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To Play or Not to Play: Mapping Unequal Provision of Children's Playgrounds

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Abstract: Children's playgrounds are an important component providing opportunities for children's play. Few studies, however, have explored the unequal geographic provision of these valuable spaces. This work addressed this research gap by identifying the key data and methods required to analyse children's playground provision at both global and national geographic scales. The aims of the paper were twofold: It firstly explored the potential for mapping children's playground provision at a global scale and validated such an approach using finer spatial scales. Secondly, the unequal provision of playgrounds was investigated at a national scale in England, UK using open data sources. Relationships with the size of the settlement and deprivation were also explored. The work used a range of secondary datasets through applying quantitative GIS and statistical approaches. The results demonstrated that, due to data quality issues, a world approach to map playground provision was not currently viable. At a national scale, results highlighted substantial inequality in provision, with some settlements in England experiencing five times the number of children per playground, despite being broadly comparable in terms of population. Deprived settlements in England tended to have fewer, smaller, and further-away playgrounds. The patterns were most stark in the largest settlements. London, however, was consistently an exception to these patterns, where deprived areas tended to have more and closer playgrounds. Acknowledging the numerous competing different metrics to measure provision of children's playgrounds, the research generated a framework for bringing together a wide range of interrelated data into a condensed form for comparison. Thus, the approach facilitated the identification of interventions within different contexts in order to reduce inequalities in playground provision and bolster children's democratic right to the city for play.

Keywords: children's playgrounds; equality; reducing inequalities; play; urban environment; mapping playground provision; geographic information systems (GIS)

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1. Introduction

Article 31 of the United Nations Convention on the Rights of the Child recognises the fundamental right of every child to play. Play is a key route through which children learn to engage and interact with the world around them [1]. As such, play is not an optional extra but is essential for children's physical, social, and mental development and integral to both health and happiness [2]. In order to be healthy, under the World Health

Organization's definition of health, children are required to thrive mentally and socially, as well as physically [3]. Although children's spaces for play are varied, including, for example, parks and other greenspaces, playgrounds, sports facilities, open spaces, domestic gardens, schools [4,5], and more informal playspaces [6], recent evidence in England has shown that access to play provision is not equal [7]. A corpus of global literature has demonstrated how children's opportunities for play are increasingly restricted across the built environment, resulting in distinct spatial justice issues, which impact children's democratic right to the city [4,6]. This paper explores the role of formal playspaces, specifically playgrounds, to demonstrate how children's access even to designated spaces for play remains exclusionary and unequal.

Playgrounds, the focus of this research, remain one of the key spaces for children's play. Public playgrounds are the most common places for children to play outside of the home [8] and playgrounds were the most common formal playspaces identified within a literature review of children's play [6]. For some children, playgrounds are the main opportunity to play outside [9]—one in five children in London live in homes without gardens or balconies, for example [7]. Playgrounds affect children's health through increasing physical activity [10] and motor development [11] and, therefore, can help prevent childhood obesity [1,12]. They have also been found to aid social interaction between children and parents of differing social and ethnic backgrounds [13].

Despite their importance, there has been very limited research exploring the spatial provision and the equity of playgrounds. This is particularly surprising considering the wealth of research investigating urban greenspace provision and equity more widely [14,15]. Such work often cites the United Nations Sustainable Development Goals (SDGs) as a motivation for the research. The SDGs are a set of 17 objectives that aim to transform our world: to end poverty and inequality, protect the planet, and ensure that all people enjoy health, justice, and prosperity. Of particular relevance for this work is Goal 11: Sustainable Cities and Communities: Making cities safe, inclusive, resilient and sustainable, which aims to "By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children..." [16]. Therefore, the equal provision of and access to children's playgrounds can be seen as an important consideration within achieving this goal by bolstering children's democratic right to play [6,17,18].

Additionally, Goal 10 aims to reduce inequalities both *within* and *between* countries. In order to reduce inequalities specifically in children's playgrounds, we need to know which countries and cities have a good or poor provision. This would also facilitate the identification of precedents to highlight best practice that other countries and cities could follow in order to reduce inequalities in provision. It underscores the importance of considering the unique experiences of children within specific urban environments for improved policy, practice, and placemaking [19].

New approaches to identifying the geographic locations of children's playgrounds across the globe may arise from the recent increases in the availability of digital data over the past decades (particularly remote sensing and crowdsourced information). For example, Open Street Map has been used to map the location of urban greenspace across the globe [20].

There are a range of different metrics that are commonly used to measure provision with little consensus concerning which ones are most appropriate [21–23], as they frequently provide differing insights [14]. Therefore, this work seeks to establish a framework that draws on the different metrics for measuring playground provision in an easy to understand, interpretable approach, whilst maintaining comprehensiveness of the outputs to facilitate a better understanding of play equity.

The aims of this research are, thus, twofold:

- At a world scale, to explore the potential of using consistent and universal data across the globe to map the provision of children's playgrounds [exploring between countries];
- At a national scale, to establish a framework/approach to explore the equality in provision of children's playgrounds [exploring within a country].

2. Previous Literature Concerning the Equity of Children's Playground Provision

The majority of studies on children's playgrounds have employed qualitative approaches [6], often with a focus on safety or accessibility of children with disabilities [24–26]. There is, however, a small body of work that has explored the geographic distribution of playgrounds using quantitative approaches. Whilst some of these set out to count the number of playgrounds (for example, API [1] and Winder [27] in the UK), others analysed the geographic distribution, usually using a geographic information system (GIS) within a variety of contexts. These include work by Talen and Anselin [21] in Tulsa, Oklahoma, USA; Lai and Low [5] in Hong Kong, China; Smoyer-Tomic et al. [28] in Edmonton, Canada; API [1,9] and Fields in Trust [29] in England, UK; Martori et al. (25] in Barcelona, Spain; and Bhuyan [30] in Dhaka, Bangladesh. Whilst most work tends to focus on a single town or city scale and, therefore, explore patterns within a city, API [9] identified inequalities in provision at large geographic scales in England, exploring patterns between locations. These studies represent a first step towards understanding existing play provision and typically demonstrate the fragmented experiences of children in their access to quality playspaces in their neighbourhoods [27]. However, research that has mapped the varying provisions of children's playgrounds in different individual settlements, at national or larger scales, remains rare.

Measuring Equity

The difference between the definitions of equality and equity are important. Equality refers to everyone receiving the same resources of need (but where privileged groups and individuals may, therefore, receive more); whereas, equity recognises that individuals and groups have different circumstances and, therefore, allocates resources in order to reach an equal outcome [31]. The focus of this work rests with equality on the basis that this can be the starting point before advancing to more complex issues around tackling inequity (which requires estimating need, understanding levels of quality, and therefore, modifying/manipulating existing geographic distribution effects).

There is no consensus on which are the most appropriate metrics to measure playground provision. In fact, the main finding of Talen and Anselin [21] was that the choice of measures of provision need to be considered very carefully due to their influence on the outputs. Previous studies typically use one or two different measures of provision: minimum distance; coverage methods; or simple counts within administrative boundaries (e.g., playgrounds per 1000 children). The minimum distance measures the closest playground, either as the crow flies or along the road/path network. The coverage approach calculates the number of playgrounds within specified distance thresholds of residents (to represent the level of opportunity). The location of children is frequently modelled using census data centroids of the smallest administrative data available, for example census tracts in the USA (on average 5000 people per census tract) [21] or Spain (~1000 people per census tract) [25]. This means that any minimum distance measurement would be affected by the offset between the child's residential household location and the census tract centroid position, leading to potential significant inaccuracies. Additionally, measurements for coverage approaches can become highly technical, for example using the two-step floating catchment area [15,25]. By comparison, this paper seeks to establish a transferable approach building on metrics that are commonly understood in order to facilitate better discussion and engagement with researchers, policy makers, community leaders, local government, and other practitioners.

This work will, therefore, also build on the more extensive research concerning greenspace equity more broadly. Notably, Kimpton [32] defined three different greenspace equity concepts: (1) greenspace provision (the proportional area of greenspace within a buffer or neighbourhood unit), (2) accessibility (the travel cost of visiting the nearest greenspace through shortest distance), and (3) population pressure (counting the numbers of people within specified greenspace distance thresholds). Based on the above metrics, this research proposes three specific domains to measure children's playground provision: (1) count of facilities, e.g., number of children per playground; (2) size of facilities—e.g., measurements that reflect the size of the playgrounds as well as their location; (3) distance to travel to facilities, counts of children within specified distance thresholds. Our domains are selected to best understand the landscape of play provision and children's access to these facilities. The details of operationalisation of these concepts are now considered further.

3. Materials and Methods

A quantitative approach to collect and analyse playground provision was employed using a range of freely available secondary datasets. These were analysed within a GIS (ArcMap 10.8.2) supported through statistical analysis generated in ArcMap, Excel (version 2402), and SPSS (version 27). Regardless of the spatial scale of analysis, three core data are required for mapping the provision of children's playgrounds and equality of play provision: (1) the location of children's playgrounds; (2) the locations of where children live; and (3) the boundaries of the countries or cities that are to be analysed. The data and methods used at the two spatial scales, world (aim 1—exploring between countries) and England (aim 2—exploring within a country), will now be described.

3.1. Methods for the World Scale

In order to test the appropriateness of using data at the world scale (aim 1), two case studies were used to validate the global data: the 534 largest English settlements (built-up areas) classified by population size (with populations over 15,000 equating to a total population of 40 million) and a single city of Guangzhou, China (population of 19 million). The populations for English settlements were downloaded from the Office for National Statistics (ONS) (https://www.ons.gov.uk/peoplepopulationandcommunity/housing/articles/townsandcitiescharacteristicsofbuiltupareasenglandandwales/census2021 (accessed on 2 September 2024)) and boundaries downloaded from the Open Geography Portal (https://geoportal.statistics.gov.uk/datasets/ad30b234308f4b02b4bb9b0f4766f7bb_0/explore (accessed 2 September 2024)). Guangzhou was selected due to the authors' working knowledge of the city, based on previous research, which would enable a greater level of testing and validity, if required [33,34].

The locations of children's playgrounds were extracted from Open Street Map (OSM) data (https://download.geofabrik.de/europe/united-kingdom.html (accessed 3 September 2024)). The locations of the children were drawn from WorldPop 2020 data (https://hub.worldpop.org/geodata/listing?id=88 (accessed 2 September 2024)), which contains broadly 5 year age bandings at a 100 m resolution (represented as 100 m grid cells). For this (world level) exploratory analysis, all children aged 15 and under were considered. Our consideration here of children aged 0–15 was pragmatic in that all three data sources used the same age categorisation and sought to both capture early years children (e.g., ages 0–5) and more frequently considered age groups (e.g., ages 6–14) [6].

Validation for the World Scale

The validation of the playground data was undertaken in England by comparing the OSM derived world data against alternative data through the Ordnance Survey (OS—the country's National Mapping Agency) Open Greenspace (https://www.ordnancesurvey.co.uk/products/os-open-greenspace (accessed 3 September 2024)), containing the location of playgrounds (termed playspaces within their data). The count of playgrounds from both datasets were compared at the settlement level using linear regression within SPSS.

The validation of the WorldPop children's geographies was undertaken by comparing aggregated WorldPop counts with official census counts for both England (lower layer super output areas, LSOAs) and Guangzhou, China (street-level data). An LSOA on average has a population of approximately 1500 people, whilst the average for street-level data in Guangzhou is much larger at just under 90,000 people. Despite these differences, street-level data in China are the smallest level of data commonly publicly available. Age data were downloaded for England LSOAs from Nomis (table TS007A: Age by five-year age bands) (https://www.nomisweb.co.uk (accessed 2 September 2024)). Street-level age data for Guangzhou were obtained from Guangzhou's Bureau of Statistics [35]. The underlying data for England and Guangzhou can be found in Supplementary Tables S1–S3. Linear regression within SPSS was used to compare aggregated outputs for both case studies.

3.2. Methods for the National Comparison in England

The same concepts as above were also applied at a national scale for England (aim 2). Playgrounds were extracted from OS Open Greenspace, and children's locations were drawn from output area (OA) centroids, with each point representing the centre location of the OA and containing the counts of children's ages drawn from the UK Census of Population from 2021 (https://www.nomisweb.co.uk/sources/census_2021 (accessed 2 September 2024)). Each OA contains on average 309 people [36], a scale much smaller than census tracts for USA and Spain, as discussed in the existing literature. Settlement boundaries used the same 534 English built-up areas classified by population size as used at the world scale for world-level validation purposes (as outlined in the first paragraph of Section 3.1). The threshold population size for medium-sized settlements was raised from 20,000 to 35,000 people to generate a more equally distributed categorisation, as shown in Table 1. The current (2011) version of the rural urban classification was used [37] to contextualise how many playgrounds occurred in urban and rural settings.

Table 1. Reclassifying the population thresholds for the 534 English settlements used in the analysis.

	Original Classification		**Reclassified**	
	Population Size	**Sample Size**	**Population Size**	**Sample Size**
London	N/A	32	N/A	32
Major	Over 200,000	23	Over 200,000	23
Large	75,000 to 200,000	86	75,000 to 200,000	86
Medium	20,000 to 75,000	347	35,000 to 75,000	138
Small	15,000 to 20,000	46	15,000 to 35,000	255

Additionally, in order to understand the socio-economic context of play provision in the settlements in which children reside, inequalities across levels of deprivation were analysed using the index of multiple deprivation [38]. LSOA data were aggregated to the settlement level using the average deprivation score for LSOAs falling within the settlement. The level of deprivation was then grouped into quartiles (where the number of data points are divided into four parts, or quarters, based on the level of deprivation) to facilitate comparison.

The equity of playground provision could be assessed using a wide range of different data. There is no consensus on what the most appropriate data should be, and this paper argues that, in such cases, there should rarely be a single measure. For example, there is no agreement on the age of children that should be considered for studies involving children's play. Whilst the UN definition centres on those under 18 [4], the literature contains a variety of different age thresholds, such as 0–14 [28], 5–11 [8], or 7–16 [30]. A systematic review of 51 studies by Martin et al. [6] identified that 5–12 years was the most common age studied, but 10% of studies focused on younger children (0–3 years) and 8% included adolescent participants (16–18 years), demonstrating the wide spread of suitable age categories used within the literature and, therefore, supporting our approach of using a number of different thresholds. Our approach uses a range of different age groupings (as shown in Table 2), which reflect the lack of consensus within the literature.

Table 2. Overview of the 21 variables used within analysis for measuring playground provision.

Playground Provision Domain 1—Count of facilities:	
-Number of children (as defined in the right-hand column) per playground using different age groups to represent 'children'	-Number of children under 16 per playground -Number of children under 18 per playground -Number of children aged 5–15 per playground [=3 variables]
Playground Provision Domain 2—Size of facilities:	
-Percentage of the total built area that comprised of playgrounds	[=1 variable]
-Metres of playground per child using different age groups to represent 'children' (as defined in the right-hand column)	-Metres of playground per child under 16 -Metres of playground per child under 18 -Metres of playground per child aged 5–15 [=3 variables]
Playground Provision Domain 3—Distance to travel to facilities:	
-The percentage of children within specified distances of playgrounds using both a variety of distance thresholds and different age groups to represent 'children' (as defined in the right-hand column)	-Four different distance of 100 m, 300 m, 500 m, and 800 m and three different age groupings (under 16, under 18, and 5–15 years))—resulting in 12 variables in total for this domain
Level of deprivation:	
Index of multiple deprivation, processed as described within the text	LSOA data averaged to settlement level and presented as quartiles, as described in the text [1 variable]
Settlement classification:	
ONS populations of settlements (built-up areas), as described in the text	Population thresholds reclassified into five categories, as shown in Table 1 [1 variable]

Similarly, there is no consensus on what distance thresholds should be used within GIS buffer analysis to determine what an acceptable distance for children to travel to playgrounds may be. Smoyer-Tomic et al. [28], in their study of Edmonton, Canada, employed a 800 m buffer distance within the analysis but reported that the minimum distance was roughly 400 m. Martori et al. [25] used a range of distances from 0–1000 m (0–250, 251–500, 501–750, and 751–1000 m) in their exploration of Barcelona, Spain, with the results identifying a median minimum distance of 226 m. Bhuyan [30] found that, in the context of Dhaka, Bangladesh, 82% of children surveyed lived within 400 m of a playground and 95% resided within 800 m. Lai and Low [5] concentrated on shorter distances, using distances of 100, 200, and 300 m in their consideration of Hong Kong, China. For these reasons, this work used a series of distance thresholds of 100 m, 300 m, 500 m, and 800 m, recognising that the distance will be influenced by the age of the children and the context of the location (in terms of barriers to visit etc). Our consideration of shorter, e.g., 100–300 m, and longer distances, e.g., 500–800 m, engages with contemporary best-practice approaches in child-friendly city planning, such as Utrecht's '3-Minute Playful City' initiative, which focuses on 200 m as the critical walking distance to a playspace from any given household [39].

To facilitate our framework, data on a large number of variables relating to playground equality were collated into different domains: based on the count of facilities; the size of facilities; and the distance required to travel to facilities. In total, 19 playground equality measures were used, summarised in Table 2. To contextualise this, playground equality measures were also combined with the level of deprivation and settlement classification, generating a total of 21 different variables.

Point in polygon GIS analysis (using the spatial join function) was used to (1) aggregate the census data at OA centroids to each settlement boundary polygon to count the number of children and (2) count the number of playgrounds drawn from OS Open Greenspace. The area of both the settlement and playgrounds were calculated in the GIS (using the calculate geometry tool) and then aggregated to generate the size measures used within the analysis. Finally, the GIS buffer tool generated buffers at 100 m, 300 m, 500 m, and 800 m, and then again, the point in polygon analysis aggregated the number of OA centroids within each buffer to count the numbers of children within the threshold distances.

Summary statistics for key variables were generated within SPSS. Z-scores of each of the three playground provision domains were generated using the average z-score for each variable within the domain ($z = (x - \mu)/\sigma$, where x is the raw score, μ is the population mean, and σ is the population standard deviation). The sign for the count domain z-score was reversed, so that a negative number represented a poor level of provision, in line with the direction of the other domains. To explore the level of support for our approach that a single variable would not suitable capture the many different elements of playground provision, principal component analysis (PCA) was undertaken on all 19 playground provision variables using SPSS. Correlation was undertaken (in SPSS) to explore the relationships between the three different domains of playground provision and deprivation for each settlement class.

In order to visualise the outputs, bubble plots were generated within ArcMap. Bubble plots are an extension of scatter plots for displaying multiple numerical variables, with each dot representing a data point and variables indicated by the horizontal position, vertical position, dot size and dot colour. Therefore, for each of the settlement size categories bubble plots showed all three playground provision domains (size domain on the X axis; distance domain on the Y axis; and count domain represented through the size of dots). The colour of the dots represented the level of the deprivation quartile. Thus, the paper showcases all 21 variables within a series of bubble plot charts for each settlement size category.

4. Results

4.1. Results for the World Scale

The world data required validation against finer resolution data from a national or local scale. Whilst the counts of playgrounds in the different settlements of England derived from both the world data from OSM and more detailed OS Open Greenspace were highly similar (see Figure 1), the completeness of data for Guangzhou, China was concerning. Only 53 playgrounds were extracted from OSM for Guangzhou, and further testing using playgrounds extracted from BAIDU/Gaode Map API resulted in just over 300 playgrounds being identified for the city. Given that London, a city less than half its size, contained over 3000 playgrounds, the completeness of the data must be questioned. A series of other cities in China were checked but also supported the Guangzhou findings (with only 137 playgrounds identified through OSM in Shanghai; 20 in Shenyang; 11 in Xi'an; and 8 in Tianjin).

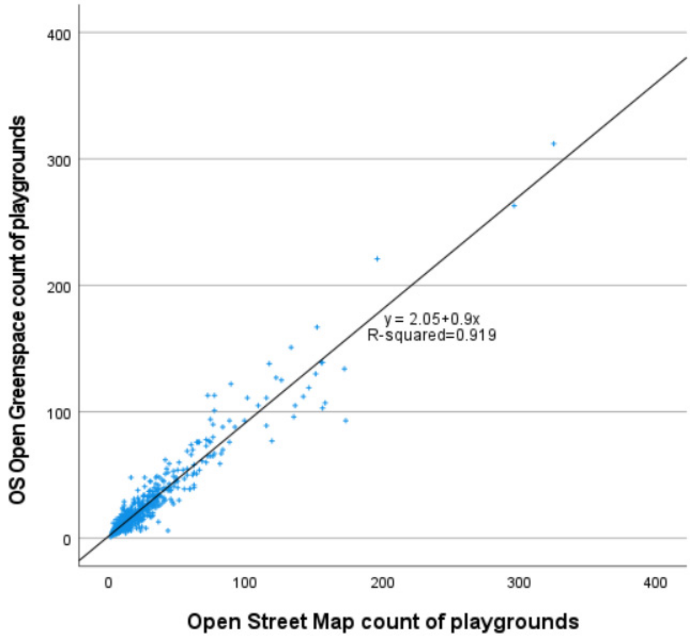
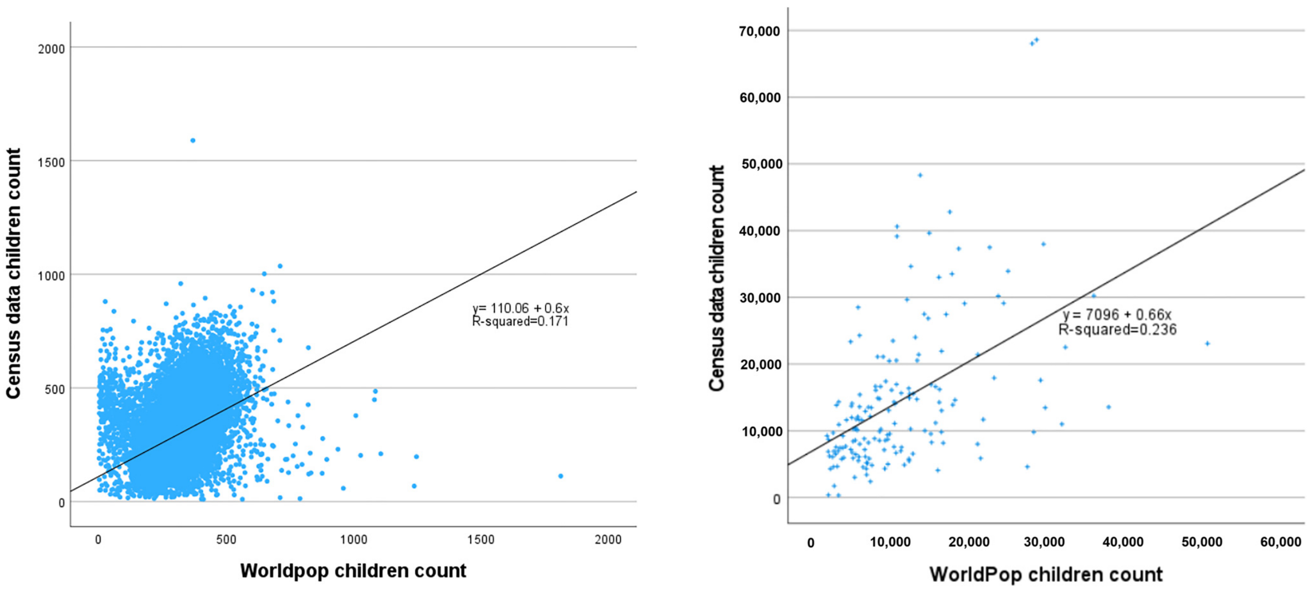


Figure 1. Comparison of playgrounds counts using different data for English settlements (with a population over 15,000).

The association between the counts of children for the two study areas were both poor (see Figure 2). The variance explained in England increased if compared against 2011 (as opposed to 2021) census data (R^2 = 28%); however, the fit remained poor overall.



(**a**) (**b**)

Figure 2. Comparison of numbers of children from WorldPop data when compared to census data in LSOAs of England and street level within the city of Guangzhou, China for (**a**) 33,755 LSOAs in England and (**b**) 164 streets in Guangzhou.

Section 5.1 discusses the implications of these findings, but it appears that a world-level analysis would not currently be appropriate due to data completeness issues. We provide recommendations for future work regarding these issues in the discussion section of the paper.

4.2. Results for the National Comparison in England

In total, OS Open Greenspace contained 33,736 playgrounds in England. As shown in Table 3, urban areas account for over 80% of England's population but only 68% of playgrounds (with 23,079 urban playgrounds). For this reason, the focus of this research centred on urban playgrounds and, in particular, the 18,077 playgrounds occurring within the 534 settlements with populations over 15,000 (70% of England's population and 54% of playgrounds). The full data table for the 534 settlements can be found within the Online Supplementary Material Table S4.

Table 3. Count of playgrounds in England by rural urban classification.

Rural Urban Classification (2011)	Population (2011)	Population Share	Playgrounds	Playground Share
Urban major conurbation	18,783,742	35.4	7209	21.4
Urban minor conurbation	1,906,101	3.6	819	2.4
Urban city and town	22,978,757	43.3	15,051	44.6
Rural town and fringe	4,657,007	8.8	4825	14.3
Rural village	2,930,464	5.5	4208	12.5
Rural hamlet and isolated dwellings	1,756,385	3.3	1624	4.8
Urban total	43,668,600	82.4	23,079	68.4
Rural total	9,343,856	17.6	10,657	31.6
Grand total	53,012,456	100.0	33,736	100.0

The principal component analysis (PCA) (see Tables A1 and A2 in the Appendix A) demonstrated that, combining all 19 playground provision measures into a single variable would only capture 66% of the variance. This result supports the idea of utilising multiple different elements of provision, rather than attempting to simply using a single variable. We retained the use of Z-scores for each domain (count, size, distance), as they are easier to interpret than PCA membership.

4.2.1. Results for Count of Playgrounds (Playground Provision Domain 1)

In London, there were fewer children per playground (i.e., less crowding) in more deprived areas compared to less deprived areas (Table 4—showing outputs for a single age group for ease). In contrast, for all other settlement class sizes, the opposite was true—with more children per playground compared to less deprived areas.

Table 4. Number of children (under 16) per playground by deprivation and settlement category.

	Deprivation Quartiles				
	1	2	3	4	
Settlement Class	Most Deprived			Least Deprived	Grand Total
London	422	490	858	634	578
Major	739	498	414	N/A	595
Large	557	386	310	506	427

Table 4. *Cont.*

	Deprivation Quartiles				
	1	**2**	**3**	**4**	
Settlement Class	**Most Deprived**			**Least Deprived**	**Grand Total**
Medium	636	406	341	364	443
Small	496	387	337	351	385
Grand Total	562	411	361	376	427

4.2.2. Results for Size of Playgrounds (Playground Provision Domain 2)

Overall smaller settlements tended to have larger playgrounds (see Table 5). The relationship with deprivation, as shown in Table 5, is complex, but with the exception of London, settlements in the two most deprived quartiles tended to have smaller playgrounds than the two least deprived quartiles. The pattern was most stark for the largest (major) settlements, where the size decreased with increasing levels of deprivation, with playgrounds in the most deprived quartile being on average 1.7 times smaller than those in the third quartile. In London, there were no clear patterns between playground size and deprivation, with deprived areas having similar sizes as the least deprived areas. Similar patterns were evident when using the percentage of the urban area that are playgrounds for the size metric (see Table A3 in the Appendix A).

Table 5. Metres of playground per child (under 16) by level of deprivation and settlement category.

	Deprivation Quartiles				
	1	**2**	**3**	**4**	
Settlement Class	**Most Deprived**			**Least Deprived**	**Grand Total**
London	1.8	1.9	1.4	1.8	1.7
Major	1.6	2.3	2.7		2.1
Large	2.2	2.6	3.9	2.7	2.9
Medium	2.0	2.8	3.3	3.2	2.8
Small	3.0	3.4	3.8	3.6	3.5
Grand Total	2.4	2.9	3.5	3.4	3.1

4.2.3. Results for Distance from Playgrounds (Playground Provision Domain 3)

Overall, there was no pattern between deprivation and the percentage of children within different distances of playgrounds, with the percentage in the most and least deprived quartiles being broadly similar (see Table 6). When the size of the settlement is taken into consideration, however, certain patterns emerge (see Figure 3).

Table 6. Percentage of children within specified distances of playgrounds by level of deprivation.

	Deprivation Quartiles				
	1	**2**	**3**	**4**	
Buffer Distances	**Most Deprived**			**Least Deprived**	**Grand Total**
Within 100 m	9.75	10.95	11.21	10.10	10.50
Within 300 m	46.11	51.20	51.99	47.97	49.26
Within 500 m	76.39	80.27	81.51	77.74	78.86
Within 800 m	94.96	95.98	96.83	94.88	95.50

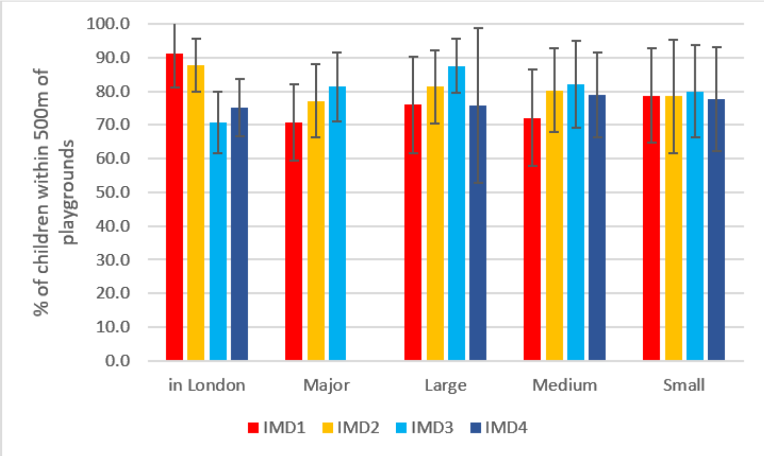


Figure 3. The percentage of children (under 16) within 500 m of playgrounds by level of deprivation and settlement category (with standard deviation bars).

In London, children in the most deprived quartile were more likely to live closer to playgrounds compared to children in other deprivation quartiles. Over 91% of children in the most deprived quartile live within 500 m of their nearest playground compared to just 75% in the least deprived quartile.

In major settlements, however, the opposite pattern was evident, with children in the most deprived quartile having to travel further to their nearest playground compared to less deprived children. Here, 71% of children lived within 500 m of a playground, compared to 81% for those in the least deprived quartile.

In large and medium settlements, there was an 'n'-shaped pattern with both the most and least deprived areas tending to have more children being over 500 m away from their nearest playground, compared to the two middle quartiles. However, the levels of standard deviations within each category were large. There was no evident pattern with deprivation for smaller settlements. These patterns are upheld when using different distance thresholds (see Table A4 in the Appendix A).

Correlation outputs between each of the three playground provision domains (count, size and distance) and the level of deprivation (as a continuous measure rather than quartile) for each settlement class confirmed the negative associations between provision and deprivation in London (see Table A5 in the Appendix A). Relationships generally were weak, with only moderate significant relationships identified between the count effect and deprivation for major and medium settlements; between the size effect and deprivation for major settlements and London (London being a negative relation); and between the distance and deprivation for London (negative relation). This highlights that the relationships with deprivation were particularly weak for the distance domain.

4.2.4. Results for the Combined Three Domains for Individual Settlements

There are significant inequalities in the playground provision between settlements in England across all the different measures. For major settlements, there are nearly five times more playgrounds per child (under 16) in Norwich compared to Liverpool (236 children per playground compared to 1104), and in London, there are nearly eight times more playgrounds per child in Islington compared to Redbridge (204 children per playground compared to 1567) (see Table S4).

In terms of playground size (Table S4), Leicester has four times more of its area devoted to playgrounds than Leeds (0.30% of the total urban area compared to 0.07%), and Norwich has seven times more metres of playground per child (under 16) compared to Liverpool (4.2 metres per child compared to 0.7 metres). In London, Islington has five times the area of playgrounds compared to Barnet (0.64% of total urban area versus 0.13%), and Islington has three times more metres of playground per child (under 16) compared to Redbridge (2.8 metres per child versus 0.9 metres).

When the distance to playgrounds is considered (Table S4), Liverpool had the lowest percentage of children within 100, 300, and 500 metres of playgrounds (3.7%, 22.6%, and 49.5%, respectively), with Coventry having the lowest percentage at 800 m (82.8%). In contrast, Southampton (15.8% within 100 m), Plymouth (66.0% within 300 m and 90.8% within 500 m), and Reading (99.9% within 800 m) had the highest percentages of children living close to playgrounds within their corresponding distance thresholds. In London, Redbridge (3.1% within 100 m; 24.3% within 300 m; 59.8% within 500 m) and Kingston upon Thames (91.7% within 800 m) had the lowest percentages of children living close to playgrounds; whereas, Islington (44.9% within 100 m), Tower Hamlets (94.1% within 300 m), and Hackney (99.9% within 500 m) had the highest levels of provision using the distance metrics.

Figures 4–6 illustrate how the three domains coalesce for major (largest) settlements, areas of London, and large settlements, respectively. Plots for medium and small settlements can be found in Appendix A (Figures A1 and A2). Maps for major settlements can be found in Figure 7 and those for London and large settlement classes are illustrated in Appendix A (Figures A3 and A4). Whilst many settlements had either good or poor provision across all three domains (for example, good provision in Norwich, Islington, and Milton Keynes or poor provision in Liverpool, Leeds, Redbridge, and Stockton-on-Tees), other areas were more complex. For example, Brighton and Hove has good-sized playgrounds (positive z-score for size domain) but a lower number than average of children close to playgrounds (negative score for distance domain), whilst places such as Plymouth and Portsmouth have high numbers of children close to playgrounds (positive z-score for distance) but have smaller playgrounds than average (negative z-score for size). The implications of these differences are considered within the discussion section (in Section 5.2.3).

Figure 4. Bubble plot for children's playground provision for major settlements in England.

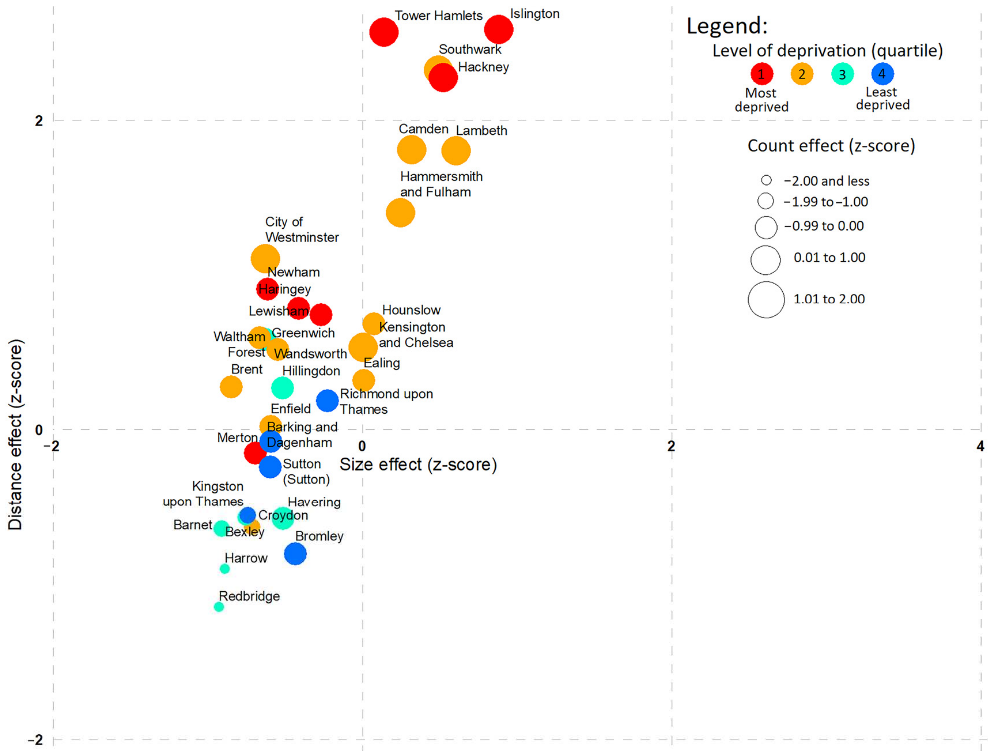


Figure 5. Bubble plot for children's playground provision for areas of London, England.

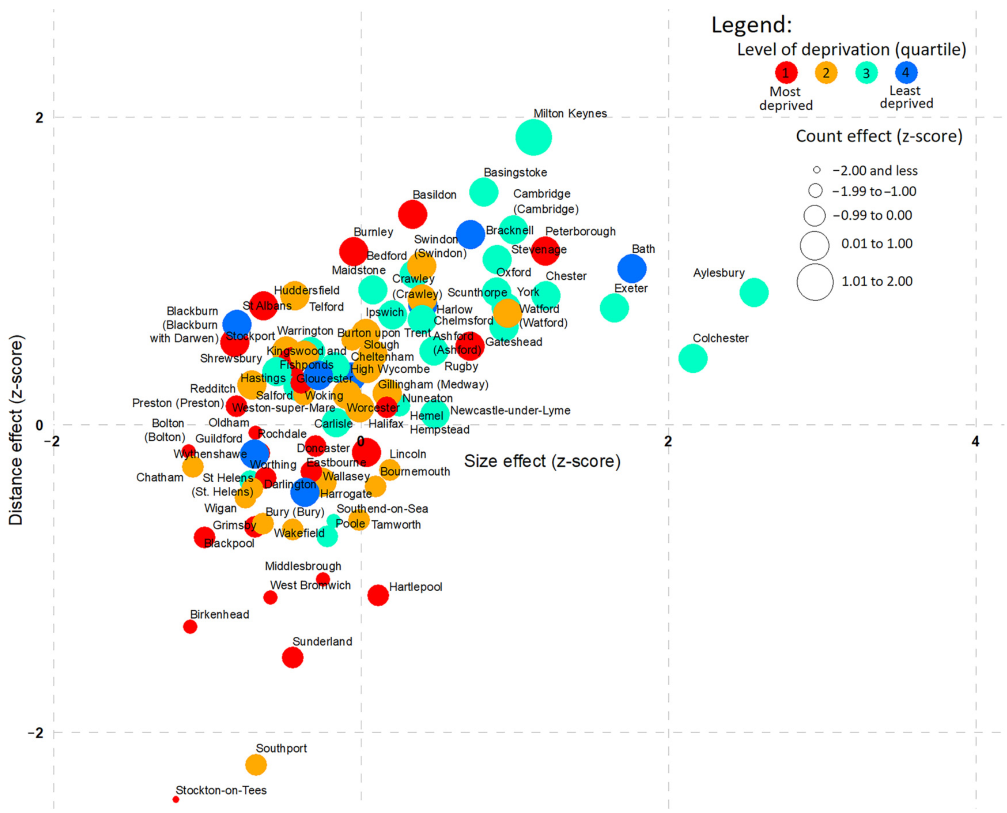
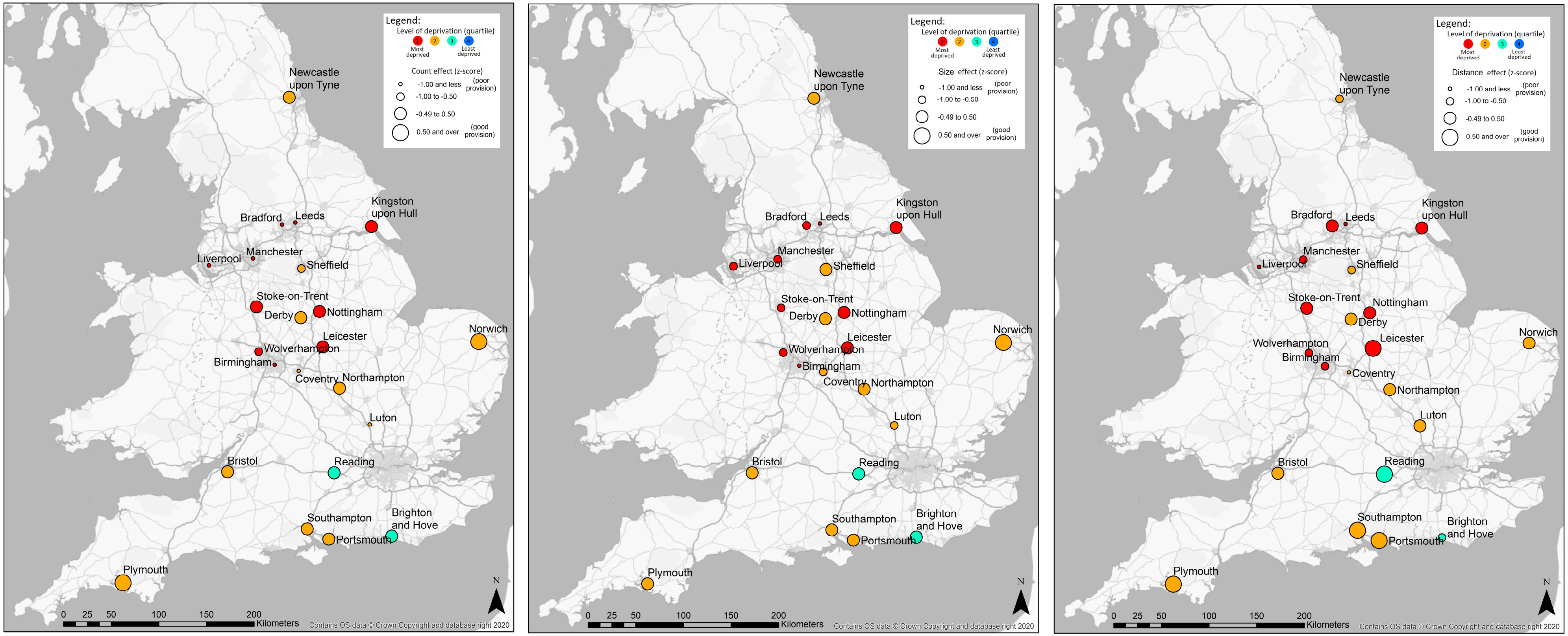


Figure 6. Bubble plot for children's playground provision for large settlements in England.



(**a**) (**b**) (**c**)

Figure 7. Maps of children's playground provision: (**a**) count; (**b**) size; and (**c**) distance, for major settlements in England.

5. Discussion

5.1. World Aspirations

Whilst a world analysis was highly ambitious, the recent growth in spatial data warranted exploration. Despite the availability of potential data to map inequalities across the globe, data completeness and quality issues meant that, currently, a robust analysis at the world scale is not viable. This means that, whilst it is not possible to compare playground provision *between* all countries, as required for a comprehensive response to the UN's Sustainable Development Goal 10, a more piecemeal comparison could potentially be made. Greater opportunities, however, exist at more local scales, such as comparisons of towns and cities *within* specific countries.

The deficiencies identified in the data used within the study are important. Whilst OSM is widely used for the identification of parks within China [15,33], our work has highlighted that the same data are not practical for the identification of playgrounds. Similarly, whilst WorldPop data have been commonly used within research [40], others have questioned the reliability of the data [41,42]. A study of park accessibility in China by Liao and Furuya [15] re-adjusted the WorldPop data using district level Census data. Such an approach was not viable within this work, which sought to test the extent to which the data were valid at lower resolutions using two study areas, with a view to potentially using the data for off-the-shelf usage across the globe, where adjustment data may not always be available.

Data differences aside, it is also important to note the differences in playgrounds within different world geographical and cultural contexts. The 'standard' playground in England (a fenced off space, to keep dogs out and children in, often with a prescribed list of equipment, frequently within an existing public park or other greenspace, defined as a kit, fence, and carpet (KFC) approach [4,43]) is in stark contrast to playgrounds in China, which are more likely to be in private gated communities. This helps to explain the difficulty in mapping playgrounds from crowdsourced data within Chinese cities.

In China, the 2002 revision to the Code for Urban Residential Areas Planning and Design explicitly mandated the inclusion of children's playgrounds as part of public service facilities in new residential developments [44]. By 2022, the Guidelines for Child-Friendly Urban Spaces Construction (Trial) further specified that the area of children's playgrounds in new residential projects must be at least 100 square metres [45]. Thus, the provision of playgrounds in Chinese cities is likely to be much higher than recorded by our data. Further research is required to effectively explore the dynamics and context of children's playgrounds across the globe. Our China case demonstrates the importance of and need for better quality data to aid our understanding of children's play in different settings.

5.2. National Comparison in England

Our national comparison of playground provision in England bolsters existing work on the extent of playgrounds nationally, helping to refine our overall understanding of dedicated spaces for play in towns and cities [1,27]. Using freedom of information requests, Winder [27] identified just over 184,000 publicly funded children's playgrounds in England. A survey undertaken by the API [1] identified 21,400 playgrounds in England; although, only 92% of local authorities responded, so the number would be higher. In contrast, this research, using OS Open Greenspace, identified 33,736 playgrounds in England, illustrating the benefit of such a comprehensive data approach but also potentially highlighting the potentially large number of playgrounds held outside local authority ownership (for example, in schools, housing associations, hospitals, and so forth). Our findings also demonstrate the need for further work to explore patterns at a more detailed level. With the availability of digital data for playgrounds in England through sources such as OS Open

Greenspace and OSM, there is no longer a lack of information regarding the geographic location of these important spaces, as previously identified [1,27]. However, gaps in knowledge persist in relation to ownership and maintenance, for example [27]. Likewise, an understanding and appreciation of playspace quality as well as inclusivity remain rare [6,7]. Research by Moore et al. [26,46], for example, identified that public playgrounds can inadvertently perpetuate social and spatial marginalisation, particularly for children with disabilities. Further work could begin to ascertain the extent of inclusive playspaces that exist nationally.

The major conurbations of England account for 35% of the population share but only 21% of playgrounds (Table 3). In contrast, rural areas tend to have a higher share of playgrounds than their population share would suggest. Given population densities, this imbalance is perhaps not surprising. However, in order to reduce existing inequalities in playground provision, strategic resourcing is required within urban areas to meet the UN's Sustainable Development Goal 10.

In a study in Dhaka, Bangladesh 82% of children surveyed lived within 400 m of a playground and 95% resided within 800 m [30]. Whilst our study also reported 95% of children (aged 16 or under) lived within 800 m of a playground in England, across all types of settlement size, only London has similar values within the lower distance threshold (using 500 m within our study). Given that Dhaka is over twice the size of London, results are unsurprising but do demonstrate that the size of the settlement and density are both important considerations when investigating the different metrics of playground provision. Our findings also demonstrate that the English context is failing to deliver on best practice for access to spaces for play, e.g., Utrecht's 3-Minute Playful City approach, where playspace will exist within 200 m of dwellings [39].

5.2.1. Discussion for Aggregated Outputs

Previous work, at the region level, identified London as having poorer playground provision than other areas of the county [9]. The EqualPlay report by API [9] identified London as the second worst region in the UK for playgrounds (866 children per playground in London, with children having five times fewer public playgrounds compared to children in Scotland). Our work supports this finding, whereby London was found to have more children per playground than the average (578 children per playground for London compared to 427 for the country—Table 4); however, other major cities were found to, on average, have worse provision (average of 595 children per playground). These findings demonstrate notable differences in the count of playgrounds between the two studies (578 children per playground in London for our study compared to 866 for the API study). The discrepancy is likely explained by data issues; notably, the API research (as noted in the previous section) was derived from responses to freedom of information requests and identified only 55% of the total number of playgrounds extracted from OS Open Greenspace as used within our research. Given the excellent fit identified between OS Open Greenspace and data from OSM (with 92% of the variance explained as shown in Figure 1), the discrepancy most likely lies with the incomplete Freedom of Information data; although, further work would be required to confirm this. That said, our paper has developed new knowledge on the overall provision and extent of playspaces nationally, helping to confirm new patterns of spatial discrepancy for play.

Additionally, work by the Fields in Trust [29] found that London had a lower percentage of children living more than ten minutes from playgrounds compared to the national average (25% of children in London compared to 32% for England as a whole) [29]. This research also supported this finding (Table A2 and Figure 3). Given densities within London, it is not surprising that a greater proportion of children are close to playgrounds.

Our research also identified that London tended to have smaller playgrounds compared to other settlements (Table 5), with just 1.7 metres of playground per child. The findings collectively for London tell a message that one single variable alone could not. In London, it is the population density influencing the outputs, whereby, despite good geographic coverage, there tends to be slightly fewer and smaller playgrounds than other parts of the country. Hence, this demonstrates the value of not generating a league table based on a single metric—which is likely to skew the results to the particular measurement used. Instead, the notion of gathering information in order to inform improved advocacy based on a wider range of measurements is supported. This upholds the findings of Talen and Anselin [21] who identified that it was difficult and not straightforward to reach a consensus on the characterisation of spatial equity in the provision of playgrounds, even when using complex spatial analysis approaches.

Our research also demonstrated that care must be taken when considering large heterogeneous areas as a whole, such as those previously used in the literature [9,29]; for example, treating any region of England as a single entity will frequently average out important patterns within the data that might otherwise be missed. Notably, in deprived areas of London, playground provision is much better than in most parts of the country, but the same cannot be said in the less deprived areas of London, which contain fewer playgrounds compared to other areas. Additionally, the Fields in Trust [29] and API [9] work, at the region scale, aggregated both rural and urban areas to provide a single value for each region, making it difficult to compare between the regions, as they frequently contain quite different compositions (different sized settlements, levels of deprivation, and so forth). In contrast, our work, by using the settlement as the focus (split by differing sizes of settlement), facilitates better comparison. The results help to support improved advocacy for children's play establishing a transferable approach on the landscape of play provision, building on commonly understood metrics. The results help to support improved advocacy for children's play, establishing a transferable approach on the landscape of play provision, building on commonly understood metrics. Our findings provide local authorities, decision makers, community leaders, and built environment practitioners with an improved evidence base to support decision making and policy preparation for children's play. At a local level, we recommend the results be used to help develop site-/area-specific play policies and strategies for improved access and provision.

5.2.2. Trends with Deprivation

Our work also identified important trends between playground provision and deprivation (Figure 3 and Tables A1 and A2). Across all three domains (count, size, and distance), deprived settlements tended to have fewer, smaller, and further-away playgrounds. Patterns were most evident within the largest, major settlements. London was consistently an exception to these patterns, where, in contrast, deprived areas tended to have more and closer playgrounds. Of particular note was the trend with deprivation in London within Figure 5, where the highest levels of playground provision (across the three domains) were dominated by deprived areas. In all other settlement classes (Figures 4, 6, A1 and A2 and Tables A1 and A2), either no pattern was evident, or the opposite was true (albeit with a less strong trend).

Supporting the findings in London but contrary to those in other English settlements, the literature tended to support that deprived areas were more likely to have better playground provision. This was the case in both Barcelona, Spain [25] and Edmonton, Canada [28]. There were, however, inequalities in playground quality identified within Edmonton [28]. Treading the middle ground, Talen and Anselin's study in Tulsa, Oklahoma, USA [21], identified what they called 'unpatterned inequality' but urged caution in its interpretation and called for further research to explore multivariate interaction between explanatory variables. The outcomes facilitate more accurate discussion and engagement on playspaces for children and support researchers, policy makers, community leaders, local government, and other practitioners to make more informed judgements on children's access to play.

5.2.3. Discussion for Outputs at the Individual Settlement Level

The findings of large differences in the provision of playgrounds across different settlements (Figures 4–6, A1 and A2 and Tables A1 and A2) needs to be placed in the context of the previous studies. The main difference between the literature and this research is that, whilst previous work investigated single settlements or large aggregated areas (regions of the UK), our research looks at differences between settlements within a country. In this light, it is perhaps less surprising to see large differences in provision, but the scale of the differences (with some areas having up to eight times the provision of others) is stark.

The importance of the choice of metrics used for measuring accessibility is stressed in the literature [21,47]. The extent to which different settlements have the highest/lowest values for differing metrics (as discussed in Section 4.2.4) validates the paper's approach of not generating a single metric league table but attempting to synthesise the complex findings in a meaningful manner. Work here specifically sought to avoid a league table approach, which would be dependent on the set of information drawn to generate it, whereby any changes in the data can result in a different ranking, raising questions concerning the robustness of the approach.

We draw on experiences learnt from ranking the greenness of town and city centres (equivalent to central business districts) within Great Britain [48], where both local government officials and policy makers raised concerns with the league table outputs. For example, with those from poorly scoring areas expressing concerns due to potentially receiving negative public attention (which were feared could potentially lead to economic consequences), and more unexpectedly, those scoring well were equally concerned that decision makers may use the information to stop making improvements (in this instance, developing on greenspaces rather than protecting them as the area was 'above' averages).

One of the key benefits of the approach of using a wide range of different metrics to measure playground provision is that it permits nuances of interpretation, whereby information can then feed into place specific interventions to improve future provision by practitioners and policy makers. For example, as shown in Figure 8 (which draws examples from data within Figures 4–6), settlements such as Portsmouth or Nottingham have above average scores for the distance effect but have poor provision in terms of the size effect. They would, therefore, benefit most from the expansion of existing playgrounds to improve overall provision. In contrast, settlements such as Brighton and Lincoln have above average size effects but are lower in terms of distance effects and, thus, would benefit from a small number of new strategically positioned playgrounds to fill current gaps in geographic provision. Additionally, high-scoring settlements that score well across all domains, such as Norwich, Milton Keynes, Islington, Hackney, or Southwark, for example, could act as precedents for those settlements with lower provision to learn from, demonstrating transferable lessons for improved play practices and playspace networks.

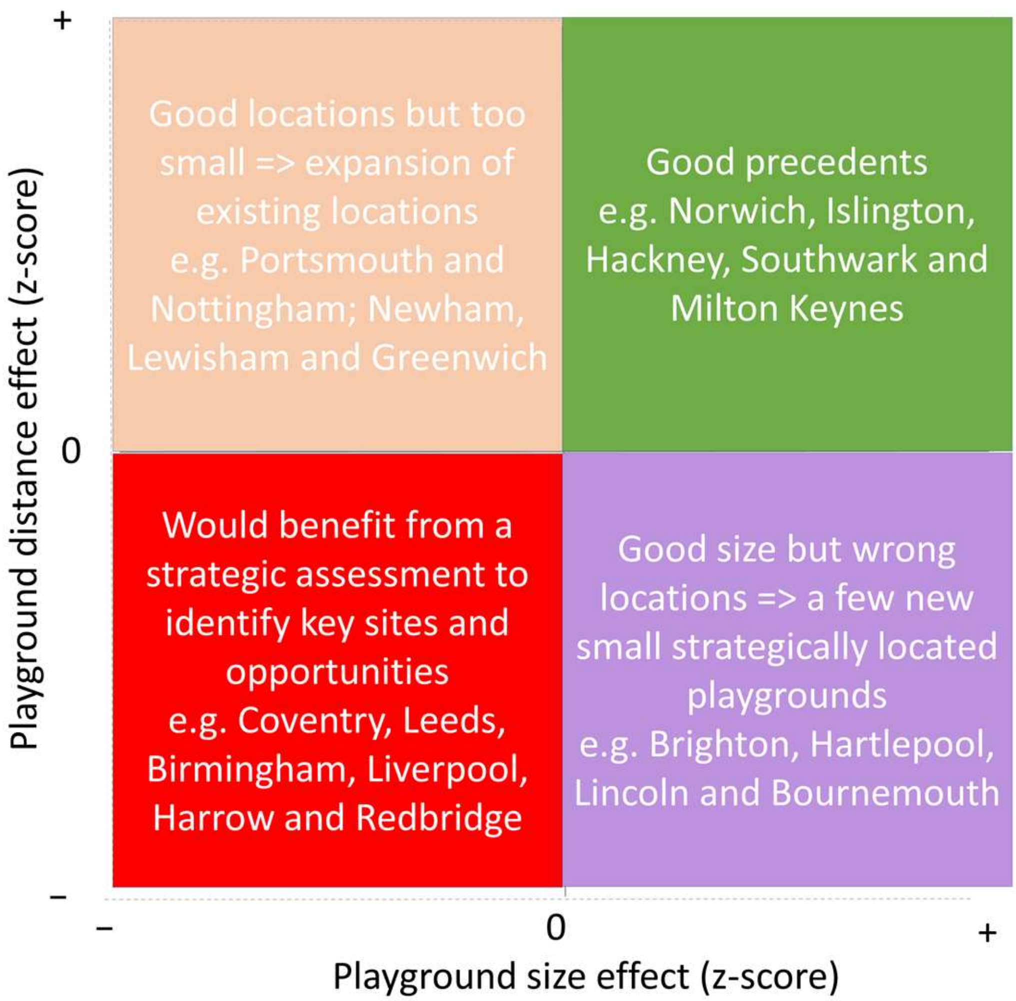


Figure 8. Framework for identifying playground interventions to improve playground provision.

5.3. Limitations and Future Research

As with any study, there are a number of limitations of our work. We acknowledge that more sophisticated measures exist for measuring playground proximity (including network approaches or supply and demand methods, such as the two-step floating catchment area). Our simple methods, however, are easy to both understand and apply by a wide range of stakeholders e.g., local government, in global contexts, where data robustness and accuracy may potentially be problematic. The use of a wide range of different buffer distance thresholds should help mitigate the principal adverse effects. It should also be noted that our work solely focuses on distance and not accessibility, which may be a substantial barrier to children using playgrounds (for example, busy traffic or lack of opportunities for independent mobility [49]). The buffer analysis generates outputs based on the residential location within OAs, but it should be acknowledged that access distances in reality depend on movements within daily activity space (for example, the home location may be distant from a playground and dependant on children and their caregiver/s passing one on their way to school).

Furthermore, the 'quality' of playgrounds is an important factor that will also influence levels of play [4,43]. In a study in Hong Kong, whilst access in terms of distance was found to be the most important factor affecting the use of playgrounds (as used within our study), other factors including adequate play equipment, safety, and cleanliness/maintenance were also important [5]. This research focused on the provision of playgrounds, analysing the potential for a child to use the space rather than measuring actual usage. The use of playgrounds as opposed to provision is key for providing health benefits; an empty playground will not help promote active childhoods. Different user groups are also likely to have their own motivations and barriers, which will affect the use of a site (as demonstrated within urban parks [34]). Whilst our work focused on equality in terms of deprivation, similar analysis is required for other aspects of equality, including but not limited to race, ethnicity, and disability [6]. The importance of historical provision influencing patterns at a settlement level would also be of interest [43].

Additionally, it must be recognised that, although playgrounds are a critical element of children's play, there are many other important playspaces for children beyond dedicated playspaces [17,18]. For example, informal playspaces provide opportunities for free exploration and unstructured play, fostering creativity, social skills, and problem-solving abilities [6,50]. These informal spaces are often deeply embedded within local communities, serving as vital play environments, particularly in neighbourhoods where access to formal playgrounds is limited [50–52]. Future research could consider informal playspaces to develop a deeper understanding of the equity and inclusivity of children's play environments, as well as children's opportunities for play on their doorstep [7]. A transnational perspective would complement our approach, demonstrating the crucial role informal playspaces have in a range of international contexts. This understanding would support a more comprehensive understanding of play equity.

Limitations within the data must also be acknowledged; whilst the official UK playground data used in this study compared well with open-source equivalents (from OSM), our work identified data quality issues within data for other countries. It was also noted that some playgrounds identified within OSM related to alternative definitions of children playgrounds—being school yards or sports facilities for example. Other data used, for example children's age and locations or deprivation, are likely to be collected at a specific timestamp and may not always be up to date. Whilst such inaccuracies might reasonably be expected to affect all areas equally (in other words be aspatial), such assumptions need further exploration and testing.

Whilst this work identified that a universal mapping of playground provision in all countries is not possible, future research is required to identify in which countries suitable data are available in order to accurately map provision at national levels (replicating and building on the work undertaken in this paper for England). Finally, although the framework developed here was used to map playground provision, the same approach could be applied to other features (beyond playgrounds), where equity mapping is important within our urban environment, for example, but not limited to, tree equity or greenspace provision.

6. Conclusions

With the exception of London, deprived settlements in England tended to have fewer, smaller, and further-away playgrounds across all three of the domains measuring children's playground provision. The patterns were most stark in the larger settlements (ranging in population size from Birmingham to Norwich). The research presented here identifies yet another inequality in green-/open-space provision within the UK [14,15,53]. Less affluent adults frequently have less opportunity to experience the social, emotional, and health benefits conferred by parks and other green spaces [54,55], and this research now suggests that children from less affluent backgrounds are also more likely to lose out in the spatial justice stakes on play, self-development, and social opportunities. The exception was London, however, where deprived areas tended to have more and closer playgrounds. This aspect requires further research.

Whilst previous work acknowledges the problems resulting from the different approaches that can be used to measure provision [21,47], our work goes one step further by attempting to address this issue. This study demonstrates how a wide range of metrics for measuring the provision of children's playgrounds can be brought together in order to identify patterns. Given that any output is dependent on the measure used, a more robust approach is to combine a series of metrics rather than arbitrarily selecting a single measure. Thus, instead of generating a single league table of provision based on a single metric, interventions can be drawn from the nuances underpinning the level of provision. Our work has impact, as it clearly demonstrates the need for a strategic approach to determine formal play provision. This is relevant to England (as evidenced by our data) but also elsewhere across the world. Ideally, such strategies should be developed at the national scale but interpreted and delivered effectively at the local government scale. Resolving inequalities in children's playground provision within a country necessitates successful policies at both national and local scales, thus directly contributing to both the UN Sustainability Goals 10 and 11 and the 'right to play' within the UN Convention on the Rights of the Child.

We hope that our work for England can help inform global strategies through providing a transferable methodology to measure the multiple domains impacting the equity of children's playground provision. The results of our work demonstrate the powerful insights that can be gathered using such an approach. If the value of the underlying data is acknowledged, this in turn may improve the quality and availability of geographical data for children's playgrounds within a wider range of countries, globally.

Our findings reveal greater appreciation and engagement with playspace provision is necessary to bolster children's right to the city. Exploring the democratic context of play underscores the importance of considering broader social and spatial determinants that impact children's opportunities for play across the built environment. Our hope is new levels of awareness—as demonstrated by our research—can result in improved policy, practice and placemaking for children.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land14030477/s1, Worldpop and Census comparisons for England (2021) [Table S1], England (2011) [Table S2], Guangzhou (2021) [Table S3], and the full data file for the largest 345 settlements in England [Table S4].

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Appendix A

Table A1. Principal component analysis—total variance explained.

	Extraction Sums of Squared Loadings		
Component	**Total**	**% of Variance**	**Cumulative %**
1	12.6	66.5	66.5
2	2.5	13.2	79.7
3	1.8	9.4	89.1
4	1.2	6.3	95.4

Table A2. Principal component analysis—component matrix.

Playground Provision: Z-Score Variables	Component 1	2	3	4
Children (5–15) per playground	0.805	0.080	0.309	−0.494
Children (0–15) per playground	0.796	0.091	0.312	−0.506
Children (0–17) per playground	0.798	0.089	0.311	−0.503
% of urban area for playgrounds	0.708	0.500	−0.197	0.281
Meters of playground per child (5–15)	0.634	0.751	0.072	0.137
Meters of playground per child (0–15)	0.623	0.760	0.082	0.130
Meters of playground per child (0–17)	0.625	0.758	0.080	0.134
% of children (5–15) within 100 m	0.797	−0.103	−0.538	−0.064
% of children (5–15) within 300 m	0.937	−0.141	−0.188	−0.001
% of children (5–15) within 500 m	0.936	−0.209	0.075	0.106
% of children (5–15) within 800 m	0.797	−0.303	0.364	0.294
% of children (0–16) within 100 m	0.787	−0.086	−0.559	−0.090
% of children (0–16) within 300 m	0.939	−0.143	−0.188	−0.025
% of children (0–16) within 500 m	0.932	−0.226	0.075	0.096
% of children (0–16) within 800 m	0.796	−0.317	0.368	0.295
% of children (0–18) within 100 m	0.786	−0.089	−0.561	−0.088
% of children (0–18) within 300 m	0.939	−0.146	−0.188	−0.022
% of children (0–18) within 500 m	0.932	−0.227	0.075	0.098
% of children (0–18) within 800 m	0.795	−0.317	0.368	0.298

Table A3. Average percentage of urban area occupied by playgrounds by settlement class and level of deprivation.

	Deprivation Quartiles				
	1	2	3	4	
Settlement Class	Most Deprived			Least Deprived	Grand Total
London	0.40	0.32	0.16	0.19	0.28
Major	0.15	0.19	0.25	N/A	0.18
Large	0.17	0.19	0.29	0.18	0.21
Medium	0.15	0.17	0.21	0.20	0.18
Small	0.19	0.20	0.20	0.21	0.20
Grand Total	0.18	0.20	0.22	0.20	0.20

Table A4. Percentage of children within specified distances of playgrounds by level of deprivation and settlement class.

Settlement Class	Buffer Distance	Deprivation Quartiles 1 Most Deprived	2	3	4 Least Deprived
London:	100 m	26.8	19.4	8.2	7.9
	300 m	72.0	63.6	38.8	42.7
	500 m	91.1	87.7	70.8	75.1
	800 m	99.2	98.0	94.9	95.3
Major:	100 m	7.5	10.4	10.2	N/A
	300 m	40.2	47.8	50.0	N/A
	500 m	70.8	77.1	81.3	N/A
	800 m	93.3	95.0	95.3	N/A

Table A4. *Cont.*

Settlement Class	Buffer Distance	Deprivation Quartiles 1 Most Deprived	2	3	4 Least Deprived
Large:	100 m	9.6	9.5	13.3	10.6
	300 m	46.3	49.3	60.2	49.0
	500 m	76.1	81.3	87.6	75.8
	800 m	94.5	96.6	98.6	91.1
Medium:	100 m	8.0	9.7	11.7	10.3
	300 m	41.5	51.3	52.5	48.8
	500 m	72.1	80.3	82.0	78.9
	800 m	93.3	96.3	97.1	95.8
Small:	100 m	9.2	10.4	10.4	10.1
	300 m	47.0	49.7	49.8	47.8
	500 m	78.7	78.5	79.9	77.7
	800 m	96.1	95.2	96.2	95.0

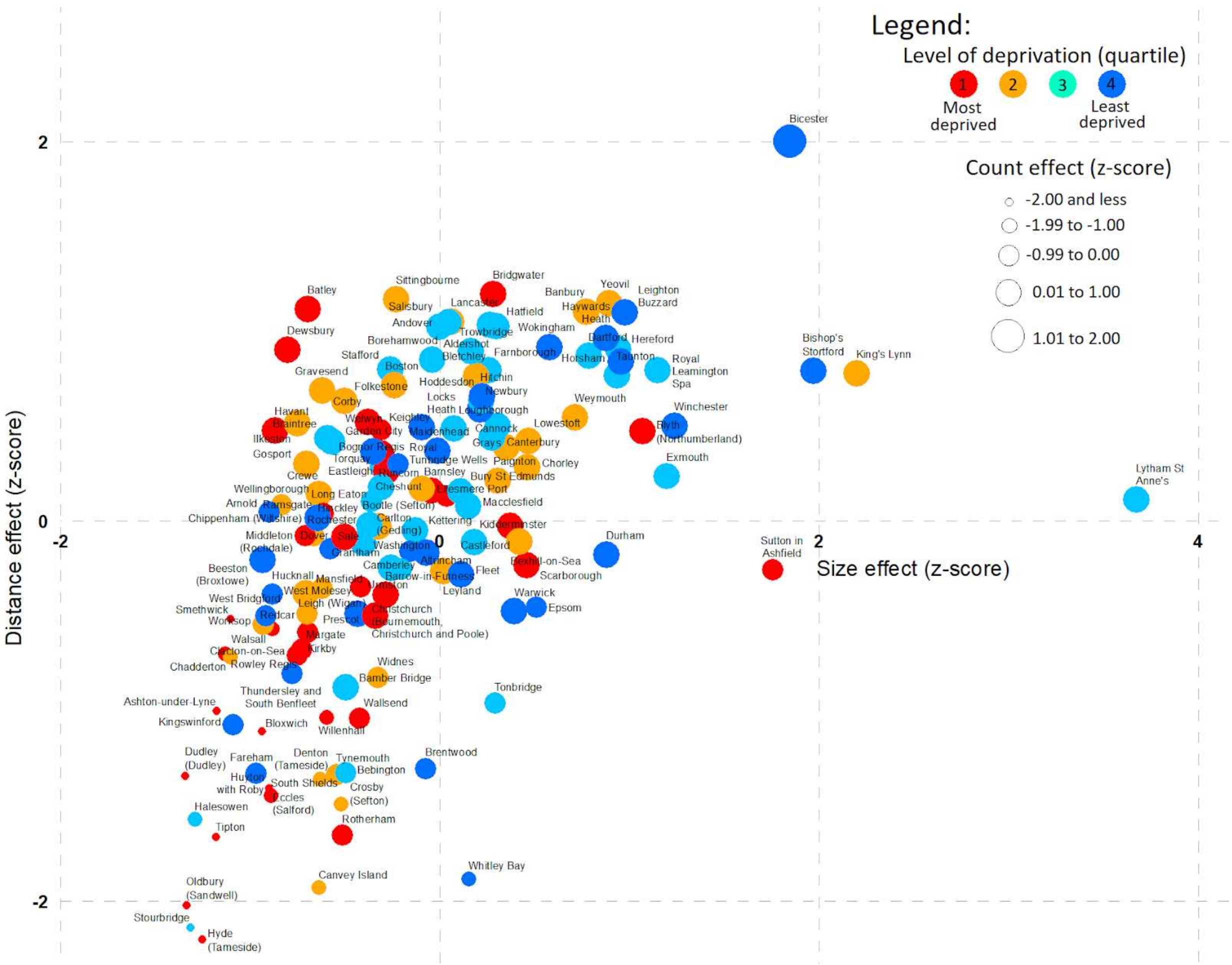


Figure A1. Bubble plot for children's playground provision for medium settlements in England.

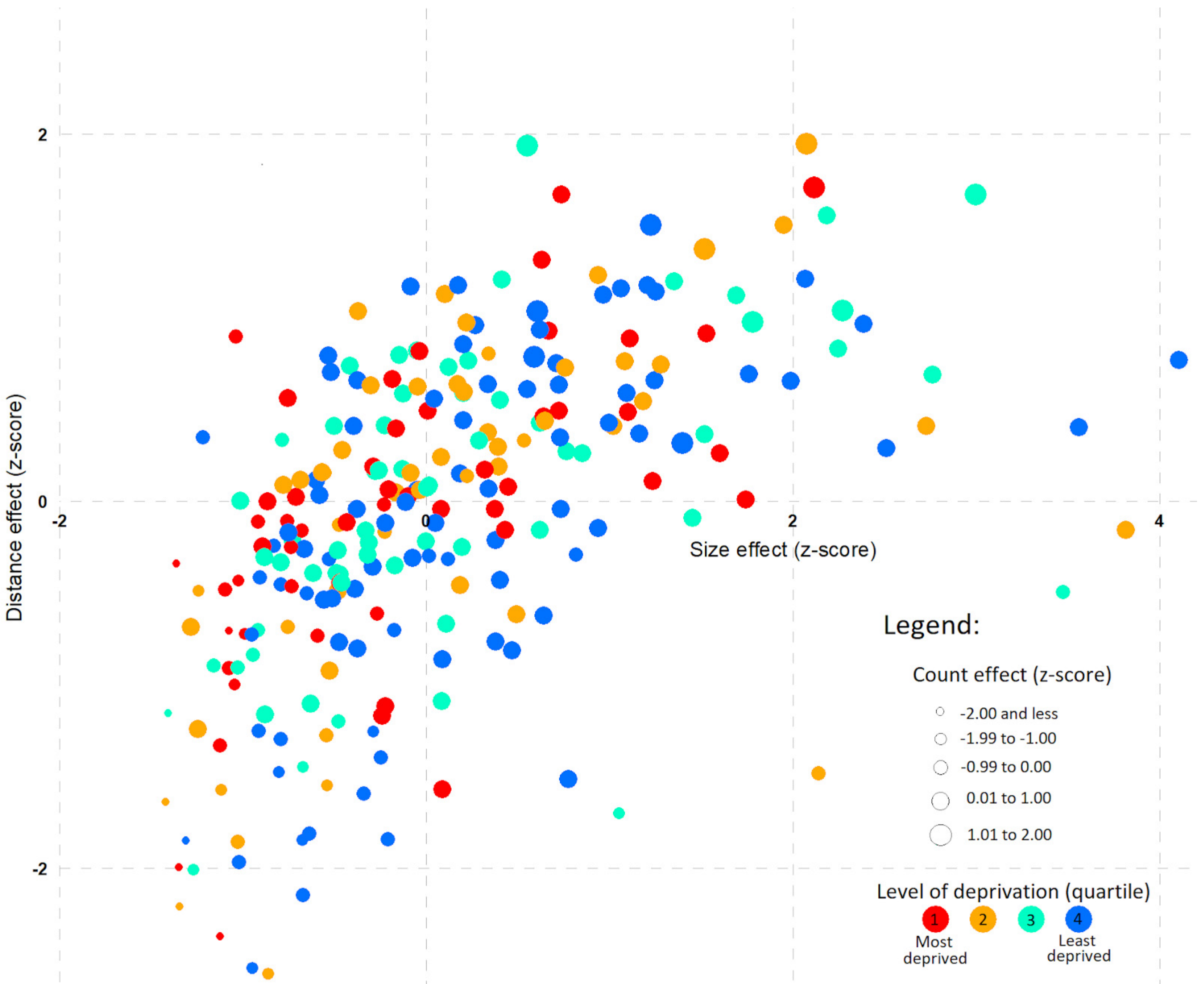


Figure A2. Bubble plot for children's playground provision for small settlements in England.

Table A5. Correlation outputs for the relationship between deprivation and the three playground provision domains (count, size, and distance), broken down by settlement class.

Settlement Class		Count Effect (z-Score)	Size Effect (z-Score)	Distance Effect (z-Score)
All (n = 534)	Pearson Correlation	0.231 **	0.178 **	0.023
	Sig. (2-tailed)	0.000	0.000	0.597
London (n = 32)	Pearson Correlation	−0.387 *	−0.411 *	−0.618 **
	Sig. (2-tailed)	0.028	0.020	0.000
Major (n = 23)	Pearson Correlation	0.591 **	0.515 *	0.340
	Sig. (2-tailed)	0.003	0.012	0.112
Large (n = 86)	Pearson Correlation	0.246 *	0.325 **	0.160
	Sig. (2-tailed)	0.022	0.002	0.140
Medium (n = 138)	Pearson Correlation	0.400 **	0.325 **	0.238 **
	Sig. (2-tailed)	0.000	0.000	0.005
Small (n = 255)	Pearson Correlation	0.139 *	0.073	−0.053
	Sig. (2-tailed)	0.026	0.247	0.400

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

(a)
(b)
(c)

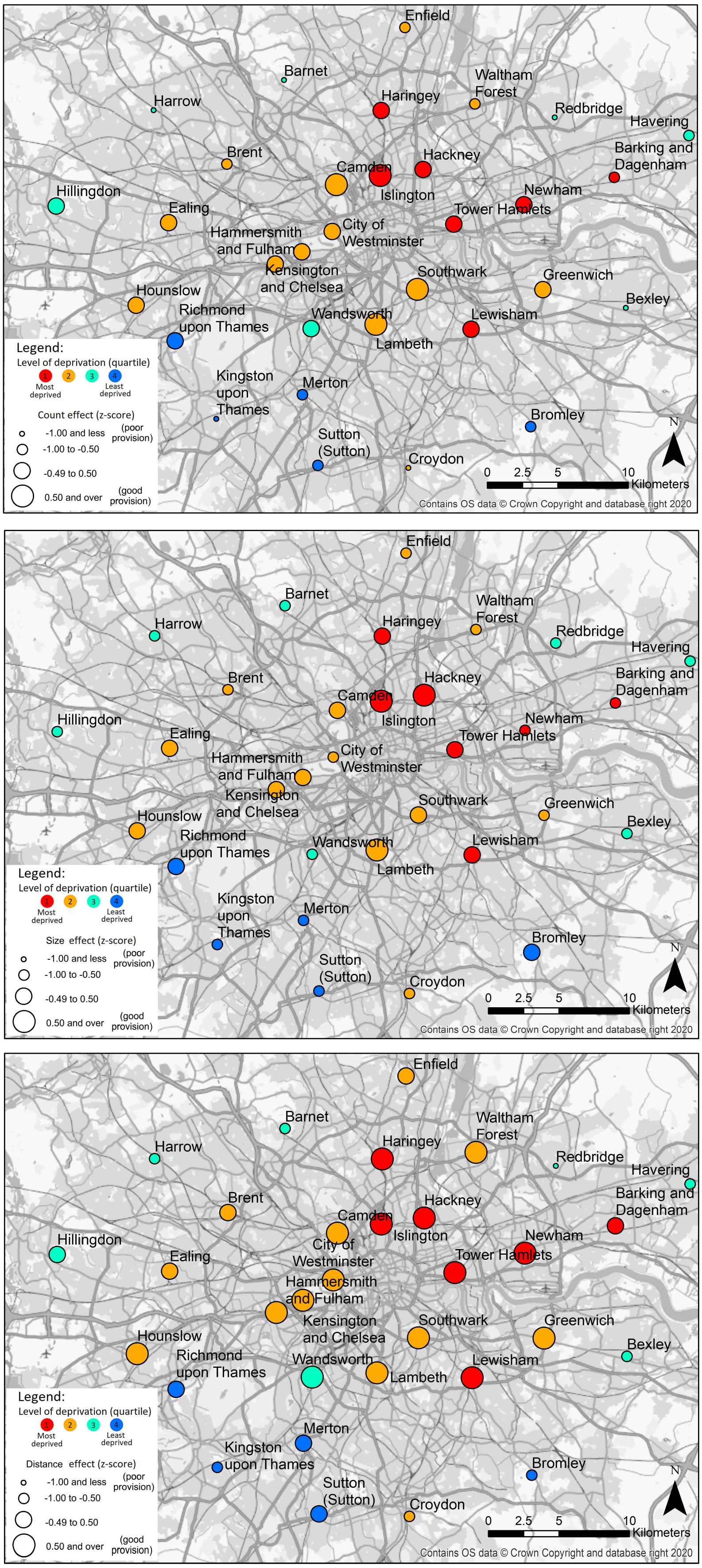
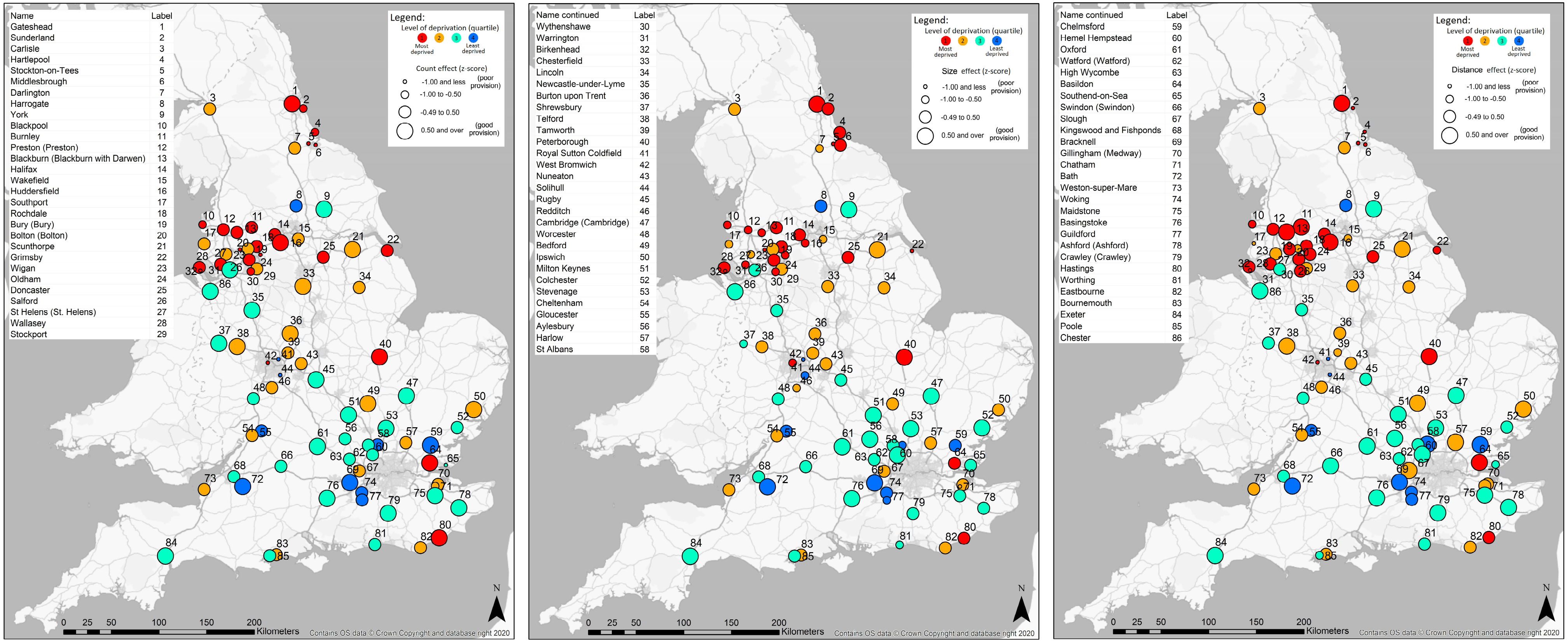


Figure A3. Maps of children's playground provision: (**a**) count; (**b**) size; and (**c**) distance, for London.



(**a**) (**b**) (**c**)

Figure A4. Maps of children's playground provision: (**a**) count; (**b**) size; and (**c**) distance, for large settlements in England.

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