2021　2023

Spatio-temporal study on walkable neighborhoods for the new normal using GPS location history data

Kato, Haruka

3,400,000

GPS

2023

The coronavirus disease 2019 (COVID-19) epidemic has dramatically changed our lives. This study elucidated the walkable neighborhood environment before and during the COVID-19 pandemic. As a research method, this study conducted urban data science using GPS location history data from smartphone users. The analysis allowed us to elucidate the walkable neighborhood environment that changed from the previously studied one to adapt the "new way of life" for the post-COVID-19 pandemic. These research results were published in academic papers and released in newspapers and online media.

1．研究開始当初の背景

　本研究の背景は、徒歩圏で日常生活を送ることが可能なウォーカブルな近隣環境の重要性である。それは、新型コロナウイルス感染症の流行により重要性を増していた。それを踏まえた本研究の目的は、「新しい生活様式」としてのウォーカブルな近隣環境を解明することである。その研究方法として、スマートフォンの GPS から収集されたポイント型流動人口データを用いて、時間地理学を援用したデータサイエンスを行う。それにより、今まで研究されてきたウォーカブルな近隣環境から変化した、「新しい生活様式」に即したウォーカブルな近隣環境を解明することが期待される。また、Evidence-Based Policy に貢献する研究成果も期待される。

2．研究の目的

　本研究の目的は、ポイント型流動人口を用いて、「新しい生活様式」としてのウォーカブルな近隣環境を解明することである。具体的に、以下の 9 つの段階的な研究テーマを設定して、それぞれ研究した。

　　（１）活動エリアとしての生活圏の変化
　　（２）時空間ポイントとしての生活場所の変化
　　（３）時空間パスとしての移動手段の変化
　　（４）生活圏と新型コロナウイルス感染者数の関係性
　　（５）流動人口と新型コロナウイルス感染者数の関係性
　　（６）流動人口と生活習慣病関連医療費の関係性
　　（７）中長期的な人流変化
　　（８）中長期的な人流変化の要因

3．研究の方法

　本研究の方法は、ポイント型流動人口データというビッグデータを用いて、時間地理学を援用したデータサイエンスを採用した。Hägerstrand, T.,(1970)が提唱した時間地理学は、3 次元時空間座標上に、個人の生活行動を時空間パスとして分析する方法であり、都市計画で利用されてきた。従来は、限られた対象者に、ヒアリング調査で生活行動を収集していた。しかし本研究は、スマートフォンの GPS から収集したポイント型流動人口を用いることで、データサイエンスとして研究した。

　本研究が利用するポイント型流動人口データは、匿名化処理した研究用ビッグデータである。このデータの内、本研究は、個人 ID、日時・時間、緯度・経度、移動速度を使用した。その個人 ID とは、匿名化処理された 96 桁の英数字である。端末ごとに永続的に付与された ID であり、年月日を超えたパネルデータ分析が可能である。それにより、COVID-19 による因果関係を解明することができる。なお、有効なデータを得る前処理として、データの時系列座標を正規分布化して外れ値を特定して、分析から除外した。

4．研究成果

（1）活動エリアとしての生活圏の変化

Haruka KATO*, Atsushi Takizawa, Daisuke Matsushita (2021) Impact of COVID-19 Pandemic on Home Range in a Suburban City in the Osaka Metropolitan Area. Sustainability, Vol.13 Issue16, No.8974. https://doi.org/10.3390/su13168974

This study aims to clarify the impact of the COVID-19 pandemic on home range. The home range is the area that individuals traverse in conducting their daily activities, such as working and shopping. In Japan, the central government declared the first state of emergency in April 2020. This study analyzed the panel data for mobile phone GPS location history from April 2019 to April 2020 in Ibaraki City, Osaka Metropolitan area. The study applied the minimum convex polygon method to analyze the data. The results show that the home range decreased significantly between April 2019 and April 2020. Specifically, the home range in 2020 decreased to approximately 50% of that in 2019 because of COVID-19 infection control measures, preventing people from traveling far from their homes and only allowing them to step outside for the bare minimum of daily activities and necessities. The results suggest that the emergency reduced people's home ranges to the neighborhood scale. Therefore, it is necessary to consider designing new walkable neighborhood environments after the COVID-19 pandemic era.

（2）時空間ポイントとしての生活場所の変化

Haruka KATO* (2021) Development of a Spatio-temporal Analysis Method to Support the Prevention of COVID-19 Infection: Space-Time Kernel Density Estimation Using GPS Location History Data, S. C. M. Geertman, Christopher Pettit, Robert Goodspeed and Aija Staffans (ed), Urban informatics for future cities, Springer Nature Switzerland AG, pp.51-67. https://doi.org/10.1007/978-3-030-76059-5_4

This study aims to develop a spatio-temporal analysis method to support planning for the prevention of a COVID-19 infection. The method focused on the space-time kernel density estimation using the GPS location history data. The data is GPS location data obtained at regular intervals from smartphones with the consent of the users. The research method was a panel data analysis for April 2019 and April 2020 with Ibaraki City. In April 2020, the Japanese government implemented a soft lockdown. As a result, this study developed a spatio-temporal analysis method that visualizes the space-time with high population density. Using these methods, local governments can restrict people's lives by designating specific space-time areas. In addition, the method helps citizens to change their lifestyle behaviors and cooperate in the prevention of COVID-19 infection. The method is an alternative to the Japanese soft lockdown, which was based on an emergency declaration. In the future, this method will be utilized for data analysis in future smart cities.

（3）時空間パスとしての移動手段の変化

Haruka KATO, Daisuke Matsushita (2021) Changes in Walkable Streets during the COVID-19 Pandemic in a Suburban City in the Osaka Metropolitan Area. Sustainability, Vol.13, Issue 13. No.7442, https://doi.org/10.3390/su13137442

The purpose of this study was to identify the walkable streets where traffic behavior changed according to each residential cluster during the COVID-19 pandemic. By elucidating the changes, it is possible to identify streets that should be redesigned following the changes in traffic behavior in relation to human mobility. This study analyzed Ibaraki City, a suburban city located in the Osaka Metropolitan Area. The analysis compared the panel data of the GPS Location History for April 2020 and April 2019. The analysis method used was Empirical Bayesian kriging. The results show that the speed significantly increased in the dense, sprawl, mountain, and old NT clusters. It was also found that the number of cyclists increased during the COVID-19 pandemic. The results suggest a need to design walkable streets according to each residential cluster for the post-COVID-19 pandemic era. For example, some car lanes need to be converted to bike lanes in the main neighborhood to create walkable streets in the clusters.

（4）生活圏と新型コロナウイルス感染者数の関係性

Haruka KATO*, Atsushi Takizawa (2022) Time series cross-correlation between home range and number of infected people during the COVID-19 pandemic in a suburban city. PLoS ONE, Vol. 17, Issue. 9, No. e0267335. https://doi.org/10.1371/journal.pone.0267335

Control of human mobility is one of the most effective measures to prevent the spread of coronavirus disease 2019 (COVID-19). However, the imposition of emergency restrictions had significant negative impacts on citizens' daily lives. As vaccination progresses, we need to consider more

effective measures to control the spread of the infection. The research question of this study is as follows: Does the control of home range correlate with a reduction in the number of infected people during the COVID-19 pandemic? This study aims to clarify the correlation between home range and the number of people infected with SARS-CoV-2 during the COVID-19 pandemic in Ibaraki City. Home ranges are analyzed by the Minimum Convex Polygon method using mobile phone GPS location history data. We analyzed the time series cross-correlation between home range lengths and the number of infected people. Results reveal a slight positive correlation between home range and the number of infected people after one week during the COVID-19 pandemic. Regarding home range length, the cross-correlation coefficient is 0.4030 even at a lag level of six weeks, which has the most significant coefficient. Thus, a decrease in the home range is a weak factor correlated with a reduction in the number of infected people. This study makes a significant contribution to the literature by evaluating key public health challenges from the perspective of controliing the spread of the COVID-19 infectuion. Its findings has implications for policy makers, practitioners, and urban scientists seeking to promote urban sustainability.

（５）流動人口と新型コロナウイルス感染者数の関係性

Haruka KATO*, Atsushi Takizawa (2022) Human mobility and infection from Covid-19 in the Osaka metropolitan area. npj Urban Sustainability, Vol.2, No. 20. https://doi.org/10.1038/s42949-022-00066-w

Controlling human mobility is thought to be an effective measure to prevent the spread of the COVID-19 pandemic. This study aims to clarify the human mobility types that impacted the number of COVID-19 cases during the medium-term COVID-19 pandemic in the Osaka metropolitan area. The method used in this study was analysis of the statistical relationship between human mobility changes and the total number of COVID-19 cases after two weeks. In conclusion, the results indicate that it is essential to control the human mobility of groceries/pharmacies to between −5 and 5% and that of parks to more than −20%. The most significant finding for urban sustainability is that urban transit was not found to be a source of infection. Hence governments in cities around the world may be able to encourage communities to return to transit mobility, if they are able to follow the kind of hygiene processes conducted in Osaka.

（６）流動人口と生活習慣病関連医療費の関係性

Haruka KATO*, Atsushi Takizawa (2024) Human mobility and medical costs of lifestyle-related diseases during the COVID-19 pandemic: A cross-sectional study in Japan. Journal of Transport & Health, 34, 101728. https://doi.org/10.1016/j.jth.2023.10172

Introduction: During the COVID-19 pandemic, restrictions on human mobility caused health problems. Therefore, it is valuable to evaluate the human mobility restrictions during the pandemic from the population health viewpoint. This study aimed to clarify the correlation between changes in human mobility types and medical costs of lifestyle-related diseases during the pandemic.
Methods: The study design was set as a cross-sectional study regarding the human mobility types and the medical cost of lifestyle-related diseases. The population was Japanese people. Boosted tree analysis analyzed the nonlinear relationship between human mobility types and medical costs of lifestyle-related diseases in Japan. The boosted tree analysis can obtain high accurate models.
Results: The results of this analysis indicated that medical costs were differently affected by walking, driving, and public transit, depending on the type of prefecture. Increasing walking by over 70% reduced the medical costs of lifestyle-related diseases, even during the COVID-19 pandemic. In metropolitan prefectures, the total effect on medical cost was higher for walking and public transit. In addition, medical costs decreased by gradually increasing public transit use by over 110%. On the other hand, in other prefectures, the total effect of public transit was lower than driving, and medical costs increased from 80% to 160%. These results were significant because they indicated the target value for each human mobility type in metropolitan areas and other prefectures.
Conclusions: In conclusion, this analysis indicated that increasing walking and public transit use correlated with a decreasing in the medical costs of lifestyle-related diseases even during the COVID-19 pandemic. The results were significant because they indicate the target value for each human mobility type according to the metropolitan and the other prefectures. Based on the target values, our findings implicate that governments can take measures other than restricting walking and public transit during the pandemic.

（７）中長期的な人流変化

Haruka KATO*, Atsushi Takizawa (2022) Impact of the Urban Exodus Triggered by the COVID-19

This study aims to clarify the impact of the urban exodus triggered by the COVID-19 pandemic on shrinking cities in the Osaka metropolitan area, where a declining population is caused by population aging. Analyzing the Osaka metropolitan area enables us to clarify how cities are shrinking due to the urban exodus. This study analyzed the monthly population data of three types of municipalities: ordinance-designed/regional hub cities, ordinary cities, and towns/villages. In conclusion, the study clarified that population change due to the urban exodus occurred in the ordinance-designed/regional hub and ordinary cities from summer to autumn 2020. The most significant population increases occurred in the municipalities in the Osaka metropolitan fringe area, which are located more than 30 km away from the center of the Osaka metropolitan area. The conclusion is important because the population increased not only in the ordinance-designed cities but also in the ordinance-designed/regional hub cities, unlike the rest of the metropolitan area. The result is the new insights unique to the Osaka metropolitan area that this study clarified. The urban exodus contributes to the need for the local governments of shrinking cities to maintain the urban services necessary for people's daily lives.

（8） 中長期的な人流変化の要因

The background of this study is the urban exodus that occurred in Japanese metropolitan areas. The research question of this study is about the reasons why the urban exodus occurred in Japanese metropolitan areas. For the analysis, the objective of this study is to clarify the residential preferences of each household type in relation to the urban exodus during the COVID-19 pandemic in Japanese metropolitan areas. The method of this study is a web questionnaire survey. The sample comprised 593 respondents who migrated from ordinance-designed cities to other municipalities in metropolitan areas between April 2020 and March 2022. In conclusion, this study elucidates that migrant household type as urban exodus is households whose eldest child had enrolled in elementary school or above. Regarding residential preferences, the household type changes the importance of community and environment, rather than the working arrangement. This result is novel and essential because it clarifies that the household type tends to place more importance on the quality of childcare environment, ties to communities, the presence of a large garden/balcony, and utilizing opportunities to experience the community, such as via trial migration support programs.

Kato Haruka Takizawa Atsushi	2
Human mobility and infection from Covid-19 in the Osaka metropolitan area	2022
npj Urban Sustainability	20
DOI 10.1038/s42949-022-00066-w	

Kato Haruka Takizawa Atsushi	17
Time series cross-correlation between home range and number of infected people during the COVID-19 pandemic in a suburban city	2022
PLOS ONE	e0267335
DOI 10.1371/journal.pone.0267335	

Komaki Miyu Kato Haruka Matsushita Daisuke	15
Why Did Urban Exodus Occur during the COVID-19 Pandemic from the Perspective of Residential Preference of Each Type of Household? Case of Japanese Metropolitan Areas	2023
Sustainability	3315
DOI 10.3390/su15043315	

Tanaka Riku Kato Haruka Matsushita Daisuke	15
Population Decline and Urban Transformation by Tourism Gentrification in Kyoto City	2023
Sustainability	2247
DOI 10.3390/su15032247	

Kato Haruka Takizawa Atsushi	14
Population Decline through Tourism Gentrification Caused by Accommodation in Kyoto City	2022
Sustainability	11736
DOI 10.3390/su141811736	

Kato Haruka Matsushita Daisuke	13
Changes in Walkable Streets during the COVID-19 Pandemic in a Suburban City in the Osaka Metropolitan Area	2021
Sustainability	7442 7442
DOI 10.3390/su13137442	

Kato Haruka	1
Development of a Spatio-Temporal Analysis Method to Support the Prevention of COVID-19 Infection: Space-Time Kernel Density Estimation Using GPS Location History Data	2021
Urban Informatics and Future Cities	51 67
DOI 10.1007/978-3-030-76059-5_4	

Kato Haruka Takizawa Atsushi Matsushita Daisuke	13
Impact of COVID-19 Pandemic on Home Range in a Suburban City in the Osaka Metropolitan Area	2021
Sustainability	8974 8974
DOI 10.3390/su13168974	

Kato Haruka Takizawa Atsushi	13
Which Residential Clusters of Walkability Affect Future Population from the Perspective of Real Estate Prices in the Osaka Metropolitan Area?	2021
Sustainability	13413 13413
DOI 10.3390/su132313413	

Kato Haruka Takizawa Atsushi	14
Impact of the Urban Exodus Triggered by the COVID-19 Pandemic on the Shrinking Cities of the Osaka Metropolitan Area	2022
Sustainability	1601 1601
DOI 10.3390/su14031601	

Kato Haruka Takizawa Atsushi	34
Human mobility and medical costs of lifestyle-related diseases during the COVID-19 pandemic: A cross-sectional study in Japan	2024
Journal of Transport & Health	101728 101728
DOI 10.1016/j.jth.2023.101728	

2	0	1
2021		

Haruka Kato

Development of a Spatio-temporal Analysis Method to Support the Prevention of COVID-19 Infection: Space-Time Kernel Density Estimation Using GPS Location History Data

Proceedings of 17th International Conference on Computers in Urban Planning and Urban Management (CUPUM2021)

2021

O

https://www.omu.ac.jp/info/research_news/entry-01982.html

https://mainichi.jp/articles/20220926/k00/00m/040/127000c
NEWS RELEASE 19-OCT-2022
https://www.eurekalert.org/news-releases/968449

O