

# Disparities in greenspace access during COVID-19 mobility restrictions

*Keywords: computational human ecology; large-scale social phenomena; computational methods to study cultural dynamics; Integration of multi-modal social data; greenspace and mobility*

## Extended Abstract

Over the past decade the link between access to some vegetated space or waterbodies in the urban landscape (greenspace) and both physical and mental health has become apparent<sup>1,2</sup>. Exposure to features of wild and urban nature-rich spaces affects physical, mental and social health<sup>3,4</sup>. There are however inequalities in greenspace access and greenspace quality associated with deprivation<sup>5,6</sup> of neighbourhoods. More than half the human population now lives in cities<sup>7</sup> and therefore has regular access to nature only in these anthropogenic landscapes. It is therefore crucial to understand how people use greenspace to maximize the equitable provision of the health benefits it confers.

People have tended to seek greenspace more during the mobility restrictions associated with the first wave of the SARS-CoV-2 pandemic (COVID-19)<sup>8</sup>. There is some indications that greenspace use during the pandemic conferred wellbeing advantages<sup>9</sup>. However, some inequalities in the ability to realise this increased interest in greenspace were reported, and some people spent less time in greenspace despite understanding its health importance<sup>10</sup>. This counterfactual show that realised greenspace use is complex and equitable access is likely affected by deprivation factors. COVID-19 offered, unfortunately, a unique natural experiment to assess the interest of people for greenspace and their ability to meet this need throughout the multiple waves of the pandemic.

Here we integrated the Facebook Data for Good programme's Population data with Twitter posts about greenspace and Google searches about Parks to assess whether people used greenspace more over the pandemic period in three European capital cities: London, Paris, and Berlin. Those cities were selected because both indices of multiple deprivation (IMDs) and curated public greenspace data were openly available at a relevant spatial resolution. For the first time, we assess how the distribution of people in relation to greenspace in cities changed over the whole span of the pre-vaccine COVID-19 pandemic period. Changes in human density where greenspace occur could emerge from multiple contributing factors. If people are to seek greenspace exposure, they will search for its availability first. We therefore also assessed whether web searches for urban greenspace changed during this pandemic period. Finally, we assessed whether self-reporting of urban greenspace experiences on social media changed during the phases of the pandemic. We anticipate that topics discussed in relation to greenspace on Twitter would change to reflect how people seek to use it.

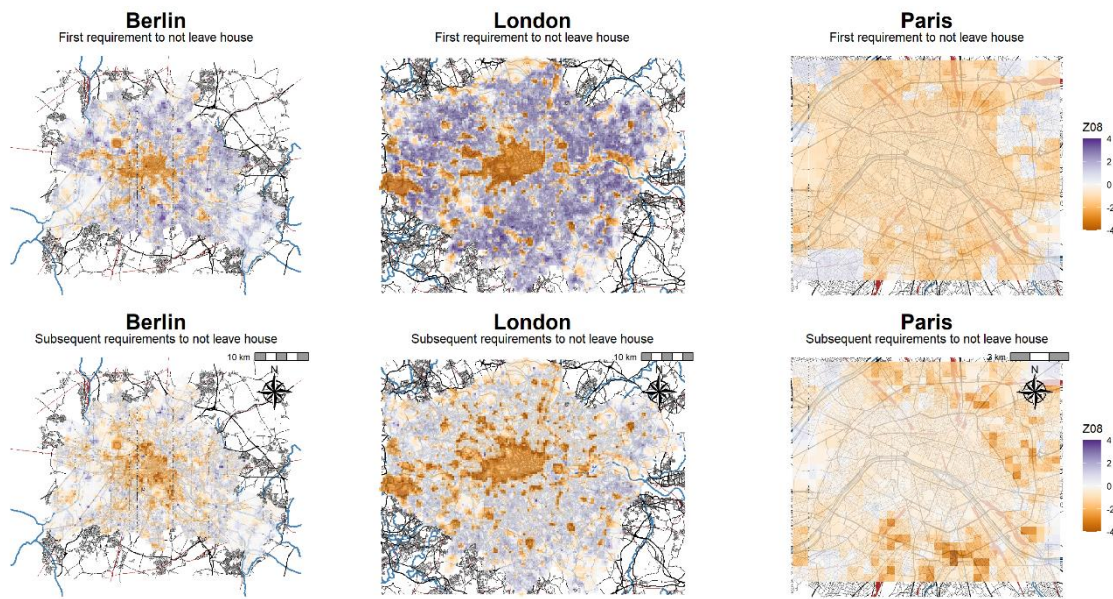
This integrative computational human ecology study aimed to longitudinally relate change in human density in urban greenspace to inferred motivation to use these spaces and realised experiences with the overall view to determine whether these experiences are equitably realised in neighbourhood of varying deprivation levels. By replicating these analyses in three cities we aimed to widen our inferential foundation to determine whether the observed responses to the mobility restrictions associated with the pandemic responses were similar across socio-cultural diversity or indeed whether specificities emerged.

People searched for Parks near them more during the pandemic, particularly when they were allowed to visit them. They discussed in positive terms greenspace and did so particularly more at the start of the pandemic. People spent more time in areas with greenspace when they could and that depended on the level of multiple deprivation of their neighbourhood (Figure 1). This was estimated at a fine scale spatial resolution, about 0.15km<sup>2</sup>, at which the Facebook Population density was aggregated and reported. Importantly, while people sought greenspace throughout the first 20 months of the pandemic, this preference intensified through the waves of lockdown. This effect was not limited to ‘greenspace-rich’ areas such as large public parks. The more greenspace was prevalent in an area, the higher the daytime Facebook population density was and the higher the contrast between daytime and nighttime densities was. However, this effect was mediated by the pandemic waves and the neighbourhood’s deprivation level. Living in an affluent area conferred a greenspace advantage in London and Paris which persisted over weekends in London. We find that in Berlin greenspace in more deprived neighbourhoods were used more. These findings emphasise the importance of replication across cultures in computational social science studies. This contrasting result was supported by additional analyses showing that non-urban greenspace forests in the Berlin district were more visited by people from more deprived neighbourhoods as well.

Overall, urban greenspace occupied a greater place in people’s lives during the pandemic. Whether people could realise greenspace access depended on the deprivation level of the neighbourhood. Public greenspace access should be integrated in national indices of deprivation given its importance for wellbeing.

## References

1. Twohig-Bennett, C. & Jones, A. The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes. *Environmental Research* **166**, 628–637 (2018).
2. Zhang, J., Yu, Z., Zhao, B., Sun, R. & Vejre, H. Links between green space and public health: a bibliometric review of global research trends and future prospects from 1901 to 2019. *Environ. Res. Lett.* **15**, 063001 (2020).
3. Hartig, T., Mitchell, R., de Vries, S. & Frumkin, H. Nature and Health. *Annual Review of Public Health* **35**, 207–228 (2014).
4. Bratman, G. N. *et al.* Nature and mental health: An ecosystem service perspective. *Science Advances* **5**, eaax0903 (2019).
5. Mitchell, R. & Popham, F. Effect of exposure to natural environment on health inequalities: an observational population study. *The Lancet* **372**, 1655–1660 (2008).
6. Song, Y. *et al.* Observed inequality in urban greenspace exposure in China. *Environment International* **156**, 106778 (2021).
7. Lederbogen, F. *et al.* City living and urban upbringing affect neural social stress processing in humans. *Nature* **474**, 498–501 (2011).
8. Lu, Y., Zhao, J., Wu, X. & Lo, S. M. Escaping to nature during a pandemic: A natural experiment in Asian cities during the COVID-19 pandemic with big social media data. *Science of The Total Environment* **777**, 146092 (2021).
9. Larson, L. R. *et al.* Greenspace and park use associated with less emotional distress among college students in the United States during the COVID-19 pandemic. *Environmental Research* **204**, 112367 (2022).
10. Burnett, H., Olsen, J. R., Nicholls, N. & Mitchell, R. Change in time spent visiting and experiences of green space following restrictions on movement during the COVID-19 pandemic: a nationally representative cross-sectional study of UK adults. *BMJ Open* **11**, e044067 (2021).



**Figure 1.** Changes in Facebook population density in Berlin, Paris and London during the day (average Z-score,  $Z_{08}$ ) compared to pre-pandemic levels during the first period when people were required not to leave home (March-May 2020 ‘lockdown’) and during subsequent lockdowns over the study period (post September 2020 ‘lockdowns’).