Does prison location matter for prisoner wellbeing? The effect of surrounding greenspace on self-harm and violence in prisons in England and Wales

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ABSTRACT

Research on prison location primarily focuses on relationships with local communities and the impact of distance on visitation. Considering the issue of prison location in a different manner, this paper deploys GIS methodology to determine whether the characteristics of prison location can impact prisoners themselves. The presence of greenspace, blue space and major roads in a 500m buffer zone surrounding prisons in England and Wales was calculated using Geographical Information Systems (GIS). An econometric analysis was then undertaken examining this location data in relation to official statistics on violence and self-harm at the institutional level. Econometric estimations confirmed that there are lower levels of self-harm and violence in prisons with higher percentages of greenspace in the buffer zone. These relationships are statistically robust, and they persist when we control for prison size, type, age, and level of crowding. The findings suggest that prisoners may be influenced by the characteristics of prison sites, and that accordingly, these characteristics should be considered when locations for future prisons are selected. Based on these initial findings, we outline the potential for future research to further examine the effect of environmental features on individuals to whom they are not visible.

Cost, convenience and local community relations are usually paramount in prison siting, whereas effects of prison location on the incarcerated are rarely considered. Yet recent discussions of incarceration and environmental justice (Bernd et al., 2017; Davis 2011; Opsal and Malin 2019; Corwin et al., 2020), and reports of prisoners' exposure to environmental hazards, raise significant questions about the effects on prisoners when a prison is located in one place rather than another. Building on recent research demonstrating the effect of characteristics of prison sites themselves on prisoner and prison staff wellbeing (Moran et al., 2021a; Moran et al., 2021b), we present exploratory analysis indicating that characteristics of the spaces *surrounding* prisons may *also* exert a significant influence.

Prison location and environmental justice

Distribution of prisons across space is neither even, nor entirely attuned to distributions of population or crime. Prison location matters

to communities surrounding prisons, to prisoners' home communities, and to the incarcerated themselves, but previous research into 'NIMBY' protest against prison siting, campaigns in favor of new prisons, and effects of prison location (e.g. Besser and Hanson, 2016; Bonds, 2013; Farkas, 1999; Martin and Myers, 2005; Rasmussen, 1992; Walker et al., 2017) has concentrated primarily on surrounding communities. Prison location also matters at the macro level; in the US, 'prison gerrymandering' draws legislative districts around large prisons to incorporate prisoners as constituents (e.g. Ebenstein 2017). Disenfranchised prisoners are counted not in the districts where they lived prior to incarceration, but where they are imprisoned, thus inflating the democratic power of voting residents in rural prison districts, and reducing the power of the marginalized urban areas where prisoners previously lived. Considering these 'home' communities, family and friends endure hardships in maintaining contact with loved ones incarcerated some distance away (e.g. Comfort et al., 2016), and the greater the distance from home, the less likely prisoners are to receive

visitors (Clark and Duwe 2017; Cochran et al., 2016; Cochran and Mears, 2013; Piacentini et al., 2009; Lindsay et al. 2017).

Although such studies move us closer to understanding the impact on prisoners of prison siting, a focus on the *distance* between prison and domicile tells us little about whether the *place* where the prison is located matters, and if so, what matters *about* it. We know very little, for example, about whether prisoners' wellbeing is affected by rural or urban prison location, about the effect of any other characteristics of the prison locale, or about how these factors might intersect with distance. A rurally-located prison is probably *also* far from home for most urban-domiciled prisoners, but whereas distances will vary from prisoner to prisoner, presence in the rural location is shared by all.

Historically, the displacement of prisoners has been framed in terms of risk of unfamiliar climates, landscapes, pests and diseases. Wilson and Reid (1949) and Shanks et al. (2008) respectively noted high malaria mortality rates in Prisoners of War on the Siam-Burma Railway, and in nineteenth century European prisoners transported to the Andaman Islands. Less tangibly, Brown and Marusek (2014: 229–230) argued that Hawaiian prisoners incarcerated in 'Appalachian coal country and South-western deserts' see them as 'alien places', not only impeding visitation but also disrupting 'connections that are vital to a sense of identity, community, and sense of local belonging', and similarly, Pallot (2007) observed disorientation in Russian prisoners incarcerated in unfamiliar forested landscapes of the distant north of the country. The nature of the actual *places* where prisons are sited seems to be important, but our understanding is currently illuminated by very few small scale studies.

In the absence of research data, prison siting usually prioritizes land prices, ease of securing planning consent, and the (questionable) potential for a prison to stimulate local economic development. Beyond the presence of appropriate infrastructure, the nature of the intended prison locality itself is rarely considered. UNOPS guidance on prison location, for example, emphasizes access to food, water, fuel supplies, medical care, fire-fighting and other essential services alongside visitor and staff access, and the difficulty and cost of prisoner transfer. But the locale itself seems to matter only in that it should not carry 'the possibility of earthquakes, flooding during the rainy season, or heavy snowfall in winter' (UNOPS, 2016, 52).

Prisons therefore tend to be sited within communities which do not resist them, in undesirable locations, and often on brownfield, post-industrial or contaminated sites (Bernd et al., 2017; Davis, 2011; Opsal and Malin, 2019). Often relatively cheap to purchase, such sites carry environmental risks. The US Environmental Protection Agency's environmental justice mapping tool, and the Human Rights Defense Center's Prison Ecology Project show that mass incarceration and environmental degradation are closely connected (Corwin et al., 2020). Prisons present an environmental hazard through high resource consumption and waste generation (Opsal and Malin, 2019), contributions to air pollution from prison industry and vehicle emissions (Bernd et al., 2017; Pellow, 2017), and extensive hard surfacing, likely to contribute to local flood risk and water pollution without stormwater management and pollution abatement infrastructure (Newman et al., 2013).

Critically, unlike other residents who could, if funds allow, relocate away from such hazards (Helppie-Schmieder, 2016), spatially-fixed prisoners are 'sitting ducks' for pollution exposure (Corwin et al., 2020). For example, at Fayette men's prison in rural Pennsylvania, US, located on the site of a coal preparation plant, respondents to a small-scale survey self-reported respiratory, throat, sinus, skin and stomach problems.[1] Yet, Silver (2018) has noted very little peer-reviewed research documenting the *effect* of a prison's immediate environment on prisoners' wellbeing. Despite growing concerns, the very few published studies (He et al., 2016) focus exclusively on internal

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[1] https://www.motherjones.com/environment/2017/06/report-americas-prisons-are-so-polluted-they-are-endangering-inmates/ accessed 4.2.2020

environmental quality in relation to prison management processes such as prison smoking bans (e.g. Jayes et al., 2019; Hunt et al., 2019). As yet, there has been no systematic investigation of wellbeing in relation to *extra*-prison environmental conditions, i.e., the effects of the characteristics of the areas *surrounding* prisons on those incarcerated within them.

We therefore explore the relationship between characteristics of areas surrounding prisons and the wellbeing of the incarcerated. In the absence of national datasets disaggregated to the prison level which evidence prisoners' levels of stress, or healthcare outcomes, or indeed any other measures which might indicate prisoners' wellbeing, instead we use available data for self-harm and violence. Whilst by no means ideal proxies, as we discuss below our contention is that in the absence of other sources, these data provide an indication of the (lack of) wellbeing of incarcerated populations. The environmental characteristics we consider are greenspace (vegetated area), bluespace (bodies of water) and presence of major highways (motorways or 'A' roads).

Prior research has suggested that these characteristics may have a positive effect on (prisoner) wellbeing through mechanisms considered within Attention Restoration Theory (ART) or Stress Reduction Theory (SRT). ART is concerned with the propensity for nature contact to facilitate recovery from directed attention fatigue (Kaplan and Kaplan 1989; Kaplan 1995), and SRT posits that exposure to nature promotes stress recovery, based on positive psychophysiological responses rooted in evolutionary processes (Ulrich 1981; Ulrich et al., 1991). Both consider that natural landscapes facilitate restoration from mental fatigue, stress, and negative mood. These benefits of nature contact are increasingly being identified in prisons (Moore 1981; Nadkarni et al., 2017; Moran and Turner 2019; Moran 2019). Recent research has also found that higher percentages of greenspace *within* prisons are related to lower levels of self-harm and violence amongst prisoners, and to lower levels of staff sickness absence (Moran et al., 2021a; Moran et al., 2021b). Although research into the therapeutic effects of bodies of water close to prisons is much less well advanced, Jewkes, Moran and Turner (2020, 7) suggested that "the sound, smells and, especially, sight of the sea were instrumental in relieving the psychological compression endured in conditions of confinement" in a coastal prison. Although there is no prior research into of the effects of proximity to major transport arteries on prisoner wellbeing, we consider the presence of a major arterial road to be an indication of the proximity of transport connections which may mediate the effects of distance previously observed to affect the frequency of visitation, but may in turn bring problems of noise and air pollution. Our selection of these characteristics is also partially determined by the GIS methodology deployed in the study.

Data and methodologies

'Wellbeing' is a complex and contested notion, comprising much more than simply the absence of disease or pathology (Dodge et al., 2012). Ideally, wellbeing would be assessed through participatory methods, generating data pertaining to self-reported characteristics and experiences of studied populations, as demonstrated in the growing body of work on salutogenesis in prisons (e.g. Moran 2019, Moran and Turner 2019, Nadkarni et al., 2017). However, in a national level study such as this, such an approach was not feasible. An alternative approach is to use data pertaining to *indicators* of wellbeing (Loveridge et al., 2020). Given the multidimensional nature of wellbeing, there are thousands of *potentially* relevant indicators for wellbeing research in general, such as level of literacy, or income, but relatively few of these are reported for the prison system of England and Wales at the level of the individual prison. For the purposes of this project, therefore, we were limited to the use of a relatively restricted range of indicators for which data has been published, of which the closest approximation to wellbeing was provided by the proxy variables of self-harm and violence. Low levels of self-harm and violence are considered here to

indicate (the presence of) wellbeing, and high levels to indicate lack of, or 'negative' wellbeing. In the absence of other data which describe prisoners' wellbeing in positive terms, following the method adopted by Moran et al., 2021a; Moran et al., 2021b), and acknowledging that these indicators cannot capture wellbeing in its fullest sense, we therefore drew on official datasets approximating to *lack* of wellbeing.

We assembled publicly available data for all prison sites for over-18s in England and Wales (Immigration Removal Centers and facilities for under-18s were not included) relating to incidents of self-harm,[2] prisoner assaults on staff, and prisoner-on-prisoner assaults.[3] Self-evidently, this analysis enables an exploration of the relationship between prison location and self-harm and violence. However, based on the assumption such incidents speak to prisoners' experiences more generally, this analysis is also intended to provide an insight into the effects of prison location on a broader sense of wellbeing. We also compiled prison-level data including prison age, type, and whether a prison was purpose-built or converted from another function. For male prisons, 'type' was divided into: Local (holding short-sentenced prisoners and those awaiting trial/ sentencing); High Security/Category A; Category B (medium-high security); Category C (medium-low security); and Open/Category D. We also noted Young Offenders' Institutes (YOI) for men aged 18–20, female prisons, and those accommodating sex offenders[4],[5] Data were compiled for all currently operational establishments. Given multiple changes in type (e.g. from Cat B to Cat C prison), mergers and closures[6] trends were considered as averages for the period from 2014 (later for prisons which opened after this date) to 2018. Data were cleaned for analysis; where establishments are jointly managed but physically distinct, they were treated separately. This resulted in an initial dataset covering 117 establishments.

First, we examined whether and how the various prison types differ in negative prisoner wellbeing. We regressed the three indicators of negative wellbeing on a set of prison type dummy variables, taking Local Prisons as reference category:

$$Y_i = \beta_0 + \beta_1 CatB_i + \beta_2 CatC_i + \beta_3 Female_i + \beta_4 Highsecurity_i + \beta_5 Open_i + \beta_6 YOI + \varepsilon_i \qquad (1)$$

This regression model posits prisoner wellbeing Y in prison i as a function of the various prison types and an idiosyncratic error term. Y is the prisoner-averaged number of self-harm incidents, prisoner-on-prisoner assaults or prisoner-on-staff assaults . We average these for the period 2014–2018.

The findings from estimating the models with the three dependent variables are presented in Fig. 1, which shows the point estimates and the 95% confidence intervals for the prison type dummy variables, together with the goodness of fit statistic and the adjusted R-square of the estimations. The results for self-harm shown in the left-hand column indicate that Female prisons are clearly characterized by a significantly higher average level of occurrences. In contrast, Open prisons have a significantly lower level of self-harm per prisoner. The estimated negative effect of CatCtrainer prisons is also significant but small in size. The other prison types do not differ significantly from the reference category.

The results from the estimations for assaults between prisoners or against staff indicate that YOIs are characterized by significantly higher levels of assaults, with the effect being particularly pronounced for assaults between prisoners. The other prison types have lower levels of assaults compared to the reference category, with Open prisons again having the largest estimated negative effect. The data show that levels of assaults between prisoners differ more according to prison type than do assaults against staff.

Measuring the geographical characteristics of prisons' surroundings

Our purpose in this paper is to identify the effect of the characteristics of the areas surrounding prisons on prisoner wellbeing (as captured by the proxy variables for lack of wellbeing), whilst allowing for the effect of other prison characteristics. In order to carry out this analysis, we required a means to capture the characteristics of the area within a specified 'buffer' zone surrounding prison perimeters. In the absence of any pre-existing dataset, we deployed a variation of the GIS methodology devised by Moran et al., 2021a,b for their study to determine the percentage of the area within a prison's perimeter wall or fence which is 'greenspace' (vegetated landcover). However, in this case, we deployed this method for a 500m buffer zone *outside* the prison perimeter, also looking for 'bluespace' (bodies of water such the sea, lakes, rivers, canals), and the presence of major roadways, as well as measuring 'greenspace' (Fig. 2).

A very detailed description of the GIS methodology is given in Moran et al., 2021a,b, so here we note simply that we used the same Mastermap data and georectified aerial photographs for all prisons in England and Wales to examine area designated 'natural', or 'multiple' (for greenspace), or 'water' (for bluespace) contained within a 500m buffer zone. The presence or absence of a major road within the buffer was noted, but no percentage area calculations were made. In the absence of any prior comparable research, the 500m depth of buffer zone was selected to give a sense of both the immediate and the further distant surroundings of each prison.

A small number of additions was made to the greenspace dataset based on a detailed examination of land-use at each prison site. Glasshouses as well as solar panels set in fields are not included in categories of 'multiple' and 'natural' but were manually added. For urban prison sites, we examined the small number of trees visible in the aerial photographs that are not included in Mastermap's 'multiple' or 'natural' polygons. We undertook a test using HMPs Cardiff and Exeter, which revealed that manually adding individual trees would contribute less than 1% to the total green space identified within the buffer zone. Given the minimal difference that painstaking manual additions would make to the overall figures, a pragmatic decision was taken to exclude these individual trees from the analysis.

[2] HMPPS (2019) *Safety in Custody: Self-harm in prison custody 2004 to 2018* https://assets.publishing.service.gov.uk/government/uploads/system/ uploads/attachment_data/file/797076/safety-in-custody-self-harm-dec-18.ods Accessed 29.01.2020

[3] HMPPS (2019) *Safety in Custody: Assaults in Prison Custody 2000-2018* https ://assets.publishing.service.gov.uk/government/uploads/system/uploads/att achment_data/file/797077/safety-in-custody-assaults-dec-18.ods Accessed 29.1.2020

[4] HMPPS (2019) *The prison estate in England and Wales, including public and contracted prisons, HMPPS immigration removal centre operated on behalf of the Home Office and secure training centres.* Revised 01.07.2019 https://www.gov. uk/government/publications/prisons-and-their-resettlement-providers accessed 29.1.2020

[5] This information was obtained from individual information webpages for prisons in England and Wales hosted at http://www.justice.gov.uk/contact s/prison-finder/. Accessed 5.5.2019.

[6] Between 2012 and 2014 two new prisons opened, two prisons merged, 11 prisons closed, four changed role, and another temporarily closed, awaiting change of role.
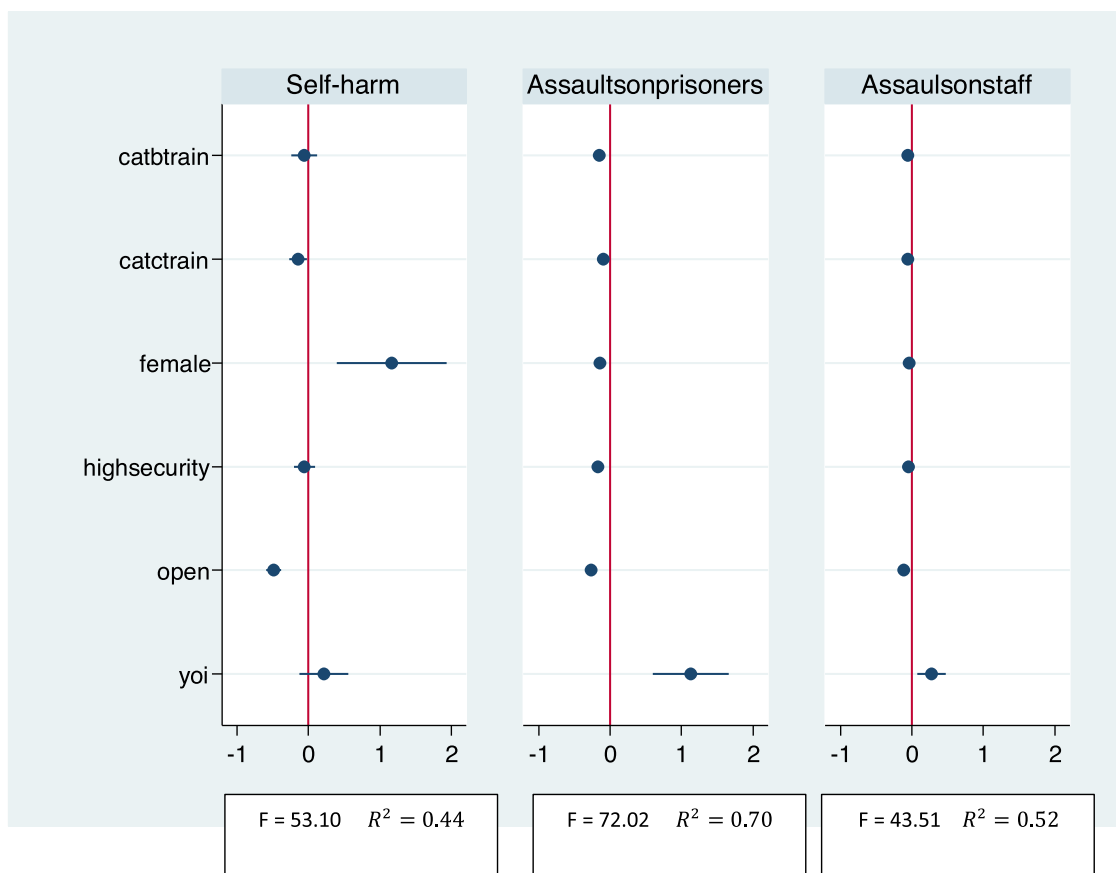
Fig. 1. Prison types and prisoner well-being: point estimates and 95% confidence intervals.

The Mastermap and aerial photograph data occasionally diverged, indicating that some features visible on the (constantly and incrementally updated) Mastermap layers had appeared since the older aerial photographs were taken. The most recent data were used in any such cases, but these divergences suggest that there may unavoidably be minor discrepancies between the exact composition of some areas during the data span of the dependent variables (2014–18), and at the date of accessing the Mastermap layers (July 2019). However, it is unlikely that any such variations are widespread or significant enough to affect our analysis.

The practicalities of how these datasets were generated led us to remove Category D/Open prisons from further analysis.[7] This decision was taken because of the difficulty of delineating these establishments, many of which do not have a physical perimeter wall or fence clearly discernible in satellite images, rendering it impossible to identify the buffer zone using the methodology described above. The remaining dataset ($n = 107$) is characterized by substantial variation in greenspace percentages, from one buffer with 16.6%, to more than 96% of another being vegetated. The sample average is 72.3% greenspace. Bluespace ranged from 0% to 26.1% (HMP Swansea being close to the Bristol Channel), with a sample average of 1.8%, while 39% of prisons within the sample were proximate to a major road. Incomplete statistical datasets for some of these 107 prisons saw the final number used in regression analysis standing at 103. As initial estimations revealed the presence of several outliers and missing information for some of the additional control variables, the regression models are estimated with sample sizes ranging between 85 and 94, depending on model specification.

It is important to note that for several reasons, we cannot assume that all prisoners in the establishments included in our dataset can see the buffer zone. In prisons in England and Wales, all cells have a view to the outside through a window, but not all of these permit a view of the area beyond the prison itself. Firstly, some prisons have high perimeter walls, which block the view at ground level, whereas others have double-layer perimeter fences, which merely obscure it. Secondly, the configuration of prison buildings means that some 'inward-facing' cell windows will look out onto spaces enclosed by other buildings, rather than facing 'outward' towards the perimeter. Most prisons have two, three or four-level accommodation buildings, and it may be the case that only outward-facing cells on upper levels afford a view of the buffer zone, especially in prisons with perimeter walls rather than fences. Without a detailed survey of the aspect of each of the many hundreds of cells at all establishments, it is not possible to determine the proportion of a prison's population with a view to the buffer zone. Even if such cell-view data were available, they would not account for views of the buffer zone that might be afforded to prisoners whilst moving around the prison site, for example to work or education activities, or during exercise. For all of these reasons, our analysis is both exploratory (intending to provide an initial evidential basis for further analysis which could include generation of such datasets), but also novel (in that it postulates that landscape features such as green space may *still* have beneficial effects for those to whom they are not visible).

Self-harm, assaults and geographical characteristics

To visualize the relationship between geographical characteristics and prisoner wellbeing, we created partial scatterplots obtained by adding the variables greenspace, bluespace or majorroad to the

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[7] Jointly-managed prisons which included one Open site, and which did not consistently report separate data for each of their constituent sites, were also removed from analysis at this point.
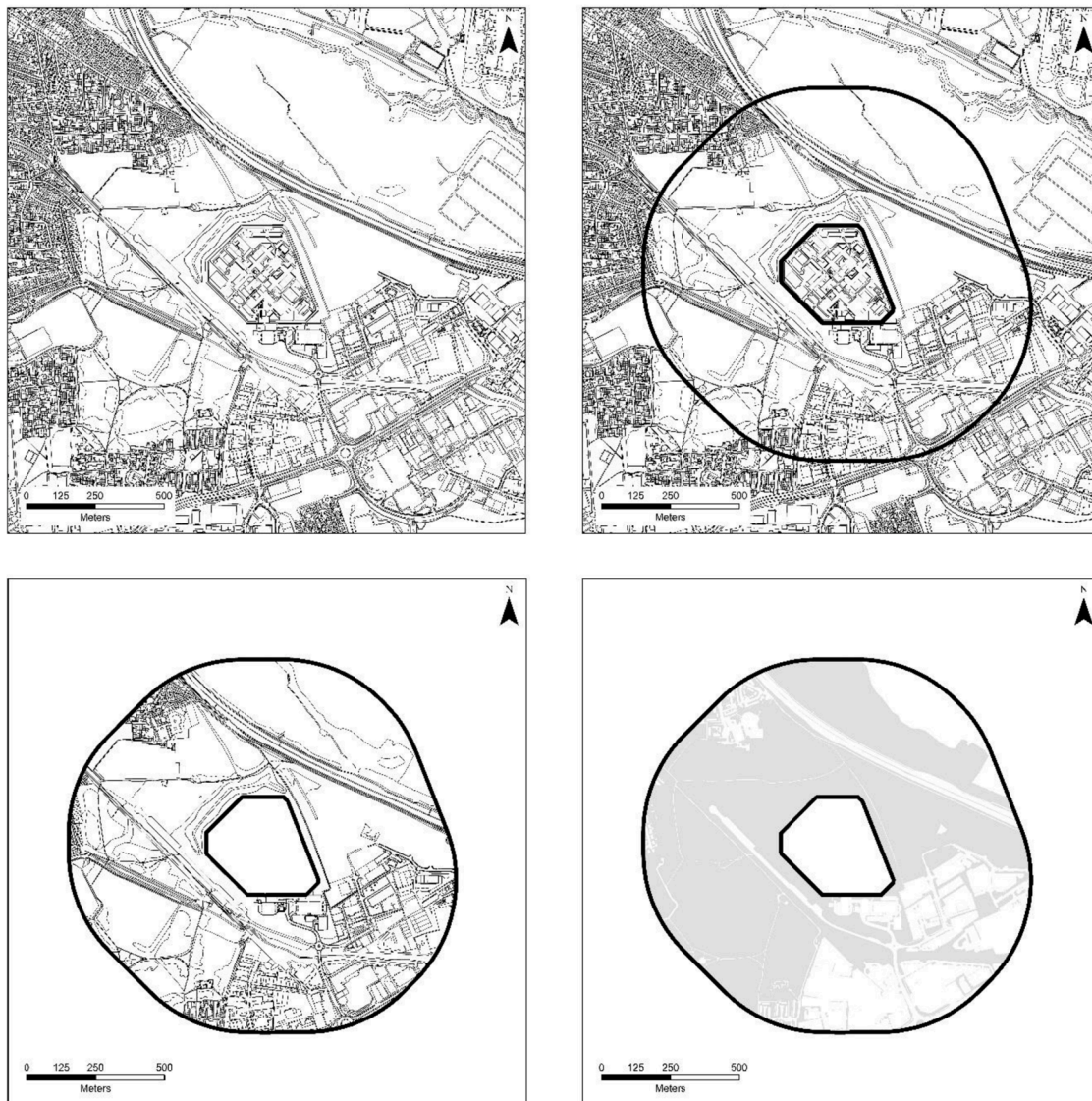
Fig. 2. Mastermap Topographic layer showing a prison (upper left); buffer zone 500 m from prison perimeter, with boundary exaggerated for clarity (upper right); polygons within the 500 m buffer zone isolated (lower left); all areas of 'natural' and 'multiple' surfaces within the buffer zone identified (lower right).

estimations with the prison type dummies in regression model (1). Figs. 3, 4 and 5 show the partial plots with these three different geographical variables. The scatterplots with greenspace all show significant negative associations, suggesting that greenspace contributes to prisoner wellbeing. In contrast, the partial plots with bluespace and

the effect of greenspace holds when we control for more prison characteristics, we augment the regression model with a number of control variables. We estimate various specifications of the following regression model:

$$Y_i = \beta_0 + \beta_1 Greenspace_i + \beta_2 Centuryold_i + \beta_3 Opcap\_pop_i + \beta_4 Population + \beta_5 Prisontype_i + \beta_6 Sexoffenders_i + \beta_7 Purposebuilt_i + \beta_8 Bluespace_i + \beta_9 Majorroad_i + \varepsilon_i \tag{2}$$

majorroad show no significant association with the dependent variables.

Multivariate regression analysis

Although suggestive, the partial plots showing significant associations between greenspace and the dependent variables must be interpreted with caution, since they are obtained by only controlling for the effects of the various prison type dummies. In order to examine whether

where Y is either the prisoner-averaged level of self-harm, prisoner-on-prisoner or prisoner-on-staff assaults of prison i, averaged for 2014–2018. 'Greenspace' is the percentage of greenspace in the buffer zone around the prisons. 'Centuryold' is a dummy variable taking the value of 1 for prisons that first opened in the 19th century. "Opcap_pop" is operational capacity/prisoner population in 2014, measuring the degree of prison overcrowding. "Population" is the log of the number of prisoners in 2014. "Staff-prisoner ratio" reflects the ratio of operational
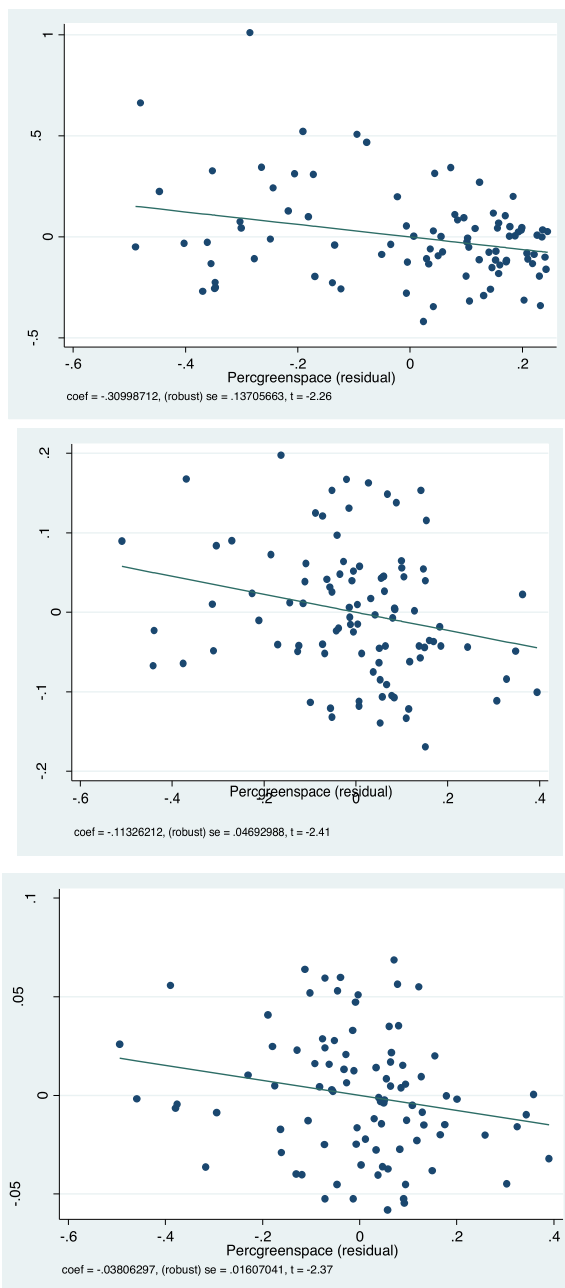
Fig. 3. Partial scatterplots between percentage greenspace and prisoner wellbeing.

Fig. 4. Partial scatterplots between percentage bluespace and prisoner wellbeing.

staff (i.e. staff working directly with prisoners, rather than in administrative roles) to prisoners in 2014. "Prisontypes" refers to the dummy variables distinguishing between the different prison types. "Sexoffenders" is a dummy variable capturing specialist sex-offender prisons. "Purposebuilt" is a dummy variable capturing whether a prison was purpose-built or converted from a previous use. Finally, we also add the other two geographical variables to some of the estimated models, to examine whether the effect of greenspace is affected by the inclusion of bluespace and majorroad and to further assess whether these two geographical characteristics may impact upon prisoner wellbeing.

It is important to note that in estimating this model we do not claim to have included every possible characteristic that might influence prisoner self-harm and violence. The inclusion of variables is largely determined by the availability of data. Ideally, given our interest in prison location, we would have included a variable controlling for prisoners' domicile, such as the average distance from home at which a
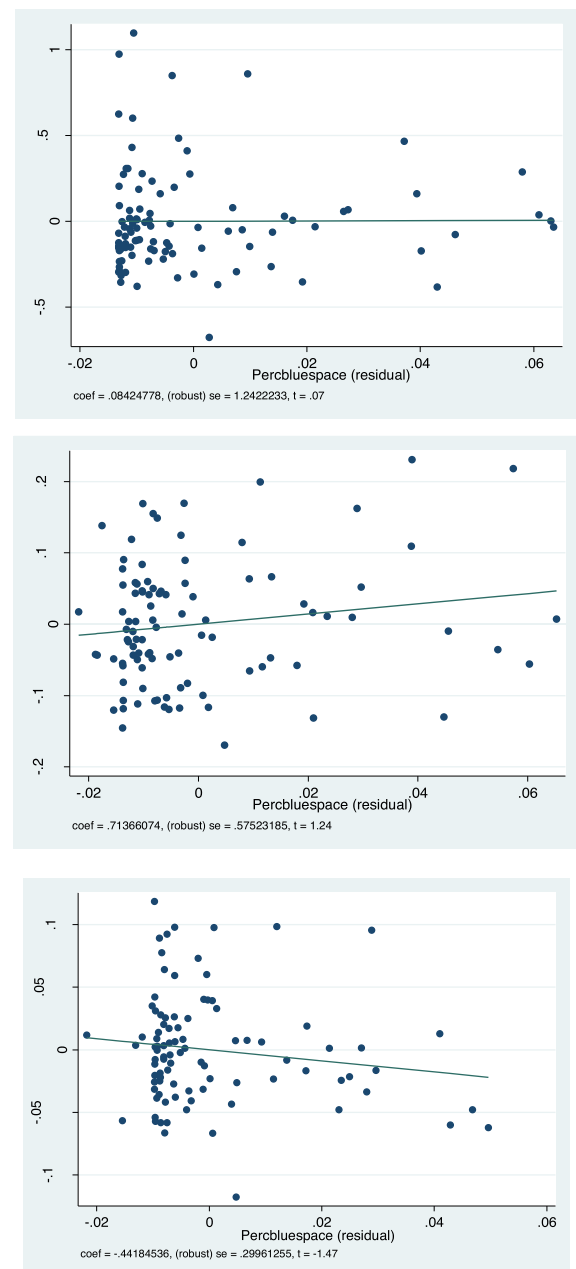
prison's residents are incarcerated. Unfortunately, this data is not available for prisons in England and Wales, and neither are data about the intrinsic risk of self-harm and violence perceived to be posed by prisoners at each establishment. Our interest here is in the nature of the spaces *outside* the prison perimeter, and although prior research has already explored the impact of greenspace *within* the perimeter (Moran et al., 2021a; Moran et al., 2021b), there are potentially other physical characteristics of the prison itself, over and above those included here (age, capacity, category), which may influence self-harm and violence. Such factors could include the propensity for a prison building to facilitate the surveillance of incarcerated populations – which one might assume would reduce the levels of self-harm and violence. It is possible that, as Morris and Worrall (2014) postulated in relation to prisoner misconduct for prisons in Florida, certain prison layouts might have this effect, but in the absence of an agreed system of categorizing prison buildings, (as well as the fact that unlike in Florida, most prisons in
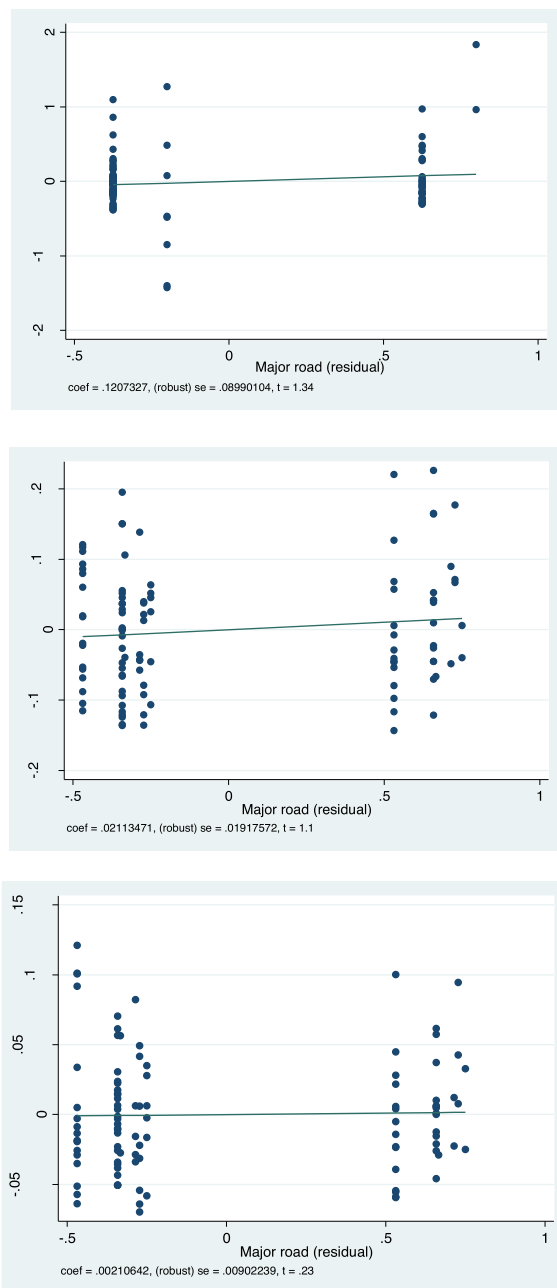
coef = .1207327, (robust) se = .08990104, t = 1.34

coef = .02113471, (robust) se = .01917572, t = 1.1

coef = .00210642, (robust) se = .00902239, t = .23

Fig. 5. Partial scatterplots between major road and prisoner wellbeing.

England and Wales comprise an assortment of buildings of different shapes and layouts, rendering them very difficult to classify), this endeavor was beyond the scope of our exploratory analysis. The 'purposebuilt' and 'centuryold' variables enabled a limited consideration of design in more general terms. Our intention here was not to undertake a comprehensive analysis of *all* possible factors potentially influencing self-harm and violence – rather to demonstrate that the methodology we deploy offers a novel and informative way to understand the significance of prison location.

Bearing in mind the limitations of the available variables, the findings from estimating model (2) with the three alternative dependent variables are presented in Table 1. The results in column (1) show that female prisons are characterized by a significantly higher level of self-harm. The estimated effect of Centuryold is significant and negative, indicating that older prisons have a lower level of self-harm, as do prisons that house sex-offenders. Purpose-built prisons have a

significantly higher level of self-harm.

Turning to the geographical variables, the estimated effect of greenspace is significant and negative in estimations (1)-(3), confirming that greenspace reduces self-harm. In regression (2), we augment the model with the variable bluespace and an interaction between greenspace and bluespace. We include this interaction term to assess whether the effect of greenspace is strengthened when the percentage of bluespace in the prison buffer is relatively high. The findings suggest that bluespace is not impacting on the level of self-harm, as the effect both of bluespace and its interaction with greenspace are insignificant.

In regression (3) we augment the model with the dummy variable that captures the presence of a major road and an interaction variable between greenspace and major road. Since prisons with good transport connections may have higher levels of prisoner visitation, we would expect the major road variable to be negatively related to self-harm, i.e. promoting prisoner wellbeing, and this is indeed what we find. Considering the interaction with greenspace, we find that the presence of a major road reduces the positive effect of greenspace on prisoner wellbeing (perhaps by reducing the level of calm and tranquility which might otherwise be associated with green surroundings).

Regression (4) shows the results from adding the staff-prisoner ratio measured for 2014 to the regression model. Together with the variable Opcap_pop, the staff-prisoner ratio is related to the degree of prison overcrowding, being linked to the extent to which prison staff can effectively oversee and manage a prison population. The limitation of using this additional control variable is that data are only available for public-sector prisons, causing a substantial decrease in the number of observations.

As the findings in column (4) indicate, the estimated effect of the staff-prisoner ratio is insignificant. Importantly, the nature and significance of the estimated effects of the main variables of interest - Greenspace, Major road and their interaction - are unaffected by the inclusion of the staff-prisoner ratio. The significance of the estimated effects of the variables Opcap_pop and the dummy variable capturing Sex offender institutes is negatively affected. This may be related to the decrease in the number of observations and to differences between private and public prisons regarding these prison characteristics.

Since the control variables are measured in different ways, it is difficult to compare the relative importance of their estimated effects. Standardized beta coefficients facilitate this by indicating by how many standard deviations the dependent variable changes with a one standard deviation change in the control variables, irrespective of how the control variables are measured. Column (4) presents the standardized beta coefficients of estimation (3), and as the results indicate, the effect of connectivity is the strongest, followed by the effect of greenspace.

The next two sets of findings in Table 1 show the results for drivers of assaults between prisoners and against prison staff. The findings are similar to those for self-harm, in that greenspace is significantly and negatively associated with the two violence variables. We also find that the presence of a major road increases prisoner wellbeing, and that the interaction between greenspace and the presence of a major road carries a positive coefficient, indicating that the effect of greenspace on prisoner wellbeing is again weakened when the prison buffer contains a major road. The estimated effects of these variables are robust to the inclusion or exclusion of the staff-prisoner ratio variable.[8] In terms of the relative strength of the estimated effects, the standardized beta coefficients

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[8] Whereas the estimated effect of the staff-prisoner ratio is insignificant when we use prisoner-on-prisoner assaults as dependent variable, its estimated positive effect is significant in the model with prisoner-on-staff assaults. An explanation for this effect could be that prisons with a greater staff presence experience more assaults on staff, or that prisons with a relatively high degree of assaults on staff are more likely to employ more staff to deal with this type of prison violence. Further research would be necessary to understand these relationships in more detail.

Table 1
Drivers of prisoner wellbeing.

Dependent variable	Self-harm/prisoner					Prisoner on prisoner attacks/prisoner					Prisoner on staff attacks/prisoner				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Greenspace	−0.48 *** (0.18)	−0.52** (0.24)	−0.80*** (0.20)	−0.53 ** (0.21)	−0.65	−0.14*** (0.04)	−0.14*** (0.05)	−0.26*** (0.08)	−0.21 ** (0.08)	−0.34	−0.06*** (0.02)	−0.07*** (0.02)	−0.09*** (0.03)	−0.07 ** (0.03)	−0.41
Catbtrainer						−0.09*** (0.03)	−0.10*** (0.03)	−0.08** (0.03)	−0.06 ** (0.03)	−0.14					
Catctrainer						−0.07*** (0.02)	−0.07*** (0.02)	−0.06*** (0.02)	−0.04 (0.03)	−0.17	−0.015** (0.007)	−0.016** (0.007)	−0.015** (0.006)	−0.01 (0.01)	−0.16
Female prison	0.61** (0.18)	0.60*** (0.18)	0.61*** (0.18)	0.65*** (0.18)	0.49										
High security						−0.17** (0.03)	−0.18*** (0.008)	−0.14*** (0.03)	−0.17 *** (0.05)	−0.23	−0.03*** (0.008)	−0.04*** (0.01)	−0.03*** (0.008)	−0.05 *** (0.01)	−0.15
YOI						0.56*** (0.06)	0.55*** (0.06)	0.59*** (0.06)	0.57 *** (0.06)	0.72	0.15*** (0.03)	0.15*** (0.02)	0.15*** (0.03)	0.14 *** (0.02)	0.59
Blue space		−2.38 (4.40)					1.81 (2.24)					−0.43 (1.02)			
Greenspace x Blue space		3.46 (5.70)					−1.62 (2.86)					0.77 (1.30)			
Major road			−0.45** (0.20)	−0.52*** (0.18)	−0.83			−0.16** (0.07)	−0.13 * (0.07)	−0.45			−0.04* (0.025)	−0.05 ** (0.025)	−0.46
Greenspace x Major road			0.56** (0.25)	0.61*** (0.23)	0.66			0.22** (0.10)	0.19** (0.09)	0.44			0.06** (0.03)	0.06 ** (0.03)	0.46
Centuryold	−0.15** (0.07)	−0.15** (0.07)	−0.16** (0.07)	0.02 (0.05)	−0.29	−0.04** (0.02)	−0.04** (0.02)	−0.04** (0.02)	−0.02 (0.02)	−0.12	−0.01 (0.009)	−0.01 (0.009)	−0.01 (0.009)	0.003 (0.01)	
Opcap_pop	−0.06 (0.12)	−0.05 (0.13)	−0.03 (0.12)	−0.17 (0.11)		−0.06** (0.03)	−0.06** (0.03)	−0.04 (0.03)	−0.05 (0.04)		−0.005 (0.02)	−0.002 (0.02)	−0.005 (0.02)	0.007 (0.02)	
Lnpopulation	−0.05 (0.05)	−0.04 (0.06)	−0.03 (0.06)	−0.07 (0.06)		0.002 (0.02)	−0.004 (0.02)	0.02 (0.02)	0.01 (0.04)		0.008 (0.008)	0.01 (0.008)	0.01 (0.008)	0.03 *** (0.01)	
Sex offender	−0.15** (0.07)	−0.15** (0.07)	−0.14** (0.06)	−0.07 (0.06)	−0.14	−0.09*** (0.02)	−0.09*** (0.02)	−0.10*** (0.02)	−0.11 *** (0.02)	−0.15	−0.04*** (0.01)	−0.03*** (0.01)	−0.04*** (0.01)	−0.05 *** (0.004)	−0.20
Purpose built	0.09** (0.04)	0.09* (0.05)	0.08* (0.05)	0.05 (0.05)	0.13	0.04** (0.02)	0.04** (0.02)	0.03* (0.018)	0.02 (0.02)	0.07	0.014* (0.008)	0.016** (0.008)	0.013* (0.008)	−0.004 (0.007)	0.12
Staff-prisoner ratio				0.14 (0.13)					0.10 (0.11)					0.08 *** (0.03)	
F	4.43 (0.00)	3.65 (0.00)	4.87 (0.00)	5.20 (0.00)		25.88 (0.00)	23.25 (0.00)	26.34 (0.00)	29.31 (0.00)		12.59 (0.00)	10.70 (0.00)	11.86 (0.00)	40.37 (0.00)	
Adj. R square	0.38	0.38	0.43	0.57		0.82	0.83	0.84	0.85		0.63	0.65	0.65	0.72	
N	88	88	88	75		94	92	94	80		89	86	89	75	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; robust standard errors in parentheses. Columns (5), (10) and (15) report standardized beta coefficients of estimations (3), (8) and (13).

reported in (10) and (15) indicate that apart from the effect of accommodating young offenders (YOI) (the factor which, as might be expected, exerts the strongest influence over levels of violence), presence of a major road in the prison buffer and the effect of greenspace are the most important factors.

Self-harm, violence and greenspace

To complete the analysis, we examine possible relationships between self-harm and violence. The dependent variables measuring levels of assaults between prisoners and towards staff capture levels of general unrest. In comparison, self-harm is arguably a more personal expression of negative wellbeing. As such, one could argue that the level of violence in prisons may impact upon the level of self-harm. To identify such an effect, we can estimate the following regression model:

$$Y_i = \beta_0 + \beta_1 Greenspace_i + \beta_2 Assaults\_pop_i + \beta_3 Centuryold_i + \beta_4 Opcap\_pop_i + \beta_5 Population_i +$$
$$\beta_6 Female\ prison_i + \beta_7 Sex\ offenders_i + â_8 Purposebuilt_i + \beta_9 Majorroad_i + \beta_{10} Greenspace_i * Majorroad_i + \varepsilon_i \tag{3}$$

where Y is prisoner-averaged self-harm for the period 2014–2018 and assaults is either prisoner-on-prisoner or prisoner-on-staff assaults.

In order to obtain an unbiased estimation of the effect of assaults on self-harm, we deploy instrumental variable (IV) estimation techniques. It is likely that the level of self-harm impacts on the level of assaults in prisons. This reverse causation makes it difficult to interpret the estimated effect of assaults β_2, capturing the effect of assaults on self-harm and vice versa. To instrument the variable Assaults_pop, we use several prison type dummy variables. As the findings in Table 2 show, in the fully specified regression model only the category Female prisons impacts on self-harm. In contrast, assaults are affected by the prison category dummies Catctrainer prisons, high security prisons and YOIs, suggesting that we can use these variables as instruments to obtain

unbiased estimated effects of assaults among prisoners and assaults of staff members on self-harm.

Table 2 shows the findings from OLS and IV estimations of regression model (3) with the two assault-related variables. Columns (1) and (2) present the findings for prisoner-on-prisoner assaults. Both the OLS and IV estimations show a positive effect of assaults on the level of self-harm. The first stage statistics of the IV estimation are satisfactory and the Sargan test statistic indicates that the over-identifying restrictions cannot be rejected, confirming that the instruments are appropriate. The effects of greenspace, major road and their interaction are the same as the findings in Table 1.

Columns (3) and (4) show the results for the model with assaults against prison staff. The nature of the estimated effects of greenspace, major road and their interaction are similar. Also, the results from both the OLS and IV estimation indicate a positive effect of assaults on self-

harm. The estimated magnitude of the estimated coefficient of assaults among prisoners with the IV estimation needs to be interpreted with caution. Although the Sargan statistic indicates that the set of instruments is appropriate, the F-value of the first stage estimation remains rather low. In any case, the findings further confirm that assaults exercise a positive effect on the level of self-harm, with the caveat that the size of the estimated effect of assaults of staff members needs to be interpreted with some caution.

Discussion

Previous work on prison location has been narrow in scope. The majority of studies highlight impacts of siting on surrounding non-incarcerated communities and, to a lesser extent, on prisoners' families traversing long distances for visitation. By contrast, our exploratory analysis considers the effect of prison location on *prisoners*. Bearing in mind the limitations of the methodology and the availability of data, we find statistically significant evidence that the characteristics of areas surrounding prisons – specifically the presence of greenspace – have a measurable impact on levels of self-harm and violence. We find that greenspace in a 500m buffer zone surrounding prisons reduces levels of self-harm and violence across all prison types, and therefore we suggest that location within greenspace may play a role in improving the wellbeing of incarcerated populations.

Given the potential implications of our findings, we next consider *why* this effect might be found – especially since 'greener' areas are likely to be distant from urban prisoners' domiciles, and previous research has identified distance from home as a barrier to wellbeing-enhancing visitation. As noted earlier, lack of data did not enable us include in our estimations all the variables that could potentially influence levels of self-harm and violence. We were unable to consider distance from urban centers as an independent variable, but by including the presence of major roads as a proxy for connectivity, we were able to show that *both* greenspace *and* connectivity are significant factors for wellbeing. Future research could more fully explore this relationship.

Further studies might also reconsider the size of the buffer zone. In the absence of any prior research of this kind, our selection of a 500m distance from the prison perimeter was a somewhat arbitrary choice, and future analysis could analyze different depths of buffer zone, testing the effects of immediate surroundings versus broader landscapes. Data availability did not permit disaggregation of 'greenspace' into different vegetation types, but future studies could explore the potential for

Table 2
Prison violence as driver of self-harm: OLS & IV estimations.

	1 OLS	2 IV	3 OLS	4 IV
Greenspace	−0.59***	−0.67**	−0.65***	−0.61
	(0.18)	(0.18)	(0.17)	(0.21)***
Major road	−0.44***	−0.45***	−0.35**	−0.33**
	(0.16)	(0.15)	(0.17)	(0.16)
Greenspace * major road	0.54**	0.56**	0.42* (0.22)	0.40*
	(0.22)	(0.21)		(0.22)
Prisoner-on-prisoner assaults	0.99***	0.66**		
	(0.25)	(0.32)		
Prisoner-on-staff assaults			4.14***	4.56***
			(0.94)	(1.66)
Centuryold	−0.11**	−0.13**	−0.14**	−0.13**
	(0.05)	(0.05)	(0.07)	(0.06)
Opcap_pop	0.06 (0.09)	0.04 (0.09)	0.07 (0.12)	0.07 (0.08)
Lnpopulation	0.002 (0.05)	−0.009 (0.05)	0.005 (0.05)	0.008 (0.05)
Female prison	0.65***	0.64***	0.75***	0.76***
	(0.12)	(0.12)	(0.19)	(0.12)
Sex offender	−0.07	−0.10	−0.04	−0.02
	(0.08)	(0.08)	(0.05)	(0.08)
Purpose built	0.07 (0.06)	0.08 (0.06)	0.05 (0.05)	0.04 (0.06)
Goodness of fit	9.00 (0.00)	87.22 (0.00)	9.83 (0.00)	113.85 (0.00)
Adj. R square	0.49	0.54	0.62	0.61
F first stage		16.59 (0.00)		7.68 (0.00)
Adj. R square first stage		0.56		0.25
Sargan		5.19 (0.16)		1.22 (0.54)
N	85	85	82	82

farmland or forest (for example) to have different effects.

Lack of cell-view data, (i.e. data determining the proportion of individual cells at each establishment which have a view to the buffer zone) means that we cannot be certain that the greenspace which our findings suggest has beneficial effects is actually *visible* to those affected. Whilst this methodological drawback could be addressed in future studies, it also highlights a need for further research to consider the potential effects of green spaces which lie *out of sight* – research which is potentially significant for understandings of the benefits of nature contact more generally. In the well-established literature evidencing benefits of nature contact, including the growing number of prison-based studies (e.g. Moran and Turner 2018; Nadkarni et al., 2017; Moran 2019; Moran et al., 2021a; Moran et al., 2021b), there is an implicit or explicit assumption that green spaces are *visible*. Since prisons' buffer zones are likely to be out of sight to many prisoners, we might usefully consider *how* they deliver these positive effects. Without the further research we advocate above, our suggestions are necessarily speculative, but buffer zones with high percentages of greenspace might have better air quality, lower levels of environmental pollution, and a more peaceful soundscape than those in more urban or less 'green' areas. Our finding that the presence of a major road reduces the effect of greenspace on wellbeing also suggests this conclusion.

Greener settings may host wildlife such as birds, which may positively effect on wellbeing should they enter the prison complex (Moran 2015; Hardy, 2018). The effects on prisoner self-harm and violence may also be mediated through the benefits of 'green' location on prison staff, who *do* have the opportunity to encounter the buffer zone on their journeys to and from work, and who perhaps reside nearby in similarly green areas. Prior research (Moran et al., 2021b) has already demonstrated that increased greenspace *within* prisons reduces staff sickness absence, possibly through reducing work-related stress, and in line with wider research into the effects of greenspace it may be the case that these benefits are also influential here. Again, further research would be necessary to explore these aspects of our findings.

Finally, as noted earlier, we used data for self-harm and violence as proxies for a general sense of prisoner wellbeing. Whilst important and noteworthy in and of themselves, these data clearly do not capture all elements of 'wellbeing', and future research could utilize different and perhaps more appropriate data sources which might be available in other jurisdictions.

Our findings suggesting that location in greenspace reduces prisoner self-harm and violence are robust insofar as the available data enables us to estimate them. Just as significant, though, are the avenues they open out for further quantitative, qualitative and/or ethnographic research probing the lived experience of prison(er)s. Such research could generate cell-view data, to determine the differences in ability to view the surrounding landscape from different cells, or classify prison layouts. It could also explore incarcerated individuals' level of awareness of the locale within which they are confined, and any effects they perceive to derive from the characteristics of the surrounding environment. Studies of prisons' environmental quality, such as air quality and levels of noise, would also help in further developing our understanding of the likely impact of prison settings. Our contention is that now that a relationship between greenspace and prison location has been demonstrated, there is a compelling case for further research to explore this relationship in more detail.

Both the exploratory nature of this study, and the need for further research, mean that the practical and policy implications of our findings must be advanced with caution. However, high levels of self-harm and violence in prisons have severe personal, emotional and social consequences for all concerned. They also have financial consequences, and carry implications for the wellbeing and retention of prison staff. Whether reductions are sought as part of a humane and rehabilitative prison system, or simply to manage the associated financial cost and associated staff attrition, our findings suggest that prisons should be located in areas with substantial greenspace, ideally with good public transport connections to enable regular visitation, and that where possible, the areas surrounding prisons should be 'greened', via planting of vegetation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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