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Original Research

Deprivation amplification due to structural disadvantage? Playgrounds as important physical activity resources for children and adolescents

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ABSTRACT

Objectives: The deprivation amplification hypothesis postulates that the socially disadvantaged are exposed to further structural deprivation by their residential environment such that social inequalities are therefore amplified. To date, no publication has investigated deprivation amplification solely using playgrounds; the present health geography study investigates this hypothesis with regard to the availability of playgrounds in a typical large German city.

Study design: Between July 2016 and January 2017, all playgrounds in the city of Mannheim, Germany, were identified and evaluated by systematic audits. The playground attributes such as availability, accessibility, surface area, and provided amenities were operationalized using well-established, validated instruments.

Methods: Geo-information about playgrounds was digitalized in ArcGIS 10.2–10.4 and linked to socioeconomic indicators on the meso-level, that is, on the level of 44 social areas. Availability and accessibility of playgrounds were quantified by calculating kernel density and Euclidean distance, respectively. Playground surface area and equipment provided were linked to the number of children and adolescents in the particular social area. The association between availability and accessibility of playgrounds and area-level indicators were assessed using bivariate and multiple Poisson regressions on the meso-level.

Results: In the city of Mannheim, which covers 145 km^2 and is home to 311,000 inhabitants, 271 playgrounds were identified. Bivariate and multiple analyses showed no association between availability and accessibility of playgrounds and area-level indicators. However, significant negative associations were found in the bivariate analyses between playground area and amenities provided per child and various area-level indicators, but not in multiple models.

Conclusions: Children are provided with different opportunities to play and to be physically active, depending upon the population density of their social neighborhood. At least in our

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study area, many socially disadvantaged families are forced to move to densely populated areas for economic reasons. Against that background, the phenomenon of 'deprivation amplification' was not confirmed for availability and accessibility of playgrounds but for playground area and number of amenities provided.

Introduction

The deprivation amplification hypothesis postulates that the socially disadvantaged are exposed to further structural deprivation by their residential environment such that social inequalities are therefore amplified. The term 'deprivation amplification' can be traced back to Sally Macintyre[1] and so far has most frequently been investigated in relation to physical activity resources; if socially disadvantaged individuals are more likely than inhabitants of richer neighborhoods to live in areas of the city which have less sporting infrastructure, are less walkable, provide less opportunities for physical activity, and have worse access to parks and green spaces, this has an adverse effect on both their organized and their non-organized daily physical activity, and subsequently on their health.[1]

Although this hypothesis may seem intuitively plausible, the studies published since it was first postulated have provided a greatly differentiated picture. The state of research into physical activity resources can be summarized into two main findings: first of all, most studies which confirm the hypothesis have been carried out in the USA (USA;[2–7] Europe/Australia[8–10]), whereas the majority of the studies which do not confirm the hypothesis were carried out in Europe or Australia (Europe/Australia;[11–16] USA[17,18]); second, these publications assessed a wide range of very different facilities (including parks, fitness studios, clubs, beaches, golf courses, and classes offered locally), most of which were only relevant for adult target groups.[2–18]

According to our research, so far no publication has investigated the deprivation amplification hypothesis solely using public streets or playgrounds. Both environmental factors represent important opportunities for children and adolescents to engage in physical activity.[19,20]

Particularly with regard to playgrounds, two central authors in the field have independently referred to a serious gap in research regarding this key aspect of a child's residential environment.[21,22] Playgrounds represent an important determinant for minors' level of outdoor physical activity: first of all, playgrounds provide the opportunity for children to fulfill their desire for spontaneous movement around the clock and in a protected environment; second, they compensate for the limited geographic mobility of children and adolescents, as reaching playgrounds does not require complicated and environmentally unfriendly passive transportation—for example, in their parents' car; third, playgrounds provide an excellent opportunity for children to be physically active without the notion of competition, something which can particularly motivate children who might be physically weaker; fourth, in contrast to fitness classes, club and team sports, or indoor playground facilities, playgrounds are free of charge and therefore provide a low-threshold opportunity for physical activity, particularly for socially disadvantaged; finally, playgrounds encourage informal social interaction and the establishment of contacts that span status and ethnicity.[3,23] For these reasons, the present study investigates the deprivation amplification hypothesis with relation to playgrounds. As a comprehensive survey in a typical large German city, we examine the association of availability and accessibility of playgrounds as well as playground area and amenities provided at playgrounds, and municipal socio-demographic indicators on the meso-level.

Methods

Investigation area

The 'PlaSMa' (playground study Mannheim) study was carried out in the city of Mannheim. Mannheim was officially listed as a settlement for the first time in 766 and is proud of its long industrial history: among other things, in 1817, Karl von Drais invented the bicycle, and, in 1886, Carl Benz invented the car in Mannheim. The city lies in the western part of Germany, has a population of 311,470 inhabitants, and covers an area of 145 km^2.[24] Mannheim is considered to be a 'typical German major city', with a historical city center surrounded by suburbs. This large city was chosen for the PlaSMa study because its social structure is similar to that of the Federal Republic of Germany as a whole and it is one of the few German cities where so-called 'social areas' have already been delineated. Social area is a well-established geographical term which is generally defined as a conjoined cluster of homogenous streets, houses, and quarters within a city which shares certain characteristics and attributes.[17,25] The cluster analytic procedure used by the municipal administration of Mannheim to define these social areas has been described in detail elsewhere.[24] The city of Mannheim contains a total of 44 of these social areas within 17 city districts.

Definition of socio-demographic indicators

Socio-demographic indicators drawn from municipal statistics were available at a district and social area level. Standard indicators such as population density in thousands per km^2, the percentage of children and adolescents (<18 years old), and the percentage of single parent households in the total population are included.

In Germany, there is no comprehensive set of composite indices of deprivation available at an area level smaller than the district level. For example, the German Index of Multiple Deprivation (GIMD) provides data at a higher area level, focusing on the municipal and district levels.[26] The authors were likewise unable to calculate the GIMD or any other relevant indicator such as the Townsend deprivation index[27] or Carstairs score[28] because of a lack of official data at a social area level (e.g., data regarding car ownership, traffic accidents, or crime). In keeping with the exploratory nature of this study, it was instead decided to use the following official indicators of social deprivation for the analysis: employment rate (percentage of employees among all 15–64 year olds); unemployment quotient (number of unemployed people among all 15–64-year olds); percentage of long-term unemployed inhabitants among those unemployed; jobseekers younger than 65 years of age who were receiving state support payments (as a percentage of all those under 65); and all those who were receiving state support payments (as a percentage of the total population).

Inclusion criteria and site audits

All public playgrounds within the municipal area of Mannheim were included in our study. Site audits were based on a publically available registry of playgrounds,[29] which included 277 publically accessible playgrounds (childrens' playgrounds and adventure playgrounds, some with skating or BMX bike facilities or with football fields or basketball courts). Football fields and basketball courts included in the public registry were very basic and only intended for recreational sports. Football fields and basketball courts with facilities which met the requirements of the respective leagues were exclusively used by clubs and were therefore not included in the public registry and therefore also not in our study. The registry did also not include facilities which had limited access (for example, due to a necessary club membership or entrance fees), facilities which were located on private property, swimming pools, ice rinks, or public green areas without playground equipment.

Between 27th July 2016 and 15th January 2017, the second author (A.B.) visited all playgrounds within the context of a systematic audit, to map their location, surface area, and the equipment provided. The researcher also used this opportunity to note whether the playground appeared to be more suitable for the under-6 age group or for the 6–12 age group. During this audit, it was discovered that one playground on the list was not publically accessible, two were in the process of being renovated, and three more had been dismantled since the list was compiled. Digitalization and geo-coding of playground locations as points and areas, respectively, was accomplished using ArcGIS 10.2–10.4 (ESRI, Redlands/California, USA).

Definition of outcome variables

A total of four quantitative outcome variables calculated are as follows:

First, we calculated the kernel density,[30] using a quadratic kernel and a bandwidth of 1 km to quantify (i) the availability (density of playgrounds) as mean number of playgrounds per km^2 within the city boundaries, which was then averaged for each social area.

Second, we calculated (ii) the accessibility (distance to a playground) using the Euclidean distance measure. Again, the shortest mean distance to any playground was calculated for each social area within the city boundary.

Third, as part of the site audits, the surface area of each playground was measured in m^2 and summed up on the social area level. In relation to the number of inhabitants younger than 18 years, (iii) playground area per child within each social area was calculated.

Fourth, the amenities provided at each playground were operationalized as suggested by Suminski et al.[31] The General Environment Inventory Page developed by Playcare, Inc. was used to account for all amenities associated with the playground. In accordance with the approach suggested by Suminski et al., amenities that were either part of a composite structure (slides, crawl tunnels), as freestanding item (swings), or associated with the site (benches) were included. The inventory form included a total of 46 different categories. According to standard practice, the audit form was translated from English into German by two German native speakers (S.S., A.B.), and then the German version was translated back into English by an English native speaker who graduated from the Johannes-Gutenberg University in Mainz, Germany, with a Bachelor degree in German Philology (Soraya Ebrahimi-Nuyken, California State University in Chico, USA). Before the form was used in the field, it was tested at a large playground outside the investigation area with five children between nine and eleven years of age, to establish from their comments which elements on the playground they considered to be independent and subsequently to define standard operating procedures for the audit. Last of all, the reliability of the German version of the form was tested by two blind evaluators (Intraclass Correlation Coefficient [ICC]: 0.997 [95% confidence interval 0.990–0.999]). The total number of amenities per playground[31] was summed up for each social area and divided by the number of residents younger than 18 years to obtain (iv), the amenities provided, i.e. the number of amenities per 100 children and adolescents per social area. All geostatistical analyses[32] were conducted in ArcGIS 10.4 using the Spatial Analyst Tool.

Statistical methods

Standard deviation and range were calculated for the description of the socio-demographic and playground-specific indicators within $n = 44$ social areas. We conducted bivariate and multiple regression analyses to investigate the association of outcome variables, i.e. availability, accessibility, playground surface area, and amenities provided with socio-demographic indicators in $n = 44$ social areas. Owing to the skewness of the outcome variables, we considered using log-linear Poisson regression models. The decision to use these models was supported by a comparison of linear and log-linear regression models in terms of Q–Q plots and residual plots, respectively. Bivariate Poisson regression models were conducted to separately investigate the association between the four outcome variables and each of the chosen socio-

demographic indicators. Finally, a multiple Poisson regression was conducted for each outcome variable. Particularly, with regard to mean density of and mean distance to playgrounds, regression models were adjusted for the proportion of residents younger 18 years. The significance level was set to $\alpha = 0.05$. All analyses were conducted using SAS 9.3 and PROC GENMOD in particular.

Results

Beside the location of playgrounds, Fig. 1 illustrates that the investigation area has less densely populated outlying suburbs and a densely inhabited city center. The socio-demographic indicators demonstrate the pronounced social diversity within the city: Table 1 presents the study characteristics of socio-demographic indicators and outcome variables within n = 44 social areas. The percentage of children in the overall population in different social areas ranged from 7% to 27%. Whereas affluent social areas had unemployment quotients well below 2%, this indicator was five times as high in socially deprived areas (Table 1). The other indicators also illustrate a very heterogeneous structure within the city boundaries.

In the entire investigation area, 271 playgrounds were identified, which represents approximately one facility per 169 underage inhabitants. In total, 260 of these facilities were typical playgrounds. Most of these playgrounds included a large range of climbing, play, and physical activity facilities (e.g., bouldering walls, tube and wave slides, climbing pyramids and climbing towers, trampolines, ropes, and balancing devices). From the auditor's point of view, half (47%) of all playgrounds were suitable for both children and adolescents; in around 30% of playgrounds, the play equipment was aimed at under-6s, and 23% of playgrounds had equipment that was more suitable for the 6–12 years age group. A typical example of a playground that can be found in similar forms all over Germany is shown in Fig. 2. The other eleven facilities included seven football fields, two basketball courts, and two skate parks.

Quantitative indicators of playground availability also showed a large variability across social areas. The availability of playgrounds (playground density) varied from 0.2 to 8.4, with an average of 2.7 (±1.5) playgrounds per km^2 (Table 1 and Fig. 3). The mean Euclidian distance indicates that, in some social areas in Mannheim, children only have to walk 140 m to reach the nearest playground, in others, they have to walk almost 1.5 km (Table 1 and Fig. 4).

The indicator for playground area per child also ranged considerably from 1 m^2 to 16 m^2. The number of amenities (per 100 children and adolescents) varied from 1 to 13, whereas on the social area level, this figure was 3.3 per 100 children and adolescents.

Table 2 presents the results of bivariate and multiple Poisson regression models; with regard to the availability of playgrounds, only population density showed a significantly positive association in both the bivariate and multiple regression models, with twice as many playgrounds per km^2 in social areas with 1000 residents more per km^2. The same results were found for the mean distance to playgrounds per social area. Again, population density showed a significant association with distance to playgrounds, where social areas with more than 1000 residents per km^2 had an estimated two-thirds shorter distance in both bivariate and multiple models (only in the bivariate model, the proportion of long-term unemployed residents showed a negative association with distance to playgrounds.).

With regard to playground area per resident younger than 18 years and the number of amenities per 100 residents younger than 18 years, most of the socio-demographic indicators showed a significant association with the outcome variables in the bivariate regression models. As per the bivariate results, children in socially deprived areas had access to significantly less playground space. In addition, more children in socially deprived areas also had to share the available playground amenities. However, in the multiple model, only population density showed a significantly negative association, where both the standardized playground area and the standardized number of amenities were lower in areas with more than 1000 residents per km^2 (Table 2). Further analysis of our data showed that social areas with a high population density do not necessarily have more children per se (correlation with inhabitants younger than 18 years: spearman's ρ −0.26; $P = 0.083$) but significantly more deprived residents (correlation with unemployment quotient: spearman's ρ +0.30; $P = 0.049$; percentage of long-term unemployed among all those unemployed: spearman's ρ +0.32; $P = 0.033$; all inhabitants who are receiving state support payments: spearman's ρ +0.33; $P = 0.031$).

Discussion

Principal findings

The large German city of Mannheim does not only have an extremely heterogeneous social structure but also greatly differentiated playground availability. A total of 271 playgrounds were identified in the city, which is home to over 311,000 inhabitants and covers 145 km^2. The size of these playgrounds varied greatly from 440 to almost 20,000 m^2.

Bivariate regression analyses showed no association between availability and accessibility of playgrounds and the aggregated social status. However, a significant negative association between the playground area available and the amenities provided per child and several socioeconomic indicators was revealed. However, in the multiple regressions, where socioeconomic indicators were controlled and the models were adjusted for population density, the latter was identified as the dominant factor showing an association with either the playground area or amenities provided.

In sum, the results show that, depending upon where they live, children in Mannheim have very different opportunities to play and be physically active, which are basically depending on the population density. Compared with less populated social areas, densely populated social areas show a higher availability and shorter accessibility to playgrounds but also a lower playground area and lower number of amenities for children and adolescents, because of less available public space.

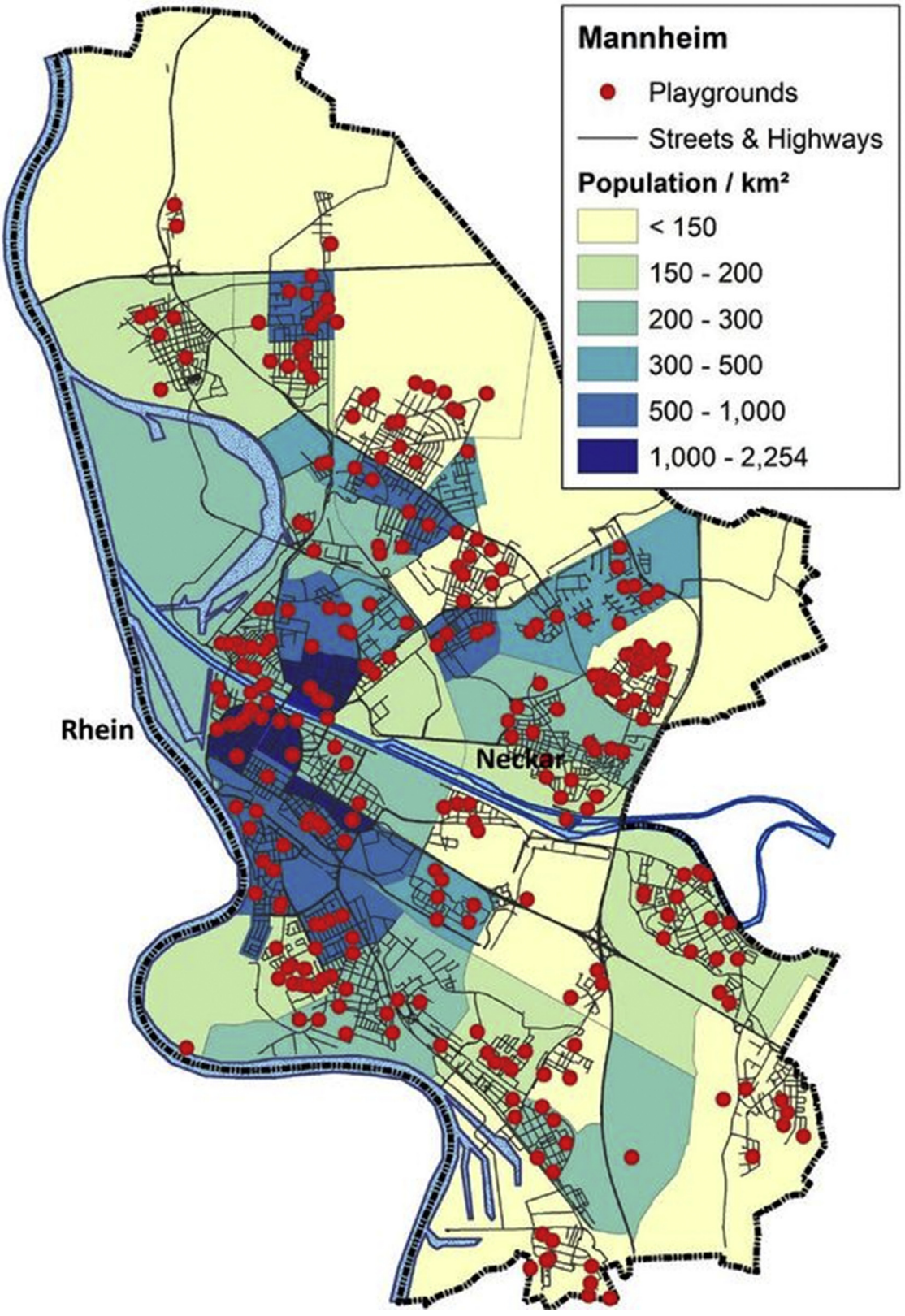

Fig. 1 – Location of playgrounds and population density in social areas within the city of Mannheim, Germany.

Table 1 – Descriptive statistics on the social area and playground variables on the level of the 44 social areas in the city of Mannheim, Germany.

Characteristics	Mean	SD	Min	Max
Socio-demographic indicators [a,b]				
Population density (in 1000 per km^2)	0.46	(±0.5)	0.01	2.3
Inhabitants younger than 18 years of age (%)	15.1	(±3.7)	7.2	26.8
Single parents (%)[c]	3.7	(±1.5)	1.2	9.5
Employment rate (%)	52.9	(±7.0)	32.9	61.7
Unemployment quotient (%)[d]	4.2	(±2.0)	1.6	8.8
Percentage of long-term unemployed among all those unemployed (%)	33.8	(±7.4)	12.7	47.7
Jobseekers younger than 65 years who are receiving state support payments (%)	10.9	(±7.6)	2.4	29.9
All inhabitants who are receiving state support payments (%)	10.7	(±7.6)	2.0	29.0
Playground variables				
Availability (No. of playgrounds per km^2)	2.7	(±1.5)	0.2	8.4
Accessibility (playground distance, in 100 m)	4.3	(±2.6)	1.4	14.4
Playground area per child in m^2	4.3	(±3.5)	1.0	16.3
Amenities (number of amenities per 100 children and adolescents)	3.3	(±2.7)	0.6	13.2
Playground area (in m^2)	4.130	(±3.815)	440	19.150

Mean: arithmetic mean; SD: standard deviation.
Unweighted average value on the level of social areas.
[a] The social indicators refer to the project start date: 31.12.2014, the playground indicators refer to the time period in which the audit was carried out, between 2016 and 2017.
[b] The percentages refer to the population of people with primary residences in the respective social area of Mannheim.
[c] The percentage of single parents among all private households, in %.
[d] The unemployment rate was 5.9% in Mannheim at the end of 2014. This indicator is not available for the local level in Germany; therefore, the unemployment quotient was used instead. Details on this are available elsewhere.[24]

Limitations and strengths

Limitations of this study mainly concern the selection of the study area, the lack of consideration of the playgrounds' qualitative aspects, and the limitations in transferring these findings to the population of older adolescents. Although we have termed Mannheim a 'typical German city', it cannot be considered to be representative for all German cities. Nevertheless, central indicators such as the percentage of children and adolescents, the unemployment rate, the number of long-term unemployed inhabitants, and the percentage of all people who receive state support payments in Mannheim were all close to the nationwide average (15% vs. 16%; 6% vs. 7%; 37% vs. 37%; 11% vs. 9%, respectively; each recorded on 31.12.2014; values differ from Table 1 as here the city averages are given). The other limitation—which is shared by many other similar studies[4–7,11,12,15,16]—is that we only took quantitative indicators into consideration. Lee et al.[18] point out that reporting on quantitative aspects does not provide information about the quality of a physical activity facility. Therefore, there is a need to assess the quality (e.g., attractiveness and cleanliness) of facilities at playgrounds in future studies. Silver and colleagues emphasize that aspects of safety may also be relevant in this context.[23] We at least took this criticism into consideration by making sure that—in addition to location, size, and availability—we also gathered very detailed information on the number of playground amenities using a validated protocol.

The findings of this study are only partially applicable to older adolescents as it has been shown that the importance of playgrounds as a resource for physical activity decreases for this population group in favor of other resources such as parks or sports clubs.[33]

One strength of our study is its internal validity—to define the deprivation status of the social areas, we used official and thus valid data instead of relying on aggregated self-reports. Another strength is that we conducted a complete survey covering the entire municipality of Mannheim and did not just look at a random sample. Furthermore, we visited every playground and did not—as others have done[4–7,11,12,15,16]—rely on registries for mapping playgrounds without an on-site visit. Finally, our multivariate approach strengthens our results and the interpretation, thereof, making it clear that the provision and equipment of playgrounds in urban environments in Germany is a result of population density, thus revealing an indirect association with neighborhood deprivation.

Fig. 2 – A typical playground in the research area.

Relevance and conclusions

In a recent leading article, Diez-Roux criticized that the state of research into the topic of 'neighborhood and health'

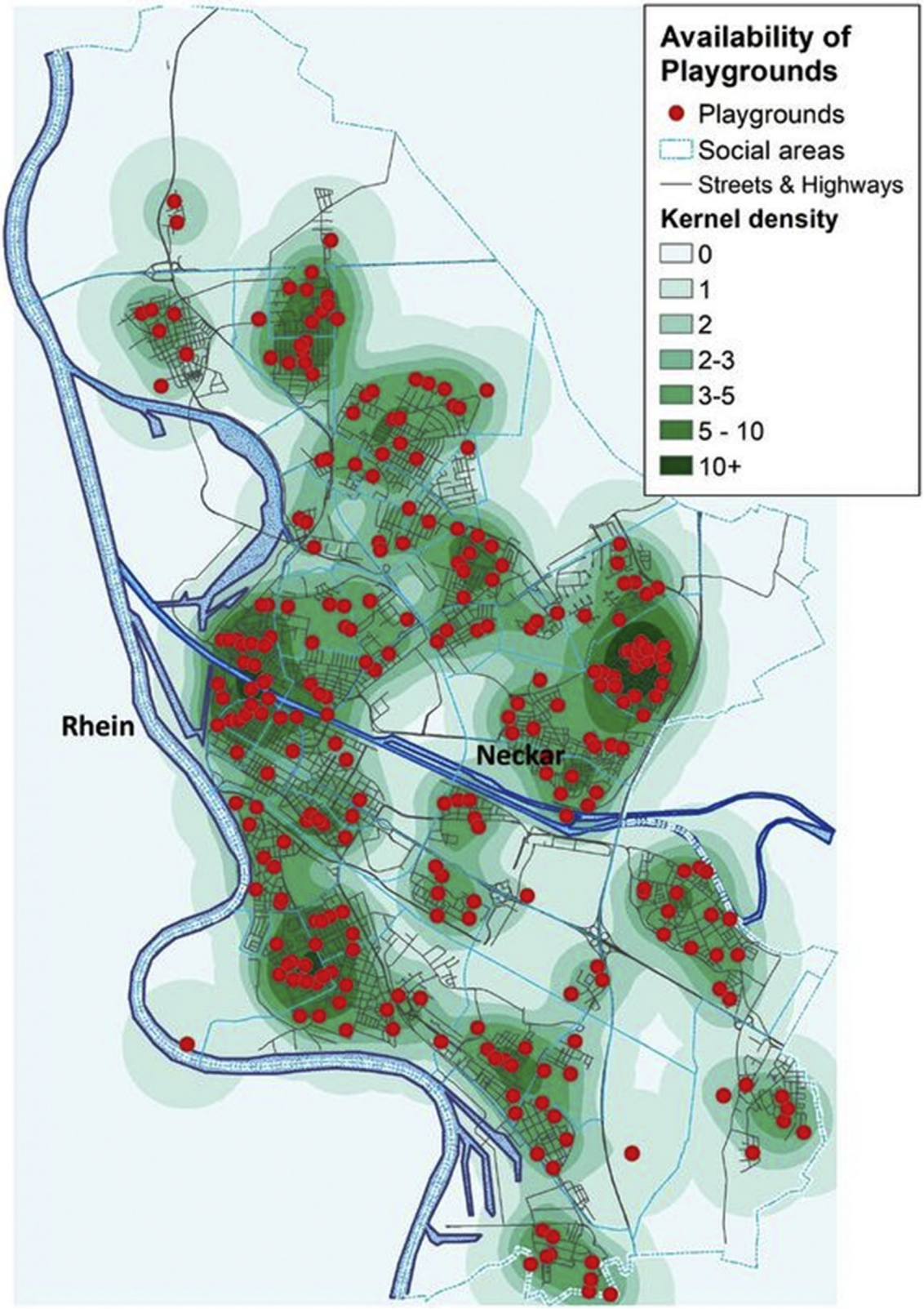

Fig. 3 – Availability of playgrounds within the city of Mannheim, Germany, depicted as kernel density assessing the number of playgrounds per km^2.

remains fragmented and discordant.[34] In particular, the lack of literature on 'physical activity resources' for children and adolescents has been lamented.[17] There is a type of intervention study available—which was not mentioned in the introduction—that investigates physical activity during periods of supervision (physical activity in the school yard during break periods or physical activity in kindergarten during regular playtime).[35–43] By contrast, outside of these periods of

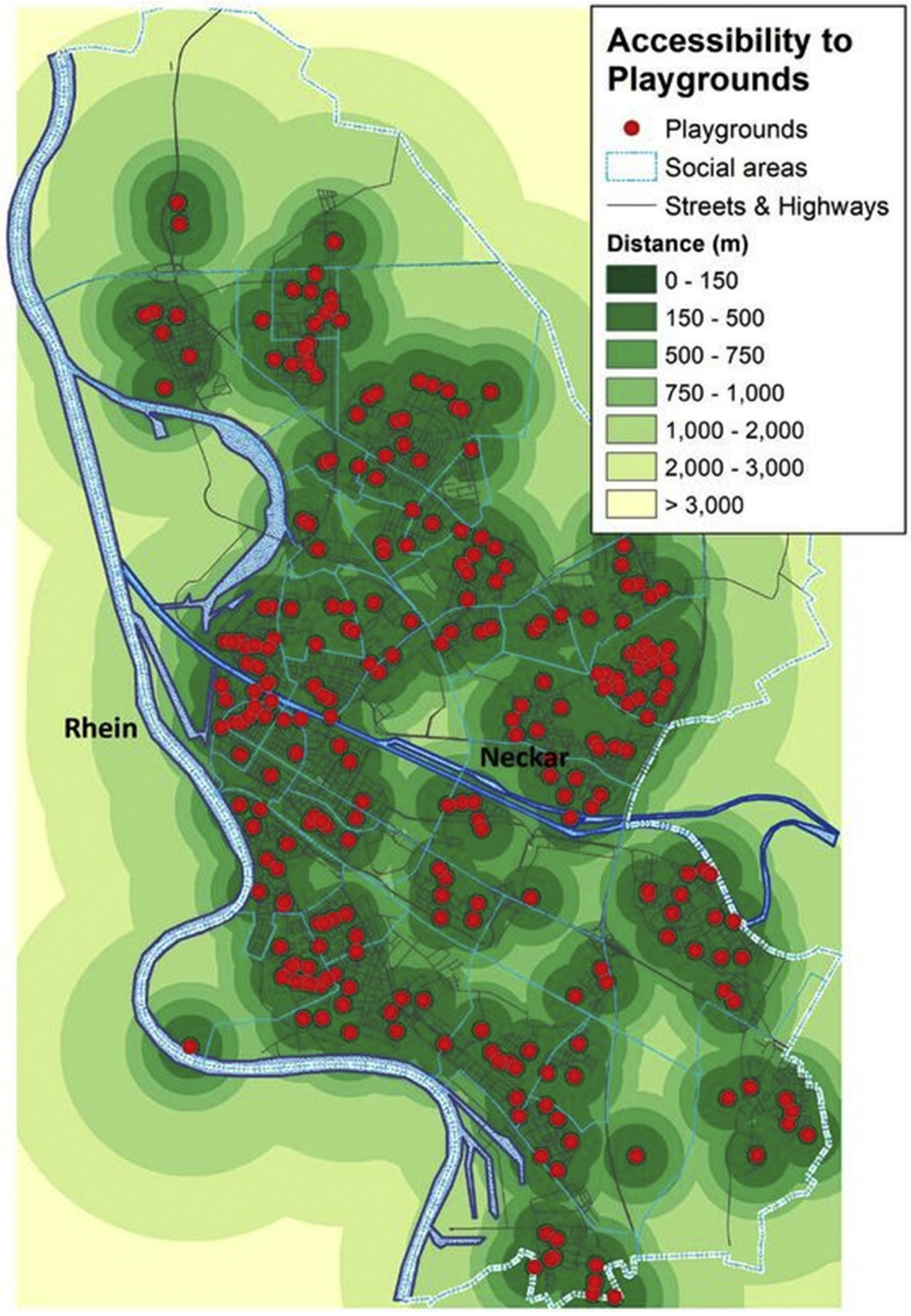

Fig. 4 – Accessibility of playgrounds within the city of Mannheim, Germany, depicted as Euclidean distance to playgrounds.

supervision, this topic is seldom investigated, as a systematic review by Ferreira et al.[44] and colleagues has shown; the authors of this review assessed the association between environmental factors—in particular, the availability of opportunities to engage in physical activity—and the actual physical activity behavior of children and adolescents. If an empirical association was shown, it was positive in the majority of the studies. Another systematic review article shows

Table 2 – Results of the bivariate and multiple Poisson regressions to investigate the association of socio-demographic indicators with playground indicators on the social area level (n = 44) in the city of Mannheim, Germany.

Socio-demographic characteristic	Availability No. of playgrounds per km²				Accessibility (playground distance, in 100 m)				Playground area per child in m²				Amenities (number of amenities per 100 children and adolescents)			
	Bivariate		Multiple		Bivariate		Multiple		Bivariate		Multiple		Bivariate		Multiple	
	Exp(β)	p	Exp(β)	p	Exp(β)	p	Exp(β)	p	Exp(β)	p	Exp(β)	p	Exp(β)	p	Exp(β)	p
Population density (in 1000 per km²)	**1.94**	**< 0.001**	**2.14**	**< 0.01**	**0.36**	**< 0.001**	**0.33**	**< 0.001**	**0.34**	**< 0.001**	**0.41**	**< 0.001**	**0.46**	**< 0.001**	**0.53**	**0.003**
Inhabitants less than 18 years of age (%)	0.97	0.17	1.00	0.99	1.01	0.69	0.98	0.59								
Single parents (%)[3]	0.95	0.44	1.04	0.83	0.98	0.67	0.91	0.47	0.97	0.55	1.06	0.54	**0.90**	**0.028**	0.96	0.68
Employment rate (%)	0.98	0.16	0.99	0.79	1.01	0.45	1.01	0.71	**1.04**	**< 0.001**	1.01	0.64	**1.03**	**0.010**	0.98	0.30
Unemployment quotient (%)[4]	1.05	0.30	0.92	0.70	0.96	0.28	1.03	0.86	**0.84**	**< 0.001**	0.85	0.34	**0.85**	**< 0.001**	1.09	0.58
Percentage of long-term unemployed among all those unemployed (%)	1.02	0.07	1.00	0.85	**0.97**	**0.004**	0.98	0.09	**0.98**	**0.007**	1.02	0.20	**0.97**	**< 0.001**	0.99	0.42
Jobseekers less than 65 years of age who are receiving state support payments (%)	1.01	0.38	1.05	0.78	0.99	0.31	0.95	0.66	**0.96**	**< 0.001**	1.13	0.34	**0.96**	**< 0.001**	1.09	0.48
All inhabitants who are receiving state support payments (%)	1.01	0.32	0.97	0.84	0.99	0.31	1.08	0.53	**0.96**	**< 0.001**	0.88	0.35	1.01	0.32	0.87	0.25

Bold values: $p < 0.05$.

that, for the majority of studies, being closer and having better access to more well-equipped play and sporting grounds significantly increases the level of physical activity among children and adolescents.[45]

Individuals in socially disadvantaged neighborhoods might face more barriers to a healthy lifestyle than their wealthier counterparts in many respects. For example, several studies on the availability of cigarettes and alcohol and on the food environment support the hypothesis of 'deprivation amplification'.[14] Based on our data, we cannot conclude that children and adolescents in socially disadvantaged neighborhoods are in general in a worse position to be physically active compared with young individuals living in socially advantaged neighborhoods. The population density appears to play a key role in the provision of playgrounds. Our findings, therefore, rather support Lineberry's old 'ecological hypothesis' that the location of urban resources (e.g., playgrounds) are a result of a city's historical and structural factors (such as population density) than his 'underclass hypothesis', whereby social status is the central determining factor.[46] To put it simply, the fact that socially disadvantaged people tend to have access to smaller playgrounds with fewer pieces of play equipment in their immediate, densely populated residential environment is primarily the consequence of these families being forced into living in such residential areas with lower rent prices because of their unfavorable economic situation.

Therefore, it is all the more surprising that only four of the studies on the association between neighborhood deprivation and physical activity resources summarized at the beginning of this article adjust for the (obviously crucially important) factor of population density.[4,5,12,13]

In addition, it is also important to point out that public law in Germany does not make any concrete provisions with regard to the design and equipment of public playgrounds. Legislative regulations such as the German Federal Building Code (Baugesetzbuch, BauGB) or the German Building Regulations (Bauordnung, BauO) only contain very general guidelines and recommendations.

Socially disadvantaged families with children do not have access to fewer playgrounds nor are these playgrounds located further away, but the playground area and the number of amenities available to these families is poorer compared with more socially advantaged families. The key determining factor seems to be population density, which restricts the urban planning possibilities in densely populated city districts.

Author statements

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Ethical approval

Not required as no human subjects or animals are involved. As this observational study evaluated existing infrastructures

(playgrounds) solely, no ethical approval was required by the German law.

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Competing interests

None declared.

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