令和３年度東北大学新型コロナウィルス対応特別研究プロジェクト「ポストコロナ社会構築研究推進支援」

新型コロナウィルス対応における移動制限とその効果・影響の分析
Examining impacts of moving restrictions against the novel coronavirus epidemics

R3活動報告/Activity report・研究成果の概要/Summary of Research Results

学際的研究による「自粛効果」の解明

❶ 人の動きと感染拡大の統計科学的分析

- 時空間ビッグデータに基づく人々の行動と感染拡大のマクロな関連性の解明

流行対策の施策・流行拡大の状況→外出行動変化→感染拡大の抑制といったマクロな統計学的関連をみるために、本年度は、人の動きからみた感染拡大の予測可能性を機械学習の手法を1kmメッシュの感染発生データに適用して検討し、一定の精度での予測可能性を確認した（Fig.1）。その一方で、どのように流行対策の施策が人の動きの変化を規定しているのかについては、課題として残された。

❷ 個人の生活行動変化の社会科学的分析

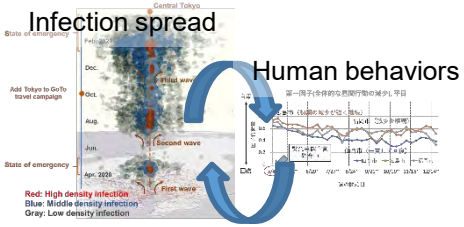
-外国人を含め外出自粛で生じうる地域格差・社会格差のミクロレベルからの解明

感染症の流行による健康や生活状況に対する地域格差・社会格差を明らかにするため、2021年10月に日本全国に居住する外国人住民と日本人に対して大規模インターネット調査を実施した（有効回答数：外国人1,986、日本人1,704）。11.6%の第一世代の外国人がCOVID-19ワクチン躊躇を示した（Fig. 2）。ホスト社会への統合度合いが高い外国人ほど、ワクチン接種意識が高かった。今後、在日外国人の在留意識の変化とその規定要因、コロナ禍における困難点などを分析する。

❸ 感染拡大防止効果の情報科学的検討

-強制力の無い感染抑制が有効な流行制御戦略となりうることの理論疫学的解明

これまでの理論疫学モデル（SIRモデル）をベースとする介入効果の研究を拡張し、複数回の介入があった場合（Fig. 3）についての最終規模方程式を導出した。1回の介入よりも複数回の介入の方が感染者数を最小化しやすく、感染者数が多い時に介入すると介入期間を短くできることを明らかにした。さらに定量的な議論を容易にするため、複数回介入した場合の回復者数を時間の関数とする近似式を導出した。



分析1： 人の動きと感染拡大の解析

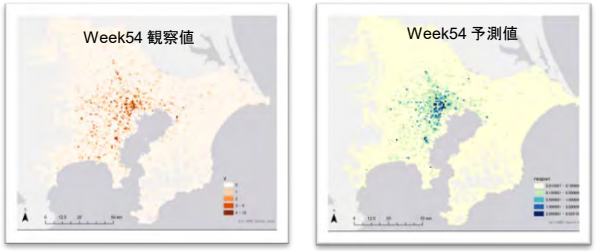
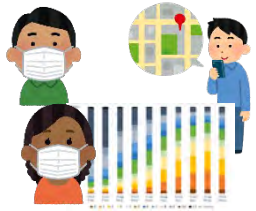


Fig. 1 機械学習による微細な流行予測の例

Social survey for micro-level analysis of social impacts



分析2： コロナ禍における在日外国人に対する社会調査

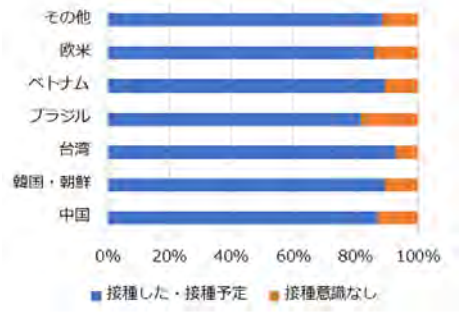
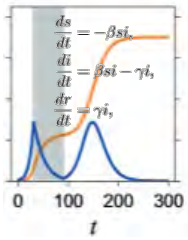


Fig. 2 第一世代在日外国人のワクチン接種意識

Theoretical epidemiological study



分析3：理論疫学モデルによる流行対策効果

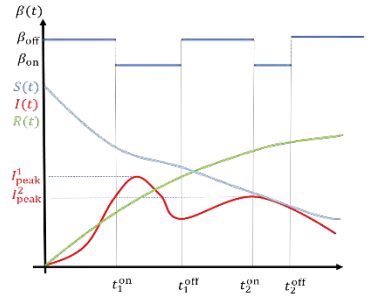


Fig. 3 複数回介入のある理論疫学モデル
β：感染拡大パラメター、S：感受性者数、I：感染者数、R：回復者数

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Clarification of the "self-restraint effect" through interdisciplinary research

❶ Statistical analysis of human movement and infection spread

- Using spatio-temporal big data to elucidate the macro-level relationship between changes in people's behavior and the spread of infection.

In the first year of this project, the predicting potential of the spread of infection with human mobility indices was examined by applying a machine learning method to the 1km gridded data of COVID-19 incidence, and the predictability was confirmed with a certain degree of accuracy (Fig. 1). Challenges remained regarding how epidemic control measures regulate changes in people's mobility.

❷ Social scientific analysis of individual life behavior change

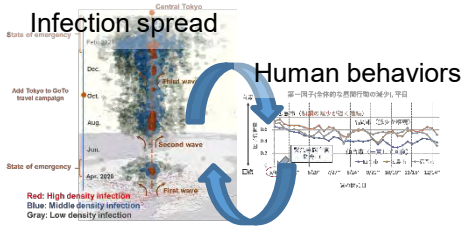
-Micro-level elucidation of the regional and social disparities that can arise when various actors (including foreigners living in Japan) reacted differently to the self-refrain requests..

An Internet questionnaire survey titled “Survey on Health and Life of Foreign Residents in Japan during the COVID-19 Pandemic” was conducted in October 2021 (valid responses: 1,986 foreign residents and 1,704 Japanese). Among 1,455 first-generation migrant participants, 11.6% reported hesitancy toward COVID-19 vaccination (Fig. 2). We found that the overall integration to the host society was associated with the vaccination intention. We will also focus on the social impact of the COVID-19 pandemic on the migrants in Japan epidemic (changes in intentions to stay in Japan and the determinants, difficulties during the pandemic, etc.) and explore the desired inclusive support for foreign residents in the with/post-COIVD-19 era.

❸ Informatics study of the effect on preventing the spread of infection

-Theoretical epidemiology of how non-coercive infection control can be an effective epidemic control strategy with spatial and social feedbacks.

Extending previous studies of intervention effectiveness based on a theoretical epidemiological model (SIR model), we derived a final scale equation for the case with multiple interventions (Fig. 3). It was revealed that multiple interventions are more likely to minimise the number of infections than a single intervention, and intervening when the number of infections is high can reduce the intervention period. To facilitate further quantitative discussion, an approximate formula was derived for the number of people recovered after multiple interventions as a function of time.



Analysis 1: Human movement and infection spread

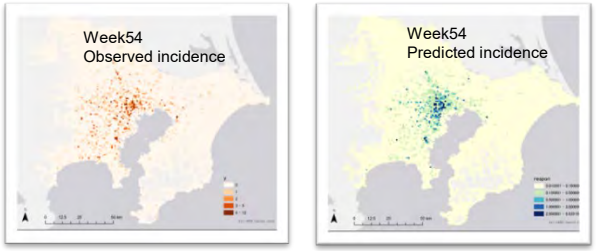
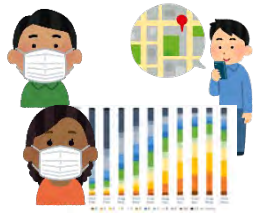


Fig. 1 Example of detailed geographic prediction of COVID-19 outbreaks with a machine learning method

Social survey for micro-level analysis of social impacts



Analysis 2: Social survey on foreign residents in Japan under the pandemic

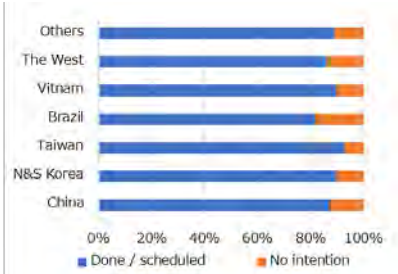
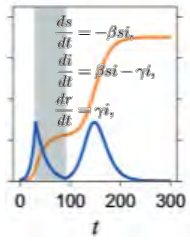


Fig. 2 Vaccination attitudes of first generation foreigners in Japan, by nationality and region

Theoretical epidemiological study



Analysis 3: Theoretical epidemic modeling of intervention strategies

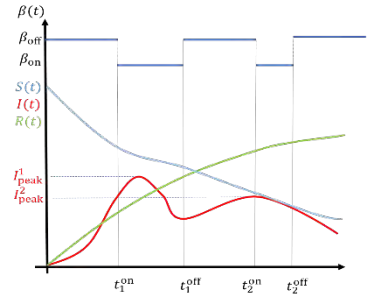


Fig. 3 Theoretical epidemic model with multiple interventions. β: infectious spread parameter, S: number of susceptibles, I: number of infectives, R: number of recovered.