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Peter Matthews, Annette Hastings & Yang Wang

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Understanding COVID-lockdowns through urban management systems: a novel application of administrative data

Peter Matthews [a], Annette Hastings [b] and Yang Wang [c]

[a]Faculty of Social Sciences, University of Stirling, Stirling, United Kingdom; [b]Urban Studies, School of Social and Political Sciences, University of Glasgow, Glasgow, United Kingdom; [c]Urban Big Data Centre, School of Social and Political Sciences, University of Glasgow, Glasgow, United Kingdom

ABSTRACT
The COVID-19 pandemic led to unprecedented 'lockdowns' and stay-at-home orders to prevent the spread of infection. Social scientists have analysed mobility during these lockdowns to understand compliance at a population-level, and whether there were systematic barriers to compliance for certain population groups. Much of this analysis has used mobility data from private companies, gathered via smartphones. In this paper, we consider an unexplored source of such data – urban management administrative data – and demonstrate its usefulness for understanding mobility, and what these patterns might reveal about socio-spatial inequality and local economic activity and suggest greater imagination when analysing such data.

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Introduction

Social scientists, data scientists and urban managers are increasingly interested in administrative, or by-product, data produced by public authorities, and the opportunities for understanding broader social problems, and potentially solving them, presented by such data. The global COVID-19 pandemic beginning in 2020 was one of the first pandemics where data from administrative processes, such as testing and hospital admissions, became public. In many jurisdictions, daily press conferences including information on infection rates and hospital admissions meant that the public became more 'data aware'. Researchers also sought to answer other questions during the pandemic, both directly related to COVID-19 infection and related public health issues, and indirectly using the affordances of the dramatically changed behaviour.

Two key themes have emerged in urban research on COVID-19. The first of these uses urban research to support public health measures by understanding their effectiveness as well as inequalities and inequities in the impact of infection (see, for example: Jay et al., 2020; Li & Huang, 2022; Mongey & Weinberg, 2020; Platt, 2021;

CONTACT Peter Matthews peter.matthews@stir.ac.uk Faculty of Social Sciences, University of Stirling, Stirling

Trasberg & Cheshire, 2021; Wright et al., 2020b; Zhou et al., 2020). Thus, early in the pandemic, it became apparent that the risk of exposure to the virus was not evenly distributed and, commonly, followed patterns of spatial economic inequality, with higher rates in infection, severe illness and death in the less affluent areas of towns and cities. Often this research was in response to immediate public health concerns about controlling outbreaks as they emerged. The second theme in the research took advantage of the dramatic changes in behaviour brought about by public health 'lockdowns', or 'shelter-in-place' orders as a type of 'extreme case' (Yin, 2003). For these studies the very specific behaviours, particularly with regard to mobility, that were allowed or not allowed under public health measures, allowed researchers to refine methodologies, or analyse data in new ways as non-observed behaviours were effectively controlled away by the enforced changes (see, for example: Aloi et al., 2020; Arellana et al., 2020; Arimura et al., 2020; Askarizad et al., 2021; Enoch et al., 2022; Fatmi, 2020; Molloy et al., 2021).

Some of this research employed what is still relatively novel data produced via smartphones, with a range of mobility indices being available from these data for researchers, and others, to use. The research we present here uses another type of novel data, data that might not, immediately, be apparently useful for understanding COVID-19: the data produced by '311'-type reporting systems to local governments (White & Trump, 2018). In this paper, we use the data from a local authority in Scotland, UK, specifically citizen reports of environmental issues such as discarded litter, dog fouling or fly-tipping. The existing research which uses such data tends to aim to ascertain two facts that are directly linked to the type of data it is. Firstly, whether such reports are an adequate proxy for the actual spatial patterning of such problems within the urban environment (O'Brien et al., 2017; Tumminelli O'Brien et al., 2015) and secondly, whether such data are an adequate proxy for the level of civic engagement within different neighbourhoods (Minkoff, 2015; White & Trump, 2018; Wu, 2020). In this paper, we suggest the data can be used in another way – as a proxy for population mobility. Working from the basic premise that, for an issue to be reported, it requires someone to be out-and-about to see the problem, and similarly many problems need similar mobility to be created (e.g. dropped litter) we analyse the frequency of reports of environmental issues in 2020 compared to 2019.

In our paper, we first summarise the research that has emerged analysing COVID infection rates, socio-economic inequalities and population mobility and how these are interconnected. We then discuss the broader challenges with analysing administrative data, and the existing research using such 311 data. We then present our data and analysis. Following the existing research focused on the COVID period, and particularly the dramatic lockdowns of 2020, we use our analysis in two ways. Firstly, what our data might tell us about the impact of the COVID pandemic and associated lockdowns in terms of revealing socio-economic inequalities. The data show that reports declined during the lockdowns, but in ways that reflect socio-economic patterns. Secondly using the 'extreme case' of the COVID lockdowns and comparing our data to other mobility data, we suggest that 311 data might be indicative of broader socio-economic trends, particularly the vitality of local neighbourhoods, as the easing of lockdown did not see an increase in reporting from commercial areas. From this we conclude that the imaginative use of administrative data, using methods available to most urban managers, particularly the sort of 311-data we analyse here, can provide urban governments with an easy-to-access source of data about wider social trends they may wish to understand.

Mobility, socio-economic and COVID policy measures

From early 2020, 'lockdowns' or 'shelter-in-place' orders became the primary public health intervention to tackle the spread of the novel SARS-Cov-2 (COVID-19) virus in cities and then nations. Understanding the impact of lockdowns on infection rates, but also other public health issues such as mental health and wellbeing and physical activity, became a key research concern (Fancourt et al., 2020a, 2020b; Trasberg & Cheshire, 2021; Zhou et al., 2020). The impact of the lockdowns as a public health measure mobility was also of broader interest beyond public health and epidemiological research. When lockdowns were first imposed, populations across the world looked at their empty roads and unused transport infrastructure in wonder (Porter, 2020; Rogers et al., 2020). In the UK for example, data from population-level surveys suggest very strong compliance with lockdown measures during the country's first national lockdown that began on 23 March 2020, when people were expected to work from home, and stay at home except for 1 hour a day for exercise or essential shopping (Fancourt et al., 2020, 2020b). These data show that, in the UK, after six weeks of lockdown, 98% of survey respondents self-reported that they followed all, or nearly all, public health restrictions (Fancourt et al., 2020b). The impact of lockdown was also seen in mobility data. By the week beginning 30 March 2020, trips by car were just 33% of their pre-pandemic peak for 2020; rail trips 6% and bus trips (outside of London) 12% (Department for Transport, 2020). Footfall data from six town centres in England suggest this fell by 68% during the lockdown period compared to before (Enoch et al., 2022). Similar changes in mobility were recorded by researchers in Switzerland (Molloy et al., 2021), Japan (Arimura et al., 2020); Spain (Aloi et al., 2020), and Colombia (Arellana et al., 2020) with data at a city-level and nation-state level. Reductions in mobility persist across different contexts, despite differing lockdown measures.

There has been research into whether public health measures were effective at protecting the population equally in terms of infection rates, death rates and poor outcomes caused by the lockdown measures themselves, both in the UK and internationally. For example, within the UK, early evidence showed a strong social gradient to adverse experiences associated with the lockdown policies – such as loss of employment; financial hardship and strain; and poor mental health and wellbeing (Li & Huang, 2022; Wright et al., 2020a, 2020b). A key issue related to which social groups were able to work from home and which were not. Many jobs could simply not be carried out from home and people remained in the workplace throughout the pandemic lockdowns – those in logistics; some manufacturing; transport; and food retail (Bowyer et al., 2021; Platt, 2021). These jobs are also often poorly paid. Early-on in the pandemic, the risk of infection in certain kinds of workplaces beyond health and social care settings was recognised, with severe outbreaks among people working in food processing plants in many countries, and a scandal in the UK with the poor working conditions in clothing manufacturing around the city of Leicester (Bland, 2020). Research into the much higher infection and death rates among black and minority ethnic (BAME) communities in the UK suggests that these were driven by occupation (taxi drivers; retail; health and social care) and then exacerbated by the greater proportion of multi-generational households within the populations (Platt, 2021). These were sectoral patterns linking employment and infection rates found globally (OECD, 2021; Song et al., 2021). Infection patterns and mobility patterns in the US, in particular, highlighted a strong socio-economic gradient, with neighbourhood poverty being associated with high infection rates as people had to go out to work during lockdowns (Jay et al., 2020).

Thus, while there has been a common assumption that the majority of people could, or did, work from home during lockdowns, data from the UK show a substantial proportion of workers had to go into their workplaces as normal. The peak of working from home in Great Britain occurred between 11 and 14 June 2020, and represented 38% of working adults. However, during the same period 29% of people were not working from home, and 21% were neither working from home nor travelling to work (Office for National Statistics, 2020b). Analysis by Dingel and Neiman (2020) suggested only 37% of jobs in the US economy could be carried out entirely at home, but that these were higher paid. They also predicted that in lower-income economies, a lower proportion of people could work from home during lockdowns. This international data on adherence to lockdown measures, reductions in reported travel, and working from home demonstrates the link between economic activity and use of transport infrastructure, and also therefore suggests a link between mobility levels during the pandemic and the ability to isolate oneself from the risk of infection.

More broadly, lockdown measures and the closure of 'non-essential' retail, leisure activities and other trip-generating activity also led to broader reductions in mobility. As described above, internationally and within the UK, 'official' Government data on mobility during the pandemic lockdowns has tended to rely on traditional methods for assessing mobility levels – passenger and vehicle counts and omnibus surveys (see, for example: Office for National Statistics, 2020a). These sources record whether people commuted to work; or travelled on a particular form of transport measured through ticketing data. These data therefore miss out the kinds of mobility which was still allowed during Covid lockdowns, such as short leisure walks in a neighbourhood or local park. As a result, while we know via these data sources that some forms of mobility decreased as result of work-from-home directives and commercial closures, these sources do not tell us about how other forms of mobility, often more local and less linked to the economy, were impacted.

However, data provided by private companies, such as Google and Apple, gathered via smartphones, has been used to understand population mobility of this kind more local kind (Pepe et al., 2020). In addition, it has been used to capture mobility at a higher geographical resolution than official transport data. This has particularly been the case in relation to the impact of COVID-19 lockdowns and both companies have made their data available for researchers for this purpose, albeit with some restrictions in access for data privacy reasons.

Mobility data harvested from smartphones rely on people acting as 'citizen sensors' and leaving a digital, spatial trace as they go about their lives (Binns et al., 2018; Raento et al., 2009). A key strength of the data is its potential coverage – smartphone penetration in markets such as the UK for example is extremely high – 91% of households in 2020 (Ofcom, 2021). However, the data also have some limitations. Thus, for both Android and iOS devices, users must agree to share their data, and many choose not to for privacy reasons (Degirmenci, 2020). With Android devices, much of the mobility data comes from specific apps which log a person's location (Binns et al., 2018). These have to be installed and have to have been used recently for them to produce a data track. However, analysis has suggested that a number of such apps were used far less during lockdown periods (Trasberg & Cheshire, 2021). On iOS devices, the data come from Apple Maps, again requiring users to use this particular app (ibid.). For these reasons, the size of the dataset available relative to population size is far smaller than one might imagine – for example, Trasberg and Cheshire (2021) could use around 42,000 records from individual smartphone users for their analysis of mobility in London during the first COVID lockdown, from a city with a population of over 8 million. This means the usefulness of such data for analysis in areas with smaller populations, or smaller administrative sub-divisions maybe limited, or involve costly and complex analysis of the datasets in secure research sites,

Without wider user data, this type of analysis can also make assumptions which may inadvertently be exclusionary. For example, to identify home location, Sinclair et al. (2022) identify the location where smartphone users remained overnight. While this may correctly identify those who work '9–5', essential workers working shift patterns may thus be excluded from this analysis, a recognised problem. Such limitations with respect to smartphone data are of particular interest for this paper. This paper is interested in socio-*spatial* dimensions of the inequality experienced in the pandemic and without access to complex data analysis in a secure location, analysis at the small area level is particularly challenging: smartphone data without such analysis will only provide a broad analysis of mobility at types of places, not at specific locations. Thus, for a local authority managing urban spaces matching smartphone data to Indices of Multiple Deprivation, that use administrative and census data to rank small area units from most to least deprived (Noble, et al. 2006), will be a particular challenge. A, further, key challenge is maintaining user privacy, as at smaller geographical scales, users become easily identifiable, a privacy concern highlighted by the media (Thompson & Warzel, 2019).

While, as discussed above, a socio-economic gradient has been seen in relation to outcomes from COVID-19, a socio-spatial gradient has not been demonstrated to the same extent. There is, for example, analysis of infection rates in the UK and US which shows significantly higher prevalence in urban and more deprived areas (Bowyer et al., 2021; Jay et al., 2020), but the mechanisms explaining this have not been fully elucidated, although Trasberg and Cheshire's (2021) analysis in London does show higher mobility in more deprived neighbourhoods throughout the pandemic. The well-reported greater negative impact of the pandemic on non-white minoritized groups has also been shown to have a spatial dimension: with greater impacts in UK neighbourhoods with a high proportion of ethnic minority residents (Platt, 2021). Further, it has been suggested that people in more deprived neighbourhoods could not 'shelter in place' to the extent that people in more affluent neighbourhoods could (Trasberg & Cheshire, 2021). The assumption has been that neighbourhoods with higher level of deprivation are home to people who worked in areas of the economy where home working was not an option, such as transport, food processing and care, that were high-risk in relation to infection, and were low-paid with few employment protections that would increase the likelihood of an infected person being able to self-isolate appropriately (Jay et al., 2020). This paper attempts to explore the validity of this assumption using a different data source.

The patterns revealed by COVID also highlight the more persistent links between mobility and economic activity. Most obviously, these relate to commuting to a place of work, such as the mobility captured in national transport statistics. Local economic development is also persistently interested in more local mobility such as footfall in retail areas and highstreets and the impact of broader changes to retailing over the past two decades (Findlay & Sparks, 2012; Jones & Livingstone, 2018; Wrigley & Dolega, 2011). As Enoch et al. (2022) show, with the closure of non-essential retail for much of the lockdown period in the UK, such mobility declined significantly recovering gradually as restrictions were lifted. The research, covering six town centres, also showed that such patterns were affected by changes not related to the pandemic and associated lockdowns, with one town centre seeing reduced footfall prior to the lockdown period because of the closure of a major department store in early 2020. Similar patterns in mobility were found tracing footfall across one urban square in Iran, with trips through to a commercial area declining significantly during lockdown, but with more people travelling to other areas to socialise outdoors (Askarizad et al., 2021). A further analytical approach used in the analysis of smartphone data is the focus on 'stops' rather than journeys through a space (Arimura et al., 2020; Sinclair et al., 2022). This is based on the assumption that people stop at a particular location if they are actively using it, or because the analysis is trying to find home locations (Sinclair et al., 2022) or workplaces. In terms of measuring footfall, or passing trade, as an indicator of high street vitality, this has the obvious drawback of removing such journeys through places from analysis. To avoid this, Enoch et al. (2022), using WiFi connection data, had to specifically focus on those who *did not* stop.

Urban design and neighbourhood management has also been interested in neighbourhood vitality, with walking and wheeling being key indicators of a 'good' neighbourhood (Lee & Moudon, 2004). Indeed, across the world, the reductions in traffic caused by the 2020 lockdowns encouraged urban managers to implement road closures, enhanced provision for pedestrians and cyclists, and low traffic neighbourhoods (Bereitschaft & Scheller, 2020; Phillips et al., 2021). 'Complete streets' that prioritised non-motorised traffic became suddenly far more popular as a policy solution as political barriers were removed. For these reasons, understanding smaller-distance, non-motorised mobility is of significant interest to urban management, as it is a broader indicator of economic and social vitality at the small-area level (Enoch et al., 2022). A challenge for urban managers is to understand such mobility without resource intensive pedestrian counts, or expensive commercial datasets. As Sinclair et al. (2022, p. 2) highlight, traditional social science methods, such as surveys cannot adequately measure such vitality as 'the broad focus and sampling strategy of survey-based techniques cannot provide the near real-time insights needed at a local level to inform management strategies'. While smartphone data might provide such insights, this requires technical and data management expertise they may not be accessible within an smaller urban management authority, and it also has the drawbacks in coverage detailed here.

In this paper, we argue that data on mobility at the small area level, beyond that captured in official transport data and via smart phone apps could, however, help answer questions related to COVID infection risk in relation to socio-spatial inequalities, **as well as** broader questions about mobility and economic activity, specifically:

- Were people who lived in deprived neighbourhoods put at greater risk of contracting COVID because they had higher mobility at different stages of the pandemic?
- What is the association between levels of mobility, economic activity and socio-spatial inequality?
- How does administrative data compare to other data sources in helping us understand mobility at a small-area level?

In the rest of this paper, we demonstrate that administrative data could be an adequate proxy to answer these questions.

Administrative data – interpretation and pitfalls

The administrative data used in this analysis is derived from citizen reports of neighbourhood environmental problems to a local authority in Scotland, UK. Such data may seem an unlikely candidate for providing a good picture of local mobility. However, while most administrative data tend to be geographically 'stuck' – a citizen either receives a service and is logged at their home address or at the location of a public service (for example, a school or a clinic) - these data capture aspects of mobility. Citizen reports of environmental and maintenance problems (for example, to clear discarded litter or dog fouling) presumes a level of mobility in a local neighbourhood, either on the part of the requester or, in some cases, the perpetrator (discussed further below). Crucially, unlike the smart phone data from private companies, these administrative data are already freely available to local councils and authorities, as the vast majority record such reports on a Customer Relationship Management (CRM) database (King & Cotterill, 2007; Offenhuber, 2015).

Data on neighbourhood problems has been widely analysed already across the social sciences (Minkoff, 2015; White & Trump, 2018; Wu, 2020; Xu & Tang, 2020; Matthews et.al. 2022). However, as mentioned, a common problem is understanding what it represents (White & Trump, 2018). For a data point to exist it requires two independent events to occur: someone to create a problem to be reported; and then a concerned citizen to come along and report the issue (Tumminelli O'Brien et al., 2015). It therefore requires that people are out-and-about and seeing issues that need reporting in their neighbourhood: that they are mobile. We therefore propose that such data can act as an effective proxy for mobility at a neighbourhood level.

Further, the extensive research from the US on what such '311' data represent also help us further interpret the data. In particular, in seeking to understand whether such data represent the extent of a problem, researchers analysing data from Boston in Massachusetts, found that residents are more likely to report issues close to their homes (O'Brien et al., 2017). Our own previous analysis of the dataset used in this paper supports the findings of the US research: a gendered analysis of the impact of neighbourhood deprivation, showed that women in more deprived neighbourhoods were more likely to report issues as part of their extended domesticity into their immediate neighbourhood (Hastings et.al. 2021). For these reasons, we can surmise that such data are likely to reflect levels of local mobility, and the gendered, socio-economic and socio-spatial aspects of such mobility.

As with the COVID-related research mentioned above, the 'extreme case' (Yin, 2003) of the behaviour changes associated with the COVID lockdowns enable us to unpack these behaviours more closely. This has been a common approach in the analysis of such data, where extreme events that produce a consistent, and rapid, change in something to report (e.g. citywide snowfall or power outages) allow researchers to specifically identify citizen reporting behaviour in terms of willingness to report these widespread issues (Levine & Gershenson, 2014; Xu & Tang, 2020). Thus, if everyone in a city or region is similarly impacted by a problem, then any differences in reporting rates are highly likely to be due to differing abilities and willingness to report issues to authorities. For our analysis, the consistency of lockdown restrictions is similar, but allows us to pinpoint the other behaviour – how much people were out-and-about and able to report and/or create problems to be reported. If people had an equal ability to shelter-in-place, then we should see a similar fall in reporting rates across a municipal area. However, with neighbourhoods in which more people were obliged to leave their homes, for example to work, higher reporting rates might be in evidence. Further, lockdown restrictions were not eased immediately, with governments developing 'road maps' for restrictions easing with key activities (such as non-essential shops reopening) resuming on specific dates (see appendix). As a result, we have observable moments when we would expect to see change in people's mobility behaviour as they were allowed to carry out activities, such as meet with other households outdoors, that had been prohibited. It should be noted that dramatic changes are required for such behaviors to be reflected in the data on reporting.

Data and methodology

Our data is derived from the CRM database of North Lanarkshire Council (hereafter NLC) in west-central Scotland. In total, the dataset includes 161,761 reports from April 2010 to July 2020. It includes reports of environmental issues in local neighborhoods such as discarded waste; fly-tipping; dog-fouling; over-flowing waste bins; and overgrown vegetation. For our analysis here, it is important to note that the data does not include reports relating to roads – such as potholes or street-lighting issues.

NLC has an estimated population of 340,000 spread across a number of large towns, with pockets of concentrated socio-economic deprivation associated with deindustrialisation, as well as more affluent areas that are suburban residential areas, including for Glasgow and Edinburgh. Its location on the trunk road network means that over the past 20 years, North Lanarkshire's economy has become increasingly dominated by employment in care, logistics and back-office functions (NOMIS, 2021). As the pandemic progressed in 2020, and the second wave of infections grew across Europe in late summer and early autumn 2020, it became apparent that NLC had factors that made it particularly high-risk for 'community' COVID-19 transmission. In July 2020, an outbreak at a call centre in North Lanarkshire used by a company with a contract to deliver the Covid 'track and trace' service for the NHS in England, made national news (B.B.C News, 2020). As the Scottish Government sought to control community transmission by progressively locking-down local authority areas, North Lanarkshire had lockdown measures re-imposed on 11 September 2020 (Scottish Government, 2020). Like neighbouring Glasgow City, North Lanarkshire spent some of the longest time periods under public health restrictions – nine months in 2020/21 – of any local authority in the UK and

Europe (McCool, 2021). Appendix 1 provides a summary timeline of public health measures in Scotland in 2020-21.

North Lanarkshire could therefore be considered a representative case *and* an extreme case (Yin, 2003). It is representative as it has an even distribution of neighbourhoods in deprivation quintiles: so we can suggest that the patterns we see in our data would be replicated across other similar areas in the Global North. It is an extreme case because it contains a substantial concentration of workplaces where people could not work from home, particularly once the most substantial restrictions had eased, and it also had high levels of community transmission of COVID throughout 2020. Therefore, we would expect to see dramatic changes in mobility quite quickly as restrictions were imposed and then eased and people were forced to change their behaviour. This would contrast with places, such as outer London, where because of employment patterns and the ability of professionals to continue working from home as restrictions eased, mobility did not change as rapidly when restrictions were eased (Trasberg & Cheshire, 2021). For these reasons, North Lanarkshire makes a good case study for understanding neighbourhood mobility and COVID-19 lockdown measures using our administrative data.

To carry out our analysis the CRM data were transferred securely from NLC to the Urban Big Data Centre (UBDC) at the University of Glasgow for analysis. The dataset contains detailed information about citizen reports of environmental issues. Crucial characteristics used to filter valid reports included the time a case was reported/logged to the system and the time the case was closed. We also cleaned the data by removing reports with invalid or unreasonable action periods, such as those reported as less than zero days and those cases longer than 365 days. Our analysis used the reported geolocation of a problem reported (either a street address or coordinates). The reports were then associated with the deprivation ranking of the neighbourhood they were in. In the Scottish Index of Multiple Deprivation these small areas are known as data zones and have an average population of 900. As datazones are based on population count, not geographical area, some are geographically very large, and others could be as small as a large block of flats or a few streets. Where reports merely had a street name, and this street covered more than one datazone, we inferred that the report was likely to be in the most densely populated datazone. Crucially, and unlike most '311' style datasets used in US-based research, we also had the address of the person who made the report. However as citizens do not need to provide an address, or live in the NLC area to report an issue, we only included reports with a home address that was in NLC, and was identified as a domestic address. This process resulted in the inclusion of 81.2% of reports from the 2010–2019 time period and 80.7% of reports from 2020.

The dataset also had additional information about the reporters. This allowed us to distinguish whether a report was made by citizens or by council staff. It also allowed us to infer the gender of citizen reporters. To do so, we predominantly used titles such as 'miss', 'mrs', 'mr'. For those reports where a title was missing, gender was assigned by matching reporters' names to the commonly used Babies' First Names index (National Record of Scotland (NRS)). These processes may have resulted in the mis-attribution of gender to people with ambiguous first names, or non-gendered titles (Dr, Prof etc.), and the exclusion of non-binary people. However, overall this matching process allowed gender to be inferred for 95% of the total reports generated by citizens.

Following researchers who used mobility patterns from mobile phones to understand the impact of the COVID lockdowns, we also used this approach to understand if our data accurately reflected mobility patterns. We relied on data from the company Huq for the period 2019 and 2020. This data tracks the location of people using Huq-affiliated apps, and due to the pandemic and the growth of the Huq, more apps were added to the collection over the period in focus. Following Trasberg and Cheshire (2021), we used data from 13 apps that had some records every month in 2019 and 2020. As with other similar datasets, the data are provided at the individual device level. We treated each device as an individual 'user'. Some users did not use the apps regularly, therefore we only selected those users with more than 50 records. This left us with 2356 unique users in NLC for the period.

Because of the issue highlighted earlier with respect to focusing on 'stops' within analysis focused on mobility, we inferred that the mobility of users is more meaningfully construed as 'trips'. We detected both trips and stops within the data using the Python Scikit-Mobility Package. This uses the settings of duration for stopping and geographical sizes of stops to segment the records into trips. With robust testing on the different combinations of stop radii (25 m, 50 m, 150 m, 250 m, 500 m, and 1000 m) and minutes at a stop (15 min, 30 min, 60 min), we report the pattern based on trips stopped within 250 m spatial radius for at least 60 min. This is likely to include many short trips, on foot, around a neighbourhood or park, although the patterns for other radius and time combinations are not substantially different.

In analysing the Huq data, we focused on walking trips for three reasons. Firstly, because there is a higher chance of people spotting an environmental issue and making a report when they walk around their home (O'Brien et al., 2017), walking trips captured by Huq data provide a better comparitor to citizen reports. Secondly, walking trips are associated with neighbourhood and high street vitality (Enoch et al., 2022). If citizens do not feel safe, or enjoy being in a place, or there are physical barriers to walking such as busy roads, then they are less likely to walk around in the location (Lee & Moudon, 2004). Finally, there is a socio-economic gradient in access to cars within Scotland – in 2016 only half of households in the most deprived 20% of neighbourhoods having access to a car, compared to 85% in the least deprived neighbourhoods (Douglas et al., 2018). Therefore, walking trips better capture inequalities in everyday mobility that may have emerged with the lockdowns. To identify walking trips, we extracted the trips with walking speed (speed≤5 km/h), while excluding those people with only one record and with a very long travel time of over 12 hours.

Following other similar analyses, we compare only data from 2019 to that of 2020, to avoid capturing confounding patterns (e.g. extreme weather events) from previous years. The final dataset after cleaning and processing is summarized in Table 1. It can be seen that the detected trips captured in the Huq data in 2020 increased by five-fold compared to 2019. Among them, walking trips increased from 17.8% to 50.49%. However, the data from the NLC CRM system show that reports of issues decreased by a third with fewer reports from the public. We explore this further below.

Table 1. Data Summary for North Lanarkshire Council and Huq 2020 and 2019 (baseline).

Time Period	Trips (Huq)	Walking trips (Huq)	Proportion Walking	NLC reports	NLC reporters
1st Jan and 31st July 2019	11919	2122	17.80%	3848	3481
1st Jan and 31st July 2020	63275	31946	50.49%	2288	2093

To understand more about trip purposes, we also transformed our Huq data to be comparable to the Google mobility indices, which the company made available for free to public health authorities to track the impact of mobility restrictions (Google Inc, 2020). To do this, we followed the method described by Aktay et al. (2020). Mann–Whitney U-Tests were used to assess whether differences in mobility were statistically significant as the distributions of the variables were not normal.

Findings

In this section, we present two sets of findings, one for each data set. Firstly, we analyse the number of valid citizen reports in the NLC urban management database over the lockdown period in 2020, compared to 2019. This is to understand how useful these data are as a proxy for general mobility over this period, and particularly socio-spatial differences in mobility. Secondly, noting that reports remained low once restrictions began to ease in summer and autumn 2020, we compare our NLC data to the Huq mobility data from smartphones. This allows us to answer our second question and suggest what *type* of mobility is captured by citizen reports compared to other data.

The impact of lockdown

Figure 1 shows citizen reports of neighbourhood problems from the NLC database across the local authority, aggregated to a weekly-basis. Not surprisingly, an immediate, dramatic decline in the number of reports to the council during the week beginning 23 March 2020, when the nationwide lockdown was implemented across the UK, is

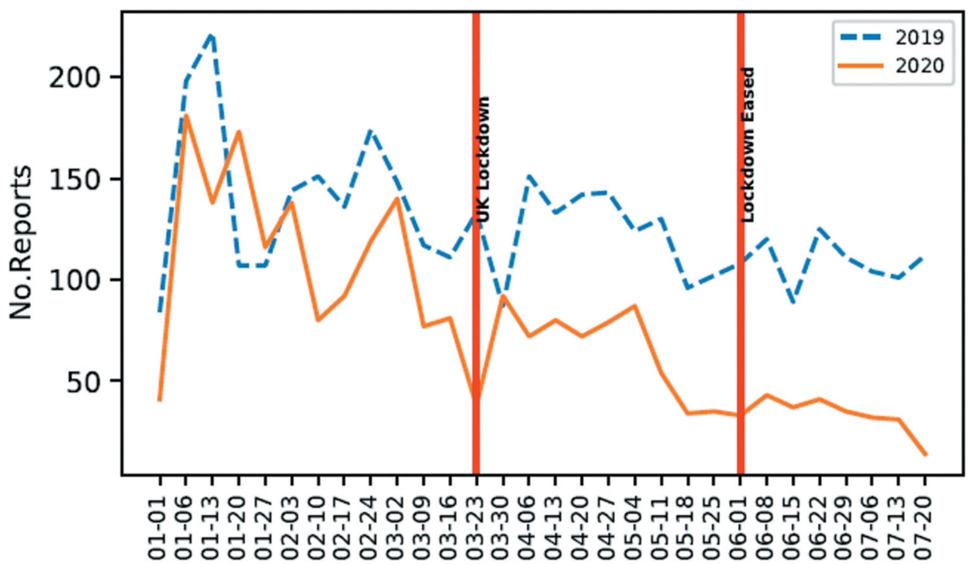

Figure 1. Total reports to North Lanarkshire Council 2019-01-01 to 2019-07-01 and 2020-01-01 to 2020-07-01.

clear. We can see that in 2019 in the week of 23 March there were around 130 of these reports, and in the same week in 2020 this reduced to around 50. This reduction is likely to be a result of: people going out less and therefore seeing fewer issues; people going out less and therefore creating fewer issues; or other changes in people's behaviours.

In the Mann-Whitney U-test, the p-value is below 0.01. This means we reject the null hypothesis that the number of reports for 2019 and 2020 are following the same distribution with more than 95% confidence.

It is also notable from Figure 1 that the decline in reporting started before lockdown. Thus while there was a similar number of reports in the week beginning 2 March in 2020 as there was in the same week in 2019, thereafter began a steady decline in reports. This may suggest that worries about infection may have curtailed movement beyond the home earlier than when the lockdown was imposed. It can also be seen that reports remain below 2019 levels for the rest of the 2020 period shown. This pattern holds for the weeks after lockdown measures began to be eased in Scotland (week including 29 May 2020).

Figure 2 reports the data just from the least advantaged neighbourhoods (Q1) and the most advantaged (Q5). On these graphs, we normalise for the population to show reports per 1,000 people in these neighbourhoods. The figures show some socio-economic inequalities. Thus, while reports from both types of neighbourhoods declined from the 9 March onwards, the decline from the most advantaged neighbourhoods began sooner, was more pronounced and indeed hit zero reports for the week of lockdown. This would appear to suggest that people in these more affluent neighbourhoods could 'shelter in place' more effectively than less advantaged people. This trend is in addition to a long term trend in the UK (and NLC specifically) of higher reporting rates in the least advantaged neighbourhoods (Matthews et al., 2022,; Hastings et.al., 2021), yet reports did decline in all neighbourhoods, however the rate of decline was different, and had different timings.

A series of Mann–Whitney U-tests comparing the weekly distribution of reports per 1000-people between Q1 and Q5 in 2019 and 2020 show the distributions in 2020 are significantly different from 2019, with a 95% confidence level (p-values were less than 0.05). Thus, our results indicate a noteworthy impact on the production of reports in the most and least deprived neighbourhoods by lockdown measures associated with the COVID-19 pandemic.

Looking at the focus of citizen reports may provide further insight into mobility and behaviour during the lockdown period. Figure 3 shows that in the period January to the end May 2020 there were fewer reports of the kind that may be produced by people being out-and-about: namely, street not clean; dog fouling; waste removal. However, the same period in 2020 did produce more reports of dumped refuse and requesting to empty the bins. By way of explanation, household waste recycling centres (where households could bring larger items for disposal), were closed in Scotland between 23 March and 1 June. There were anecdotal reports in the media at this time of increased fly-tipping, supported by increased reports to relevant authorities, as people sought to dispose of waste and could not access municipal waste site, and our data reflect this (Chapman & Bomford, 2020).

In relation to mobility, these data also provide an insight into changes in distance travelled within neighbourhoods between the two years. By measuring change in the distance between the reporter's address and the location of the report a proxy measure of the impact of lockdown on the extent of local, neighbourhood mobility can be derived.

Figure 2. Total reports to North Lanarkshire Council in the most deprived quintile of neighbourhood (Q1) and least-deprived quintile of neighbourhoods (Q5), 2019-01-01 to 2019-07-01 and 2020-01-01 to 2020-07-01.

Figures 4a–4c thus suggest that, although fewer reports overall were made, people living in the most advantaged neighbourhoods (Q4 and Q5) reported environmental problems further from their homes in 2020 compared to 2019. This was not the case for people living in more deprived areas – suggesting that people in more affluent areas may have travelled further in their limited time outdoors. Figure 4b also suggests a gendered aspect to this, with similar patterns to men and women’s mobility in the least advantaged

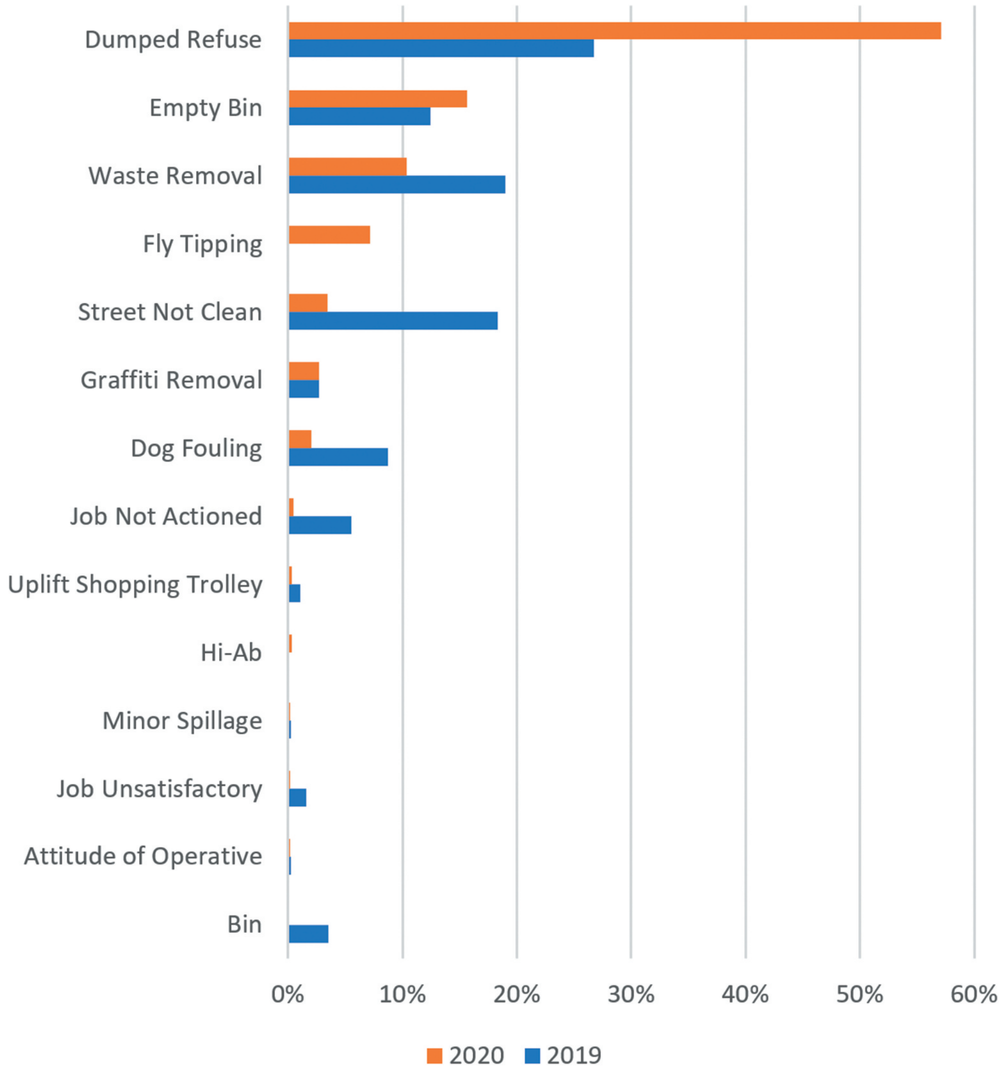

Figure 3. Proportions of different types of reports to North Lanarkshire Council 2019-01-01 to 2019-07-01 and 2020-01-01 to 2020-07-01.

neighbourhoods (Q1) yet an increase in distance between home and address for men in the most advantaged neighbourhoods (Q5).Median distance between home address and report location in neighbourhood deprivation quintiles (Q1 most deprived; Q5 least deprived) to North Lanarkshire Council 2019-01-01 to 2019-07-01 and 2020-01-01 to 2020-07-01.Median distance between home address and report location in neighbourhood deprivation quintiles (Q1 most deprived; Q5 least deprived) by women to North Lanarkshire Council 2019-01-01 to 2019-07-01 and 2020-01-01 to 2020-07-01.Median distance between home address and report location in neighbourhood deprivation quintiles (Q1 most deprived; Q5 least deprived) by men to North Lanarkshire Council 2019-01-01 to 2019-07-01 and 2020-01-01 to 2020-07-01.

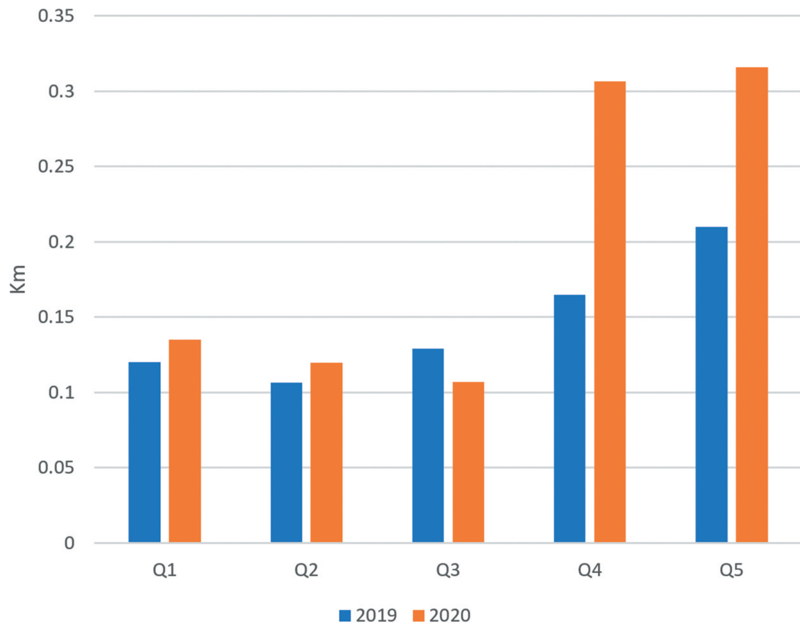

Figure 4a. Median distance between home address and report location in neighbourhood deprivation quintiles (Q1 most deprived; Q5 least deprived) to North Lanarkshire Council 2019-01-01 to 2019-07-01 and 2020-01-01 to 2020-07-01.

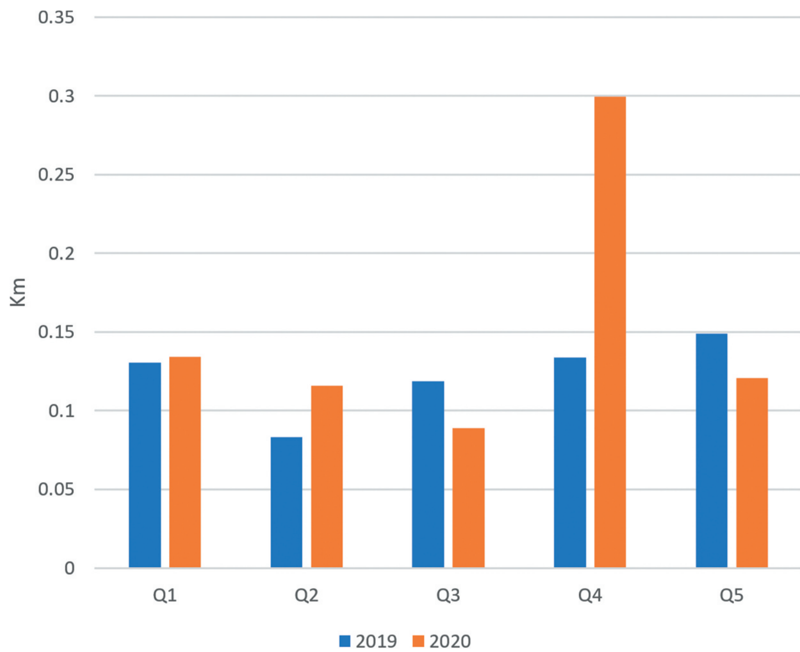

Figure 4b. Median distance between home address and report location in neighbourhood deprivation quintiles (Q1 most deprived; Q5 least deprived) by women to North Lanarkshire Council 2019-01-01 to 2019-07-01 and 2020-01-01 to 2020-07-01.

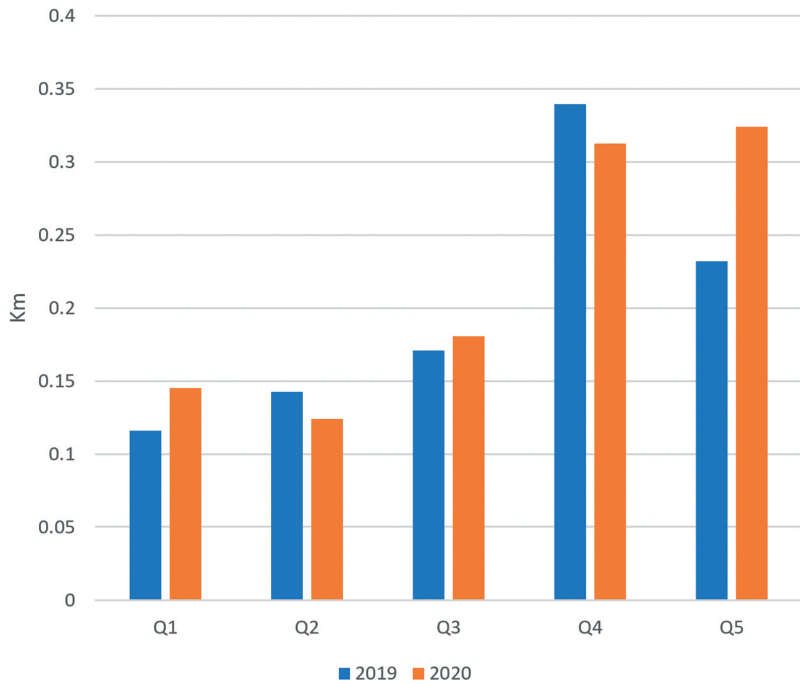

Figure 4c. Median distance between home address and report location in neighbourhood deprivation quintiles (Q1 most deprived; Q5 least deprived) by men to North Lanarkshire Council 2019-01-01 to 2019-07-01 and 2020-01-01 to 2020-07-01.

In summary, our data reflect many of the same patterns that we see in broader literature on COVID-19 and mobilities. Those residents in NLC who lived in the most deprived neighbourhoods, and thus were more likely to be working in occupations where they could not work from home easily, reported more environmental problems just before lockdown and during lockdown than their more affluent counterparts did. And their reporting rate increased sooner than it did in the least-deprived neighbourhoods. This does suggest that reporting rates for neighbourhood environmental issues are a good proxy for broader mobility trends. The one finding that does not align with this is our analysis of the proxy of distance travelled measured as the distance between the reported issue and the reporters home address, with men in less-deprived neighbourhoods seemingly travelling further. However, this does not negate the overall pattern of socio-spatial distribution (there are still fewer reports from less deprived neighbourhoods) and this may reflect the ability of this group to travel further by car during their limited allowed time outdoors, more rural or suburban housing locations, or even leisure activities such long-distance cycling.

We now turn to analyse trends in reporting as lockdown restrictions eased after June 2020 and compare the trend in our data from the NLC database to the mobility dataset from Huq.

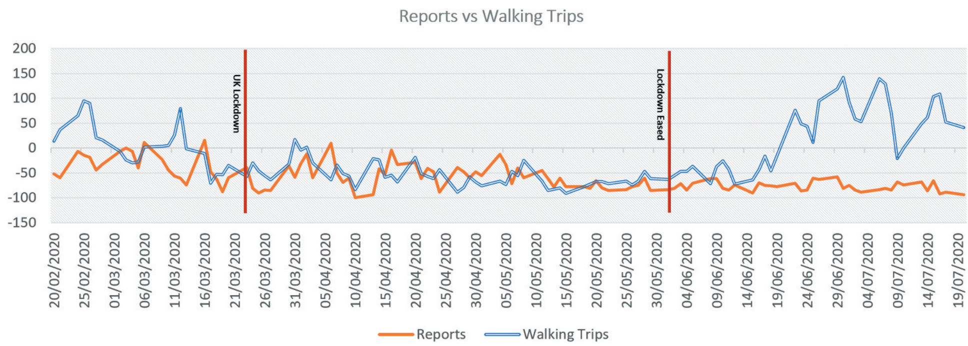

Figure 5. Percentage change in reports to North Lanarkshire Council compared to walking trips detected in Huq data, 2020-02-20 to 2020-07-19.

Comparing reports with Huq data after lockdown

For this analysis, we compare our citizen reporting data with that produced by the company Huq. Figure 5 compares our report data (orange line) with Huq data estimating walking trips (blue line). This figure would seemingly counter our hypothesis that report data is a proxy for mobility: while the Huq data show that walking trips increased dramatically when restrictions begin to ease in June 2020, the citizen reporting data showed no such increase. To understand this, we need also to note that the restrictions eased in June 2020 were just those which were the most severe. From June 2020 people were now allowed out of their houses more than once a day, and for any length of time, but other restrictions remained in place. The Huq data suggest people took advantage of this easing and took additional walking trips. Further, as restrictions were eased social meetings outdoors were also allowed. Mann–Whitney U-tests show that this difference is statistically different.

Figure 6 adds in Huq data on trips to retail and recreation locations and workplaces. This suggests that, although walking trips did increase substantially following the easing of lockdown restrictions, mobility associated with economic activity – commuting to a workplace or going shopping on a local high street – increased only marginally. Rather, people were enjoying more leisure trips with their freedoms. Trips associated with economic activity that might lead to reports could be, for example: someone walking to a train station for their regular commute and reporting overgrown bushes that block a path; or someone walking to their local high street, purchasing some food, and then discarding the packaging on the street as they continue their journey. We can surmise from the comparison of our data, that it was these sorts of trips that remained at a lower level in the latter part of 2020.

Discussion and conclusion

As we have outlined, the lockdowns in 2020 associated with the novel COVID-19 pandemic have provided a lot of interest for social scientists, both in understanding their impact, but also using this situation as a 'extreme case' of a change in social behaviour. In the analysis, we

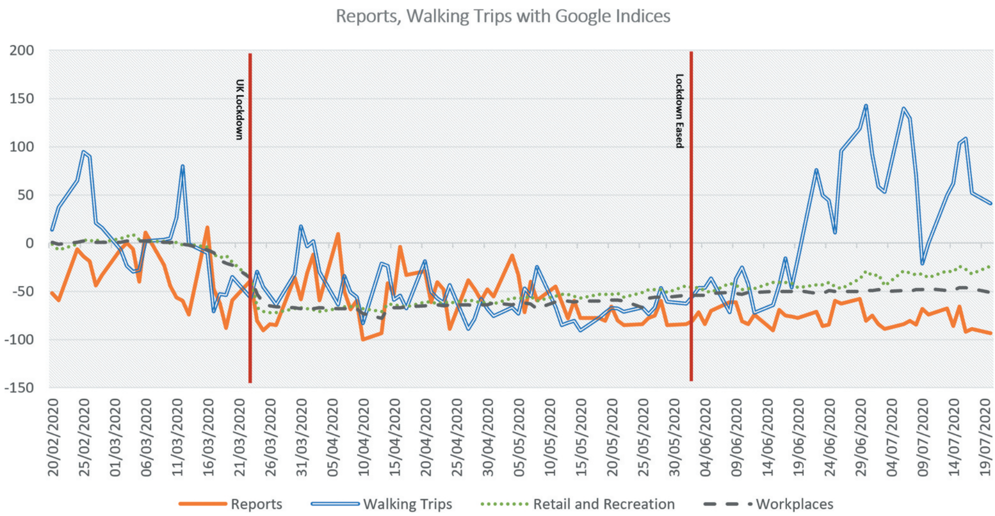

Figure 6. Percentage change in reports to North Lanarkshire Council compared to walking trips detected in Huq data and destination of Huq trips as identified through Google Mobility Indices, 2020-02-20 to 2020-07-19.

have presented here, we suggest that this extreme case shows how '311'-type data can be used in two ways as a proxy for broader mobility. Firstly, in the initial lockdown, the data were a good indicator of how much people were out-and-about in neighbourhoods and their ability to follow public health measures to reduce community transmission of COVID. However, the utility of such analysis should, hopefully, be fairly limited. None of us want to return to a dangerous pandemic situation where lockdowns are a necessary public health measure and monitoring how equally they can be adhered to is a question we want to answer.

Secondly, this analysis also highlights the longer-term inequalities in environmental outcomes in more deprived neighbourhoods in the UK and associated reporting rates, which suggest greater unhappiness with local environments in these neighbourhoods (Matthews et al., 2022; Hastings et.al. 2021) There is evidence that, because of lower car-ownership, the residents of deprived neighbourhoods, and particular women who are parents of children, are much more likely to walk around their neighbourhood to access services (Criado Perez, 2020). Therefore, the fact that reporting rates are higher in deprived neighbourhoods, even with the lockdown being imposed and many local trips being curtailed, should be of concern to urban managers – this suggests when people are out-and-about even on a limited basis in these neighbourhoods *and* they are unhappy with aspects of the environment that are outside of their control. Such feelings of resentment towards your local environment, and complaints about issues that can seem trivial like dog fouling, have been suggested as being linked to wider feelings of not being in control of aspects of your life (Derges et al., 2012).

Finally, looking beyond the lockdown period, our analysis suggests a broader use for analysis of such data as a proxy measure for other types of mobility associated with neighbourhood vitality and economic activity. Our analysis suggests 311-type data may be a good, proxy measure for such mobility, that is easily accessible to urban managers. A service manager may see a substantial and unexpected decline in reports about local environmental problems and view this as a positive outcome iof an improvement in local environmental quality. However, our analysis suggests caution at such an interpretation. The link between economic activity and reports that our analysis reveals, would suggest that inspection, or local knowledge from operatives on the ground, needs to be used to interpret changes in reporting rates. A sudden decline in the number of reports could be a product of a sudden decline in retail on a high street or a decline in neighbourhood environmental quality leading to people avoiding an area or preferring to remain in their own homes and gardens. The international evidence on mobility during COVID, and the reductions in mobility in commercial areas, supports this interpretation further (Arimura et al., 2020; Askarizad et al., 2021; Enoch et al., 2022) Thus, such report data could be a 'canary in the coalmine' indicator for wider urban management issues.

While commercial data sources, such as those from Huq, have benefits in terms of their breadth of coverage and how this reflects the wider population (Sinclair et al., 2022), they are commercial products that come with a financial cost. They also require advanced data processing skills to analyse and produce results, particularly while maintaining data privacy. Finally, some of the assumptions that need to be made to use the data, as they do not come with complete user demographic indexing, can lead to particular groups being excluded from analysis (ibid.). In comparison, data relating to citizen reports is more readily available (King & Cotterill, 2007) and can be analysed more easily. These urban management systems often contain demographic and locational information about reporters. As we suggest here, such data seem to be a useful proxy for analysing patterns of mobility. Rather than seeing such data as evidence of a problem: urban mismanagement or issues to be dealt with; it can be reframed as evidence of a benefit: the active use of space for socio-economic reasons. A simple test for statistical significance. Because of this, we would also advocate for greater imagination when using administrative data. The promise of 'big data' and the use of administrative data in urban management has been complicated by the nature of the data – it is not collected for social science purposes with known and unknown biases (Kitchin et al., 2015; Kitchin, 2014). We would suggest that our analysis here shows that, combined with local knowledge, such data could be applied to a wider range of administrative data and questions of interest to urban managers. With some '311' services providing their data open-acess, such an analysis could also be the product of citizen-initiated co-production (Bovaird et al., 2015; O'Brien et al., 2017)

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ORCID

Peter Matthews http://orcid.org/0000-0003-2014-1241
Annette Hastings http://orcid.org/0000-0001-9174-0677

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APPENDIX

Key dates of lockdown and easing of lockdown within Scotland (SPICE, n.d.)

Date	Measures in place
23 March 2020	Full lockdown. Non-essential businesses and schools closed. Working from home recommended. People allowed out of their homes for one hour a day for exercise or essential shopping. Five-mile limit on non-essential journeys.
27 March 2020	Prime Minister Boris Johnston tests positive for COVID-19
11 May 2020	People can go outside more than once a day
29 May 2020	People can go outside for an unlimited period of time and meet-up with up-to eight people from two households outdoors, while remaining two-metres distant. People strongly encouraged to stay close to their homes. Garden centres reopen.
1 June 2020	Household recycling and waste sites reopen across Scotland
29 June 2020	Non-essential retail reopens
15 July 2020	Hairdressers, restaurants, pubs etc. open with some restrictions