The Road Violence Toll of Urban Sprawl:
A Registered Report of Collisions with Cyclists and Pedestrians in England and Wales

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Abstract

The risk of road collision for cyclists and pedestrians is higher in sprawls than in city centres. As a result of commuting, we also suspect that the higher risk of collision caused by residents from car-dependent sprawls is not confined to their own areas but disproportionately imposed on city dwellers. However, due to the absence of direct comparisons we do not know the specific road violence imposed by urban sprawls. This registered report will combine collision data from the Department for Transport and the Urban Grammar Spatial Signatures dataset that characterises geography by form and function to estimate the share of road violence induced by sprawls' residents within and outside their localities, and relative to levels of road violence generated by city dwellers in England and Wales. Furthermore, using the subset of collisions data including contributory factors, we will provide a lower bound estimate regarding the share of collisions that could be classified as motoring offences. Drawing on these findings we will reassess the widely held beliefs of: i) sprawls as safer than city centres; ii) residents from urban sprawls are more law-abiding than city dwellers; and iii) crime prevention strategies that promote car-dependent developments as effective.

Keywords: Urban sprawl; Road collisions; Motoring offences; Spatial signatures; Motonormativity

Introduction

Dense urban areas, especially those populated by working class and ethnic minority groups tend to be stigmatised as dangerous and disorderly (Wacquant, 2007), whilst rural areas and suburban sprawls are often epitomised as orderly and safe. Such implicit assumption is likely shared by most crime researchers, who have disproportionately focused their research efforts on urban areas (Rocque & Posick, 2017), and crime prevention strategies, which often promote planning features typical from low-density sprawls (Pina-Sánchez & Loader, 2026). One clear example of the latter is the Secure by Design programme in the UK, which encourages developers to adopt residential designs based on cul-de-sac layouts, and reiterates the importance of abundant parking space for residents and visitors, all of them preferably visible from the front of their residence (Secured by Design, 2025).

A range of questionable assumptions have likely led to such ill-conceived crime prevention recommendations (Pina-Sánchez & Loader, 2026) and to the disproportionate attention placed to city centres in criminology literature. Key among them is the view that motoring offences are not real crime (Corbett, 2000; Poulter & McKenna, 2007), rather, under the prism of motonormativity (Walker et al., 2023), these are normally seen as an inevitable side-effect of modern life: driving is an activity in which we all participate and therefore dispossessed of criminal intent. Such view, however, normalises a vast amount of preventable violence - e.g., in England and Wales convictions for causing death by dangerous or illegal driving are approximately equal in number to convictions for murder (Ministry of Justice, 2025), while globally 1 in 34 deaths are caused by car collisions (Miner et al., 2024) - and ignores the broader impact of motoring offences to the functioning of overloaded criminal justice systems – e.g. motoring offences account for 60% of all cases sentenced in England and Wales in 2024, while the median duration from the moment an offence is recorded to a sentence imposed in the Crown Court is 346 days (Ministry of Justice, 2025).

Beyond motonormativity, we believe that the moral pass offered to motoring offenders (Corbett, 2000) and the view of sprawls being safer than city centres are both explained by demographic segregation and economic inequality. Particularly by the fact that motoring offences tend to be imposed by older, wealthier, residents of urban sprawls, on younger, more deprived, city dwellers, than the other way around. It is that spillover effect that we seek to estimate in this study. Specifically, we seek to question the law-abiding condition attributed to residents of urban sprawls - in contrast to the deviant condition attributed to residents of city centres – by: i) focusing on collisions against vulnerable road users (i.e. cyclists and pedestrians; ii) estimating the share of these collisions that also meet the stricter, motoring-offence-based definition of criminal behaviour, and iii) estimating the extent to which this road violence is imposed by drivers from other areas.

We have known for a long time that, on a per capita basis, motoring offences are far more prevalent in low-density areas (Ewing et al., 2003), and that drivers from rural areas are more likely to engage in collisions (Blatt & Furman, 1998). More recently a few studies have also shown specific forms of road harm induced by residents from sprawls on city centre dwellers. Boeing et al. (2023) established that Los Angeles residents from tracts whose residents drive less and are less-White are more exposed to air pollution from traffic, and that commuters from majority-White tracts disproportionately drive through non-White tracts, compared to the inverse. This disproportionate harm induced by commuters is also corroborated by Mitsova et al. (2021), who looked at road collisions against cyclists and pedestrians in Florida, and found disproportionate concentrations along commuter corridors crossing lower income communities. Similarly, for the case of England, Beecham (2026) shows drivers from rich neighbourhoods to be involved in collisions with cyclists in more deprived neighbourhoods than the other way around. Yet, we still do not have a direct estimate of the share of road violence stemming from urban sprawls compared to city centres, nor an assessment of whether that toll is reciprocal, or the extent to which we could attribute a criminal origin to those patterns.

In this study we propose to combine road collision data (Department for Transport (DfT), 2025a) and spatial signature data that characterises geography by form and function (Fleischmann & Arribas-Bel, 2022). The former offers the location of all collisions recorded by the police in England and Wales, but also, crucially, the location of the driver(s) involved in it. The latter provides a novel and more accurate categorisation of the level of density and compactness in the built environment (form) and how the land is used (function), from which we could derive more accurate measurements of urban sprawls. Together, these two datasets will allow us to estimate not only differences in risk of collision with cyclists and

pedestrians by type of area, but also the extent to which drivers from different types of area imposed this harm on each other. Furthermore, using the restricted subset of collisions data that includes contributory factors identified by police officers, we will be able to offer a lower bound estimate for the extent to which collisions generated and imposed on different areas may be the result of motoring offences. In short, this study will allow us to reassess the criminal nature of city centres compared to urban sprawls, and in so doing challenge long held cliches in the public psyche and the criminology literature influencing crime prevention practice and policy. More broadly, beyond criminology and crime prevention, our findings could help provide a new way of thinking to Researchers, practitioners and policy-makers working on transport, urban design and public health.

Conceptual Framework

Before detailing our analytical strategy, we clarify a key conceptual choice. We use the term road violence deliberately throughout this report, and we do so in a sense that foregrounds culpability. Therefore we depart from the term's narrower use in the road-safety and law enforcement literature, where it is typically reserved for overtly aggressive acts such as road rage or deliberately dangerous driving (Smith, 2006). We extend it instead to the broader class of collisions whose harm is predictable and preventable, regardless of whether the driver acted with hostile intent.

To justify this broader conceptualisation, and to clarify how it applies to our two outcome variables - collisions against vulnerable road users, and collisions against vulnerable road users indicative of a motoring offence (see Analytical Strategy) - we draw on Vorobej's (2016) framework. Vorobej argues that the many uses of the term violence can be distinguished along five criteria: harm, agency, victimhood, instrumentality, and normativity (HAVIN). For clarity, we adapt this framework slightly by separating intentionality from agency and treating it as a sixth, final criterion. Table 1 summarises how each of these six criteria applies to our two outcome variables.

The suitability of describing collisions as a form of violence is clear with regard to the first four criteria: harm, agency, victimhood, and instrumentality. All collisions against cyclists or pedestrians involve physical harm, roughly a quarter lead to post-traumatic stress disorder (Bhateja et al., 2025), and even 'near-misses' produce withdrawal behaviour (Aldred, 2016). In all cases we can clearly identify a perpetrator and a victim, a distinction harder to sustain for the broader term road harm, where victims are not always identifiable as it covers forms of automotive harm beyond collisions (e.g. air pollution, noise, social isolation). Lastly, following Hannah Arendt's view 'On Violence', collisions are inherently instrumental: they always involve the use of a tool, the car.

Table 1. Applicability of 'collisions against vulnerable road users' and 'collisions against vulnerable road users indicative of motoring offences' to key dimensions of the concept of violence.

	Collisions against vulnerable road users	Collisions against vulnerable road users indicative of motoring offences
Harm	✓	✓
Agency	✓	✓
Victimhood	✓	✓
Instrumentality	✓	✓
Normativity	X/✓	✓
Intentionality	X/✓	X/✓

The more questionable criteria are normativity and intentionality. Normativity concerns the morality of the act (Vorobej, 2016). Collisions indicative of a motoring offence are straightforwardly morally wrong, since they reflect typified offences in criminal law (Clarkson, 2007). Collisions where no illegal behaviour can be ascribed to the driver are more contentious, and tend to be treated as unintentional and therefore free of culpability. This is a view rooted in the restrictive liberal conception of violence as an agent's deliberate exercise of physical force to inflict harm, echoed in how law enforcement organisations typically define road violence (Smith, 2006).

We challenge such narrow view of intentionality. As Bufacchi (2007) notes, intentionality is useful for distinguishing benevolent from malevolent action (a surgeon performing an operation, versus Josef Mengele's experiments at Auschwitz), and for distinguishing violence from genuine accident (the 9/11 attacks versus a genuine airplane accident). But Bufacchi (2007, p. 66) also recognises that *"there are times when it is possible, and necessary, to relax the prerequisite of intentionality, and replace it with other necessary conditions such as knowledge or foreseeability of inevitable consequences of one's actions."*

This is the position leading medical research institutions adopted over two decades ago, when the British Medical Journal (Davis & Pless, 2001) and the Journal of Traumatic Stress (Stewart & Lord, 2002) banned the term 'accident' in favour of 'collision' (the preferred UK term) or 'crash' (the preferred US term). Both journals recognised that most collision-related injuries, and the events that precipitate them, are predictable and preventable rather than chance occurrences. For example, the DfT (2023a) indicates that 56.1% of fatal collisions in Great Britain are related to speed, 19.6% to alcohol or drug intoxication, and 1.7% to mobile phone distraction. Most - if not all - drivers are aware that such practices increase collision risk, and that this risk is imposed not only on themselves but disproportionately on others, vulnerable road users especially.

Focusing on vulnerable road users sharpens the question of drivers' culpability. The harm produced by a collision is far higher for pedestrians and cyclists than for motorists (motorcyclists aside), and unlike motorists, they impose no - or limited - risk on others, and do not consent to the risk imposed on them. We could go further and argue that most collisions affecting vulnerable road users involve some degree of intentionality and culpability on the part of drivers. Speed, even within legal limits, is a necessary precursor of collisions, and this is a risk drivers are generally aware they are taking. That the law and social convention tolerate it does not make it ethically acceptable.

It is this moral pass, and the inequities it sustains, that we dispute in this study. Treating collisions with vulnerable road users as a form of violence rather than an inevitable side-effect of driving, and questioning the moral pass that has traditionally shielded drivers from culpability is a necessary correction if we are to challenge the shocking neglect afforded to road collisions by crime prevention researchers, practitioners, and policy-makers.

Analytical Strategy

To minimise researcher bias and avoid HARKing (Kerr, 1998) our hypotheses and analytical strategy have been defined before undertaking the analysis. Three of the four authors of this study have previously used GB road collision data, but only one has accessed the restricted contributory factors, and none of us has accessed the spatial signatures data, nor have we combined these three datasets from which we will derive our analytical sample. Since the spatial signatures data - that we have not yet accessed - is essential to undertake the analysis proposed here we establish a mid-level of bias control, equivalent to a level 3 category in the 'Peer Community In Registered Reports' risk of hindsight bias classification.[1]

Datasets and analytical sample

The official GB road collision data contains details of all collisions that occur on public roads and footways, result in personal injury, are reported to the police (who either attend the collision or receive a report from the public), and are reported within 30 days of the incident (DfT, 2024a). It consists of three datasets, linked by a unique identifier, that contains extensive variables describing the collision, drivers involved, and individuals harmed. Most of this data is available as open data (DfT, 2025a), however certain variables are considered 'sensitive' and are restricted to approved researchers (DfT, 2025b). These include up to six factors identified by the police as contributing to the collision such as driver behaviour, inexperience, distraction and impairment, and issues with the roads and/or vehicles. Other sensitive data includes the results of driver alcohol breath tests, use of seatbelts, whether the collision was a 'hit and run' and the home postcodes of drivers and casualties. Data collection guidance and forms are available online (DfT, 2024b & 2025c).

[1] See here: https://rr.peercommunityin.org/help/guide_for_authors#h_957904905104916133094903336

The spatial signatures data is a theory-informed, data-driven, geographical characterisation of Britain (Fleischmann & Arribas-Bel, 2022). It uses spatial units generated from the environment (such as roads, rivers and railways) then characterises each spatial unit by form and function. Form is derived from the built environment such as buildings and streets and their patterns based on dimensions, shapes, spatial distribution, intensity, connectivity and diversity. Function captures how the land is used, for example, retail, cultural, workplace, leisure, industrial, transport and agricultural. Following clustering analysis, 16 spatial signatures were identified[2] and described, ranging from 'Wild countryside' to 'Disconnected suburbia', 'Dense urban neighbourhoods' and 'Hyper concentrated urbanity', then assigned to each spatial unit. These are available at the original spatial unit level and at LSOA level.

We will access the open GB road collision data from the DfT using the STATS19 R package (Lovelace et al, 2019) and we will apply to access the sensitive data from the DfT. We will use data from the years 2018/2019 as this corresponds to the timeframe of the spatial signatures dataset, and is unaffected by the COVID-19 pandemic and by subsequent changes in the recording of contributory factors (DfT, 2025d). We will link the collision, vehicle, casualty and sensitive datasets using the unique identifier so that we have all the data for each individual collision. Having downloaded the spatial signatures dataset (Fleischmann & Arribas-Bel, 2023), we will spatially-join the crash locations, drivers home postcodes and casualties home postcodes to the spatial signatures.[3]

To facilitate our analysis, we will consolidate the 16 spatial signatures into fewer categories. For the exploratory part of our analysis we will use seven broader typologies: Rural countryside (wild countryside and countryside agriculture), peri-urban fringe (urban buffer and open sprawl), suburban residential (disconnected suburbia and accessible suburbia), urban residential (gridded residential quarters, connected residential neighbourhoods, and dense residential neighbourhoods), inner urban mixed-use (dense urban neighbourhoods and local urbanity), urban core (regional urbanity, metropolitan urbanity, concentrated urbanity, and hyper concentrated urbanity) and industrial & large-format land (warehouse/park land) as a distinct category due to its specialised function. For the confirmatory part of our analysis we will focus on an even simpler binary contrast: suburban sprawls (composed of peri-urban fringe, suburban residential areas, and urban residential) versus inner-city drivers (including inner urban mixed-use and urban core areas).[4]

Hypotheses and data analysis

The confirmatory part of our analysis is composed of three hypotheses to be tested through simple comparisons of means after adjusting for the population size and age distribution in each of the two areas under comparison.[5] For simplicity, from now on when we use the term collisions we refer specifically to collisions perpetrated by drivers of cars resulting in pedestrians or cyclist casualties.

H1: Residents from suburban sprawls are more likely to perpetrate collisions than inner-city residents.

H2: Residents from suburban sprawls are more likely to perpetrate collisions in inner-city areas than inner-city residents are in suburban sprawls.

H3: Perpetrators of collisions from suburban sprawls commit more motoring offences than perpetrators of collisions from inner-city areas.

These three hypotheses map directly onto the dual classification set out in the Conceptual Framework: H1 and H2 rest on the broader definition of collisions against vulnerable road users as violence, while H3 isolates the narrower subset that also satisfies the stricter, uncontested definition requiring an identifiable motoring offence.

[2] Fleischmann and Arribas-Bel (2023) description of each of these 16 categories is reported in Appendix 1.

[3] The merged datasets, together with the R code to be used in our analysis, will be made available in the OSF project's folder (https://osf.io/24naj/overview). The only exception being the sensitive data from the DfT, which access requires a research application, see here: https://www.gov.uk/guidance/road-accident-and-safety-statistics-guidance#data-protection-and-privacy.

[4] We exclude 'Rural countryside' and 'Industrial & large-format land' from our confirmatory analysis, to maintain a precise comparison between suburban sprawls and inner-cities.

We adjust for population size and age using direct standardisation to make comparisons across areas taking into consideration the different share of their populations of driving age (DHSC, 2025). Specifically, we calculate age-specific collision rates for residents aged 17 to 70 years, multiply these by the standard population proportion (from the official mid-2019 population estimates for Lower Layer Super Output Areas (ONS, 2025) and sum the totals to obtain an age-standardised rate. expressed as collisions per thousand population. For this process we will use the same age-bands reported in the Census ('16-19', '20-24', '25-29', '30-39', '40-49', '50-59', '60-69'). We do not consider additional controls commonly employed in the literature - such as area socio-economic characteristics, share of residents participating in active travel (Ewing et al., 2003; Tortosa et al., 2021), or the average distance covered by drivers (Marstrand, 2019) - because we see these as mediators of the area effect that we seek to estimate. That is, we are not trying to compare the risk of collision for drivers, cyclists or pedestrians across areas, rather how much more criminogenic - in terms of collisions and motoring offences - are car dependent areas compared to walkable areas. The fact that inner city residents are encouraged to adopt active travel while those from urban sprawls are pushed into car-dependency is part of the effect that we seek to estimate, and should therefore not be controlled away.

More precisely, our theoretical estimands could be defined as the age-adjusted rate of police recorded: a) collisions committed by residents from urban sprawls; b) collisions committed by residents from inner cities; c) collisions committed by residents from urban sprawls on inner cities; and d) collisions committed by residents from inner cities on urban sprawls. To test H1 we will compare a and b, and to test H2 we will compare c and d. We do not consider inferential statistics because we use data referring to the whole population of police recorded collisions. Instead, we will simply corroborate H1 if $a > b$, while if $a < b$ we will fail to corroborate it. Similarly, if $c > d$, we will corroborate H2, and we will fail to corroborate it if $c < d$.

We test H3 in a second part of our analysis by estimating the number of motoring offences that can be derived from each collision. Specifically, for each collision we will count the following characteristics of the case available in the standard STATS19 data: whether a breath test was refused or came negative, likewise for a drug test, whether the driver fled the scene of the collision, and driving unlicensed. This initial count will be further expanded using the following contributing factors[6] to the collision available in the restricted version of STATS19: driver using a mobile device, exceeding the speed limit, or being aggressive, dangerous or reckless.

The resulting count should only be taken as a lower bound of the total number of motoring offences to be attributed to drivers from each of the areas under analysis. By focusing on collisions we are only covering the tip of the iceberg of motoring offences, most of which do not even come to the police attention (DfT, 2023b). Furthermore, we discard offences that do not increase the risk of collision against cyclists and pedestrians, such as failing to use seat belts, and other highway offences where we cannot determine driver's intent or awareness of their wrongdoing, such as illegal turn, or failed to comply with traffic sign. Yet, even if an extreme underestimate of the true extent of motoring offences, by focusing on collisions, our estimates are less exposed to measurement error due to differential reporting rates or police activity across areas (Pina-Sánchez et al., 2023) than if we were to rely on other measures of motoring offences with a geospatial mark, e.g. alcohol or drugs stops.

As with H1, we will corroborate H3 if the age-adjusted rate of police recorded motoring offences derived from collisions perpetrated by residents from suburban sprawls is higher than the equivalent rate from inner-city area residents, and we will fail to corroborate it if the opposite is true. In presenting the interpretation of our three hypothesis tests, we have used the wording 'fail to corroborate' rather than 'reject', to acknowledge the mismatch between our target theoretical population (all collisions) and our analytical population (collisions recorded by the police). Based on the National Travel Survey, the DfT (2021) estimates that only 50% of collisions are reported to the police, with that proportion increasing to approximately two-thirds when considering serious collisions. Given that the seriousness of collisions is directly proportional to the driving speed, and that speed limits are lower in denser areas, we expect this form of differential measurement error to lead to a stronger underestimate of the rate of collisions in urban sprawls than in inner city areas. As such, when we use police recorded collisions to infer disparities

[6] The full list of contributory factors is shown in Appendix 2.

in the risk of collision posed by drivers from different areas, it is possible to wrongly fail to corroborate H1, H2 and H3. Put differently, the analytical strategy we have designed relies on conservative tests, where our hypotheses may fail to be corroborated even when they are in fact correct.

Our three hypotheses, the research questions they refer to, together with the sampling and analytical plan designed to test them, and the interpretation to be provided for our results, including theoretical implications, are summarised in Table 2. Lastly, beyond hypothesis testing, our study will also include an element of exploratory analysis. We will take the same measures of collision and motoring offences to document their prevalence across the 16 area categories originally used in the spatial signatures data (see Appendix 1). Specifically, using a matrix we will report collision and motoring offence rates for every combination of drivers' residence and area where the collision took place.

Table 2. Study Design

Question	Hypothesis	Sampling plan	Analysis Plan	Rationale for deciding the sensitivity of the test for confirming or disconfirming the hypothesis	Interpretation given different outcomes	Theory that could be shown wrong by the outcomes
Are residents from suburban sprawls more likely to perpetrate collisions than inner-city residents?	Residents from suburban sprawls are more likely to perpetrate collisions than inner-city residents.	We will access open and sensitive GB road collision data from the DfT, and spatial signatures data from Fleischmann & Arribas-Bel (2023), for the years 2018/2019. We will link DfT datasets using their unique identifier, so that we have all the data for each individual collision. We will spatially-join the crash locations and drivers home postcodes to the spatial signatures.	We will reduce the number of spatial categories to two: suburban sprawls and inner-city areas. We will then compare the number of collisions across those areas after adjusting for age and population size.	We do not employ inferential statistics because we observe the full population of police recorded collisions.	Given the age-adjusted rate of police recorded: a) collisions committed by residents from urban sprawls; b) collisions committed by residents from inner cities; c) collisions committed by residents from urban sprawls on inner cities; and d) collisions committed by residents from inner cities on urban sprawls. We will corroborate H1 if $a > b$, while if $a < b$ we will fail to corroborate it. Similarly, if $c > d$, we will corroborate H2, and we will fail to corroborate it if $c < d$. We will corroborate H3 if the age-adjusted rate of police recorded motoring offences derived from collisions perpetrated by residents from suburban sprawls is higher than the equivalent rate from inner-city area residents, and we will fail to corroborate it if the opposite is true. If residents from one area (suburban sprawls or inner-city) are more likely to perpetrate collisions than residents from the other area, we will conclude that the former are more deviant than the latter. This conclusion will be further reinforced if the share of collisions transferred from the former to the latter area is higher than vice versa, and if motoring offences are also found to be more common. If residents from one area are more likely to perpetrate collisions, but the share of motoring offences present is higher in the other area, (i.e. if collisions and motoring offence rates are not consistently higher for one of the areas), we will declare our findings inconclusive.	If we conclude that residents from suburban sprawls are more likely to engage in collisions and motoring offences, we will show that the stigmatisation of the former is unjustified. This has important implications to the disciplines of Criminology and crime prevention, which have directed their efforts to traditional forms of street crime, while paradoxically neglecting arguably more harmful crime types such as white-collar crime and motoring offences – at least by their sheer volume and second order effects. This paradox could be explained by how deviance is defined, which focuses on stranger's If the opposite is true, residents from suburban sprawls are less likely to perpetrate collisions and these are less commonly caused by motoring offences we will corroborate long held beliefs of deviance applied to city-dwellers.
Are residents from suburban sprawls more likely to perpetrate collisions in inner-city areas than inner-city residents are in suburban sprawls?	Residents from suburban sprawls are more likely to perpetrate collisions in inner-city areas than inner-city residents are in suburban sprawls.					
Do perpetrators of collisions from suburban sprawls commit more motoring offences than perpetrators of collisions from inner-city areas?	Perpetrators of collisions from suburban sprawls commit more motoring offences than perpetrators of collisions from inner-city areas.		We will compare the number of motoring offences across areas after adjusting for age and population size.			

Contribution

As far as we are aware, this will be the first study providing a clear comparison of how different urban layouts induced different levels of collisions with cyclists and pedestrians, and, similarly, the first study considering the criminal nature of such collisions. As such, our findings will help correct widely held but - in our view - mistaken perceptions of the relative criminogenic nature of cities and urban sprawls. We also hope that our findings will spark the curiosity of criminologists and encourage them to delve into the largely ignored research area of road violence and motoring offences (Loader, 2025).

Most importantly, the evidence generated by this study has the potential to prompt a reassessment of current crime prevention strategies that inadvertently undermine walkability and reinforce car dependency, such as the UK Secured-By-Design scheme (Pina-Sánchez & Loader, 2026). Given how motoring offences represent the majority of police recorded crime, a paradigm change in crime prevention that sees motoring offences as a form of crime just as harmful as traditional forms of street crime, could be shown to be the most effective crime prevention strategy yet conceived. Relatedly, our findings will help further underscore the value of active travel policies by highlighting their crime prevention dimension. Ultimately, our findings will touch on questions of public health and social justice. Beyond collisions, the noise and pollution stemming from motor traffic represent health risk factors (Oosterlee et al., 1996; Jensen et al., 2018), and this brunt is not equally distributed but disproportionately imposed on deprived areas by affluent ones (Beecham, 2026; Tortosa et al., 2021). If our hypotheses are confirmed, findings from this study will provide further support for policies seeking to mitigate such spillover effect, such as council tax that factor in the harms of car-dependency, or the introduction of residents-only parking restrictions.

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Appendix 1: Description of the area types used in the spatial signatures data

Wild countryside

In "Wild countryside", human influence is the least intensive. This signature covers large open spaces in the countryside where no urbanisation happens apart from occasional roads, cottages, and pastures. You can find it across the Scottish Highlands, numerous national parks such as Lake District, or in the majority of Wales.

Countryside agriculture

"Countryside agriculture" features much of the English countryside and displays a high degree of agriculture including both fields and pastures. There are a few buildings scattered across the area but, for the most part, it is green space.

Urban buffer

"Urban buffer" can be characterised as a green belt around cities. This signature includes mostly agricultural land in the immediate adjacency of towns and cities, often including edge development. It still feels more like countryside than urban, but these signatures are much smaller compared to other countryside types.

Open sprawl

"Open sprawl" represents the transition between countryside and urbanised land. It is located in the outskirts of cities or around smaller towns and is typically made up of large open space areas intertwined with different kinds of human development, from highways to smaller neighbourhoods.

Disconnected suburbia

"Disconnected suburbia" includes residential developments in the outskirts of cities or even towns and villages with convoluted, disconnected street networks, low built-up and population densities, and lack of jobs and services. This signature type is entirely car-dependent.

Accessible suburbia

"Accessible suburbia" covers residential development on the urban periphery with a relatively legible and connected street network, albeit less so than other more urban signature types. Areas in this signature feature low density, both in terms of population and built-up area, lack of jobs and services. For these reasons, "accessible suburbia" largely acts as dormitories.

Warehouse/Park land

"Warehouse/Park land" covers predominantly industrial areas and other work-related developments made of box-like buildings with large footprints. It contains many jobs of manual nature such as manufacturing or construction, and very little population live here compared to the rest of urban areas. Occasionally this type also covers areas of parks with large scale green open areas.

Gridded residential quarters

"Gridded residential quarters" are areas with street networks forming a well-connected grid-like (high density of 4-way intersections) pattern, resulting in places with smaller blocks and higher granularity. This signature is mostly residential but includes some services and jobs, and it tends to be located away from city centres.

Connected residential neighbourhoods

"Connected residential neighbourhoods" are relatively dense urban areas, both in terms of population and built-up area, that tend to be formed around well-connected street networks. They have access to services and some jobs but may be further away from city centres leading to higher dependency on cars and public transport for their residents.

Dense residential neighbourhoods

A “dense residential neighbourhood” is an abundant signature often covering large parts of cities outside of their centres. It has primarily residential purpose and high population density, varied street network patterns, and some services and jobs but not in high intensity.

Dense urban neighbourhoods

“Dense urban neighbourhoods” are areas of inner-city with high population and built-up density of a predominantly residential nature but with direct access to jobs and services. This signature type tends to be relatively walkable and, in the case of some towns, may even form their centres.

Local urbanity

“Local urbanity” reflects town centres, outer parts of city centres or even district centres. In all cases, this signature is very much urban in essence, combining high population and built-up density, access to amenities and jobs. Yet, it is on the lower end of the hierarchy of signature types denoting urban centres with only a local significance.

Regional urbanity

“Regional urbanity” captures centres of mid-size cities with regional importance such as Liverpool, Plymouth or Newcastle upon Tyne. It is often encircled by “Local urbanity” signatures and can form outer rings of city centres in large cities. It features high population density, as well as a high number of jobs and amenities within walkable distance.

Metropolitan urbanity

Signature type “Metropolitan urbanity” captures the centre of the largest cities in Great Britain such as Glasgow, Birmingham or Manchester. It is characterised by a very high number of jobs in the area, high built-up density and often high population density. This type serves as the core centre of the entire metropolitan areas.

Concentrated urbanity

Concentrated urbanity” is a signature type found in the city centre of London and nowhere else in Great Britain. It reflects the uniqueness of London in the British context with an extremely high number of jobs and amenities located nearby, as well as high built-up and population densities. Buildings in this signature are large and tightly packed, forming complex shapes with courtyards and little green space.

Hyper concentrated urbanity

The epitome of urbanity in the British context. “Hyper concentrated urbanity" is a signature type present only in the centre of London, around the Soho district, and covering Oxford and Regent streets. This signature is the result of centuries of urban primacy, with a multitude of historical layers interwoven, very high built-up and population density, and extreme abundance of amenities, services and jobs.

Appendix 2: List of contributory factors used in police descriptions of collisions

B3 – Driver / rider overshot junction or poor turn / manoeuvre

B4 – Ineffective observation by either the driver, rider or pedestrian

B5 – Driver / rider inexperienced or learner

B6 – Driver / rider passing too close to another road user or pedestrian

B7 – Vehicle door opened into path of another road user or pedestrian

B8 – Sudden braking or braking in a way unsuitable for conditions

D3 – Driver / rider too tired to drive / ride safely

D7 – Distraction to driver / rider from inside / outside or on vehicle

P1 – Incorrect use of crossing facility by person crossing the road

P2 – Vehicle entering road from pavement

P3 – Pedestrian showing risk-taking behaviour in carriageway

P4 – Pedestrian careless or in a hurry

P5 – Pedestrian, cyclist, equestrian hard to see

R1 – Poor or defective road surface or deposits on road

R2 – Road surface was slippery due to weather

R3 – Driver / rider's view obscured by stationary or parked vehicles

R4 – Driver / rider's view obscured by vegetation, buildings, layout or road signs

R5 – Driver / rider's vision affected by adverse weather or dazzling sun

S3 – Vehicle used in course of crime

S5 – Driver / rider moving too slowly for conditions

V4 – Driver / rider view obscured by blind spot

V5 – Vehicle with defective lights or not using headlights when visibility is reduce