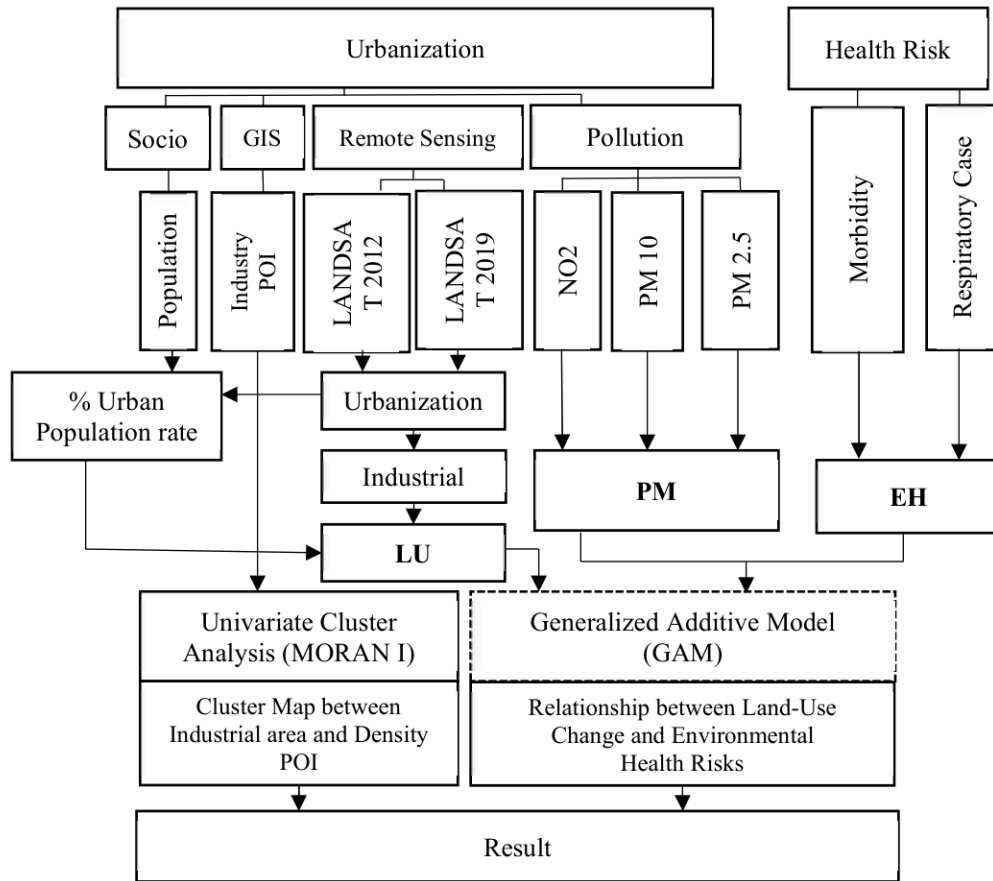


Fig. 2. Research Work process

Moreover, In MORAN's I statistical study, the relationship between area and building density was also evaluated by urbanization rate and Point of interest (POI) focused on industry, factories, and hotels to prove the association as a cluster in Chiang Khong.

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### III. THE RESULT

According to data management, Chiang Khong has seen rapid urbanization (Figure 3). The urbanized area in 2012 was 30.60 km<sup>2</sup>. In 2019, it reached 7%. during the same period, the industrial building sector grew rapidly. In 2019, the industrial area was 0.545 km<sup>2</sup> and 1.20 km<sup>2</sup>. As cities expanded, there was an increase in industrial land.

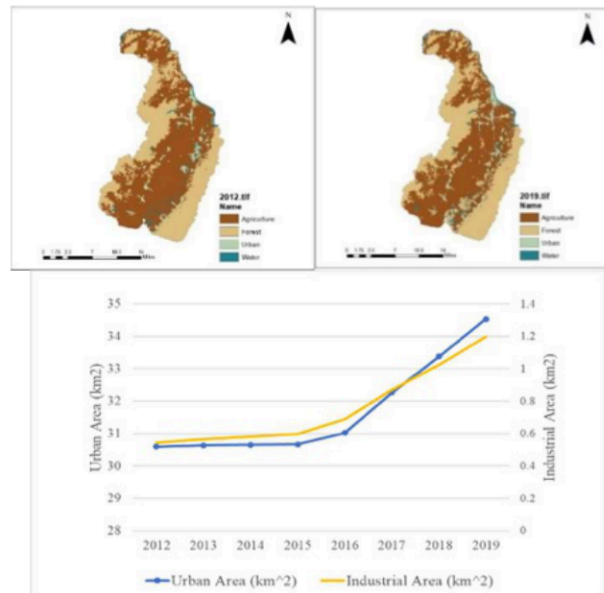


Fig. 3. Chiang Khong Land Use Change in 2012 - 2019

The findings of the land use change analysis (Figure 3) show the rate of change from forest to agricultural land was

0.98 km<sup>2</sup>, in terms of urbanization, agricultural land to urban area was 17.81 km<sup>2</sup>, the rate of transformation from forest area to the urban area was 4.9 km<sup>2</sup>, and the water-to-urban change was 0.25 km<sup>2</sup> (Table 1).

TABLE I. LAND USE CHANGE DETECTION 2012 – 2019

Land Use 2012	Land Use 2019	Change detection	Area Change (km <sup>2</sup> )
Forest	Agriculture	Forest -> Agriculture	30.9713993
Urban	Agriculture	Urban->Agriculture	7.17839
Water	Agriculture	Water->Agriculture	2.8958099
Agriculture	Forest	Agriculture->Forest	0.1325656
Urban	Forest	Urban->Forest	0.426005
Water	Forest	Water->Forest	0.882807
Agriculture	Urban	Agriculture->Urban	17.8185997
Forest	Urban	Forest->Urban	4.8938298
Water	Urban	Water->Urban	0.250262
Agriculture	Water	Agriculture->Water	0.524026
Forest	Water	Forest->Water	0.577085
Urban	Water	Urban->Water	0.122888

However, the rate of urban area changes to be forest equal to 0.427 km<sup>2</sup> which is unreliable, the study assumed that it may be an error in specifying a class. According to the above findings, the trend of the transferring from forests to agricultural land is increasing. The transition from agricultural land to urbanization will impact the changes in the following phase. As a result, this study concludes in this section that Chiang Khong's urbanization tendency will continue to increase in the future.

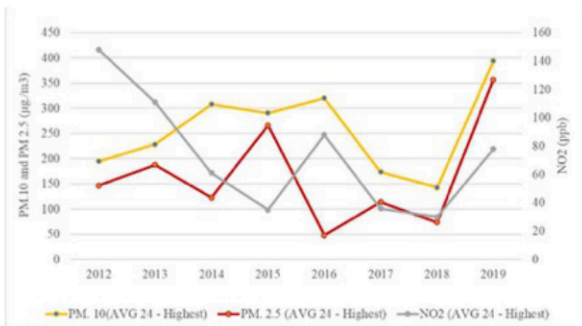


Fig. 4. Pollution density of PM 10, PM2.5 and No2 in 2012 - 2019

However, the urbanization of Chiang Khong had a significant impact on the ecology. Figure 4 depicts the pollution index from the Air Quality Index, which according to several studies, causes respiratory issues due to three emissions: PM.10, PM. 2.5, and NO2 are released through industrial waste, transportation, fire spots, and construction. The highest PM.10 emissions increased by 102% from 195 g/m<sup>3</sup> in 2012 to 394 g/m<sup>3</sup> in 2019. PM2.5 emission rates increased from 147.1 g/m<sup>3</sup> in 2012 to 359 g/m<sup>3</sup> (143%) in 2019. NO2 levels fell from 148 parts per billion in 2012 to 78 parts per billion in 2019. PM 10 and PM 2.5 both raised health risks. More contaminants and pollution exposure raised the risk to health.

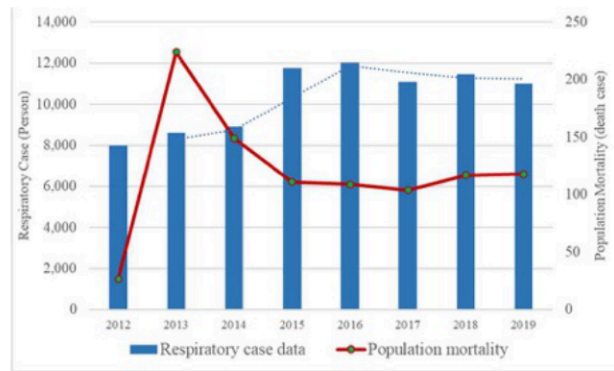


Fig. 5. Respiratory disease rate and the mortality rate in Chiang Khong in 2012 - 2019

Pollution in Chiang Khong had conspicuous effects on health. Total respiratory case in Chiang Khong was 7,982 cases in 2012 but increased markedly to 11,009 cases in 2019. The number of mortality cases was 27 cases and reached 118 cases in 2019 (Figure 5). The incidence of respiratory disease tends to be higher. According to the study hypothesis and literature review from several research, it was found that the incidence of respiratory cases was caused by air pollution and air pollution tends to increase. Likewise, the expansion of urbanization and industrial area impacted directly to pollution emission in the urban area.

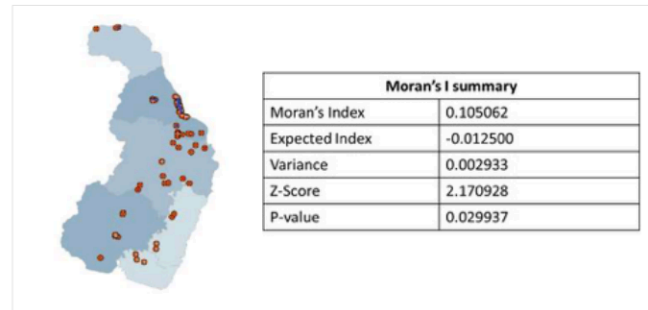


Fig. 6. Moran's I statistic and density map

According to Moran's I statistics test found that the number of industry and building up in 2019 related to the Moran's spatial as 0.105062. The z-Score equal to 2.170928 and p-value equal to 0.029937 which showed a statistically significant of coefficient. From the above results, it was found that the trend of industrial construction location has a clustered distribution pattern. Considering the density of industries build up found that Moran's I value greater than 0. It shows that the industrial density has a positive correlation. The results of statistics suggest that new industrial construction is more likely to stick as the cluster, affecting the density of the industry and having a significant impact on the health of local in people who living in such locations (Figure 6).

Changes in pollution, land use, and industry are all important aspects of urbanization. Therefore, Industrial Area (lu1), Urban Change (lu2), Urban Population Rate (lu3), PM.10 (pm1), PM.2.5 (pm2), and NO2 (pm3) were selected as variables and independent variables in the

Generalized Additive Model to further validate the impact of urban growth or urban land-use change on health hazards. Table 2 displays the results. The amount of Nitrogen Dioxide (No2) and the percentage of urban change (lu2) were discovered as a non-linear association with total mortality ( $p < 0.01$ ). The explained deviations ranged from 95.30% to 65.20%. On the other hands, Industrial Area (lu1), PM2.5 (pm2), and Nitrogen Dioxide (pm3) revealed strong non-linear associations with the number of respiration cases ( $p < 0.01$ ). Nitrogen Dioxide has 93.30% of the explained deviances, Pm 2.5 has 87.6 and Industrial Area has 81% of the explained deviances. (Table II)

Figure 7, In terms of mortality and urbanization factors, all three features were non-linear correlations, but the urban change parameter was the greatest deviance explanation (65.20%). The mortality rate will grow non-linearly with the percentage of urbanization rising (Figure 7 (A)).

TABLE II. RESULT OF GAM MODEL

Pairs of Variables		<i>f</i>	Dev (%)	<i>p</i>
Total mortality	Industrial Area	0.032	4.14%	0.0252
	% Urban Change	1.402	65.20%	0.00623
	% Urban population Rate	0.023	3.03%	0.0256
	PM 10	0.729	49.30%	0.0106
	Pm 2.5	0.181	19.50%	0.02
Case of Respiration	Nitrogen Dioxide	15.26	95.30%	0.000327
	Industrial Area	3.197	81%	0.000104
	% Urban Change	0.781	51%	0.000427
	% Urban population Rate	0.829	52.50%	0.000408
	PM 10	0.704	48.40%	0.00461
Pm 2.5	5.316	87.6	0.00000547	
Nitrogen Dioxide	10.48	93.30%	0.00000217	

In terms of mortality and pollution factors, No2 can be described as a non-linear relationship. As the rate of No2 increases, there is a tendency toward mortality as decreasing (Figure 7 (B)). The prevalence of respiratory disease and the effects of urbanization There was a non-linear relationship, however, the most likely reason was Industrial Area (81%). The probability of developing respiratory disease grows in a non-linear with industry area rate (Figure 7 (C)). Moreover, factors of respiratory case rates and pollution was a non-linear relationship. The Pm2.5 and No2 factors have deviance explanation as 87.6% and 93.30% respectively. It was discovered that when Pm2.5 was increased to a safe level. The number of respirations was decreasing. However, when the Pm2.5 rate rises in the high level (200+), the rate of respiratory disease will continue to increase as non-linear (Figure 7 (D)).

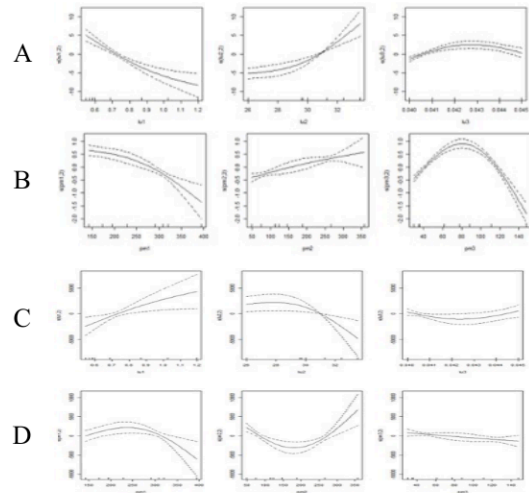


Fig. 7. Effect of urbanization on health

#### IV. DISCUSSION AND CONCLUSION

Based on Chiang Khong, Chiang Rai, Thailand, this research assessed the correlation of health risks linked with rapid urban expansion from a spatial perspective. According to the findings, the trajectory of urbanization in Chiang Khong is typical of industrial land expansion, which has aggravated environmental deterioration. [10]. Chiang Khong population's health troubles grew with time and proximity to pollution. This sort of urbanization exposed individuals to a polluted environment, which has been related to higher health risks and a rise in the number of environmental health occurrences. [10]. When pollutant emissions proliferate in metropolitan areas, urban inhabitants risk diminishing environmental benefits and possibly a poisoned environment [3, 11, 12].

The study was gathered data from other sources to explain this association. Our findings revealed that Chiang Khong's urbanization was characterized by quick development, rapid population growth, wide urban land expansion, and industry dominance (Figure 2). In a deteriorating climate, industrial waste emissions increased in tandem with rising population levels [3]. Urban expansion affects PM10 and PM 2.5 emissions [12]. PM 2.5 and PM 10 emission have quite a short-term impact on public health, especially the respiratory case [14]. The effects on respiratory diseases are consistent with existing research. People are more likely to suffer with respiratory disease from the PM2.5 emission [15].

The GAM analysis also found that total mortality and respiration cases have generally increased in tandem with the development of urbanization variables such as pollution, land use, and industry. When the industry land area reached, the variance in respiration cases showed a nonlinear response in the deviation explain as 81%. Industry building land or urban area may disperse concentrated populations, preventing them from congregating near pollution sources and limiting increases in environmental health concerns. Increases in the rate of urbanization and development of

land area have also been linked to increases in respiration cases.

Nitrogen Dioxide was found to have a modest association with mortality and the occurrence of respiratory disease. Several research declared that only works for some people who have weak bodies [16]. This is consistent with data indicating that the majority of No2 affects youngsters. However, it has little effect [17]. Many people who die in Chiang Khong are elderly. It clearly shows that, while there is an explanatory relationship, they are not related [18]. As a result, the relationship is concisely stated. Mortality was found to be substantially associated with urbanization. as well as the industry's growth together with PM 2.5 air pollution, there is a significant increase in the incidence of respiratory disease.

In this study, there was a weakness of land change over a period of 7 years (2012-2019), a relatively small change. According to previous research, there is a minimum of ten years of study and some of studies analyze the land use land change less than ten years. There is a study of spatial changes in the pre- and post-COVID period from 2015 to 2020 [19], which is six years of LULC analysis was used, and results that could be analyzed were obtained, but there are a few land changes. Furthermore, the study of land use land change in 2016 - 2020 using machine learning [20] and land use land change with respiratory health [21] demonstrates that the spatial change was studied in a short period of time (5-6 years) depending on the suitability and goals of the analysis. This research perspective aims to the trends in land urbanization and respiratory disease. There are data limitations in the respiratory database, which began recording in 2012 and 2019, with increased COVID 19 records, which may affect the analysis's accuracy. However, this research could be used to further analyze other health data, particularly non-COVID 19 related diseases, from 2012 to 2022.

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