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Dog fouling and potholes: understanding the role of coproducing 'citizen sensors' in local governance

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ABSTRACT

Local governments around the world are increasingly coproducing services with citizens, commonly as a response to austerity. A common approach is to use 'citizen sensors', relying on citizens to report issues digitally through web portals or apps. There is mixed evidence about how different citizens act in different environments with concerns about resulting (in)equity in outcomes. This paper examines citizen-reporting of maintenance of the public realm through a UK digital platform (FixMyStreet.com). We find service requests follow a parabolic relationship between neighbourhood deprivation levels and reporting, but ignoring the contributions of 'superusers' there is a more linear relationship, with more reports in less-deprived areas. We find that the presence of significant infrastructure (transport, schools) leads to more reports, suggesting guardianship over journeys as well as residential neighbourhoods. We conclude that local government, when directly coproducing services with citizens, need to be careful to ensure equitable outcomes between neighbourhoods.

Keywords 311; neighbourhood management; inequalities; citizen reporting

Introduction

As widely discussed across literatures in public administration, public management and political science, coproduction, in a variety of forms, has become a more common way of delivering public services over the past two decades (Bovaird, 2008; Bovaird et al. 2015; Needham 2008; Whitaker 1980). A driver for this is to deepen deliberative democracy, but a more practical reason is to use citizen knowledge to better target the increasingly limited resources of governments (Bailey, Bramley, and Hastings 2015; Bovaird et al. 2015). A widely researched example of coproduction in local government is encouraging citizens to make direct requests for a range of services and repairs and improvements to the public realm. Which citizens

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make these requests, and how often, will affect the distribution of resources and neighbourhood quality. Reporting issues such as cleanliness, upkeep and maintenance of public areas are commonly referred to in North America as '311' services (Clark et al. 2020; O'Brien 2017; Offenhuber 2015). These can be reported via telephone, web portals and mobile phone apps channelled through Customer Relationship Management databases. Aggregated, the data from these requests can be used to explore citizen demands for place-keeping – the management and maintenance of the local environment (Dempsey et al. 2011, 2011). Local governments may perceive of such data as an accurate report of problems requiring services. However, this presupposes all citizens are equally able and willing to report such issues – an empirical question to which there are varying answers.

The complex and varying relationship between citizen contact and measures of socio-economic status has been well established in 311 studies from North America (Clark et al. 2020; White and Trump 2018;). In this paper, we report on analysis of data from FixMyStreet.com (FMS) from across the UK. FMS allows citizens to report problems through an online portal that sends the report to the appropriate local authority. This can be done via a smartphone, tablet, or personal computer through a crowdsourcing platform. This kind of citizen reporting via technology is part of a wider suite of 'smart city' tools, which use reported and automated data collection to improve the efficiency of service and asset management in a city (Meijer 2011; Norris and Reddick 2013).

The data from FixMyStreet is quite different from that contained in many 311 analyses. Firstly, 311 analyses commonly cover a single urban area (for example: Xu and Tang 2020 in Tallahassee, FL; O'Brien et al. 2017 in Boston, MA), whereas FixMyStreet data have coverage nationwide, in varied urban and rural areas. 311 analyses also often rely on a subset of types of citizen reports, whereas we look at all reports. FixMyStreet data can also help us understand whether people are motivated to mainly report issues in residential areas where they may live, or whether altruistic guardianship of areas can be detected for places that are not a 'home', such as transport infrastructure. The richness of our data thus allows us to interrogate further whether the coproduction of place-keeping services through direct citizen reporting may drive inequalities in outcomes through a number of under-examined routes.

This paper uses FMS reports from between 2011 and 2015 to explore how access factors (broadband and mobile connectivity), geographic and infrastructure factors (presence of schools, companies and train stations) and socio-economic factors (measures of neighbourhood deprivation) relate to the number of reports from neighbourhoods. As with other analysis, we find a parabolic relationship between socio-economic status and volume of reports, but also find that this effect is modified by the presence of superusers in areas of higher deprivation. However, this relationship differs for types of issues

reported, with a direct relationship between lower deprivation and higher reporting of road defects, and an inverse relationship with lower reporting for environmental problems (dog fouling and littering). We also find that, while rural use of FMS is in the minority, this usage demonstrates how online services can solve different problems in different contexts. Taken together, we suggest there are risks that direct coproduction of place-keeping services by local government could lead to worsening outcomes for more deprived neighbourhoods. This suggests local governments need to be critical and analytical in their use of such data, and in-line with previous research on place-keeping (Hastings 2007) maintain investment in planned services to maintain neighbourhood quality.

Citizen sensors and local service provision

Place-keeping services are a core activity for local government. In the UK and globally, such services are at the forefront of changes in local administration. In the short term, services are being transformed as a consequence of 'efficiencies' and austerity cuts: service redesigns and staff reductions; cuts in service levels; facilities closed or merged; contracting-out (APSE 2017; Hastings et al. 2017). Within England, Gray and Barford (2018) estimated that central government funding to local government had reduced by 23.7% over 2009–2017. Further, it was local authorities with the highest proportion of deprived neighbourhoods that were hit hardest by the cuts (Hastings et al. 2017). As spending for statutory services has been protected, cuts to placekeeping services amounted to £2 billions between 2009 and 2017 (Gray and Barford 2018; Eckersley and Tobin 2019). These budget cuts have led to the exploration of new (and cheaper) ways of delivering services.

Coproduction can be seen as a spectrum of approaches where citizen knowledge is brought together with service expertise to deliver greater efficiency (Needham 2008; Alford 2002; Bovaird 2007; Offenhuber 2015; Osborne 2018). The spectrum of approaches ranges from long-term, in-depth collaboration with citizens groups where they are empowered to deliver for their community with the state, to one-way reporting by a citizen to a government to report a problem which requires a service response (Bovaird et al. 2015). For placekeeping services, this might mean participation in strategic and operational planning, such as highlighting local problems; the delivery of service, such as community litter-picks; or particularised contacting (Cantijoch, Galandini, and Gibson 2016) – making use of citizens acting as sensors reporting individual problems (Offenhuber 2015; O'Brien, 2016) or apps such as FixMyStreet (Sjoberg, Mellon, and Peixoto 2017; Offenhuber 2015). Citizen reporting is especially useful for reports that are a matter of human perception, such as perceived safety (Sepasgozar et al. 2019). The data recorded from such service interactions provide new ways

to understand either environmental quality or levels of citizen engagement with services.

Citizen demand for placekeeping can be rooted in private or collective motivations, and will have both private and public benefits (Schmidthuber et al. 2017). Cantijoch, Galandini, and Gibson (2016, 1898) argue that ‘particularised contacting’ has been seen as less meaningful engagement than voting and communal activity as it is ‘driven primarily by private instrumental interests and did not seek to address broad and collective policy issues’. While place-keeping will reflect individual concerns, their resolution can have collective benefits. The pothole in the road outside someone’s home is both of concern to them, but of general concern to all users of that road; dog fouling in a park may be of concern to the citizen who steps in it, but improving the quality of public places will benefit the community. Research from the Austrian city of Lintz found motivations for reporting driven by this concern for collective benefits (Schmidthuber et al. 2017).

Requests for services are also subject to feedback loops between citizens and service providers. Hastings (2009a), Hasting (2009b) found expectations of citizens and service providers interact, where less responsive services lead to fewer requests for services by citizens. This in turn suggests that residents of an area are more likely to discard litter, or take less pride in their neighbourhood, justifying differences in service levels. Similarly, Schmidthuber et al. (2017) found that previous experience of reporting issues to city authorities in Lintz was a motivator for citizens reporting through a new online platform. Michener (2013) found evidence of neighbourhood effects aligned to the ‘broken-windows’ thesis, that when a particular threshold of neighbourhood environmental disorder is reached citizens stop engaging as they feel overwhelmed by the sheer volume of problems. In the opposite direction, areas with greater political resources may be able to lobby for better service, improving the environment and creating an expectation of successful response to service requests (Hastings et al. 2014). More directly, the responsiveness of authorities affects the behaviour of citizens, with Sjoberg, Mellon, and Peixoto (2017) finding that swift resolution of problems led to greater likelihood of producing future reports. This suggests the level of participation from individual citizens is not fixed but shaped by contextual factors (Przebylłowicz et al. 2022).

Online reporting services: FixMyStreet and 311

In the US, 311 services began in Baltimore in 1996 as a reaction to the large number of non-emergency calls going to the 911 system (Clark, Brudney, and Jang 2013). After this success, it was promoted by the Clinton administration to improve local government performance and taken up by various local governments in the USA to access government services. While primarily a

telephone service, websites and smartphone apps now offer alternative reporting channels. The term '311' has become a generalised global label for this kind of reporting service.

As noted, FMS (Figure 1) is both a product that local governments in the UK can use as a 311 portal, and also a charitable service that refers reports to local authorities via email. The website provides a simple-to-use interface to report problems in a user's local area (identified by their postcode/zipcode). Reports are then channelled to the relevant local authority via email, or through integration with internal systems. The software is available as open-source and there are 20 instances running outside the UK. Since its launch in 2007, FMS has processed over a million problem reports across the UK, so it provides a large, national dataset of where problems are being reported.

The format of FMS data and 311 data is very similar, but differences in its generation mean they need to be interpreted differently. Both datasets detail the reported problem, location and when reported, but 311 data sometimes have detail about the reporter not captured in FMS. FMS covers multiple authorities, and so category names differ between areas. As a voluntary system, FMS reports will also only be a partial picture of issue reporting, as many of which will go directly to the authority. As FMS is used as an official reporting system, this makes comparisons between areas more difficult as this represents more official engagement than voluntary citizen engagement. Further, duplicate reports are ideally reduced in FMS by people being aware of others already having reported the same issue as all reports are public, whereas duplicate reports in a 311 dataset indicate how visible a problem may be.



Figure 1. Screenshot of FMS interface.

Disentangling reports of problems, the *actual* problems and equity

A key challenge in analysing equity and coproduction via direct citizen reporting is disentangling attributes that make someone more likely to report an issue, and 'neighbourhood' effects that make it more likely that issues will be present (Hastings 2009a; White and Trump 2018). The socio-economic status (SES) of citizens is related to both incidence of problems in their area *and* reporting rates. Nearly 40 years ago, Hero (1986) synthesised this literature suggesting there was a parabolic relationship between contacting and SES being driven by two different factors: awareness of the ability to contact (which increases with SES), and need to contact (which decreases with SES) giving a peak of contacting in the middle. A 'median' contactor lives in an area with problems, but expects these problems can be fixed by contacting government. This means that two factors drive reports: the instances of problems, and the likelihood of citizens reporting these problems. These effects are difficult to identify from the administrative data alone. Researchers have attempted to overcome this through analysing subsets of the data or collecting additional data for comparison (O'Brien). While this may seem to be a social science methodology problem, the parabolic relationship also points to equity issues in resource distribution if local governments rely on reports to target services. If there are a lower number of reports from deprived neighbourhoods with greatest service need due to structural issues (Hastings 2009a), and a higher number of reports from neighbourhoods with fewer problems, and reactive services flow from these requests, then inequalities in environmental outcomes will be exacerbated. Ultimately, this could lead to citizens to disengage from reporting the state entirely, if they feel local problems are too great to overcome (Michener 2013).

One way to understand the relationship between reporting and neighbourhood or individual characteristics is to analyse reports when there is a uniform problem, such as snowfall or storm damage. As snowfall is evenly distributed across a city, this creates an even demand for snow-clearance, allowing uneven use to be examined. Researchers thus checked 22 other services and found that 'unlike snow removal, the initial distribution of need for these other services is likely endogenous to the city's unique geography and neighbourhood-level demographics' (Levine and Gershenson 2014a, 616). Xu and Tang (2020) used a similar approach to understand the impact of smartphone app-based reporting of power cuts following a hurricane in Tallahassee, FL, finding that app use resulted in faster reporting and quicker response time in poorer neighbourhoods. White and Trump (2018, 14) argue that experimental design to control for one effect can be 'inventive and interesting, but in many potential research designs involving 311 data, they may be infeasible and/or inapplicable'.

Additional data can be used to validate or enrich data collected through 311 systems. White and Trump (2018) argue that creating a direct measure of need is the best approach to exploring citizen engagement with reporting data, thus O'Brien, Sampson, and Winship (2015b, 41) used an audit of street light problems alongside 311 data. A similar approach can be explored with third-party surveys of issues. In England, the Keep Britain Tidy neighbourhood survey found a higher incidence of dog fouling in more deprived neighbourhoods; however, FMS data show a peak of reporting in the middle of the scale, with declining reports of dog fouling in more deprived areas (Parsons 2017). O'Brien (2016: 91) separately used a survey to investigate the motivations behind reports in Boston, MA, and found 'clear specialization by individuals in reporting either issues arising from natural deterioration or incivilities', findings supported by research by Schmidhuber et al. (2017) in Austria.

Data are generated by users, not geography

Previous analysis of FMS users show they are not representative of the wider population, and this affects the kind of data that is produced. A 2016 survey showed that users were older and more likely to be male than the population at large. Cantijoch, Galandini, and Gibson (2016) found the user base was 64.4% male, with a mean age of 55 and ethnic minorities were under-represented, representing 2% as opposed to 14% of the UK population. Some of this difference is due to the voluntary nature of FMS. When FMS is used by a local authority as its CRM system, 42% of reports were made by women versus 28% on FixMyStreet.com (Parsons 2019). This unevenness is significant because it affects the kinds of problems that are reported and where they live. Solymosi, Bowers, and Fujiyama (2017) found that different categories of reports were more likely to be reported by men and women (with a rough division between problems noticed while driving as opposed to while walking) and Hastings, Matthews, and Wang (2021) found that reports are more likely to be from women who live in deprived neighbourhoods. This suggests that FMS and 311 reports should be seen as 'bundles' of related services, with different drivers of reporting (Parsons 2019b). Where different groups have different needs but have different rates of reporting, this affects which problems are addressed, and in-turn the provisioning of services.

Evidence from 311 studies suggest existing resources and relationships to the state also affect reports. Feigenbaum and Hall (2015) found in Boston that a 10% increase in per-capita income predicts a 3% increase in the number of requests for snow removal and 'higher income areas are more likely to place requests using the city's smartphone app'. White and Trump (2018) sound a note of caution, finding 'the relationship between income/poverty and 311 calls can look dramatically different depending on which time period the

researcher chooses to aggregate calls over' suggesting poverty rates and household incomes should not be taken as a proxy for the need for services. Levine and Gershenson (2014a) and Pak, Chua, and Vande Moere (2017) both note differences in participation levels between ethnic groups and between first-generation migrants and others. There is evidence that newer technologies, particularly smartphones, are a mediating factor here. Xu and Tang (2020) suggest that services accessible through a mobile phone can help close distributional inequality in public service provision and overcome some of these barriers and Young (2021, 13) found that reports made through an Open311 app were resolved faster on average than those made by telephone, People's interactions with the state are part of feedback loops which lead some to not engage, and others to engage far more than average. This is supported by Schmidhuber et al. (2017) who, applying the technology acceptance model, found that although new technologies could encourage new people to report, it was previous experience of reporting that more strongly predicted reporting on new platforms.

Where a subset of users engage far more than others, this may also affect the impact of the service. Recognition of such 'superusers' or 'super-engagers' with the local state has been widely acknowledged in a broad range of literature on coproduction in public services (Naff 2009; Hastings, Matthews, and Wang 2021). For example Bang and Eva (1999) identified 'everyday makers' who work to improve neighbourhoods and communities. A wider literature has identified a gendered aspect to this, with women often extended their domestic guardianship out to the wider neighbourhood (Grimshaw 2011; Hastings, Matthews, and Wang 2021). As Haklay (2016, 42) argues '[t]he specific background and interests of high contributors will, by necessity, impact on the type of data that is recorded', and in the case of requests for public services, this could bias the distribution of those public services in their favour (Matthews and Hastings 2013). However, this does not necessarily produce socio-economic inequalities in patterns of reporting, with Hastings, Matthews, and Wang (2021) finding that women 'superusers' in more deprived neighbourhoods (reporting issues over 100 times in a year) mediating the impact of men reporting more in less-deprived neighbourhoods. User activity on FixMyStreet is similar to other prominent online services in that most reports are created by a small number of the total users, 10% of users account for over 60% of reports (Parsons 2019a).

Barriers to access and the smart countryside

Online forms of 311 have the potential to improve services but also present new barriers to access. Improving the efficiency of the information gathering process can improve the level of service (Clark et al. 2020; Schmidhuber et al. 2017; Wu 2020; Xu and Tang 2020). The internet can lower the costs of

engagement, but these reduced costs might reinforce existing participation divides (Bimber 2001). Internet use had reached 78% of the UK population by the midpoint of our data's range in 2013 (Dutton, Blank, and Groselj 2013, 12), but less internet use is associated with other social or individual factors. Existing 311 studies that have considered the impact of new web-based services (open government platforms; smartphone apps) have tended to consider urban areas (Schmidhuber et al. 2017; Xu and Tang 2020). While the initial digital divide was solely related to factors of access like geography and socio-economic status, as access has become easier it has become clearer that participation is also moderated by cultural factors, where use or non-use is affected by perceived utility, and intermediaries may be available to gain some of the benefits of participation (Scheufele and Nisbet 2002; Dutton, Blank, and Groselj 2013; Schmidhuber et al. 2017). These cultural factors interweave with factors like age, and geography, complicating the question of who can easily access internet resources. The nationwide coverage of the FMS dataset allows us to answer some of these questions, particularly whether poorer internet access in rural areas may make it more difficult for citizens to access web-based public services.

There are potentials for unique benefits from technology in rural areas. Online citizen reporting is often described as a component of 'smart cities', which aim to use technology to increase the efficiency of urban life. A British Standards Institute (2014) report positions smart cities as a solution to problems of urbanism, and defines a smart city as the 'effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens' (British Standards Institute 2014). Nothing in this description could not also apply to programmes and technologies deployed in rural areas, and the citizen-centred approaches described by Sepasgozar et al. (2019) can equally be applied to rural areas. Ashmore, Farrington, and Skerratt (2015, 276) argue that rural broadband can increase rural citizens 'control over everyday activities', and improved speed leads to greater reliability and resilience for personal and business decisions. Parker (2000) argues internet access in rural areas has a greater payoff than in urban areas as rural areas benefit less from the inherent network and amalgamation effects generated in dense urban environments. Digital technologies can bring some of the benefits of the urban environment to less physically connected businesses and places, with the significant limitation of needing to increase skills in the population.

It is important to recognise that rural local authorities have different needs and demographics to urban authorities, and this affects the applicability of solutions developed for cities. Finland has explored 'Smart Countryside' approaches, narrowing in on the importance of familiarising 'people with digital tools and [investing] in building the capacity and willingness of people to use digital services' (ENRD 2018). The presence of good infrastructure

(while important) is not sufficient and the researchers found areas with good infrastructure but ‘no solutions for products or services that would be built on this infrastructure’. Rural areas in the UK have, on average, a population that is older, less wealthy and less well educated than urban areas, all of which are factors that lead to different profiles of internet use. Thus, Blank et.al. (2018) suggest studies highlighting the lack of broadband use in rural areas treat rurality as independent, when it is highly related to these other factors. As demographic characteristics are unevenly spatially distributed, what appear to be regional factors might in reality be demographic ones. For digital services that operate in both urban and rural areas, differences in use may result from different kinds of users as well as different access to online infrastructure.

The overwhelming proportion (80%) of FMS users are in urban areas, but in rural areas there are slightly more reports as a proportion of the population. Table 1 shows that 20% of reports in England and Wales (2011–2015) are made in rural areas, while only containing 18% of the population. This is especially noticeable in rural villages who make up 11% of reports from 7% of the population. While containing a minority of the country, they contain most of the physical area – and so of equal population areas in rural and urban areas, the rural area will be physically far larger. Alternatively, this difference could result from different effectiveness of engagement feedback loops, where more affluent rural authorities have seen their funding decline far less than urban authorities (Hastings et al. 2017), and so may have more capacity to respond to reported issues. The environment is also different, and there are different needs linked to the local built environment (Keep Britain Tidy 2015; O’Brien, Sampson, and Winship 2015b). For example, densely populated areas and high streets have greater littering and place-keeping issues; and peripheral neighbourhoods with large open-spaces are difficult to manage (Hastings 2007). Thus, rural areas possibly represent not just a minority use of FMS but a distinct use.

Table 1. Urban–Rural classification.

Rural–urban classification	Proportion of FMS reports	Proportion of population (2015)
Urban major conurbation	37%	34%
Urban minor conurbation	3%	3%
Urban city and town	40%	45%
Urban city and town in a sparse setting	0.20%	0.20%
Rural town and fringe	8%	9%
Rural town and fringe in a sparse setting	0%	1%
Rural village and dispersed	11%	7%
Rural village and dispersed in a sparse setting	1%	1%

Research questions

Existing research on coproduction via 311 services has variously found a complex and contradictory story about how this is linked to (in)equity in outcomes in terms of place-keeping. Our data does not allow us to link reporting to outcomes, however the UK-wide scope of our data allows us to understand differences in reporting rates in a UK context, and to understand the impact of a wider range of geographies than much of the existing 311 research. Our analysis investigated four main questions examining platform effects; rural/urban distinctions; the effects of multiple deprivation; and the impact of built infrastructure in driving reports. Intersecting these areas of concern is a common question of whether factors should be understood as relating to the *entirety of services reported*, or if effects are more limited to the *type of issue* being reported. This produces our four research questions:

(1) the dataset contains reports from where FMS is the official reporting mechanism in some areas, while a voluntary system in others. Areas where it is the official system almost certainly have higher reports compared to the baseline, so our first question is: can this effect be isolated by removing the reports made through these branded portals, or is there any effect for reports made through FixMyStreet.com that needs to be controlled for regardless?

(2) There is some evidence suggesting that there is a distinct rural use of FMS, but this might be affected by different demographics and internet access in rural areas. Our second question therefore is: controlling as much as possible for demographic, population and access factors, is FMS used notably differently in rural areas?

(3) Our third question is, similarly controlling for population factors, what is the relationship between levels of neighbourhood deprivation in an area and reporting rates? Further, do the different motivations and much higher activity of a small group of superusers (users who make more than 50 reports) affect this relationship?

(4) Experiments related to 311 studies find that most reports are made in a tight radius of a reporters' home. This cannot be explored in FMS data. However, the data allow us to explore if people's sense of guardianship extends over their daily journeys and wider environment. Our fourth research question therefore is: are there more reports around 'non-home' focal points, such as schools, offices or transport hubs?

Methodology and data processing

The research questions were explored by constructing a model exploring the relationship between FMS reports and relevant variables. This was run against four different possible ways of counting the reports: with and without superusers (people who reported more than 10 times in one area); and with

and without reports made through official partner websites, where all reports will come via FMS. The model was then examined on subsets of the data that represent different kinds of reports made.

The model uses a dataset covering England, Scotland and Wales covering 2011–2015. While more years of data have become available since, using this range simplifies the other datasets used for comparison. FixMyStreet.com collects data through the whole of the UK, but there are comparatively few reports (844) made in Northern Ireland during this time range so these were excluded. Almost all UK local authorities accept reports via FixMyStreet.com (the public facing site maintained by mySociety), with 22 councils refusing reports for at least some of the 2011–2015 period. Reports in these areas are excluded.

FMS records report incidents as latitude and longitude, for this study these have been converted into counts for small geographical areas. These are Lower Super Output Areas (LSOAs) for England and Wales and Datazones (DZs) for Scotland, which have a lower average population. LSOAs have an average population of approximately 1,700 people, whereas Datazones are about half that size, with an average population of 900.

A count without superusers was made by excluding all reports but one in a LSOA/DZ made by a user who had made more than 10 reports. This means all superusers are reduced to one report in an area, but may have reports over several areas. A count without reports made via official portals was made by excluding individual reports made through all portals other than FixMyStreet.com or the mobile app. A dataset of how long local authorities were FixMyStreet clients in the time period is used to construct a measure of 'client_years' as a control. While FMS contains data for many councils, the reporting service is customised by council. Either by email coordination or through the Open311 standard, FMS tries to mirror the internal reporting categories of the different local authorities. As such, it is not simple to group reports in one area with reports in another. There are hundreds of separate categories, many of which describe similar problems. To examine if effects are similar on different kinds of reports, reports were amalgamated into Nyanzu (2018)'s C-level categories grouping all FixMyStreet reports into eight meta-categories (Table 2).

We sourced the population size, population density, and average age for each LSOA/DZ across Great Britain. The respective Rural Urban Classification from the ONS and National Records of Scotland have different scales but have a common definition of the difference between an urban and rural area. This was used to create a binary 'rural' variable across the dataset. Ofcom's 2015 Connected Nations report provided statistics on internet speed by postcode and on mobile coverage by local authority. Mobile connectivity was represented by '3 G signal available inside homes', and a variable of the number of broadband lines was constructed by joining several counts of different speed

Table 2. FMS service categories.

C-level category	A-level category
Abandoned Vehicles and Parking Access	Abandoned Vehicles, Parking, Untaxed Vehicle
Environmental Disruptions	Countryside RoW, Gates/Stiles RoW, Obstruction, Right of Way, Trees and Hedges RoW, Trees on RoW, Vehicle Access
Environmental Health	Benches/Bicycle Racks, Bridge/Culvert Defects, Broken Fire Hydrant, Broken Kerbs, Bus Stops Damage, C.C.T.V Faults, Dangerous Building/Structure, Fences, Leafing, Property Damage, Retaining Wall, Street Name Plates, Trenches, Utility Works
Incivilities	Accumulated Litter, Bin Collection, Bin Repair/Replacement, Blocked Drains, Dead Animals, Debris/Spillage, Discarded Syringes, Dog Fouling, Dog Litter Bin, Dumped Rubbish, Environmental Health, Flooding, Fly-tipping, Garden Waste, Grids and Drains, Gullies, Gully/Manhole Defects, Highway Drainage, Litter/Litter Bin, Manhole Covers, Manhole Defects, Missed Bin Collection, Pest Control, Recycling, Rubbish, Spillage on Road, Street Cleaning, Trade Waste, Trip Hazard
Road Safety and Defects	Flyposting, Graffiti, Noise, Shopping Trolley
	General Highways Enquiries, Grit Bins, Gritting, Grounds Maintenance, Highway Condition, Ice and Snow, Potholes, Road Markings, Road Safety, Road Surface Defects, Road Works, Road/Pavement Defects, Salt Bins, Sign or Marking, Street Lights, Traffic Lights, Verge Damage, Zebra Crossing
Other	-

lines together. Using data from Edubase, the Scottish schools database, the National Public Transport Access Nodes (NaPTAN) and Companies House, variables were constructed of how many schools are in a LSOA/DZ, a z-score converted indicator of how many companies were registered (some areas contain a disproportionate number) and a binary indicator of a train station in a LSOA/DZ.

To examine the effect of socio-economic status on reporting, we used measures of multiple deprivation calculated for each LSOA/DZ. The Index of Multiple Deprivation is a measure used in the UK to examine relative poverty/deprivation across different geographic areas. These combine measures across a range of different domains of 'deprivation'. Each UK nation publishes a separate index that is not directly comparable (Noble et al. 2006). Abel, Barclay, and Payne (2016) produced a UK-wide score based on the income and employment indicators from each nation. These are based on the English 2015 index, the Welsh 2014 index, and the Scottish 2012 index. This index was used to create a single UK-wide model, with binary variables for data from Scotland and Wales included to account for any source dataset variability (for instance, datazones having a lower population than LSOAs). The scores were normalised and converted to a percentile. A squared polynomial relationship was used to test for the expected parabolic distribution.

Nine per cent of small areas had no reports in this time range and so were recorded as '0' observations. This breaks the assumption for Poisson

regression that the variance is not larger than the mean and led to the choice of a negative binomial regression model.

Results

Table 3 shows the results of the national dataset against four models with different ways of constructing the count variable (including/excluding data from official portals and superusers). Table 4 shows (including both official portals and superusers) how the model performs against different groupings of reports made to FixMyStreet.

The coefficients have been transformed into odds ratios, where each increase of 1 unit of a dependent variable represents an X times increased likelihood of a higher count in the independent variable versus the baseline odds of a report. Values below 1 are negative effects (reduce the odds of a report).

Controls

Unsurprisingly, areas had more reports when reports through their official website were used in the model. More significant is that these areas have more reports even when data through the official website is ignored. As official portals are often branded as 'FixMyStreet', this suggests that additional reports are made through FixMyStreet.com even when there is an official website available. This highlights the importance of controlling for client status even when data from client websites is excluded.

Rural drivers of reports

Controlling for the population of the LSOA/DZ (positive), the average age of residents in a LSOA/DZ (negative) and the effects of broadband and 3 G access, there is a negative effect of population density on reports. This reflects a slight increase in reports in more sparsely populated areas. There is an additional (significant, but weak for the size of model) effect of being a rural area only in Model 1, which contains both official portals and superuser reports. This suggests this finding of an additional effect (beyond that of reduced population density) is not robust, and this result likely reflects a different mix of categories of reporting in that dataset.

Looking at individual groups of reports, controlling for population, population density consistently has a negative effect (with no significant effect for public space issues). Additionally, there is a strong effect of an area being a rural LSOA/DZ for every grouping of reports. Most major types of reports were more common in urban areas, with the exception being environmental

Table 3. Four regression models with different ways of constructing the count variable

Variables	Model 1	Model 2	Model 3	Model 4
Include official portal	Yes	Yes	No	No
Include super users	Yes	No	Yes	No
(Intercept)	3.43*** [2.95, 3.98]	2.19*** [1.94, 2.47]	3.62*** [3.12, 4.21]	2.37*** [2.10, 2.68]
Client Years	1.86*** [1.83, 1.89]	1.87*** [1.85, 1.89]	1.25*** [1.23, 1.27]	1.20*** [1.18, 1.21]
Scotland	0.71*** [0.68, 0.74]	0.72*** [0.70, 0.75]	0.73*** [0.70, 0.76]	0.74*** [0.72, 0.77]
Wales	0.81*** [0.78, 0.85]	0.87*** [0.84, 0.91]	0.82*** [0.78, 0.86]	0.88*** [0.84, 0.91]
Rural	1.03* [1.00, 1.07]	1.02 [0.99, 1.04]	1.02 [0.99, 1.05]	1 [0.97, 1.02]
Average Age	0.99*** [0.99, 0.99]	0.99*** [0.99, 0.99]	0.99*** [0.99, 0.99]	0.99*** [0.99, 0.99]
Population (in thousands)	1.14*** [1.09, 1.19]	1.14*** [1.11, 1.18]	1.14*** [1.10, 1.19]	1.16*** [1.12, 1.19]
Population/ km2	0.96*** [0.96, 0.96]	0.96*** [0.96, 0.96]	0.96*** [0.96, 0.96]	0.96*** [0.96, 0.96]
Broadband connections (thousands)	1.93*** [1.81, 2.06]	1.88*** [1.79, 1.98]	1.91*** [1.79, 2.03]	1.85*** [1.76, 1.94]
% Premises with 3g availability	1.01*** [1.01, 1.01]	1.01*** [1.01, 1.01]	1.01*** [1.01, 1.01]	1.01*** [1.01, 1.01]
Number of schools	1.02** [1.01, 1.03]	1.02*** [1.01, 1.03]	1.02*** [1.01, 1.03]	1.02*** [1.01, 1.03]
Companies registered (scaled)	1.33*** [1.31, 1.35]	1.26*** [1.24, 1.27]	1.34*** [1.32, 1.36]	1.26*** [1.25, 1.28]
Contains railway station (binary)	1.14*** [1.10, 1.19]	1.11*** [1.08, 1.15]	1.13*** [1.08, 1.18]	1.10*** [1.06, 1.14]
IMD (scaled)	1.03*** [1.01, 1.04]	0.97*** [0.96, 0.98]	1.03*** [1.02, 1.05]	0.98*** [0.96, 0.99]
IMD (scaled)^2	0.99* [0.98, 1.00]	1 [1.00, 1.01]	0.99** [0.98, 1.00]	1 [0.99, 1.01]
McFadden R2	0.08	0.12	0.05	0.06
Report count	497,471	319,115	381,832	240,229
N	37,157	37,157	37,157	37,157

* <0.05, ** < 0.01, *** < 0.001

health and access issues (obstructions to rights of way for vehicles and pedestrians), and Road Safety.

Multiple deprivation

While most features of the model are consistent in direction and scale across the three models, this is not the case for multiple deprivation. Only Models 1 and 3 (which contained reports made by superusers) show the expected parabolic relationship, with a positive score for multiple deprivation (reports increase as there is more deprivation) and negative score for squared multiple deprivation (reports decrease for areas with the highest levels of deprivation). Excluding superusers, there is no significant polynomial effect and instead there is a negative linear relationship, where reports are less likely as an area



Table 4. Model performance for different groupings of reports

Category model	Client		Scotland	Wales	Rural	Age	Pop'n Density	Broadband	Premises With 3G	Schools	Companies	Railway Station	Deprivation 1	Deprivation 2
	(Intercept)	Years												
Abandoned Vehicles & Parking	0.57***	1.85***	0.43***	0.97	0.58***	0.97***	1.26***	1.36***	1.01***	1	1.18***	1.29***	1.04*	0.91***
Access	0.25***	4.16***	0.05***	0.07***	1.25**	1	0.94	2.19***	0.98***	1.01	1.29***	1.12	0.81***	1.05
Environmental	0.14***	2.42***	0.44***	0.74***	0.83***	0.99***	1.18***	1.50***	1.01***	1.01	1.20***	1.13**	0.87***	1
Disruptions	1.54**	2.23***	0.65***	1	1.12***	0.96***	1.17***	1.59***	1.01***	0.99	1.44***	1.08*	1.45***	0.88***
Health	0.22***	1.85***	0.48***	0.95	0.36***	0.95***	1.09	1.64***	1.02***	1	1.58***	1.42***	1.18***	0.93***
Incivilities	0.20***	0.93*	0.44***	0.98	0.44***	0.97***	1.61***	0.99	1.01***	0.99	1.09***	1.02	1.12***	0.92***
Public Space	1.36***	1.67***	0.77***	0.74***	1.07***	1	1.08***	2.26***	1.01***	1.03***	1.31***	1.14***	0.92***	1.03***
Road Safety & Defects	0.42***	1.51***	0.51***	0.81***	0.85***	0.99***	1.19***	1.85***	1.01***	0.99	1.14***	1.13**	1.15***	0.98**

<0.05,

** < 0.01,

*** < 0.001

Table 4. (Continued.)

Category model	McFadden R2	Report count	N
Abandoned Vehicles & Parking	0.1	23,045	37,157
Access	0.22	6,007	37,157
Environmental Disruptions	0.15	24,682	37,157
Environmental Health	0.1	116,028	37,157
Incivilities	0.1	13,964	37,157
Public Space	0.03	5,266	37,157
Road Safety & Defects	0.08	284,254	37,157
Other	0.04	24,225	37,157

* < 0.05, ** < 0.01, *** < 0.001

gets more deprived. Looking at individual groups of reports, the parabolic relation remains for most categories (it is present but weaker for abandoned vehicles), but there is a negative linear relationship for environmental health and access issues, and an inverse parabola for road safety issues.

In this dataset, a higher score is a more deprived area. [Figure 2](#) shows the different relationships between a standardised IMD score and the associated change in the risk factor depending if superusers are included. [Figure 3](#) shows how road safety issues has the reverse pattern while environmental health has a more exaggerated version of the pattern over all reports. As these are z-scores, that the reversal points are not centred on 0 (and tend to be towards 2 standard deviations from the average small area) means the reversals should mostly be understood as being in the small number of areas with significantly higher deprivation than the average. In measures of multiple deprivation, the most deprived areas will be experiencing several kinds of overlapping

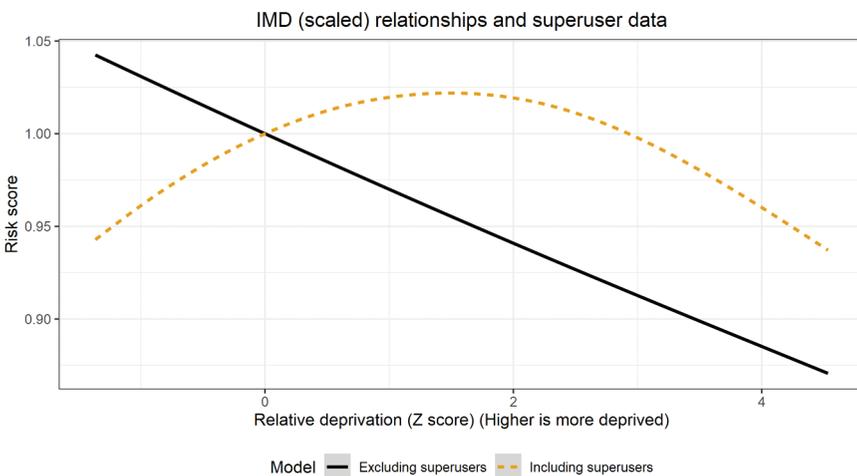


Figure 2. Relationship between standardised deprivation score change in risk factor.

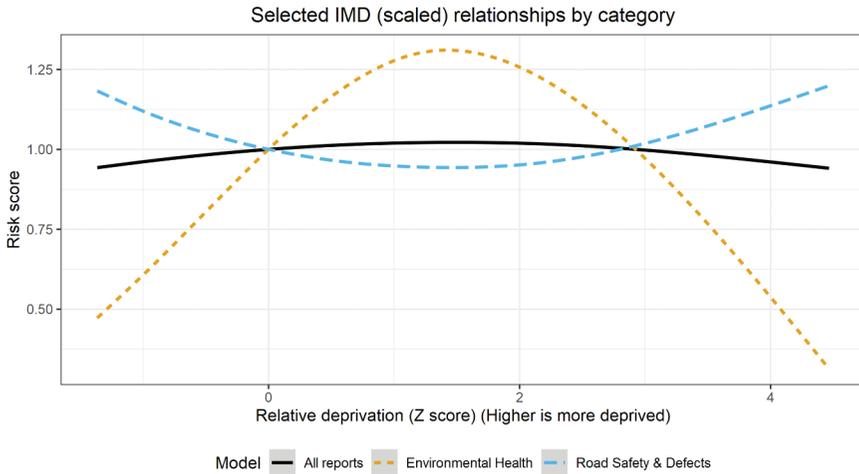


Figure 3. Comparison of reports of road safety issues and environmental health issues.

deprivation and so residents will be disadvantaged in cumulative ways. This is reflected directly in much higher multiple deprivation scores for these areas, and in this case with distinct patterns of use of FixMyStreet from less-deprived areas, even after accounting for other potential factors.

Guardianship

Infrastructure points lead to an increase of reports. There were more reports in areas with schools, more registered companies, and where there is a railway station was common across the four national models, making the effect robust against questions of data selection. Looking at individual groups of reports, the presence of registered companies has a significant positive effect across all types of reports. The effect of a railway station is positive for all, but insignificant for access and public space issues. The effect of schools is only significant (positive effect) for road safety issues.

Conclusion

This paper explored the applications of the FMS dataset to problems raised by the literature analysing data from 311 services and the implications of these problems for using citizen reports to target place-keeping services. In particular, we were concerned to understand whether a greater reliance on coproducing place-keeping services in this way might lead to growing inequalities between neighbourhoods, as the more socio-economically advantaged and able would report issues more often (Matthews and Hastings 2013). The most important finding is that the parabolic curve related

to socio-economic status observed from other forms of contacting is present in the FMS dataset. This pattern is only observable on the inclusion of superusers, without whom there is only a negative effect of higher measures of deprivation. While there are concerns super-contributors may shape the end result of the data against the general interest, in the case of FMS, the effect of superusers seems positive. They lead to more reports from deprived areas than would otherwise be the case. There is, therefore, a risk of services becoming unequally distributed if citizen reports are prioritised over regular inspection. Such regular inspections have been cut as part of austerity measures, so there is a risk that this is exacerbating inequalities in environmental outcomes between deprived and less-deprived neighbourhoods, that had previously been mitigated by targeted service delivery (Hasting 2009b).

Examining a national dataset allows exploration how 'smart city' technology can be applied to rural services. While most FixMyStreet reports are made to urban local authorities, there are distinct categories of reports that have more use for rural authorities, beyond any direct effect of decreasing population density. Different kinds of infrastructure have positive effects on the number of local reports, but schools only seem to have an effect on reports of road safety. This reflects a broader idea of guardianship than explored in distance from home analysis, and is a conclusion that can be tested in all 311-like datasets without a requirement for additional information. It suggests people will report issues they pass by on their commute (railway stations) or while in areas with a high number of businesses, such as shopping streets.

This analysis has shown the limitations of looking for general explanations of FMS reports. Including all data only explain 8% of the variation (using a McFadden pseudo- R^2). However, when restricted to certain categories, the explanatory power is higher for five out of eight categories, with the Access mode explaining 22% of the variation. Different kinds of reports have different drivers that need to be explored separately.

Finally, our analysis shows that for local government, citizen-reported environmental data can provide information about the perceived need for placekeeping. What it cannot do, is reflect the actual need. Automated sensors and regular scheduled surveys can provide more thorough coverage, but what this research suggests is that encouraging 'superusers' may help improve the overall results of user submitted data. As found by Hastings, Matthews, and Wang (2021) such individuals in deprived neighbourhoods do a lot of the 'work' in maintaining neighbourhood quality, and so should not be dismissed as 'the usual suspects' but rather 'everyday makers' (Bang and Eva 1999). For researchers, or policymakers, exploring factors that drive this local need, user submitted data can be suggestive but will rarely be sufficient on its own to draw conclusions.

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Alex Parsons is employed by mySociety, the charity that produces and runs FixMyStreet, as a researcher.

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