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研究課題名（和文）Mapping seasonal demography and mobility for malaria elimination

研究課題名（英文）Mapping seasonal demography and mobility for malaria elimination

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研究成果の概要（和文）：本研究では、モザンビークを研究対象として、マラリア伝播に影響を与えると考えられている季節性の高い人口流動パターンを明らかにした。分析結果をマッピングすることで、季節に応じて変動する人口の都市間移動パターンを明らかにし、それをマラリア患者の分布と結びつけることで、リスク予測に活用することも可能になり、伝播のピーク時にリスクが高い人口を特定することも可能になると期待される。
分析では、移動性の高い人口の居住地分布やその変化の特性を明らかにし、特定の時期と場所で高リスク人口が集中する傾向があることをあきらかにした。当該分析結果は、アフリカの他の国々にも適用可能である。

研究成果の学術的意義や社会的意義
Outcome of our research helps understand seasonally-varying mobility patterns, crucial for advancing intervention in public health domain. It enables predicting disease spread and optimizing healthcare delivery. These insights enable policy makers to tailor interventions and policies effectively.

研究成果の概要（英文）：In this study we identified the population mobility patterns that are considered to influence the spread of infectious diseases. By mapping the analysis results, we were able to identify seasonally varying mobility patterns. Linking these to the distribution of malaria cases, enables us to predict risk. This approach makes it possible to identify populations at high risk during peak transmission periods.

The analysis clarified the characteristics of the residential distribution and its changes among highly mobile populations, revealing a tendency for high-risk populations to concentrate in specific times and places. The findings of this analysis can be applicable to other countries in Africa.

研究分野：GIS

キーワード：mobile phone data　big data　developing countries　mobility pattern　evidence-based policy　Africa

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１．研究開始当初の背景

Understanding the geographic distribution of high-transmission locations (hotspots) and high-risk population is crucial for targeted malaria control efforts. Much of the research in this area uses geospatial and case data to identify these hotspots, while mobility data helps track where high-risk population are most likely to encounter malaria and potentially spread. However, these studies often underestimate how demographic factors correlate with mobility and risk, which are crucial for understanding and intervening in malaria dynamics effectively.

Demographic information is not usually included in mobility and risk analysis due to data limitations, yet understanding these relationships is essential. High-risk groups, defined either by behavior or socioeconomic factors, may travel differently, affecting the spread of malaria. For instance, children under 15, who are particularly susceptible to symptomatic malaria, generally do not travel as far as adults. Such specific travel patterns can influence where and how malaria spreads.

Additionally, the relationship between demography and mobility can be related to seasonality, which in turn affect malaria transmission. Seasonal workers, for example, might spend more time in mosquito-prone areas during certain months, increasing the risk of contracting and subsequently spreading malaria. General population movements, influenced by work or holiday schedules and even environmental factors like seasonal flooding, also play a role. These movements can alter the demographic makeup of areas, influencing malaria transmission rates and patterns.

２．研究の目的

It is important to understand the seasonally varying population and mobility landscapes for effective malaria control. This project aims to integrate understanding of these patterns with data on malaria patients to enhance the effectiveness of interventions. It enables malaria elimination efforts to be informed by timely, frequent, and quality data.

３．研究の方法

Our approach consists of two work packages.
Work Package I: Linking seasonal demography and mobile phone patterns to map seasonal demography
We first addressed how sociodemographic factors vary with movement and mapped demographic variables important to malaria transmission and risk. We linked surveys with sociodemographic information to CDRs. This work built on Phase I where we predicted demographic patterns using mobile phone mobility patterns. We interpolated spatio-

temporal travel patterns from sparse CDR data using a methodology for unsupervised latent topic extraction from massive data sets. From the spatio-temporal patterns extracted from CDRs, we estimated the probability distribution over locations for each user independently. We used a Hidden Markov Model with latent variables as the smoothed trajectory to account for spatio-temporal autocorrelation in movement. Movement probability was calculated from the spatio-temporal patterns, while the probability of traveling from one base station to another was estimated using the distance between the base stations. We trained Random Forest, K-Nearest Neighbors, and Naïve Bayes classifiers to predict the attributes of mobility between base stations using demographic information. To quantify how demography varied seasonally using this model, we initially fitted the best-fit model using the entire survey and CDR dataset to understand how mobility and demography related across the year. We then modeled demographic patterns for each month of the year by subsetting CDR data for each month and predicting the associated demography of each community nationwide. We tested the hypothesis that populations expected to experience higher malaria risk for sociobehavioral reasons (such as farmworkers) were the most likely to move seasonally, affecting the local risk of certain populations more than seasonal changes in population density implied. Previous research had shown that high-risk populations often moved long distances seasonally

Work Package 2: Targeting High Transmission Seasons and Broader Geographic Application

In this package we aimed to integrate the findings from WP1 regarding seasonal demography and movement with monthly malaria risk maps to identify communities at high risk during peak transmission times. We isolated the key transmission months and assessed the dynamics of malaria parasite sources and sinks during these periods. We utilized existing transmission models and developed monthly risk maps, adjusted for variable risks across different sociodemographic groups.

The hypothesis for this package posited that demography and mobility vary seasonally, altering the interaction between communities and malaria hotspots monthly. We expected that incorporating these seasonal dynamics would result in more accurate mappings of at-risk communities, aligning closely with actual case data. By comparing models that used annual averages with those reflecting high transmission month data, we highlighted the importance of considering seasonal variations. Validation of these findings was conducted through collaboration with local partners and expert reviews, leveraging real-time data for confirmation.

４．研究成果

In this research, we focused on identifying the mobility patterns of populations that are thought to significantly influence the spread of infectious diseases, particularly malaria. Through detailed mapping and analysis, we were able to discern patterns of movement

that varied with the seasons. By correlating these mobility patterns with the geographic and temporal distribution of malaria cases, we established a method to forecast areas and periods of heightened disease risk.

This approach has proven invaluable in pinpointing populations that are at elevated risk during the times of year when disease transmission is most intense. By understanding when and where these high-risk populations move, we can better predict and potentially mitigate the spread of the disease.

Further analysis provided insights into the living patterns of highly mobile populations, identifying clear trends in how these groups move and settle. It was observed that populations with a higher risk of infection tend to gather or pass through specific locations at particular times of the year. This concentration in certain areas during certain periods could be linked to various factors, including economic activities, seasonal employment, or climatic conditions that influence the prevalence of disease vectors.

The insights gained from this study are not only relevant to the specific regions analyzed but also hold potential for application in other parts of Africa. Understanding the mobility and residential tendencies of populations in relation to infectious disease spread can assist health authorities and policymakers in other regions to devise targeted interventions. By applying similar analytical methods, other countries can anticipate potential outbreaks and focus resources more effectively, tailoring public health responses to the dynamics of population movement and disease transmission observed in this study.

５．主な発表論文等

〔雑誌論文〕　計3件（うち査読付論文　3件／うち国際共著　2件／うちオープンアクセス　3件）

１．著者名 Witayangkurn Apichon、Arai Ayumi、Shibasaki Ryosuke	４．巻 11
２．論文標題 Development of Big Data-Analysis Pipeline for Mobile Phone Data with Mobipack and Spatial Enhancement	５．発行年 2022年
３．雑誌名 ISPRS International Journal of Geo-Information	６．最初と最後の頁 196～196
掲載論文のDOI（デジタルオブジェクト識別子） 10.3390/ijgi11030196	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 該当する

１．著者名 Arai Ayumi、Knippenberg Erwin、Meyer Moritz、Witayangkurn Apichon	４．巻 3
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１．著者名 Jansen Ronald、Kovacs Karoly、Esko Siim、Saluveer Erki、S?stra Kaja、Bengtsson Linus、Li Tracey、Adewole Wole A.、Nester Jade、Arai Ayumi、Magpantay Esperanza	４．巻 3
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掲載論文のDOI（デジタルオブジェクト識別子） 10.1017/dap.2021.21	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 －

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１．発表者名
Ayumi Arai

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2020年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

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６．研究組織

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７．科研費を使用して開催した国際研究集会

〔国際研究集会〕　計0件

８．本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関