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Toxic Prisons? Local Environmental Quality and the Wellbeing of Incarcerated Populations

Dominique Moran [1,*], Jacob A. Jordaan [2] and Phil I. Jones [1]

1 School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK; p.i.jones@bham.ac.uk
2 Utrecht University School of Economics, Utrecht University, Kriekenpitplein 21-22, 3584 EC Utrecht, The Netherlands; j.a.jordaan@uu.nl
* Correspondence: d.moran@bham.ac.uk

Abstract: A growing body of scholarship draws attention to prisons and environmental justice, pointing out the propensity for prisons to be located on contaminated sites and to be in close proximity to polluting industries, as well as for prisons themselves to contribute to local environmental degradation. Prisoners' immobility renders them unable to relocate away from harmful environments, and there are now numerous suggestions that their wellbeing suffers as a result of the poor quality of many local environments. However, since a relationship between environmental quality and prisoner wellbeing is yet to be robustly demonstrated, there is currently no firm evidence base from which to argue for positive change. This paper therefore examines the effect of the environmental quality of the locations of prisons, approximated as the presence of greenspace in the immediate vicinity of prisons, local species biodiversity and local levels of air and noise pollution, on wellbeing outcomes in a set of prisons in England and Wales. It finds that good environmental quality, in the form of high biodiversity and/or low air pollution, enhances the already-recognized positive effects of greenspace on the wellbeing of incarcerated populations. On the basis of these findings, this paper makes evidence-based policy recommendations intended to enhance the wellbeing of incarcerated populations.

Keywords: prison; biodiversity; wellbeing; planning

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1. Introduction

A growing body of work is calling for dedicated attention to the issue of 'toxic prisons,' a term referring to the propensity for prisons to be located within, and to contribute to, environmentally degraded landscapes, with an assumed impact on the wellbeing of both incarcerated populations and communities proximate to prisons—all within the context of climate change and its anticipated effects. This evocative term has become something of a call to arms for environmentalists and green criminologists, working together with prison abolition organizations to 'fight the epidemic' of such conditions [1] (p. 10). Environmental hazards impacting prison populations disproportionately affect minority populations who are themselves disproportionately incarcerated, rendering this toxicity a pervasive form of racialized and gendered environmental injustice [2] (p. 230) in that a problem that lets 'a simple prison sentence become a death sentence for those inmates who are exposed to toxins' cannot be allowed to continue.

At the same time, there is a growing movement supporting the 'greening' of corrections. In many jurisdictions, often in response to growing awareness of climate change and sustainability imperatives, prison and correctional authorities are recognizing a responsibility to minimize the environmental damage associated with incarceration and to retain and enhance biodiversity within prison estates which can often cover extensive acreage (such as [3]). However, the introduction of greenspaces, especially those containing diverse vegetation to support biodiversity, can be perceived as a threat to the security of facilities, with the potential risk of concealment of contraband items in vegetation, the weaponization of natural materials and the obscuring of surveillance sightlines by shrubs and trees. Until very recently, there has been a relative absence of evidence of the effects of greenspaces in prisons, and decisions about the design of carceral facilities have traditionally been heavily influenced by issues of cost and security. In this context, green (and biodiverse) spaces have tended to be omitted, or to be limited to closelymown lawns. Insights into the potential effects of greenspaces, and particularly of greenspaces which are more biodiverse than those usually included, would be valuable to those advocating for changes in the ways in which facilities are designed, to support sustainability agendas.

This paper sets out to address both of these critical issues.

1.1. Toxic Prisons

'Toxic prisons' arguably exist for economic reasons. Prisons have tended to be situated in locations such as brownfield, post-industrial or contaminated sites [4,5] where unwanted land is cheaper to purchase. However, mass incarceration and environmental degradation are closely connected [6]. Prisons' high resource consumption and waste generation, contribution to air pollution and vehicle emissions, and impermeable hard surfacing present both a local environmental hazard and local flood risk [5,7,8]. In many cases, prisons are located in places with poor environmental conditions and, by their own presence, they continue to degrade that environment.

Unable to relocate away from such hazards [9], prisoners cannot avoid pollution exposure [6], and there have been numerous reports of adverse prisoner health and wellbeing outcomes attributed to local environmental quality. For instance, a small-scale survey at Fayette men's prison in rural Pennsylvania, US, found self-reported respiratory, throat, sinus, skin and stomach problems, which may be connected to the location of the facility on the site of a coal preparation plant[1]. In recent years, more evidence of environmental contamination at prison sites has come to light, with a study identifying levels of arsenic in drinking water in a California prison that periodically exceeded legal limits [10].

Although there is clearly a need for more empirical research to quantify the environmental harms of incarceration [11], we now know much more than we did about the potential exposure of incarcerated populations to harmful environmental conditions. Numerous studies now identify the proximity of prisons to potentially hazardous sites; for example, one showing that in nine western states of the United States, juvenile detention centers are in close proximity to hazardous waste ('Superfund') sites [12].

A growing body of work also clearly lays out the causal processes through which environmental hazards, be these chemical contaminants, increasing temperatures or the effects of climate change, are likely to be impacting upon the wellbeing of incarcerated populations [13,14]. However, the observation of a paucity of research conclusively linking these conditions to resulting wellbeing effects still holds [15]. So far, only the work of Moran and colleagues [16–19], which identifies a statistically significant relationship between greenspace within and around prisons and prisoners' wellbeing, has been able to robustly link characteristics of the environment to outcomes for incarcerated populations.

Very recent work demonstrates a critical commitment to quantifying the 'toxicity' of prisons [6]. Toman [20] examined, for one US state and for the whole of the US, respectively, whether industrial facilities located close to correctional facilities emitted higher levels of toxic chemicals than those located further away. By comparing the differences in toxic releases between US zip (area) codes that do and do not contain a prison, they aimed to indicate whether incarcerated people might be at greater risk of exposure to such chemicals compared to the population as a whole. The key finding was that at a national level, prison zip codes did *not* experience higher toxic emissions than non-prison zip codes. At a regional level, the picture was mixed, with statistically significant higher levels of emissions in prison zip codes in only three of the nine regions into which the US was divided for the purposes of analysis. Two limitations of the study may have delivered this rather unexpected lack of connection: the emissions data used were self-reported by the facilities in question (with attendant risk of under-reporting) and, as the authors pointed out, emissions released in one zip code may be affecting populations in another, in ways that the methodology could not capture.

Whilst this study represents an important step in quantifying the nature of 'toxic' prisons, it faced two main impediments—likely arising from the non-availability of data—that we hope to address in the present paper. Firstly, the study assumed that the levels of toxic chemicals *emitted* acted as a proxy for the levels of toxins to which incarcerated populations were actually *exposed*. Data describing levels of pollutants *present in the environment* local to prisons were not deployed. Secondly, although contextualized in robust wider research which links toxic emissions to health outcomes in general, the study did not deploy data pertaining to the health or wellbeing status of incarcerated populations, and therefore could not explore the potential relationship between prisoners' wellbeing and local environmental quality.

In this paper we therefore seek to build on the work of Toman [20] by deploying, in our study of prisons in England and Wales, indicators of local environmental quality—specifically local levels of greenspace, local levels of air and noise pollution and local species biodiversity—and analyze these in relation to measures of wellbeing for incarcerated populations. Like Toman and others, we lack health data for incarcerated populations, but instead we are able to deploy proxy data for prisoners' wellbeing in a more general sense, namely data for incidents of self-harm and violence published annually by the UK government. Our contention here is that, as argued by Moran et al. [16], high levels of self-harm, violence or both are clearly indicative of a lack of wellbeing, and that as their work has demonstrated, in our study context self-harm and violence are very strongly correlated with poor self-reported wellbeing and a high incidence of mental health problems [16–19]. We use data from a set of prisons in England and Wales to estimate regression models that relate self-harm and prison violence to indicators of environmental quality, whilst controlling for prisoner and prison characteristics that are commonly found to affect prisoner behavior and wellbeing (e.g., prison size, age of prisoners, age of prisons and percentage of unsentenced prisoners) [21–23].

1.2. Greening Corrections

Sustainability discourses are increasingly intersecting with carceral policies [24,25]. New prisons are being built according to 'green' industry standards, there are efforts being made to minimize the environmental harms of prison buildings, renewable energy initiatives are being introduced and 'green collar' work and training is being offered to prisoners. Whilst there is, as Jewkes and Moran point out [24], undoubtedly a risk that such initiatives 'green-wash' prisons such that it is mass incarceration that is really being sustained rather than the environment, in terms of the design of individual prisons, in some jurisdictions, serious efforts are being made to utilize the prison estate in support of wider government commitments in relation to climate change.

For example, as the second largest government estate in England and Wales, the Ministry of Justice has a total land holding of over 3000 hectares, of which 65% is within its prison portfolio [26]. Despite the significant extent of this estate, for reasons of security and cost, much of the land 'inside the wire' of individual prisons is characterized by tarmac roads and hard landscaping. Where greenspaces exist, these are often closely mown lawns offering limited wildlife habitats. Recognizing these shortfalls, the Ministry of Justice lists biodiversity as a strategic focus and has recently established a biodiversity baseline, a natural capital assessment tool and a nature recovery plan for the estate which seeks to substantially improve biodiversity, wellbeing and other ecosystem services such as carbon sequestration and flood alleviation [27]. However, genuine operational concerns—that greenspaces present security risks when accessed by the incarcerated people who may derive benefit from them—hamper progress [28]. Specifically, it is feared that contraband may be concealed in vegetation, weapons furnished from natural materials and that vegetation may obscure the clear sightlines that are important for security. Both in the development of new prisons and in any redevelopment of existing prisons, these concerns tend to stifle the introduction of greenspaces in any form other than lawns. In the absence of clear evidence of its direct benefit for the operation of prisons—as opposed to those for the wider climate change agenda—landscaping for biodiversity and wellbeing is often 'value-engineered' out of construction plans altogether. At best, a lawn is laid, but tarmac often prevails.

Recent evidence attesting to the benefits of nature in prisons demonstrates that significant wellbeing effects derive from the presence of greenspaces. The work of Moran et al. [16–19], demonstrating a robust connection between greenspaces within and around prisons (including where greenspaces *may not be visible* to those benefiting from them) [18] and prisoners' wellbeing, has already been cited as evidence for changes to prison design (e.g., [29]). However, in order to support the introduction of more biodiverse greenspaces in prisons and to temper the persuasive arguments about cost and security, policymakers require evidence of the ways in which biodiversity might influence the wellbeing of incarcerated populations and by extension the ways in which prisons can be managed. In short, in order to take potentially risky decisions to diversify greenspaces in prisons by introducing trees and other forms of planting, policymakers need robust evidence of the potential benefits of such a move.

In analyzing the effects of local environment on wellbeing, we are therefore both addressing concerns about the 'toxicity' of prisons and taking first steps to establish whether the nature of greenspaces in and around prisons makes a difference to the ways in which they influence wellbeing.

2. Materials and Methods

2.1. Concepts and Methods

The question of what influences prisoner wellbeing features in a set of recent studies by Moran et al. [16–19]. In the absence of direct indicators of prisoner wellbeing, these studies take self-harm and prisoner-on-prisoner violence as indicators of (a lack of) prisoner wellbeing. In our present study we adopt these same two indicators. Data on incidences of self-harm and violence are publicly available for England and Wales, provided by His Majesty's Prison and Probation Service (HMPPS). We collected data on these outcome variables for all prisons in England and Wales that house prisoners aged 18 and over. We also collected data on the age of the prisons, their type (predominant function, e.g., female prison, local prison, young offenders' institution), category (security level) and whether prisons were purpose-built or converted from previous functions (such as military bases)[2].

We use indicators of various aspects of the environmental quality of the localities of the prisons: percentage of greenspace within a 500 m buffer zone of each prison, the presence of a major road within this 'buffer' zone, local climatological conditions, degree of species biodiversity and local level of air pollution.

Our purpose in this paper is to identify the effect of the characteristics of prisons' local environment on prisoner wellbeing whilst allowing for the effect of other prison characteristics. Our approach linking wellbeing to environmental characteristics relates to other studies. For instance, a significant association has been identified between air pollution and self-harm in studies based in China [30], Denmark [31] and Toronto, Canada [32], with a systematic review of the broader research field of greenspace exposure and psychopathology symptoms recently published [33].

In order to carry out this analysis, we needed to be able to quantify the characteristics of the area within a specified 'buffer' zone surrounding prison perimeters. Since no such dataset existed, we deployed a variation of the GIS methodology initially devised by Moran et al. [16] to determine the percentage of the area within a prison's perimeter wall or fence which is 'greenspace' (vegetated landcover). We also followed their study [18] in defining a 500m buffer zone outside the prison perimeter which, in addition to measuring 'greenspace', also looked for 'bluespace' (bodies of water such the sea, lakes, rivers, canals) and the presence of major roadways. Full details are available in these published works, but in brief, we used the same Mastermap data and geo-rectified aerial photographs for all prisons in England and Wales to examine areas designated 'natural' or 'multiple' within a 500m buffer zone, thus calculating the percentage of these buffer zones that consist of vegetated landcover and noting whether or not a major roadway was present.

We use data from the Met Office (the national meteorological service for the UK) to capture local climatological conditions. The Met Office provides annual climate datasets at the lower-layer super output areas (LSOAs) scale. LSOAs are geographical areas defined by the UK's Office for National Statistics which comprise between 400 and 1200 households and usually have a resident population of 1–3000. We link prisons to their relevant LSOAs. To align this climate data with our other control variables, we use the Met Office dataset for 2014. We select data on several climatological characteristics, such as annual rainfall, mean temperature, hours of sun, days with snow, wind speed and days with ground frost. To obtain an aggregate indicator of these local climatological conditions, we performed a principal component analysis on this set of variables and used the predicted score of the first component as the indicator of local climate. Higher values of this variable capture relatively 'favourable' local climate, which we characterize as having more hours of sun, higher temperatures, lower rainfall and fewer days with ground frost.

We obtained species biodiversity data from the National Biodiversity Network (NBN) atlas. The NBN is an independent data partnership that integrates biodiversity data from different sources and enables them to be searched by postal (zip/area) code. Representing the UK's largest repository of publicly available biodiversity data, the atlas has more than 200 million records of over 46,000 species [34]. From their dataset we take the (natural log of) the total number of species (plants and animals) for the postal codes of the prisons as the indicator of local species biodiversity.

To capture the local level of air pollution, we use data from the UK's first freely available postcode-level dataset, provided by Imperial College London. This dataset rates the levels of three toxic pollutants—PM2.5, PM10 (inhalable fine particulate matter, such as emissions from vehicle exhausts or combustion, and dust) and NO2 (nitrogen dioxide, a gas produced from combustion of fossil fuels)—from low to very high according to the World Health Organization (WHO) limits[3]. Based on the underlying scores, UK postal codes are ranked according to their level of air pollution. We use the percentile rank of the prison's postal codes, with a high score representing a high level of pollution. To capture the effect of local air pollution, we construct a dummy variable identifying those prisons that are located in a postal code with a level of air pollution that places them in the top 40% of the UK. Figures 1–3 show these variables for the locations of the prisons within our study context.

2.2. Data and Regression Model Specification

To estimate the relationship between the environmental characteristics and prisoner wellbeing, we specify the following regression model:

$$Y_i = \beta_0 + \beta_1 EQ_i + \beta_2 Majorroad_i + \beta_3 EQ_i x Majorroad_i + \beta_4 Prisonerchars_i + \beta_5 Prisonchars_i + \beta_6 PD_i + \varepsilon_i; \tag{1}$$

where Y either captures the prisoner-averaged number of occurrences of self-harm or violence between prisoners in prison i, averaged for the period 2014–2018. Regression model (1) is an augmented version of the model specified by Moran et al. [16–19], who estimated the relationship between greenspace percentage and the outcome variables whilst controlling a set of prison characteristics.

The variable EQ stands for environmental quality. To compare the findings of the augmented regression model with the original results presented by Moran et al. [16], we will start our estimations in the present paper by specifying that EQ contains the level of greenspace. After these estimations, we will replace greenspace with local climate, species biodiversity and air/noise pollution.

The variable Majorroad is a dummy variable capturing whether the 500m buffer zone surrounding a prison contains a major road. The challenge with this variable is that it may capture both the presence of air/noise pollution and the degree of connectivity of a prison. Whereas the first aspect is likely to negatively affect prisoners' wellbeing, the second aspect may support it since connectivity facilitates visitation. To capture both these effects, we include both the variable Majorroad and its interaction with environmental quality, where the variable Majorroad captures the effect of connectivity sand the interaction variable the negative environmental effect of the presence of a major road.

Next, we include several characteristics of the prison populations[4]. The motivation for including these variables is twofold. First, there is ample evidence that characteristics of prisoners are related to prisoner wellbeing [19,35,36]. By controlling for these characteristics, we therefore reduce the possibility that estimated associations between environmental quality and prisoner wellbeing are affected by omitted variable bias. Second, the inclusion of these variables allows us to assess whether prisoner characteristics influence the estimated relationship between environmental quality and prisoner wellbeing. For instance, it may be that this relationship is stronger for prisons that house a relatively high percentage of young prisoners or a high percentage of prisoners serving longer sentences.

One variable that we include relates to the degree that prisons house persons awaiting trial or sentencing, given evidence from extant research that such prisoners are more likely to feel distressed and/or to violate prison rules [37,38]. To control for this effect, we construct a dummy variable labelled 'D_nosentence", taking the value of 1 for prisons with an above-sample-mean percentage of unsentenced prisoners.

Second, we include controls that relate to the ethnic composition of the prison population. We hypothesize that there will be fewer power struggles in a prison housing a population characterized by a relatively high degree of heterogeneity in nationality and ethnicity [39,40]. We use two different indicators in our estimations. The first is the percentage of the prison population that is of British nationality. We expect a positive association with the dependent variables, as a high percentage may foster tensions with other minority nationalities. The other indicator, labelled 'ethnic fractionalization,' is defined as $1 - \sum_i s_i^2$, where s_i = share of an ethnic group (white, mixed, Asian/Asian British, Black/Black British, other ethnic groups) in a prison population [41]. This variable can be interpreted as indicating the probability that two randomly-selected prisoners in a prison population belong to different ethnic groups.

Third, we control for the age structure of the prison population. In particular, we control for the degree that the prison population consists of young prisoners, as many studies indicate that young prisoners are significantly more likely to engage in acts of self-harm and violent behaviour [36,42]. To control for this effect, we include a variable labelled 'age 18–21,' measured as the percentage of the prison population that are 18–21 years old.

Fourth, we construct a variable that captures the average sentence length of the prison population. Prisoners with longer sentences have had more time to adjust to prison life and to come to terms with their sentence, resulting in fewer violations of prison rules [36,43,44]. The HMIP reports provide information on groups of prisoners of prison populations with different sentence lengths. Using this information, we calculate the average sentence length of the prison populations. Based on this variable we construct a dummy variable labelled 'D_highlength,' identifying prisons whose populations have an above-sample-mean average sentence length.

Fifth, we control for the effect of the degree that prisoners may benefit from visitation, given available evidence showing that visits from friends and family have positive effects on prisoner wellbeing and conduct [45,46]. To capture this effect, we include a variable labelled 'difficulty_visits,' measured as the percentage of prisoners that indicate to HMIP that it is (very) difficult for their families and friends to visit them.

'Prisonvars' contains variables for several prison characteristics that were found to be important by Moran et al. [16–19]. One variable is labelled 'Centuryold,' capturing the prisons that first started operating in the 19th century. Another variable controls for the size of prisons, measured as the (natural log of) the number of prisoners in 2014. We also control for the effect of overcrowding, measured as the ratio of the official capacity of a prison over its actual number of prisoners in 2014. Finally, 'PD' contains dummy variables identifying prison categories (security level). Following Moran et al. [16–19], depending on the dependent variable of the regression model, we include controls for female prisons, young offenders' institutes, category B and C training prisons and high security prisons.

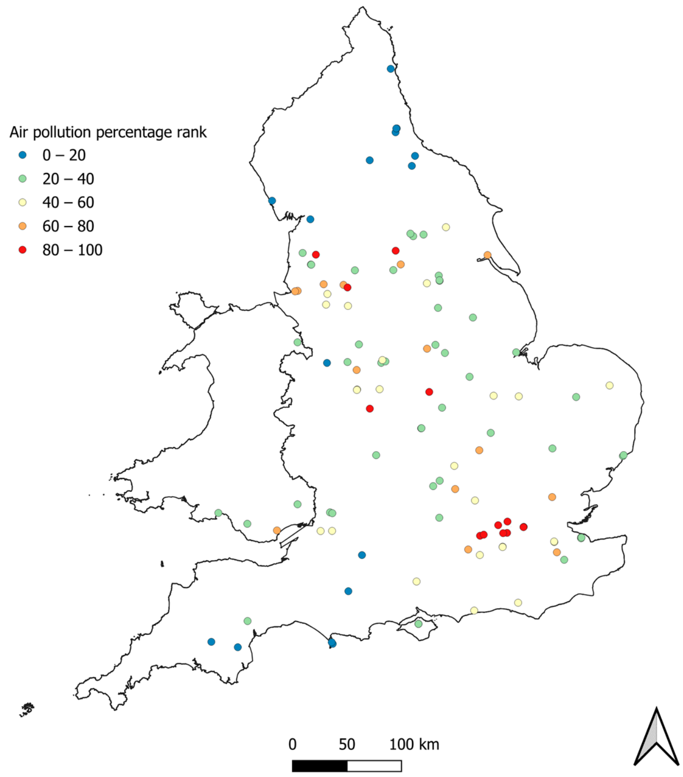


Figure 1. Levels of air pollution at prison locations.

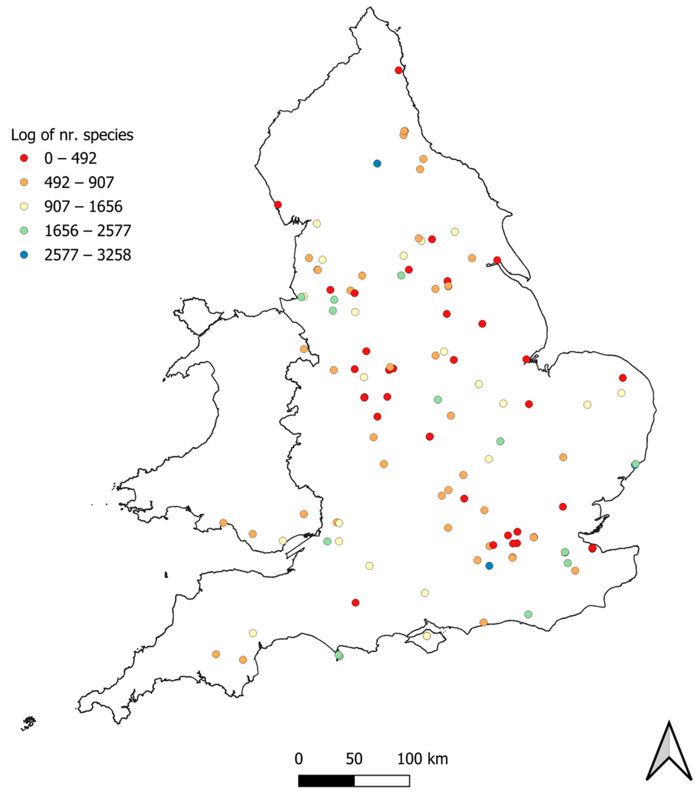


Figure 2. Log of number of species at prison locations.

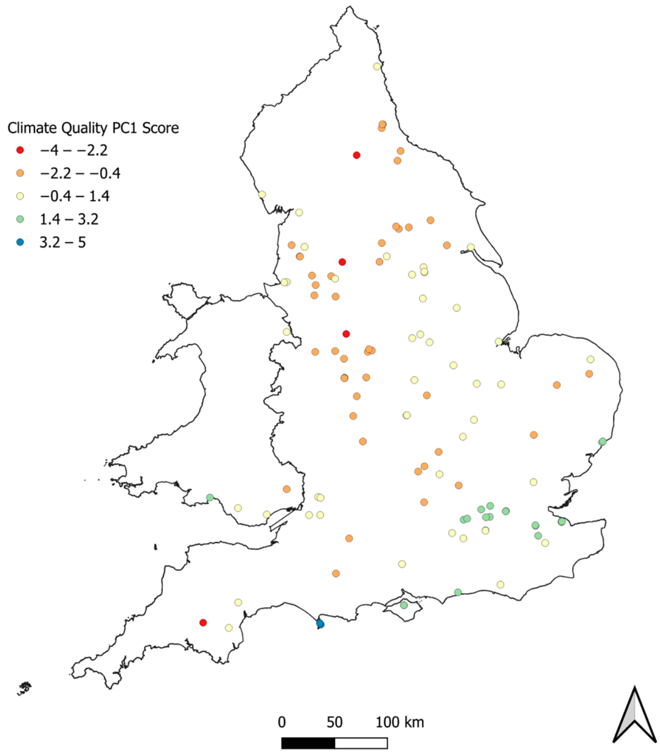


Figure 3. Climate quality at prison locations.

3. Results

3.1. Greenspace and Prisoner Wellbeing

Table 1 presents the main findings from estimating several specifications of the regression model with greenspace and the presence of a major road in a prison's 500 m buffer zone as indicators of environmental quality. As the results in column (1) indicate, the estimated significant association of greenspace with self-harm is negative, suggesting, as we would expect, that greenspace promotes prisoner wellbeing. The estimated coefficient of the major road dummy variable suggests that relative accessibility has a similar positive effect. At the same time, the interaction term between greenspace and the presence of a major road carries a significant and positive coefficient, indicating that the dampening effect of greenspace on self-harm is weakened due to noise and/or air pollution caused by the presence of a major road.

In column (2) we augment the model with the prison population characteristics. The nature of the estimated associations of greenspace, major road and their interaction term remains the same. Turning to the effect of prisoner characteristics, we identify a positive relationship between self-harm and prisons having a high percentage of unsentenced prisoners, indicating that prisoner wellbeing is negatively affected by the uncertainty associated with awaiting trial or sentencing. The share of young prisoners is also positively associated with self-harm, confirming that self-harm occurs more frequently in prisons with a youthful population. Prisons with a relatively high level of ethnic fractionalization are characterized by a lower level of self-harm. The estimated positive coefficient of the variable capturing the degree that prisoners experience difficulties with visitations indicates that prisons where visits are difficult are characterized by a significantly higher level of prisoner self-harm.

Column 3 contains the results from adding the three prison characteristics that previous research showed to be important [16–19]. The results show that prisons that have their origins in the 19th century are characterized by a significantly lower level of self-harm, in line with Moran et al. [16]. The inclusion of the prison characteristics affects the significance of the estimated coefficient of the degree that families have difficulties visiting prisoners. The significance and nature of the estimated coefficients of greenspace, the presence of a major road and their interaction are unaffected. The importance of these variables is further indicated by the standardized beta coefficients reported in column 4, indicating that the effects of greenspace, major roads and their interaction generate the largest effects among the control variables.

The next set of findings (columns 5–8) are obtained from estimating the model with violence between prisoners as a dependent variable. The findings for greenspace, the presence of a major road and their interaction are similar to the results with self-harm. As for the other control variables, prisons with high shares of unsentenced and young prisoners have significantly higher levels of violence. We identify similar positive associations for the percentage share of prisoners of British nationality and the degree that families of prisoners experience difficulties with visitation. As for the relative importance of the estimated effects, the standardized beta coefficients reported in column 8 indicate that the percentage share of young prisoners is the most important driver of prisoner violence, followed by the presence of a major road, greenspace and their interaction. These results are all in line with expectations and echo the findings of Moran et al. [16–19].

Table 1. Effects of greenspace, major road and prisoner characteristics on self-harm and prison violence.

Dependent Variable	**Self-Harm**				**Prisoner-on-Prisoner Attacks**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Greenspace	−0.70 a (0.18)	−0.50 a (0.17)	−0.75 a (0.20)	0.44	−0.31 a (0.07)	−0.23 a (0.06)	−0.27 a (0.07)	0.38
Majorroad	−0.68 a (0.20)	−0.52 a (0.18)	−0.63 a (0.18)	0.80	−0.15 b (0.07)	−0.14 b (0.06)	−0.17 a (0.06)	0.49
Greenspace × Majorroad	1.01 a (0.27)	0.81 a (0.24)	0.92 a (0.24)	0.78	0.21 b (0.09)	0.21 a (0.08)	0.24 a (0.08)	0.47
D_nosentence		0.11 b (0.05)	0.10 b (0.05)	0.13		0.03 b (0.016)	0.028 c (0.015)	0.08
Age 18_21		0.35 b (0.15)	0.39 b (0.20)	0.27		0.63 a (0.15)	0.58 a (0.12)	0.64
Ethnic fractionalization		−0.28 a (0.13)	−0.37 a (0.12)	0.17				
British						0.06 c (0.034)	0.06 b (0.03)	0.06
D_highlength		−0.07 (0.05)	−0.04 (0.05)			−0.005 (0.015)	0.01 (0.015)	
difficultyvisits		1.21 b (0.51)	0.85 c (0.50)	0.09		0.51 b (0.21)	0.41 b (0.18)	0.11
Centuryold			−0.15 b (0.06)	0.19			−0.03 c (0.017)	0.09
Size			0.05 (0.06)				0.03 b (0.015)	0.09
Overcrowding			−0.02 (0.06)				−0.03 (0.027)	
F	7.84 (0.00)	9.31 (0.00)	7.75 (0.00)		32.82 (0.00)	24.42 (0.00)	25.85 (0.00)	
R-square	0.42	0.62	0.65		0.73	0.82	0.85	
N	101	96	95		99	95	94	

Notes: Robust standard errors in parentheses. a $p < 0.01$, b $p < 0.05$, c $p < 0.10$. Regressions contain dummy variable for female prisons (self-harm as dep. variable); catbtrain and high security (prisoner-on-prisoner attacks); columns 4 and 8 report standardized beta coefficients of significant variables in columns 3 and 7.

3.2. Local Climate, Biodiversity, Air Pollution and Prisoner Wellbeing

Turning now to the focus of the present paper (the significance of environmental quality for prisoner wellbeing) the most direct way to ascertain the importance of local climatological conditions, biodiversity or air pollution would be to replace the greenspace variable with variables capturing these other dimensions of local environmental quality. A summary of the findings from these estimations is presented in Table 2. Overall, the results are uninformative. The estimated effect of the three environmental quality variables is insignificant in all but one of the estimations. The estimated effect of the variable Majorroad is also mostly insignificant, and in the two cases where it does carry a significant coefficient, the nature of the effect is opposite from what we find with greenspace. Taken together, the findings suggest that there is very little evidence of significant direct associations between these indicators of environmental quality and prisoner wellbeing.

Table 2. Effects of local climate, biodiversity and air pollution on self-harm and prison violence.

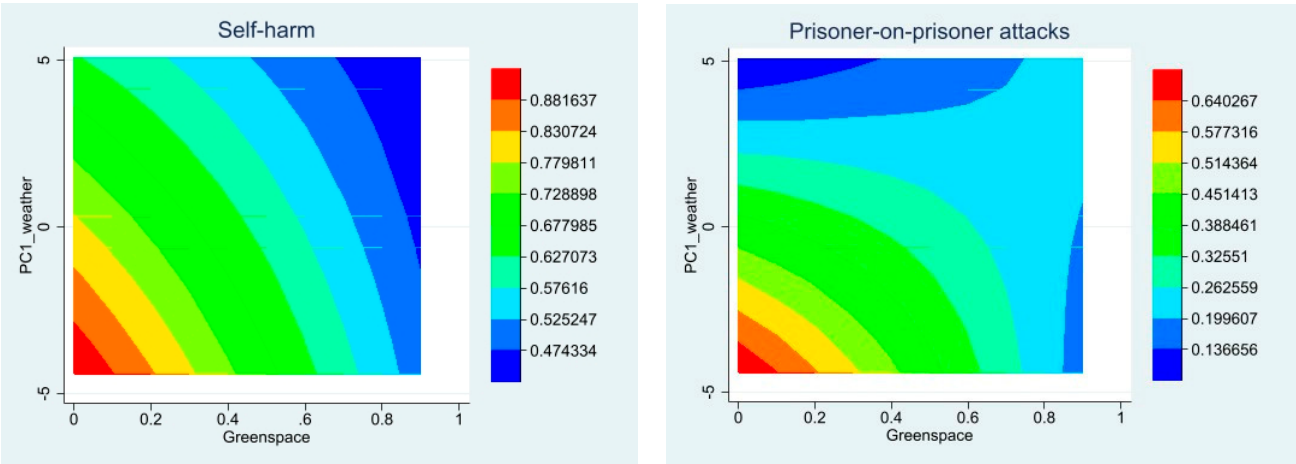
Dependent Variable		Self-Harm			Prisoner-on-Prisoner Attacks	
Local climate	−0.03 (0.03)			0.006 (0.008)		
Biodiversity		0.07 (0.08)			−0.001 (0.018)	
Air pollution			−0.04 (0.08)			0.05 c (0.03)
Majorroad	0.088 (0.07)	1.36 b (0.65)	0.06 (0.09)	0.016 (0.018)	0.14 (0.17)	0.036 c (0.20)
Local climate × Majorroad	−0.017 (0.045)			−0.025 (0.011)		
Biodiversity × Majorroad		−0.23 b (0.10)			−0.02 (0.025)	
Air pollution × Majorroad			−0.001 (0.14)			−0.085 b (0.038)
F	4.72 (0.00)	5.88 (0.00)	4.64 (0.00)	22.98 (0.00)	21.83 (0.00)	22.10 (0.00)
R-square	0.40	0.42	0.44	0.82	0.83	0.83
N	99	96	95	99	95	94

Notes: Robust standard errors in parentheses. b $p < 0.05$, c $p < 0.10$. Estimated regression models control for prison population characteristics and prison characteristics as used for Table 1. Regression models also contain dummy variables for female prisons (self-harm as dep. variable) or catbtrain and high security prisons (prisoner-on-prisoner-attacks).

Given the growing body of work on toxic prisons detailed earlier, as well as the strong case put forward for negative effects of poor environmental quality on incarcerated populations, these results seem unexpected. However, it is important to take account of the data quality. Some of the externally-sourced environmental indicators we have used contain measurement errors which limit the precision of their estimated association with the outcome variables. The variables capturing climatological conditions, biodiversity and air pollution are not measured at the precise locations of the prisons, but rather capture values for wider areas (i.e., postcode or LSOAs), and as a result are very likely to contain errors. The actual values for the prisons may deviate to an unknown extent from the measured values for these wider areas. By contrast, the highly accurate methodology we deployed to measure the extent of greenspace surrounding prisons, and the presence of a major road in their buffer zones, means that the estimated effect of the variables greenspace and major road are unlikely to be affected by measurement error.

Given these data limitations, as an alternative way to determine whether the environmental characteristics of the localities of prisons may affect prisoner wellbeing, we estimate an additional set of regression models that, next to the set of variables capturing prisoner- and prison-characteristics, contain the variable greenspace and interaction variables between greenspace and the other environmental quality variables. By including these interaction terms, we can assess whether these other indicators of local environmental quality, given the differences in greenspace between the prisons, generate *additional* impacts on prisoner wellbeing. In doing so, we are able to include these environmental characteristics into the estimations whilst minimizing the effect of measurement error.

We estimate predictive margins of the interactions between greenspace and the environmental characteristics of the localities which are presented graphically in Figures 4–6. When both variables are measured continuously, a plotting of the predictive margins of their interaction would generate a three-dimensional surface. To simplify the visualization and interpretation, we estimate the predictive margins for sets of pre-specified values of these variables.[5] We plot these pre-specified values against the predictive margins in contour-plots, in which different colours capture the ranges of the predictive margins. Taking for instance the left image of Figure 4, the bottom left captures the predictive margins range of the combination of a poor local climate and a low-percentage greenspace in the prison buffer zone. The predictive margins are the highest for this combination, as indicated in the vertical bar next to the box.



PC1_weather: first principal component of rain, temperature, sun, snow, wind & frost

Figure 4. Predictive margins of interaction between greenspace and local climate.

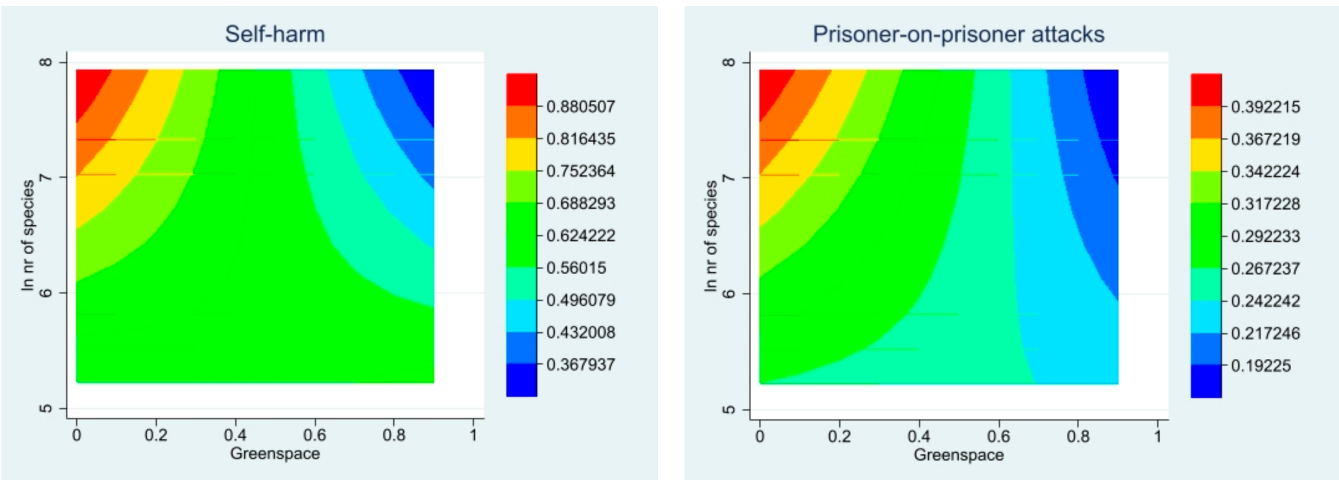


Figure 5. Predictive margins of interaction between greenspace and local biodiversity.

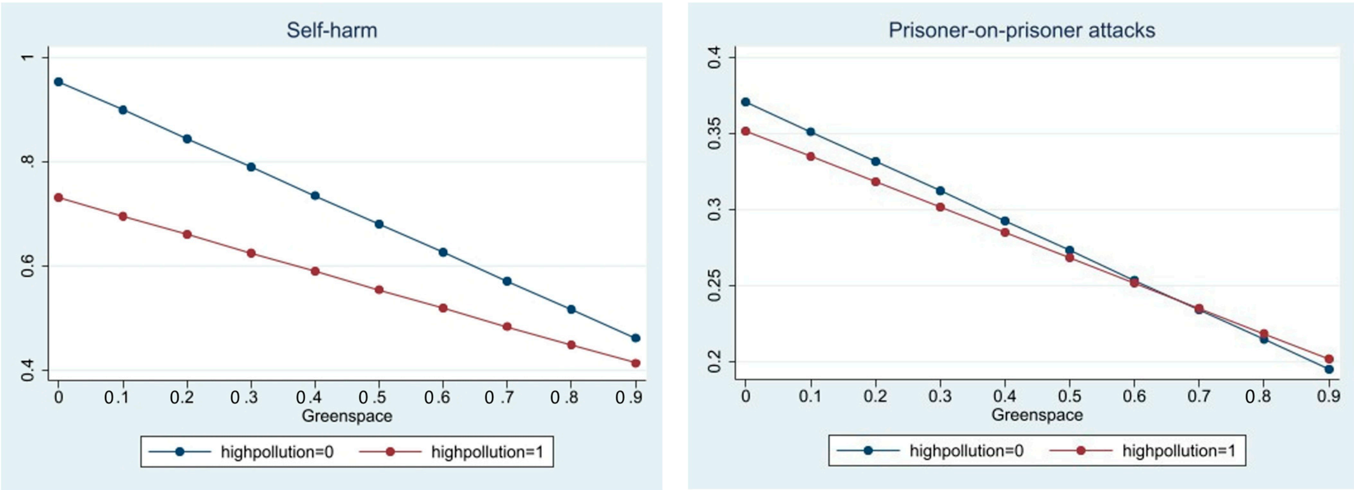


Figure 6. Predictive margins of interaction between greenspace and high level of local air pollution.

Considering the results shown in Figure 4, there is evidence for both dependent variables that an increase in greenspace has a particularly beneficial effect in prisons in localities with relatively poor climatological conditions. This is shown by the fact that a higher percentage of greenspace (moving rightwards on the horizontal axis) results in a larger movement across the segments for prisons located in areas with poor climatological conditions (i.e. with low values on the y-axis). This suggests that for these prisons an increase in greenspace may generate an important compensatory effect for any negative impact of poor climatological conditions on prisoner wellbeing. For prisons characterized by relatively high levels of violence, this applies only up to intermediate levels of the variable capturing climatological conditions. When climatological conditions are more favourable, there is no clear magnified effect from higher levels of greenspace.

Figure 5 shows the results for the interaction between greenspace and local biodiversity. Starting at the top left of the image—representing a high level of biodiversity and a low percentage greenspace—higher percentages of greenspace generate a relatively stronger dampening effect on the levels of self-harm and violence. This relationship ceases to be important when the level of biodiversity is at intermediate or low levels, indicating that an increase in greenspace is particularly beneficial where local biodiversity is sufficiently high, or in other words, that local biodiversity acts to magnify the effects of greenspace.

Figure 6 presents the findings on the predictive margins of the interaction variable between greenspace and air pollution. As the air pollution variable is dichotomous (high/low) rather than continuous, we can show the predictive margins for the two types of prisons over the range of greenspace. The results for self-harm are qualitatively similar to the findings for biodiversity (in Figure 5), as higher percentages of greenspace are associated with a decrease of self-harm in prisons located in lower pollution areas, suggesting that low pollution magnifies the beneficial effect of greenspace. An increase in greenspace clearly reduces violence, however different levels of air pollution seem to have no impact on this effect.

Overall, the results from estimating the model with interaction terms between greenspace and other indicators of local environmental conditions reveal two effects. We find that, firstly, in a relatively unfavourable local climate (colder, wetter and frostier), higher percentages of greenspace appear to generate something of a compensatory effect on prisoner wellbeing. Secondly, the positive effect of greenspace on prisoner wellbeing is stronger when biodiversity is high and air pollution is low, indicating that the nature of the local environment mediates the effects of greenspace on prisoner wellbeing.

4. Discussion

We set out in this paper to address a question which has thus far eluded researchers concerned with 'toxic' prisons [1,2,4–7]: whether the quality of the local environment affects prisoner wellbeing. In a significant advance on recent scholarship, we were able to link measures of environmental quality such as biodiversity and air pollution to proxy variables for prisoner wellbeing (self-harm and violence). This is an advancement of the findings presented by Moran and colleagues [16–19], who focused primarily on identifying the effect of greenspace. In the present study, we find that several environmental characteristics of prison locations mediate this effect of greenspace. Although issues of data quality for the biodiversity and air pollution data meant that we were unable to identify a direct relationship with wellbeing, by considering the ways in which local environmental conditions might impact the already-recognized beneficial effects of greenspace, we were able to generate findings which have implications for future prison design and location.

When considering the effects of greenspace, it is important to note that, as we use a cross-sectional dataset of prisons, our results can only be interpreted as capturing (conditional) associations of greenspace with self-harm and prison violence. In order to obtain results that are more in line with identifying causal effects of greenspace, some sort of experimental design would need to be devised. However, most significantly, we find that the recognized relationship between greenspace and prisoner wellbeing—where higher levels of greenspace are associated with lower levels of self-harm and violence—is mediated by biodiversity and air pollution, in that this beneficial effect is magnified where biodiversity is high and where air pollution is low. In other words, better outcomes from increasing prison greenspace are likely to be found in areas of high biodiversity and/or low air pollution. In addition, greenspace also appears to provide some sort of compensatory effect in prisons located in areas characterized by poor climatological conditions.

The 'toxic prisons' literature argues forcefully that because prisons are often located in contaminated areas (close to hazardous waste dumps or to polluting industries) and because prisons further degrade these environments through their own emissions, incarcerated populations are exposed to environmental conditions which are deleterious for their health and wellbeing. Although our analysis of local air pollution and biodiversity data, as proxies for local environmental quality, do not evidence such a direct relationship with wellbeing, quality limitations of the available data are likely to be affecting our analysis. To minimize the effects of these limitations, we considered the ways in which local environmental quality might impact the already-evidenced relationship between greenspace and wellbeing, and we find that better environmental quality enhances this relationship, thus indicating that local environmental conditions do influence the wellbeing of incarcerated populations.

Our analysis here cannot fully address the critical questions raised in the live debate over 'toxic' prisons. Future analysis would ideally incorporate more accurate and comprehensive information for a wider range of indicators of environmental quality, and ideally higher quality data at much a finer spatial scale would enable more accurate analysis of the directs effects of local environmental quality on wellbeing. In extension, the use of data that captures health characteristics of prisoners more directly would also advance such analysis.

5. Conclusions

The toxic prison debate raises critical questions about the collateral effects of (mass) incarceration and the human rights implications of confining already marginalized and vulnerable populations in unhealthy environments. For many scholars in this field, these questions are closely intertwined with critiques of practices of incarceration in general and are the basis for calls for the unification of environmental and abolitionist movements, to 'fight against the prison industrial complex and develop radical alternatives to the expanding police state' [1].

Decarceration and downsizing of the carceral state would undoubtedly reduce the harms, environmental and otherwise, of the carceral system. However, and recognizing the risk of the 'greenwashing' of prisons [20,21] within carceral systems as they currently stand, the findings reported here have significant implications for the potential wellbeing of incarcerated persons. As noted earlier, policymakers who are already persuaded by the growing evidence base about the positive effects of greenspaces in prisons now need further information to inform the sorts of greenspaces that would ideally be provided. In prior research which identified the relationship between greenspace and prisoner wellbeing, Moran et al. [16–19] recommended that, as a result of their findings, greenspaces in and around prisons should be retained and expanded wherever possible. Based on the present analysis, we would support this recommendation, but nuance it in two important ways. Firstly, wherever possible, increases in greenspace should take place in areas which are *already* high in biodiversity or low in air pollution in order to maximize their effect on well-being. In practical terms, given the static nature of the prison estate and likely limitations on the ways in which prisons' localities can be modified, this may be challenging to achieve. So secondly, and more pragmatically, we recommend that in increasing greenspace, efforts should be made to do so in a way which will *also* improve biodiversity and/or reduce air pollution, so that the maximum benefit to wellbeing can be delivered. In practical terms this means creating greenspaces in and around prisons which feature a range of planting (i.e., more biodiverse than simply closely-mown lawns), both to attract insects and other organisms (further boosting biodiversity) and to remove some particulate pollution from the air by catching tiny particles on leaf surfaces. Importantly, given that our findings show associations between greenspace around prisons and prisoner wellbeing, prisons where security concerns prevent meaningful increases in greenspace on prison grounds may therefore still be able to benefit from improving environmental characteristics in their localities. In policy contexts where biodiversity net gains are required in new infrastructure developments, for example, our findings suggest that achieving these gains either on-site or in very close proximity to new prisons would be more beneficial for prisoner wellbeing than achieving them off-site.

The findings we present here are oriented towards two quite different agendas: a 'toxic prisons' movement which mobilizes environmental activism in service of an abolitionist agenda and a community of prison policymakers who need evidence to support their ambitions to enhance prison environments in line with climate change mitigation policies. We do not seek to resolve here the fundamental ideological differences between these two positions, however, in presenting our analysis, we are able to provide evidence which supports both agendas, insofar as they seek to address both environmental concerns and the suffering of incarcerated populations.

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Data Availability Statement: Other than the published data used in this analysis, the data presented in this study are available upon request from the corresponding author. These data are not publicly available for security reasons.

Conflicts of Interest: The authors declare no conflicts of interest.

Notes

1 https://www.motherjones.com/environment/2017/06/report-americas-prisons-are-so-polluted-they-are-endangering-inmates/ (accessed on 3 November 2023)

2 See Moran et al. [16,18] for more information. The initial sample with information on self-harm and violence contains 111 prisons. This sample does not include open prisons as they do not have an identifiable perimeter required to calculate the greenspace variable. The sample size in our empirical estimations varies between 95 and 101, due to missing values for some of the control variables.

3 https://records.nbnatlas.org/explore/your-area#52.9548%7C1.1581%7C12%7CALL_SPECIES (accessed on 3 November 2023).

[4] We use information from reports published by His Majesty's Inspectorate of Prisons (HMIP) to construct variables capturing prison population characteristics. HMIP is an independent inspectorate that applies surveys to random samples of prison populations in their inspections of prisons. We aimed to collect data on characteristics of the prison population for 2014 when possible; the actual publication year of the reports ranges from 2012–2016.

[5] For each variable we take 10 equally-spaced values, ranging from their minimum to maximum values.

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