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Spatial and Socioeconomic Patterns of Mental Health and Healthcare Utilization in Cologne, Germany

Räumliche und sozioökonomische Muster der psychischen Gesundheit und der Leistungsinanspruchnahme in Köln, Deutschland





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ABSTRACT

Background Children and adolescents are significantly tied to their family's socioeconomic position and living environment. Neighbourhood and the living environment have been identified as potential risk factors for mental disorders in this age group.

Aim of the Study The aim of the study was to investigate the distribution of mental and behavioural disorders (prevalence) and the provision of mental health services for children and adolescents aged 0–19 years in the city of Cologne. In particular, the study aimed to examine the association of these factors with area deprivation and the availability of mental health services covered by statutory health insurance. Finally, possible spatial variations in these aspects were analysed.

Method Claims data of children and adolescents aged 0 to 19 years included in four statutory health insurance of the year 2021 were analysed. A deprivation index using data on the level of the ZIP code area was calculated. Analyses were carried out descriptively, using ordinary least squares (OLS) and geographically weighted regression (GWR).

Results The prevalence of mental and behavioural disorders in children and adolescents varied across ZIP code areas, with higher rates in the northern, southern, and eastern parts of the city. The results indicated that the use of services by male chil-

dren and adolescents with a prevalent diagnosis of mental and behavioural disorders was higher in areas with a higher density of healthcare providers. However, prevalence was on the whole lower in areas with a higher density of healthcare providers. In addition, the density of health care providers was higher in the city centre with comparatively lower deprivation.

Conclusion These results indicate inadequate access to care for children and young people outside the city centre. However, due to the heterogeneity of the population in these areas, this study provides only preliminary insights. Data with a finer geographic resolution are needed for further research in order to analyse the association further.

ZUSAMMENFASSUNG

Hintergrund Kinder und Jugendliche sind in hohem Maße von der sozioökonomischen Stellung ihrer Familie und ihrem Lebensumfeld abhängig. Die Nachbarschaft sowie das Wohnumfeld stellen potenzielle Risikofaktoren für die Entwicklung psychischer Erkrankungen bei Kindern und Jugendlichen dar.

Ziel der Studie Ziel der Studie war es, die Verteilung von psychischen Erkrankungen (Prävalenz) und die Leistungsinanspruchnahme ambulanter psychotherapeutischer Leistungen für Kinder und Jugendliche im Alter von 0–19 Jahren in der Stadt Köln zu untersuchen. Ein besonderer Fokus lag dabei auf dem Zusammenhang der Prävalenz und Hyphenation: Leistungs-inanspruchnahme mit der räumlichen Deprivation auf Postleitzahlebene und der Verfügbarkeit von Psychotherapeut*innen und Psychiater*innen mit Kassensitz. Schließlich wurden mögliche räumliche Unterschiede bei diesen Aspekten untersucht.

Methode Analysiert wurden Daten von Kindern und Jugendlichen im Alter von 0 bis 19 Jahren, die im Jahr 2021 in der gesetzlichen Krankenversicherung versichert waren. Darüber hinaus wurde ein Deprivationsindex auf Basis von Daten auf der Ebene des Postleitzahlengebiets berechnet. Die Analysen wurden deskriptiv, als Ordinary Least Square (OLS) und Geographically Weighted Regression (GWR) durchgeführt.

Ergebnisse Die Prävalenz von psychischen Erkrankungen bei Kindern und Jugendlichen variiert je nach Postleitzahlgebiet, wobei diese in den nördlichen, südlichen und östlichen Gebieten der Stadt höher sind. Die Inanspruchnahme von psychotherapeutischen Leistungen sind im Stadtzentrum höher, wobei in diesen Gebieten die Deprivation geringer ist. Die Ergebnisse deuten darauf hin, dass eine höhere Leistungsinanspruchnahme durch männliche Kinder und Jugendliche mit einer prävalenten Diagnose für psychische- und Verhaltensstörungen mit einer höheren Dichte an Psychotherapeut*innen und Psychiater*innen assoziiert ist. Andererseits ist die Prävalenz in Gebieten mit weniger Versorger*innen mit Kassensitz geringer. Außerdem sind die Versorger*innen vor allem im Stadtzentrum ansässig, wo die Deprivation vergleichsweise gering ist.

Schlussfolgerung Diese Ergebnisse deuten auf einen unzureichenden Zugang zur Versorgung von Kindern und Jugendlichen außerhalb des Stadtzentrums hin. Aufgrund der Heterogenität der Bevölkerung in den Postleitzahlgebieten liefert diese Studie nur vorläufige Erkenntnisse und unterstreicht die Notwendigkeit von Daten in feinerer geografischen Skalierung für zukünftige Forschung.

Introduction

Social determinants of health and well-being tend to cluster in specific neighbourhoods [1]. The socioeconomic status is known to be a strong social determinant of health at the individual level [2]. Individual health is strongly influenced not only by personal socioeconomic status, but also by the socioeconomic status and living conditions of the environment [3]. Children and adolescents are strongly linked to their families socioeconomic position and living environment [4]. The neighbourhood is of particular importance to children and adolescents compared to adults, as they spend a significant amount of time in their local environment due to restrictions on free exploration and access to different environments [5, 6]. Neighbourhood characteristics have been emphasised as important for the development of children and adolescents in addition to individual and family characteristics [7]. Among the various neighbourhood effects, neighbourhood deprivation has been studied and recognised as a social determinant of young people's health [6]. Deprivation at the individual level is defined as the inability to participate in common activities and to access the resources and opportunities that are considered customary or essential for a reasonable standard of living within a particular society [8]. Deprivation thus refers to a relative phenomenon of poverty and social exclusion [8]. Deprivation tends to cluster spatially, with groups with similar socio-economic circumstances often living in close proximity to each other [9]. Research has identified neighbourhoods, the social environment and area-deprivation as potential risk factors for mental health among children and adolescents [6, 10]. Moreover, an unequal effect of the COVID-19 Pandemic on mental health between different population groups, moderated by the distance to urban parks was observed [11]. During the COVID-19 pandemic, an increase in psychosomatic diseases in children and adolescents compared to the previous period was found [12] with an disproportionately impact on children with disadvantaged social backgrounds [13].

Access and healthcare utilization in Germany

Access to mental health care in Germany can be challenging despite acute illness and can be accompanied by long waiting times [14–16]. One reason is commonly seen in the mechanisms for care demand planning. In order to be able to provide and bill services within the statutory health insurance (SHI), primary care physicians and psychotherapists need a social security license (*Kassensitz)*. The number of social security licenses are determined for a given region, based on demand planning that was last adjusted in 2019 [17]. The planning regions are divided into four levels of care. The

planning regions for psychologists are administrative districts or cities, and child and adolescent psychiatrists are planned in larger so-called spatial planning regions [17]. However, a point of criticism of the demand planning is the uneven distribution within planning areas, some of which cover large areas [18]. This has been studied with focus on general practitioners and paediatricians in the city of Essen, showing a maldistribution in favour of more affluent districts and a resulting social inequality in access to care [19]. Moreover, the resulting care situation was studied in particular in comparison with regional differences, showing an unequal distribution especially in rural areas [20, 21].

This type of supply-side planning has particular implications for urban areas. The city of Cologne, for example, is the fourth largest city in Germany with a population of over one million, which raises issues of inequality and potentially long travel times. For children and adolescents in particular, long journeys from their place of residence to where healthcare is provided can be a barrier to healthcare access. As an urban centre of a densely populated metropolitan region, Cologne has strong links with neighbouring rural areas and towns. This creates a large catchment area for specialised healthcare services. In this capacity, it is an example of the urban centre of a prototypical European metropolitan area within a densely populated zone. Not least for this reason, it is important to examine the role of the neighbourhood and the areal distribution of providers of mental health care services for children and adolescents.

Focusing on children and adolescents aged 0 to 19 years living in the city of Cologne, this article addresses following questions:

(1) How are prevalence of mental and behavioural disorders and mental health services distributed across the city of Cologne?

(2) Whether and how are area deprivation and the availability of mental health service providers providing services to patients covered by the SHI system associated with the prevalence of mental and behavioural disorders and utilization of mental health services?

(3) How do the associations between area deprivation, availability of mental health service providers, prevalence of mental and behavioural disorders and health care utilisation vary across space?

Methods

Data

Claims data

The research questions will be investigated using claims data from children and adolescents residing in the city of Cologne and insured by four statutory health insurances. These data are made available for research by the CoRe-Net project (Cologne Research and Development Network) [cf. 22]. In the CoRe-Net project, the insurance data of four statutory health insurances cover around 50 % of the population of the city Cologne [22]. In 2021, a total of 193,844 children and young people aged 0 to 19 lived in the city of Cologne. From this database, the present research used 2021 data from children and adolescents aged 0 to 19 years who were continuously insured with one of the statutory health insurers in the observation year. Sex was included as a binary category (male, female) due to data availability. Analyses focus on prevalence of ICD-10 diagnoses (F00-F99) and utilization of mental health services (EBM). Definitions of ICD-10 diagnosis and mental health services are reported in the online-appendix (Table 3–4). In accordance with common practice for claims data [23], diagnoses were validated before analysis. Diagnoses coded by registered physicians were included if they were documented in at least two of four quarters (M2Q criterion (minimum 2 quarters)). Discharge/primary diagnosis from the hospital were included. For the analysis of utilization of mental health services, the study population includes all children and adolescents with a prevalent diagnosis of mental and behavioural disorders.

The 45 ZIP-code areas in the analyses of prevalence and utilization of mental health services reflect the places of residence of the children and adolescents. All results are sex- and age standardized and adjusted to case numbers per 1,000 children and adolescents based on the respective ZIP-code areas. The adjusted rate provides a measure of the case count's magnitude, irrespective of the number of children and adolescents in the respective areas. This approach offers the advantage of facilitating comparisons between ZIP-code areas of varying sizes and population densities.

Further data sources

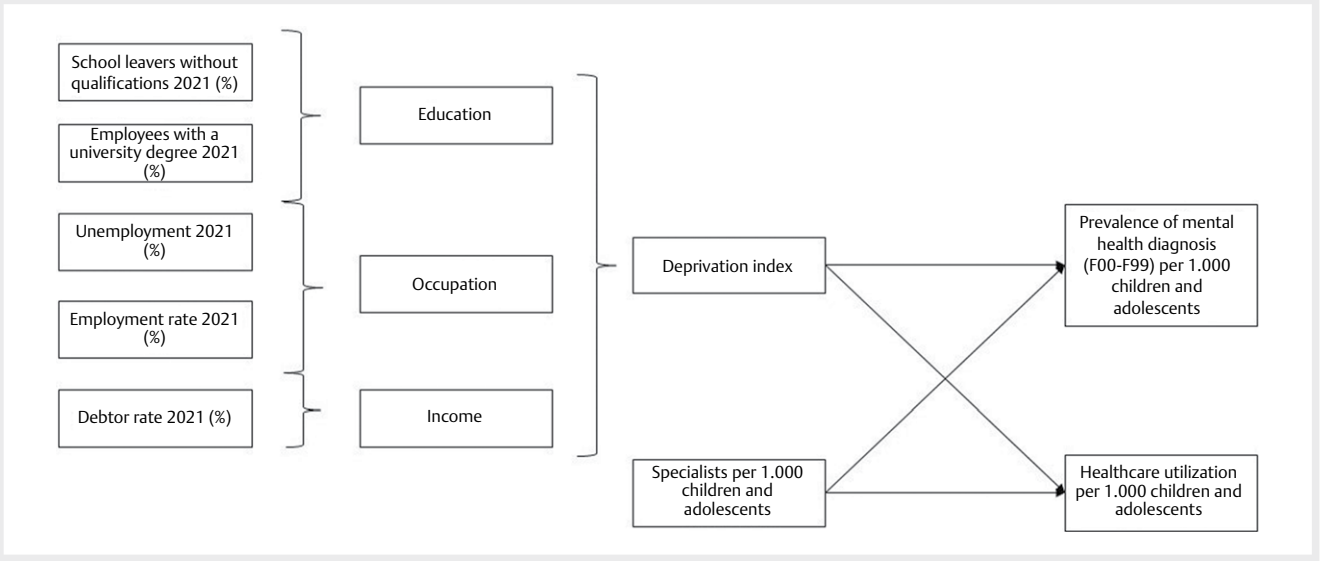
As the aim of the study was to evaluate, whether the diagnosis for mental and behavioural disorders and the utilization of mental health services are associated with area deprivation, the German index of socioeconomic deprivation (GISD) was calculated [24]. The index includes the dimensions education, occupation and income. Due to data availability, a modification of the GISD was necessary. ▶ **Fig. 1** displays the included indicators for each dimension. Data on school leavers without a degree, employed persons with a university degree, unemployment and employment rate are provided by the City of Cologne. The debtor rate is based on the publication of the Debtor Atlas for the Cologne/Bonn Metropolitan Region [25]. The data is available at district level and in percentages. The 45 ZIP-code areas were defined by the post office, with the 86 districts being determined by the city itself. Both classifications are subject to other regulations and only overlap to a limited extent. Due to the availability of data area, shares of the city districts in the ZIP-code areas were calculated using QGIS 3.30. In the next step, the indicators were calculated according to their area share (e. g., 33 % district X, 77 % district Y) for the ZIP-code areas. Based on this, the dimensions and finally the deprivation index with a possible range from 0 to 100 was calculated for each ZIP-code area for the year 2021.

In order to account for availability and access to care, the ratio of child and youth mental health service providers per 1.000 children and adolescents per ZIP-code area is used. The numbers are based on providers reported on the website of the Association of Statutory Health Insurance Physicians of North Rhine (www.kvno.de). The number of providers by ZIP-code area was extracted on March 22th 2023.

▶ **Fig. 1** shows the study models for research questions 2 and 3.

Statistical analysis

In the first step, the distribution of the prevalence of diagnoses for mental and behavioural disorders, the utilisation of psychotherapeutic services, deprivation index and the distribution of mental



▶ **Fig. 1** Study model for research question 2 and 3.

health service providers with social security license were mapped. For visualization, QGIS 3.30 was used.

Analyses have been carried out using R 4.3.1/R studio. Before creating a geographically weighted regression model, all significant explanatory variables were identified through exploratory regression. Therefore, a linear regression model (OLS) with robust standard error has been used. In order to control for normal distribution as requirement of OLS, the distribution of the untransformed and the log-transformed dependent variables were evaluated. The untransformed dependent variable prevalence was closer to the normal distribution, for healthcare utilization the log transformation was closer to the normal distribution and was therefore chosen as the final dependent variables in the analyses. The explanatory variables identified for the final model are based on the following criteria: (1) the variables are statistically significant ($p < 0.005$) and (2) free from multicollinearity. The correlation between the study variables was tested as a sensitivity analysis (Table 5, online-appendix). Correlations between the deprivation index and the distribution of mental health service providers working within the SHI system (-0.51) as well as correlation between deprivation index and utilization of mental health services (-0.67) were found. The control variable share of children aged < 11 correlates strongly with the distribution of mental health service providers (0.86). In order to control for lower diagnosis rates and utilization of mental health services due to a younger average age between ZIP-code areas, the proportion of children aged under 11 is included in the analyses as a control variable.

One goal was to estimate the strength of association between the identified explanatory variables and prevalence for mental and behavioural disorders/ utilization of mental health services. The socio-demographic composition and deprivation of the population varies widely across the city of Cologne. Therefore, it is hypothesized that a geographically weighted regression (GWR) model provides a better explanation than a global OLS model [26, 27]. GWR offers the capability to quantify changes in relationships between predictors and outcome variables across different spatial locations, all within a unified modelling framework [28, 29]. GWR has been carried out using the R package *spgwr.* The data analysis followed established standards of secondary data analysis [30].

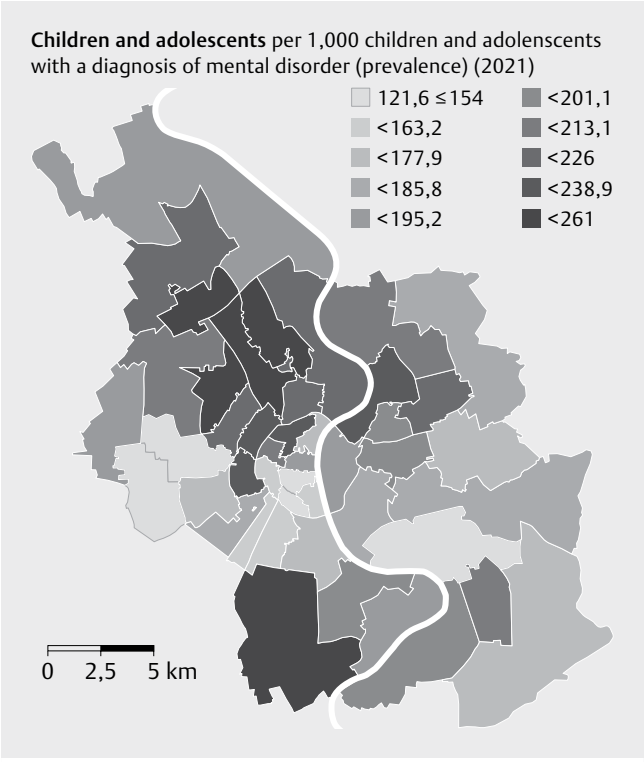
Results

Cartographic visualization

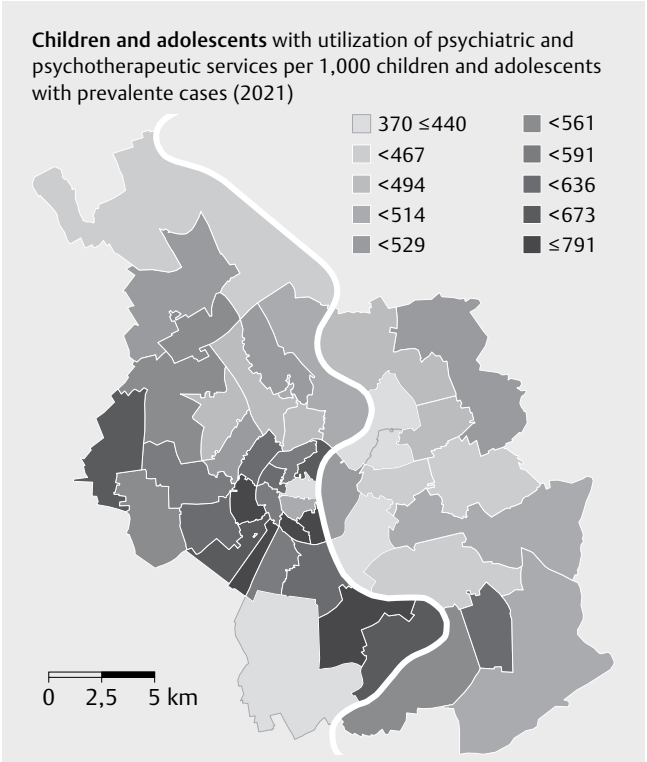
The data was analysed broken down by ZIP-code and presented cartographically in order to detect areas with elevated prevalence rates for mental and behavioural disorders and utilization of mental health services (research question 1). ▶ **Fig. 2** shows the prevalence of validated diagnosis for mental and behavioural disorders per 1,000 children and adolescents. The utilisation of mental health services per 1,000 children and adolescents in the Cologne ZIP-code areas are displayed in ▶ **Fig. 3**.

The overall prevalence of mental and behavioural disorders in the year 2021 was 195.22 per 1,000 children and adolescents aged 0 to 19 years. The spatial distribution of the prevalence varies between the 45 ZIP-code areas. The prevalence of mental and behavioural disorders ranges from 121.57 to 261.04 per 1,000 children and adolescents. There is a trend of higher prevalence in the northern and southern areas of the city as well as the areas East of the river Rhine, while the inner city and the west exhibits comparably lower prevalence.

▶ **Fig. 3** illustrates mental health service utilization among children and adolescents with a prevalent diagnosis for mental and behavioural disorders. The utilization rate ranges from 370.37 to 790.32 per 1,000 children and adolescents. The average utilization rate was 549.06 per 1,000 children and adolescents with prevalent diagnosis for mental and behavioural disorders. Local clustering of service utilization can be observed in the north western part of the city (low rates of utilization of mental health services). Looking further at the geographical patterns, the lower health service utiliza-



▶ **Fig. 2** Geographical representation of the prevalence of diagnoses for mental and behavioural disorders (F00-F99, M2Q) by children and adolescents per 1,000 children and adolescents. Underlying data: Health insurance data (claims data) from the CoRe-Dat database.



▶ **Fig. 3** Geographical representation of the utilisation of psychotherapeutic services (EBM) by children and adolescents per 1,000 children and adolescents with prevalent diagnoses for mental and behavioural disorders. Underlying data: Health insurance data (claims data) from the CoRe-Dat database.

tion rates on the eastern side of the Rhine contrast with the high health service utilization rates in the southern parts of the city centre on the western side of the Rhine.

The second aim of the study is to uncover potential links between area deprivation, the availability of mental health service providers offering services to patients covered by SHI and the prevalence for mental and behavioural disorders as well as utilization of mental health services (research question 2). For this purpose, the deprivation index (▶ **Fig. 4**) and the distribution of mental health service providers in 2023 (▶ **Fig. 5**) were analysed cartographically.

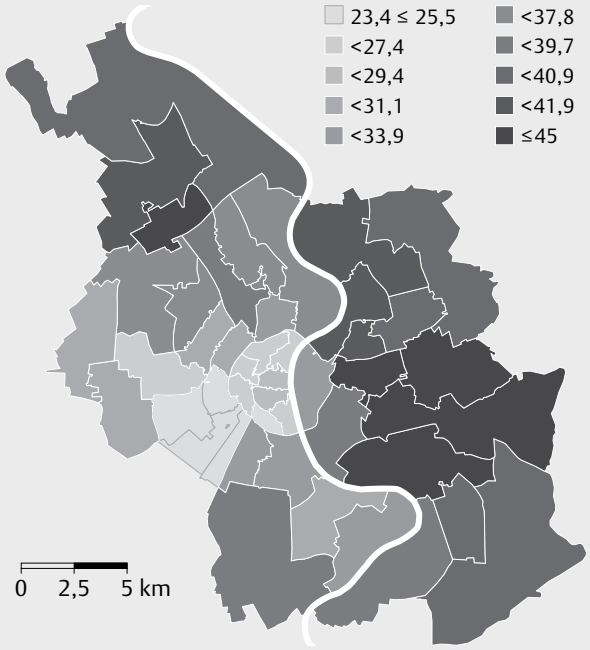
The deprivation index indicates higher levels of deprivation on the eastern side of the Rhine and in the northern areas compared to the rest of the city (▶ **Fig. 4**). Compared to this, deprivation levels in the city centre on the western side of the river are lower. Overall, deprivation index ranges from 23.42 to 45.00 with a mean of 31.85.

Mental health service provider for children and adolescents with social security license are clustered in the city centre (▶ **Fig. 5**). In 2023, no mental health service providers were registered in the northern areas, southern areas and eastern areas of the city.

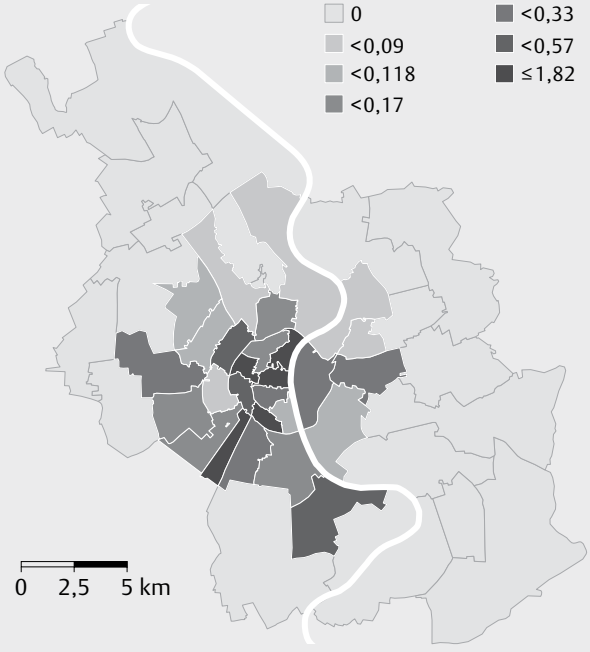
OLS regression

We identified the deprivation index as a significant predictor of the prevalence of mental and behavioural disorders (research question 3, ▶ **Table 1**, online-Appendix Table 6). The model including the share of children ages under 11 years explains 11,17 % of the prevalence (▶ **Table 1**). The residuals of the model were significantly clustered (Moran's I: SD = 0.40, $p < 0.01$). However, by comparing the AICc (Akaike Information Criterion) of the OLS and GWR model, the OLS outperforms the GWR ($\Delta AICc = 13.58$) and is therefore to be preferred. The OLS model shows a significant increase in the prevalence with an increase of the deprivation index (ß = 1.66, $p < 0.05$, SE = 0.80) (▶ **Table 1**). Analyses by sex show no significant effect of the deprivation index on prevalence (online-Appendix, Table 7–8).

Explaining the utilization of mental health services among prevalent cases the deprivation index, the share of children under 11 years old as well as distribution of mental health service providers were identified as a significant predictor with an explained variance of 61.32 % (▶ **Table 2**). A global OLS model can be considered as appropriate for modelling the utilization of mental health services within the city of Cologne based on the Global Moran`s I of residuals (SD = -0.02, $p > 0.05$, ($\Delta AICc = 1.75$). The final model indicates an increase in the utilization of mental health services with an decrease in the deprivation index (ß = -0.02, $p < 0.001$, SE = 0.00) as well as an increase of healthcare utilization with increasing ratio of mental health care providers (ß = 0.15, $p < 0.05$, SE = 0.07). Analyses by sex support the finding of a significant effect of the deprivation index. The distribution of mental health service providers is significant only for male (online-Appendix, Table 9–10).



▶ **Fig. 4** Geographical representation of the deprivation index. Based on own calculations. Data used as a basis: Data from the City of Cologne, Debtor Atlas for the Cologne/Bonn Metropolitan Region.



▶ **Fig. 5** Geographical distribution mental health service providers for child and youth with social secext-linkty license per 1,000 children and adolescents. Based on own calculations. Data used as basis: www.kvno.de (22.05.2023).

▶ **Table 1** OLS Regression for the prediction of diagnosis of mental and behavioural disorder.

Model	Coefficient	Std. error (robust)
Intercept	139.37***	28.32
Deprivation Index	1.66*	0.78
Percentage of children aged < 11 years	−1478.13	7479.53
Adjusted R^2	0.11	
Global Moran`s I of residuals	I = 0.40 (p < 0.001)	
Significance levels: *≤0.05; **≤0.01: ***≤0.001.		

▶ **Table 2** OLS Regression for the prediction of healthcare utilization.

Model	Coefficient	Std. error (robust)
Intercept	7.04***	0.10
Deprivation Index	−0.02***	0.00
Ratio of mental health care providers	0.15*	0.07
Percentage of children aged < 11 years	−420.87***	80.20
Adjusted R^2	0.61	
Global Moran`s I of residuals	I = 0.06 (p > 0.05)	
Significance levels: *≤0.05; **≤0.01: ***≤0.001.		

Discussion

Differences were found in the prevalence of diagnoses of mental and behavioural disorders in children and adolescents between ZIP-code-areas, with a discernible trend towards higher prevalence in more deprived areas. This is consistent with previous studies that have identified neighbourhood deprivation as a potential risk factor for mental illness in children and adolescents [6, 10]. In addition, the COVID-19 pandemic was found to have a particularly adverse effect on the mental health of children and adolescents from lower socio-economic backgrounds [13]. Going in line with previous research on general practitioners and paediatricians [19], an uneven distribution of mental health service provider to disadvantage of deprived areas was found. Areas with a higher density of mental health service providers have comparatively higher health care utilisation. Area deprivation has been found to be associated with an increase in the prevalence of mental and behavioural disorders and, among children and adolescents with a prevalent diagnosis, with a decrease of healthcare utilization. Moreover, there was a negative effect of the distribution of healthcare providers on healthcare utilization for male children and adolescents with a prevalent diagnosis. The results show a clustering of increased need in deprived areas, with availability of mental health service providers and healthcare utilization behaviour higher in less deprived areas. From an economic point of view, this indicates an allocation problem, but from a patient's point of view, it is a fundamental problem of possible underuse and, in particular, the additional burden caused by the greater distance to the nearest

treatment centre. Additional burdens can be a barrier to use and can be of a financial or psychological nature. In particular, socially disadvantaged people are more likely to experience additional burdens due to a lack of resources.

The analyses do not suggest that the associations vary across space. However, based on previous research, a high number of unreported cases can be assumed, particularly in areas with a negative association as young people in deprived areas are generally more affected by mental and behavioural disorders than those in non-deprived areas [6]. On the one hand, the under-reporting can be explained by access to or general utilisation of medical services. Secondly, it should be kept in mind that the data basis for the study is the year 2021, which was a year influenced by the COVID-19 pandemic. An analysis of the prevalence of the individual diagnostic groups of mental disorders before and during the coronavirus pandemic revealed three different trends for the city of Cologne [31]. On the one hand, there was an increase in the prevalence of individual diagnostic groups that was not visible before the pandemic or a continuous increase that was already present before the start of the pandemic [31]. On the other hand, there were decreases in the prevalence of certain diagnostic groups potentially indicating under-reporting [31]. Additionally, fewer school entry examinations were carried out this year, which puts deprived children at a particular disadvantage [32]. This reduction disproportionately affects deprived children, as these examinations are crucial in identifying developmental disorders, particularly in children with less contact with the healthcare system. The lower general utilization of the healthcare services during the COVID-19 pandemic may also play a role in this under-reporting.

Claims data of statutory health insurance funds have certain limitations. Diagnostic codes only reflect administrative prevalence, i. e. cases of insured persons who visited a service provider to receive treatment. Undetected and untreated cases are not included. There is also a selection bias based on the collective of insured persons of the four statutory health insurance funds providing the data. These do not reflect the full socio-economic spectrum of all statutory health insurants in the city. People with private health insurance (~8,7 % of the population of Germany [33]) are also not included in the data set. Due to data availability, the deprivation index was calculated according to area shares of city districts in ZIP-code areas. This may lead to a possible underestimation of the deprivation of individual areas due to the heterogeneity of neighbourhoods within the city of Cologne. It is possible that areas with lower socioeconomic status of certain neighbourhoods are located exclusively in one ZIP-code area and better-off areas of these neighbourhoods than others. Since the values were reported for city districts and not ZIP-code areas, the effect would be underestimated in this case. Another limitation is the formation of the deprivation index. Due to the availability of data, it was not possible to include all of the indicators provided for in the GISD, which is why it cannot be modelled in full.

ZIP-code areas are tailored to the demands of the postal service and do not reflect socio-geographic logic. Therefore, these areas are heterogeneous in relation to most variables used in this study. As no other geographical markers are currently available in the data, the analyses were calculated on the basis of the ZIP-code areas.

CONCLUSION

Healthcare utilisation was found to be higher in the city centre, with comparatively lower prevalence and a higher density of mental health service providers. The results suggest a lower healthcare utilization in areas with higher deprivation and indicate a need for improved demand planning. Due to the great heterogeneity of the population in the ZIP-code areas, this study only provides initial indications of the link between the deprivation index and the prevalence and utilisation of mental health services. Therefore, smaller-scale data is required to analyse the topic in further studies. In order to make this possible, additional steps must be taken to ensure data protection in the transfer of data between the health insurance funds and the trust centre. Moreover, further studies should look at the temporal development of deprivation and the prevalence of mental and behavioural disorders as well as utilization of mental health services in order to gain deeper insights into the interplay between these.

Data availability

The specific dataset used for the present study is not publicly available due to strict data protection regulations for social data. Researchers can apply for general use of the CoRe-Dat database, subject to certain criteria and an approval procedure.

Contributions

AP, LM, IM contributed to conception and design of the study. AP wrote the first draft of the manuscript and performed the statistical analysis. LM, IM, TKP supervised the work. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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