Habitat International 130 (2022) 102685

Contents lists available at ScienceDirect

Habitat International

journal homepage: www.elsevier.com/locate/habitatint

Spatial disparity and structural inequality in disability patterns across Tianjin municipality: A multiple deprivation perspective

Ning Qiu [b], Jianquan Cheng [c], Tianjie Zhang [a,*]

[a] School of Architecture, Tianjin University, Tianjin, China
[b] School of Architecture and Urban Planning, Shandong Jianzhu University, Jinan, China
[c] Department of Natural Sciences, Manchester Metropolitan University, Manchester, UK

A R T I C L E I N F O

Keywords:
Disability-related multiple deprivation
Structural inequality
Spatial disparity
MGWR
Tianjin
Disability database

A B S T R A C T

Reducing the spatial disparities and structural inequalities faced by disabled people is a global challenge in both developed and developing countries that requires an understanding of disability-driven deprivation. This study aims to develop and validate a conceptual framework for analysing the structural inequality and spatial disparity of disability-related deprivation. To achieve this goal, an Index of Disability-Related Multiple Deprivation (IDMD) based on six specific domains, including employment, education, marital status, health, services and barrier-free environments, is proposed. The IDMD was calculated at the sub-district level within the Tianjin municipality using aggregated registration information from the Tianjin Disability Database in 2020. Principal component analysis (PCA) was used to assign the weight of each indicator of IDMD. Moran I and LISA analysis were used to quantify the spatial disparity of IDMD across the municipality. Multi-Scale Geographically Weighted Regression (MGWR) was used to model the structural factors shaping the spatial disparity of disability-related deprivation in terms of gender, age, and disability types. Three key findings have been generated as follows. The spatial variability of IDMD revealed significant urban-rural disparity across the municipality, highlighting the difficulties faced by vulnerable and disadvantaged disabled people in rural areas. Men, working age groups and those with intellectual disability contributed most to the structural inequalities of IDMD. Thirdly, the location of greatest deprivation varied for different groups; working age groups faced the highest levels of deprivation in the urban centre, males faced the most deprivation in the urban fringe and those with intellectual, limb, visual, speech or mental disabilities were most deprived in rural areas. These findings reflect the complexity of structural factors affecting disability-related deprivation at the municipality scale. This study points to the need for informed, targeted welfare facilities planning and management strategies to improve spatial equity and social justice for disabled people.

1. Introduction

Disabled people face an increased risk of poverty and deprivation as a result of barriers to paid employment and education, the inaccessibility of services and the physical environment, stigma, and the lack of affordable, good quality disability-related services and support (Banks et al., 2017). The proportion of disabled people living below the national or international poverty line is greater than that of non-disabled people and is more than double in some developing countries (UN, 2018). In China disabled people account for 12% of the population living below the poverty line, more than 80% of which live in rural areas (CDPF, 2019). Disabled people are recognized as a vulnerable group by the UN's 2030 Agenda for Sustainable Development. Its first principle, 'leaving no one behind', includes a commitment to eradicating poverty, ending discrimination and reducing inequality (UN, 2015). To this end, the UN's 2030 Agenda and *Disability And Development Report* call for an in-depth understanding of what poverty is and how the characteristics of disability can be a factor in increasing the risk of poverty and deprivation (UN, 2015; UN , 2018).

Poverty is increasingly measured on multiple dimensions of deprivation, over and above material poverty (Alkire & Kanagaratnam, 2021; Noble et al., 2006). Sen (1999) defines poverty as the "deprivation of basic capabilities rather than merely as lowness of incomes" (p.87). Similarly, the poverty and deprivation faced by disabled people must

* Corresponding author.
E-mail address: tianjie_zhang08@tju.edu.cn (T. Zhang).

https://doi.org/10.1016/j.habitatint.2022.102685
Received 2 August 2021; Received in revised form 22 August 2022; Accepted 1 October 2022

also be defined by more than income. In some countries and regions, such as South Africa, disabled people have incomes equal to or higher than those without disabilities due to the provision of government grants (Loeb et al., 2008). However, they have fewer education or employment opportunities (She & Livermore, 2007) whilst also incurring extra costs associated with a disability, such as health-related expenditure, assistance with daily care, and transport (Mitra et al., 2017; Morris & Zaidi, 2020). This suggests social welfare payments for disabled people are not enough to support their standard of living. Recent studies have focused on the multiple ways in which the life of disabled people can be impoverished (Mitra et al., 2013).

Studies have shown that the incidence and intensity of poverty experienced by disabled people varies spatially between countries (Mónica et al., 2020; Pinilla-Roncancio & Alkire, 2020), provinces (Mont & Nguyen, 2018), cities (Liao et al., 2016), counties (Hollar, 2017, p. 518), and districts (Goli et al., 2014), due to significant spatial disparities in health care access, levels of urbanisation, and epidemic disease. Within the disabled population gender (Belzunegui-Eraso et al, 2018), age (Flores-Flores et al, 2018), ethnicity (Mónica et al., 2020), and the severity and type of disability (Clausen & Barrantes, 2020) may exacerbate deprivation due to differences in specific capabilities and functioning, stigma, or household income. Empirical evidence regarding the spatial and structural variations in deprivation experienced by disabled people remains mixed and inconsistent because the two aspects – where and who - have typically been studied separately. A full picture of disability deprivation would reflect the distribution, spatial variation, and mechanism of deprivation within a given area (Yuan & Wu, 2014). Most studies have analysed disparities on regional and national scales, and have not reflected the spatial variability within a city.

This study presents a conceptual framework to evaluate the spatial disparity and structural inequality of disability-related deprivation in developing countries, using an Index of Disability-Related Multiple Deprivation (IDMD). Using aggregated registration information from the Tianjin Disability Database, the framework will be validated with principal component analysis (PCA) and Multi-Scale Geographically Weighted Regression (MGWR). Specifically, two key research questions will be answered: (1) where are the most deprived sub-districts for disabled people? (2) who are the most deprived groups, and what is the spatial disparity within each deprived group? This paper, the first empirical study of disability in China with a deprivation and inequality focus, will contribute to urban studies of disability.

This paper is organized into six parts. Following this introduction, section 2 aims to review relevant literature on deprivation and disability. Section 3 justifies the analytical and modelling methods used in this study, and describes how the data were collected and processed. The results are presented and interpreted in Section 4. A critical discussion of the structural inequality of deprivation faced by disabled people follows in Section 5 and conclusions are drawn in Section 6.

2. Literature review

2.1. Measuring disability-related multiple deprivation

Deprivation describes a condition of relative poverty (Kearns et al., 2000). Townsend (1987, p.131) suggests, "people can be said to be *deprived* if they lack the types of diet, clothing, housing facilities and fuel and environmental, educational, working and social conditions, activities and facilities which are customary". Multiple deprivation is denoted as an accumulation of several types of deprivation. Measures of deprivation, such as the English Indices of Deprivation (EID) (Noble. et al., 2004; Noble et al., 2008; Mclennan et al., 2011; Smith et al., 2015; McLennan et al., 2019), typically include seven domains: income; employment; health and disability; education; housing and services; crime; and living environment. Collectively these domains capture economic, social and environmental outcomes of deprivation.

Within these core domains, disabled people may experience additional deprivation as a result of their disability, such as social stigma or difficulty accessing assistive technology or rehabilitation (Banks et al., 2020). In terms of social deprivation, Masasa (2002) pointed out that marriage and childbearing were regarded as a way of increasing the support base for disabled people. However, in some societies disabled people are viewed as less attractive as partners owing to difficulties accessing education, employment, and economic opportunities (Taghizadeh et al., 2020). Therefore, Puschmann et al. (2014) suggest that marital status can explain social exclusion of disabled people. A lack of social welfare, such as government grants (Groce et al., 2011) and medical insurance (Chatterjee & Mitra, 1998), can further reduce disability living standards. In the health domain, Yoshida et al. (2012) indicated that the severity of a disability determined the level of participation in economic and social life. In terms of environmental deprivation, Katarina and Nik (2018) demonstrated that the absence of barrier-free environments failed to successfully include the physically disabled in the environment. Furthermore, groups in impoverished areas were less able to access disability services, with the possible consequence of adverse long-term health and quality of life outcomes (Lakhani et al., 2019). To date, disability-related deprivation has been represented by disability-specific domains or indicators measured using secondary data or participatory exercise data. Secondary data includes demographic, health, and environment variables, such as education, employment, occupation (Awasthi et al., 2017), accessibility and physical barriers in urban environment (Hacini et al., 2022). Participatory data obtained via qualitative methods have shown a group-specific trend. It is about various basic capabilities, psychosocial dimensions, household level material wellbeing for children (Trani & Cannings, 2013), social hindrances, environmental and attitudinal barriers in the workplace for working-age persons (Parey, 2020), food, healthcare, information, and transport for older persons (Parey, 2021) (Fig. 1).

2.2. Structural inequality amongst disabled people

Solving poverty and deprivation issues requires insight into how the characteristics of disability can increase the risk of deprivation. A key question is who are the most deprived disability groups and where are they located?

Structural inequality refers to the unequal distribution of, or access

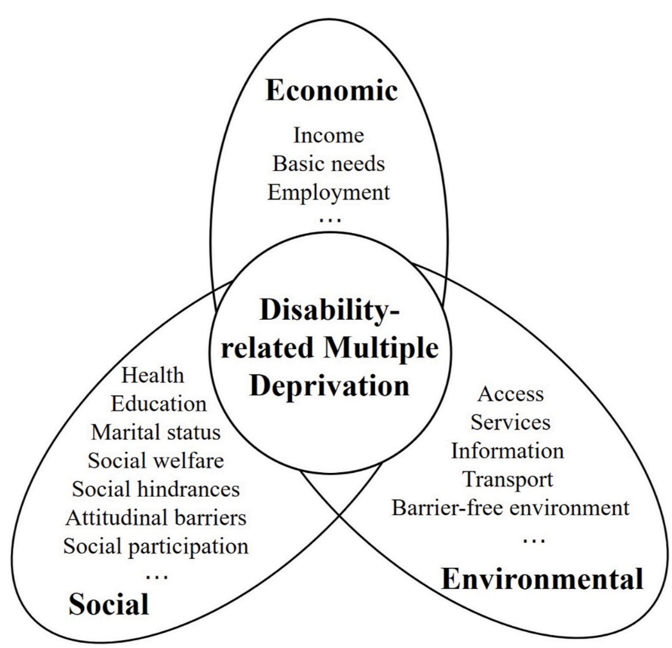

Fig. 1. The domains of disability-related multiple deprivation.

to, societal resources between different groups of people. Individual residential space, gender, race, and class all affect socio-economic differentiation (Shi & Dorling, 2020) and health outcomes (Horse et al., 2021). The structure of the disabled population is described by disability prevalence, counts, gender, age, and disability types (Chandirli et al., 2019). Recently, more studies have explored the structural inequalities of disability-related deprivation. In terms of gender, women were more likely to experience poverty and social exclusion in Vietnam (Nguyen & Mont, 2011), Morocco and Tunisia (Trani et al., 2015). However, Mónica et al. (2020) demonstrated that this was not the case in all countries; disabled women were more disadvantaged in Cameroon and India but there was no significant difference in deprivation between disabled men and women in Guatemala. Age also makes a difference; the probability of social exclusion increased with age for those with disabilities in Spain (Belzunegui-Eraso et al, 2018) and Korea (Park & Nam, 2018). However, Mont and Nguyen (2018) found that elderly disabled people in Vietnam who were not disabled during their education, training or working years, were not adversely affected by their disability as they had been able to accumulate assets and make a family that cared for and housed them in old age. Other studies have shown that different disabled age groups experienced a higher risk of poverty. For example, Loeb et al. (2008) found that school aged groups experienced education deprivation that had a lifelong impact. Haveman and Robert (2000, pp. 995–1051) and Stapleton et al. (2006) highlighted significantly lower employment rates amongst working-aged disabled groups. Similarly, in China, the population-based survey on disability in 2006 showed that age was a better predictor of poverty than disability type; young disabled people, regardless of disability type, were associated with experiences of poverty (Guo et al., 2019).

Evidence as to which type of disability is associated with higher levels of deprivation is inconclusive. Trani et al. (2015) found that in Morocco and Tunisia people with intellectual, mental, and multiple disabilities have the highest probability of falling into poverty. Visual disabilities were not associated with poverty in Vietnam (Hong-Luu et al., 2012) or Indonesia (Bella & Dartanto, 2018), however, Solan and Mozlin (1997) suggested they do have a significant influence on poverty. Therefore, although certain gender, age, and disability types are associated with an increased probability of being poor, differences in the level of poverty may relate to disparities of geographical context (Mónica & Islay et al., 2020).

2.3. *Spatial disparity in disability-related deprivation*

Evaluation of the spatial disparity of disability-related deprivation on different scales has produced disparate results. Some studies suggest that disabled people in poor areas tend to be more deprived due to lower levels of socio-economic development and an insufficient supply of services (e.g. health care, education, training, job opportunity, and transportation) (Stapleton et al., 2006). Pinilla-Roncancio and Mónica (2017) and Bella and Dartanto (2018) demonstrated that differences in socio-economic development, such as urban-rural disparity, can increase the deprivation gap of the disabled. Awasthi et al. (2017) suggest that disabled people in regions with higher illiteracy and lower socio-economic status may be subject to increased social stigma. Banks et al. (2017) and Pinilla-Roncancio and Alkire (2020) found the opposite to be true; in regions or countries with higher levels socio-economic development the disabled population were not being supported by public policies designed to reduce poverty and deprivation. Mónica et al. (2020) termed the phenomena the "Disability and Development Gap". In addition to the overall spatial disparity of disability-related deprivation, there is the added complexity of the heterogenous spatial effects of group-specific disability. A few studies have discussed spatial disparities within disability sub-groups (e.g. Awasthi et al., 2017; Trani et al., 2015) between regions or administrative areas. This paper contributes to this line of inquiry with an empirical analysis of a major Chinese city, where the disability structure and spatial development have shown distinctive features. During rapid industrialization, urbanization, and population ageing, there has been significant growth of the disabled population. Growth patterns of the disabled population (Zhang, 2007) and several aspects of urban development, such as economic development (Giles et al, 2006), the provision of public services (Bosker et al., 2018) and housing conditions (Chen & Guo, 2011), are characterized by spatial disparity. This is suggestive of structural dynamics within Chinese cities. Consequently, it is worth exploring the structural characteristics of the disabled population and spatial disparity of resources to better understand the mechanism of disability deprivation inequality at the municipality scale in China.

3. Data and methodology

3.1. *Study area*

Tianjin, an important industrial megacity southeast of Beijing, was selected as the study area. In 2020 the disabled population was approximately 570,000, with a cross-section of ages, genders and types of disability (TJDPF, 2021). Tianjin can be classified into three main areas: the urban centre (the central urban area and other fully urban areas); the urban fringe (urban and rural areas around the central urban area); and rural areas (the outer urban areas and predominantly rural areas). Fig. 2 shows the relative proportion of urban and rural areas at the sub-district (*jie dao*) and town level.

3.2. *Development of the sub-district-level Index of Disability-related multiple deprivation (IDMD)*

3.2.1. *Data collection and processing*

A domain reflects a specific socioeconomic condition and comprises a set of indicators. Based on the limited data availability of disabled people in China, this study proposed and used six domains: employment, marital status, education, health, services, and barrier-free environment. The six domains are composed of nine indicators. A full description of the domains, indicators, data sources and processing methods is detailed in Table 1.

This study collated all data from three sources. Firstly, the social and health attributes of 350,000 certified disabled people were collated from

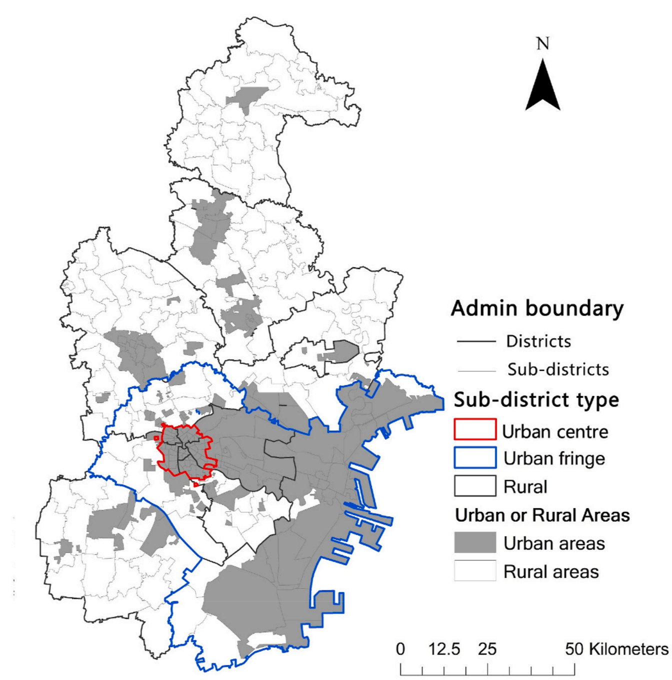

Fig. 2. Location of the Tianjin municipality study area.

Table 1
The domains and indicators of the IDMD.

Domain	Indicators	Definition of Indicators	Data source	Data accuracy
Employment	Unemployment	% disabled people who are either unemployed (aged 18 to 60) or receive zero pension (aged >60)	Tianjin Disability Database, 2020	Registration information of certificated disabled people (N = 350,000); Updated annually
Marital status	Unmarried	% disabled people (aged >20) who have never been married		
	Divorced	% divorced disabled people		
Education	Illiteracy	% disabled people leaving school without diploma		
	Low educational achievement	% disabled people (>15 years old) with lower educational attainment (under junior high school)		
Health	High dependency	% people with the most severe level[a] of disability		
Services	Disabled services facilities	∑closest distances of each type of disability services facilities to sub-district population weighted centroid	Tianjin disabled facilities Database, 2020	Information of disabled services facilities (N = 500); Real-time update)
	Basic public services facilities	∑closest distances of each type of basic public services facilities to sub-district population weighted centroid	Gaode Map, 2020	POI data of basic public facilities (N = 50,000); Real-time update
Barrier-free environment	Barrier-free areas/ facilities	The total number of barrier-free facilities	*Rongchang* application, 2020	Barrier-free facilities data (N = 100,000); Annual update

[a] Each type of disability is divided into 4 levels depending on their severity, according to the "*Practical Assessment Standards for People with Disabilities in China*". The most severe level (1st level), across all disability types, indicates very serious barriers to participation in social life.

the Tianjin Disability Database, which contains personal data (gender, age, disability type, disability level, household registration, present address, workplace, education, marital status) of those disabled people across Tianjin who meet the national criteria for the issuance of disability cards. The current residence address of these disabled people is updated annually to determine the jurisdiction in which benefits are issued. Secondly, the location and descriptors (type, year of construction, area, medical and nursing personnel numbers) of 500 disability service facilities (60 disability schools, 300 disabilities daycare centres, 94 rehabilitation centres, 7 integrated disabled services, and 44 disability employment services) were collated from Database of Disabled Facilities in Tianjin. These include both public and private facilities accredited by the Disabled Persons' Federation and the information is updated in real time. The above-mentioned two types of data are provided by the Tianjin Disabled Persons' Federation (TJDPF).[1] Thirdly, location data for public service facilities were drawn from Gaode Map 50,000 POI data (Gaode Map, 2020). Fourthly, the location and prevalence of 100,000 barrier-free facilities (20,000 barrier-free elevators, 1000 barrier-free toilets, 10,000 wheelchair ramps, 50,000 curb-ramps, 3000 low-level service facilities, 1000 wheelchair seats, 500 barrier-free parking spot, and 1000 barrier-free entrances) were taken from the Rongchang application.[2]

The number of disabled people with different attributes and the number of barrier-free facilities were calculated and further aggregated to sub-district level using ArcGIS 10.2. In terms of measuring the distance to service facilities, firstly, ArcGIS 10.2 was also used to calculate the road distance to the closest facility from the population weighted centroid of each sub-district. Secondly, the sum of distances to all types of facilities was used to indicate the adequacy and proximity of facilities. All the indicators listed in Table 1 were calculated at the sub-district level and followed a normal distribution.

3.3. Measuring IDMD using PCA

The weights given to each indicator influenced the resulting value of IDMD. This study used principal component analysis (PCA) to determine the weight for each indicator, attempting to reduce error and subjectivity. Components whose eigenvalues are higher than 1.0 and indicators whose loadings exceed 0.80 in each component were kept (Cumming & Vervier, 2002). The IDMD was calculated using Equation (1) (Min et al., 2011):

$$IDMD_i = \sum_{i=1}^{n} E_i \times \sum_{j=1}^{k} L_{j=1} \times x_j \quad (1)$$

Where E_i is the eigenvalue of component *I*; L_i is the loading score for indicator *j*; x_j is the standardized value of indicator *j*. All indicators were in the same direction. In each spatial unit (sub-district), the weight of each domain was multiplied by each indicator, and the IDMD value was calculated by adding all the products together. This study aggregated individual scores to sub-district level, firstly because it is the smallest administrative unit in China and most reliable scale of population data in municipality (Cheng et al., 2006), and secondly because of the significant socio-economic spatial heterogeneity at this level (Liu et al., 2022). IDMD measurement at this scale is an interpretative measurement which has significance to, and can be easily shared with, planners and policy makers. In addition, it can be combined easily with many other statistical and census data to inform future research. A higher IDMD score suggests a higher degree of multiple deprivation. The 313 sub-districts were then classified into quintiles according to their deprivation index (Q1: least deprived; Q5: most deprived). A choropleth map was created to visualize the geographical distribution of IDMD by quintile. Moran I and LISA analysis were used to quantify the spatial disparity of IDMD across the municipality.

3.4. Modelling the structural determinants of disability on IDMD

3.4.1. Disability structural factors

Solving the problem of disability-related deprivation requires a clear understanding of its structural inequalities. Drawing on existing research on disability structural inequalities, this study uses eleven structural factors as the independent variables, including gender, age, and six disability types, and the IDMD value as the dependent variable (Bella & Dartanto, 2018; She & Livermore, 2007) (Table 2). The distribution of the percentage of all subgroups in Tianjin showed a significant circle structure although patterns varied between each structural factor (Appendix, Figures A1-A3). The dependent variable is the score of IDMD.

3.4.2. Spatial heterogeneity analysis using MGWR

In previous studies the relationship between disability-related deprivation and disability structural factors has been measured using nonspatial regression analysis, such as logistic regression (Guo et al., 2019) or Poisson regression models (Flores-Flores et al, 2018). In order to better understand the spatial heterogeneity, spatial dependence and spatial non-stationarity, Geographically Weighted Spatial Modelling

[1] The Disabled Persons' Federation is a public institution that participates in the administration of civil servants and is an organization that represents and addresses disabled people's issues in China.

[2] *Rongchang* application is a barrier-free signage system based on the Internet navigation electronic map.

Table 2
Description of the disability structural factors.

Independent variables		Description
Gender structural factors	%Female	Percentage of disabled people who are female
Age structural factors	%Aged < 18	Percentage of disabled people aged <18 years old
	%Aged18-40	Percentage of disabled people aged 18–40 years old
	%Aged41-59	Percentage of disabled people aged 41–59 years old
	%Aged≥60	Percentage of disabled people aged ≥60 years old
Disability type structural factors	%Visual	Percentage of disabled people with a visual disability
	%Limb	Percentage of disabled people with a limb disability
	%Hearing	Percentage of disabled people with a hearing disability
	%Mental	Percentage of disabled people with a mental disability
	% Intellectual	Percentage of disabled people with an intellectual disability
	%Speech	Percentage of disabled people with a speech disability

(GWSM) is commonly used in geographical studies (Li et al., 2022). Geographically weighted regression (GWR) models have been used successfully to analyse local attributes at small spatial scales (Fotheringham et al., 2002). MGWR allows the associations between different independent variables and the dependent variable to be inconsistent in scale by allowing the data-borrowing ranges (bandwidths) to vary, thus generating a more realistic spatial process model (Fotheringham et al., 2017, p. 1247). This study, therefore, employed MGWR. (Equation (2)).

$$y_i = \beta_{i0}(u_i, v_i) + \sum_{k=1}^{m} \beta_{bwk}(u_i, v_i) x_{ik} + \varepsilon_i \quad (2)$$

Where y_i is the dependent variable, x_{ik} is the independent variable, bwk represents the bandwidth used by the regression coefficient of the k-th variable, (u_i, v_i) is the spatial coordinate of the i-th region, and ε_i is the random error term. Each regression coefficient β_{bwk} is based on local regression, and the bandwidth is specific.

In this study, MGWR was performed using the open-source python package provided by the School of Geographical Sciences and Urban Planning at Arizona State University (https://github.com/pysal/mgwr).

4. Results

4.1. Spatial pattern of IDMD

Three factors with eigenvalues larger than or close to 1 were selected from the PCA results, which together explained 72% of the total variance. These factors were named according to the loading of key indicators: the employment and education factor, the accessibility factor, and the marital status factor. For each component, indicators with high loadings (>0.70) were kept. IDMD was calculated using the equations set out in Table 3.

Fig. 3 shows that IDMD scores gradually increased with distance from urban centre to rural areas and exhibited significant urban-rural disparity. Global spatial autocorrelation was used to test the overall trend of spatial correlation between adjacent regions across the whole study area. The Global Moran's I index was 0.258, at a 1% significance level, indicating that IDMD values were significantly and positively spatially correlated. Local spatial autocorrelation analysis revealed four types of spatial correlation between local and neighboring IDMD values (Fig. 4). The L-L (cold spot clusters) type represents the least deprived sub-districts, mainly concentrated in the urban centre and in eastern areas of the district (a new national industry district). The L-H type

Table 3
Formulation of the IDMD based on PCA.

Component	Formula
A- The employment and education and factor	F_A = 0.808* Unemployment +0.738* Illiteracy +0.902*Low educational achievement
B-The accessibility factor	F_B = 0.909* Disabled services facilities +0.832* Basic public services facilities +0.933* Barrier-free areas/facilities
C-The marital status factor	F_C = 0.843* Unmarried
IDMD	IDMD = 3.879*F_A +2.328*F_B +0.991*F_C

The value of each component is the sum of products of indicators (with a eigenvector > 0.7).

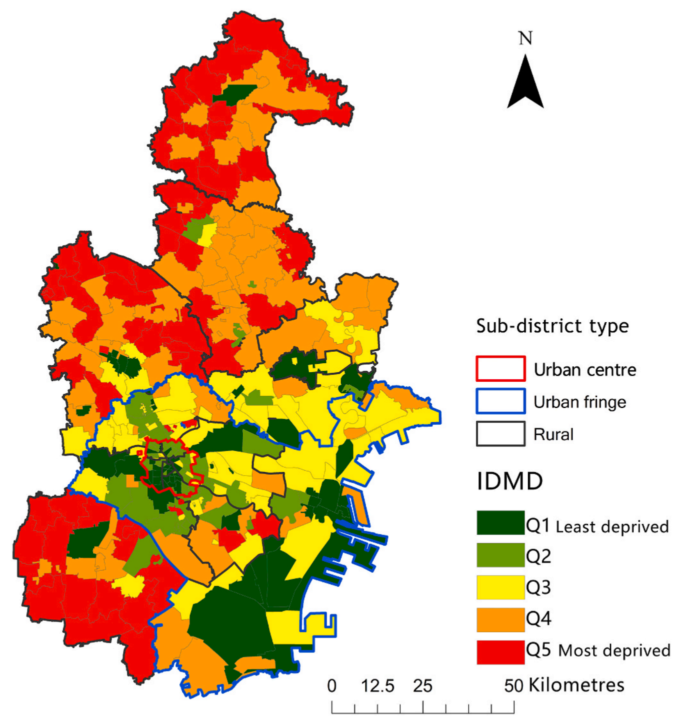

Fig. 3. The overall spatial pattern of IDMD in Tianjin (2020)

represents sub-districts that were less deprived than surrounding areas. These were located in the centre of rural areas across the municipality. The H-L type represents sub-districts that had higher levels of deprivation than those surrounding them. These were located in the periphery of the urban centre. The H–H type (hot spot clusters) represents the most deprived sub-districts, most of which were located in rural areas of the municipality. The components of IDMD showed similar patterns (Appendix, Fig. A4). In summary, the results confirm that the urban-rural disparity increases the risk of disability-related deprivation in rural areas (Goli et al., 2014; Pinilla-Roncancio & Mónica, 2017).

The value of IDMD is the sum of products of components and extraction of Squared Loadings.

4.2. The multiscale structural determinants of IDMD

OLS was used to identify the structural determinants of IDMD. The outcome of the OLS global model is shown in Table 4. Five disability types (%Visual, %Limb, %Mental, %Intellectual, %Speech) and two age groups (%18–40, %44–59) had a significant positive impact on IDMD, while %Female had a negative impact. The VIF values for all independent variables revealed low multi-collinearity (all values were less than the threshold of 5).

GWR and MGWR were used to explore the local spatial variation of the determinants of IDMD. MGWR yielded a larger adjusted R^2 (0.941)

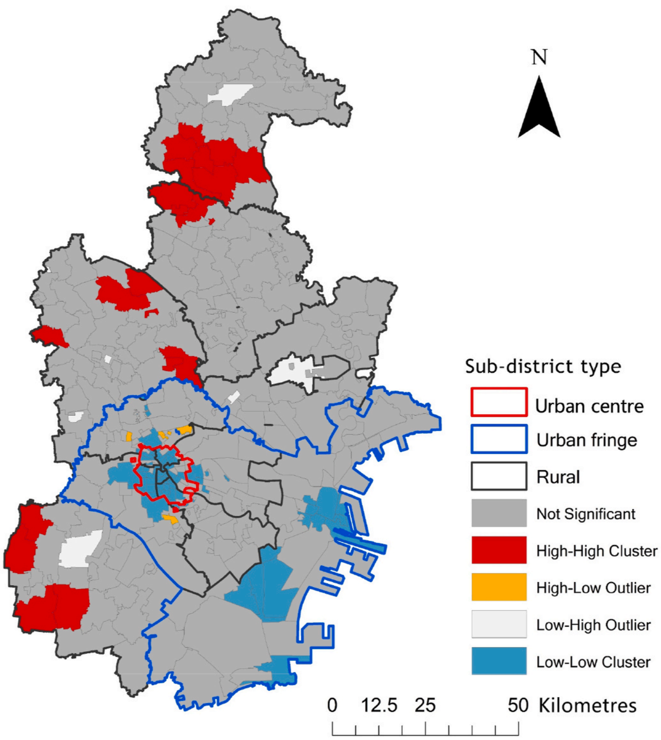

Fig. 4. The LISA cluster map for IDMD in Tianjin (2020)

and a lower AICc (102.41) than GWR, indicating a better model fit. Different influencing factors have different heterogeneity and scale, that is, within a certain range, the effect size is similar, but beyond this range, the effect size is significantly different. The MGWR model produced a vector of optimal bandwidths that described the spatial scale at which each structural factor in the model varied (Table 4). One way to interpret these results is as follows: (1) The bandwidth of %Female was 237, indicative of a global-scale variable that exhibits minimal spatial heterogeneity. (2) The bandwidths of %Aged 41–59, %Mental, %Speech scales were 179, 152, and 128 respectively, suggestive of regional-scale variables that were relatively stable spatially. (3) %Aged 18–40, %Visual, %Limb, and %Intellectual were local-scale variables accounting for 27%, 24%, 15%, and 18% of the total sample size respectively. This scale is close to the district level suggesting that once the scale is exceeded, the coefficient would change dramatically, and that IDMD values were sensitive to these variables.

The mean coefficients for each structural determinant in the sub-districts in each of the three areas (urban centre, fringe and rural) were calculated for the purpose of comparison (Table 5). ANOVA tests indicated that the mean coefficient values differed significantly between the three areas, as reflected by small p values. Higher mean coefficient values indicate the sub-districts which are most vulnerable to deprivation due to a positive or negative contribution from structural disability factors. As shown in Table 5, %Visual and %Limb were structural determinants throughout the whole municipality, whereas %Aged41-59 and %Aged18-40 were significant structural determinants in the urban centre, %Aged18-40 and %Intellectual were structural determinants in the urban fringe, and %Intellectual was the strongest structural determinant in rural areas.

In terms of gender structure, the average coefficient of %Female was −0.059, indicating a significant negative impact on IDMD. This result showed that disabled women were less deprived than men. It highlighted the disadvantaged status of men, in contrast to most previous studies which showed women suffered higher levels of deprivation (Trani et al., 2018; Clausen & Barrantes, 2020; Mónica et al., 2020). The impact of gender structure was clearest in eastern urban fringe areas (−0.057) of the municipality (Fig. 5a) where the urbanisation growth rate has reached the highest level in three decades.

In terms of age structure, the working age groups (%Aged 18–40 and %Aged 41–59) both had a significant positive impact on IDMD. The result supports the findings of previous studies that identify working age disabled people as an economically vulnerable population with a high probability of experiencing poverty (She & Livermore, 2007). The mean value and standard deviation of %Aged 18–40 were 0.163 and 0.065 respectively, and that of %Aged 41–59 were 0.123 and 0.024. The younger working age group had a slightly larger impact on IDMD and showed more regional differences (Fig. 5b & c). The high-value areas of %Aged 18–40 were in the urban fringes (0.156) and neighboring rural

Table 5
Mean coefficient values in the three areas of the municipality.

Independent Variable	Sub-district type (number of significant units)			Variance	
	Urban centre (61)	Urban fringe (107)	Rural (145)	F value	P value
%Female	−0.032 (29)	−0.057 (76)	−0.058 (18)	35.030	0.000**
%Aged18-40	0.156 (54)	0.263 (90)	0.095 (120)	20.321	0.000**
%Aged45-59	0.160 (61)	0.183 (107)	0.050 (145)	7.430	0.001**
%Visual	0.270 (31)	0.400 (106)	0.560 (141)	99.180	0.000**
%Limb	0.312 (33)	0.630 (107)	0.712 (145)	206.857	0.000**
%Mental	Not significant	0.090 (4)	0.150 (50)	120.324	0.000**
%Intellectual	0.090 (61)	0.232 (107)	0.560 (145)	36.221	0.000**
%Speech	Not significant	0.086 (58)	0.236 (61)	40.913	0.000**

Note: the number (e.g. 29) in the bracket means the total number of units significant at 5% level.
*$p < 0.05$ **$p < 0.01$.

Table 4
Summary statistics of global OLS model and bandwidths.

Variable		Coefficient	St. Error	*t*-Statistic	*p*	VIF	Bandwidth	
Dependent	Independent						GWR	MGWR
IDMD	Intercept	−3.430	0.103	−33.285	0.000		68	43
	%Female	−0.871	0.276	−3.150	0.002	2.293	68	237
	%Aged18-40	3.269	0.316	10.320	0.000	1.156	68	83
	%Aged45-59	1.124	0.358	3.136	0.002	2.877	68	179
	%Visual	2.843	0.322	8.829	0.000	1.964	68	74
	%Limb	3.138	0.246	12.755	0.000	3.875	68	56
	%Mental	1.555	0.413	3.766	0.000	1.243	68	152
	%Intellectual	8.131	0.655	12.401	0.000	1.797	68	47
	%Speech	5.480	1.456	3.761	0.000	1.193	68	128

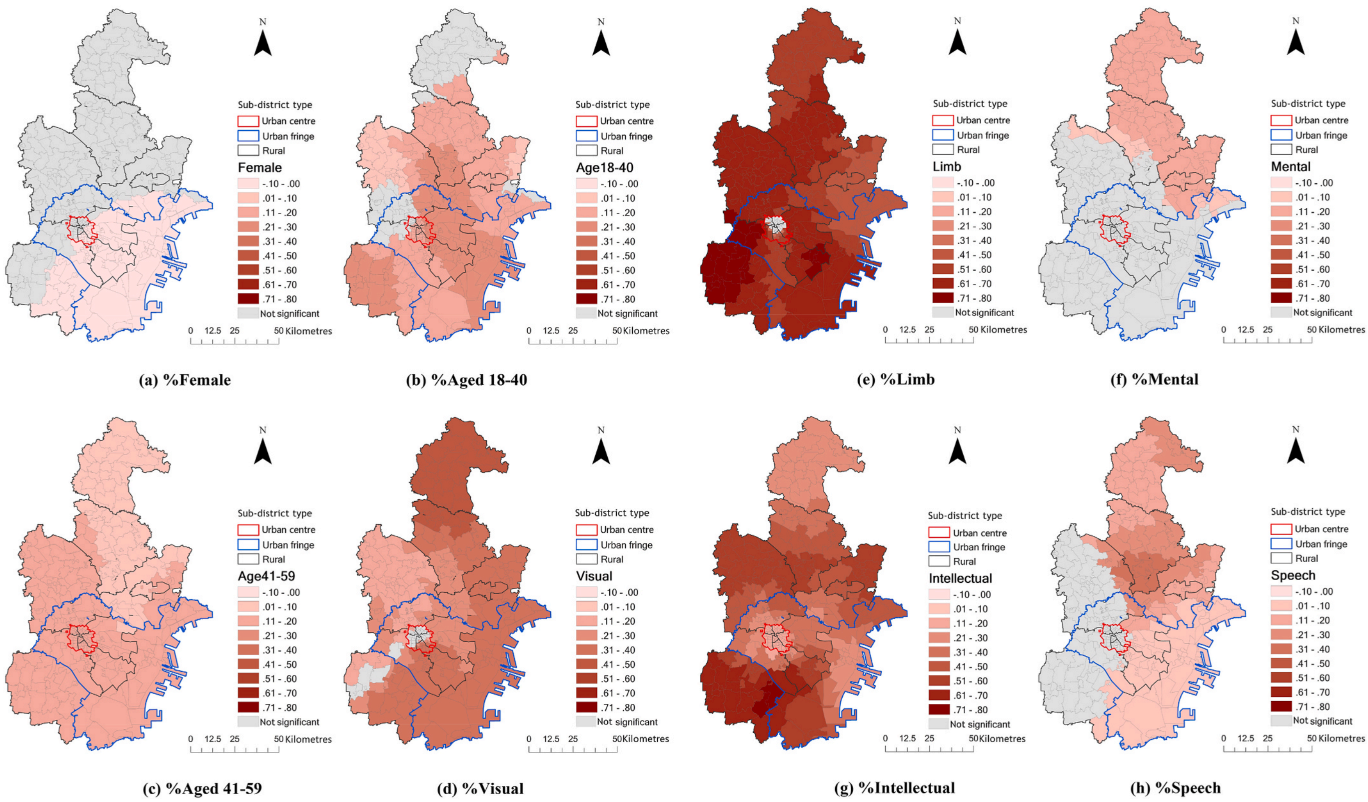

Fig. 5. The impact of structural factors of disability on IDMD.

(0.195) sub-districts, while that of %Aged 41–59 were mainly clustered in urban centre (0.160) and urban fringe (0.183) sub-districts. This indicates that these two age groups in these areas experienced the highest level of deprivation.

Five of the six disability types had a significant positive impact on IDMD. The order of their relative influence was: %Limb > %Intellectual > %Visual >%Speech >%Mental. The results supported Trani et al. (2015) and Clausen and Barrantes' (2020) conclusions that people with intellectual and speech disabilities had a higher incidence of deprivation, but did not concur with Bella and Dartanto (2018) or Pham et al.'s (2013) conclusions that people with visual disabilities were the most vulnerable. The differences in the results were probably due to variations in stigmas associated with different disability types in different countries (Trani et al., 2015), and the impact of existing policies towards group-specific disabilities (Clausen & Barrantes, 2020). The impact of visual disabilities on deprivation was much higher in remote rural (0.560) areas in the northern corner of the municipality, than it was in urban centre sub-districts (0.270) (Fig. 5d). The mean coefficient of %Limb was 0.557, the highest of all disability types. High values occurred in all areas of the municipality (urban fringe 0.630; rural 0.712) with the exception of most urban centre (0.312) sub-districts where its impact was marginally significant (Fig. 5e). %Mental had a significant positive impact on IDMD, but the lowest impact of all the disability types, and its significance was limited to northern rural areas (0.150) of the municipality (Fig. 5f). The impact of intellectual disabilities showed a pattern of concentric bands across the municipality. The impact was low in the urban centre (0.120) and the new national industry district but increased in the urban fringe (0.232) and rural areas (0.560), then decreased again in the northern, rural extent of the municipality (Fig. 5g). The coefficient of %Speech ranged from −0.103 to 0.362. Its significance was concentrated in the urban fringe (0.086) and rural areas (0.236), with particular impact in the midnorth rural area (Fig. 5h).

All determinants exhibited significant spatial non-stationarity in their contributions to IDMD, and the urban-rural disparity was evident. There was little impact of disability on deprivation in the urban centre whereas most structural factors of disability increased deprivation in rural areas. The urban fringe region showed different patterns, especially in the new national industrial district in the east of the municipality. This could be explained by the high concentration of manufacturing industries in this area which provide ample employment opportunities to people with intellectual or speech disabilities.

5. Discussion

5.1. Gender: informal employment and marriage exclusion in the urban fringe

Our results showed that disabled men were more deprived than disabled women, particularly in urban fringes. One possible explanation is the prevalence of informal employment in this area, which is associated with a low-income, low-capital, low-skilled, self-employed, and poor workforce (Hong, 2013). Informal employment is also more likely to create physical and mental health problems (Carles et al., 2010). Disabled people for whom low-income and informal employment opportunities are prevalent, self-employment serves as a practical alternative to formal work or employment (Ebuenyi et al., 2019). Rapid urbanisation in developing countries, particularly during early phases of industrialization, has created informal employment for the majority of rural workers, especially those who live in the urban fringes (Elgin & Oyvat, 2013; Huang, Xue, & Zhang, 2016). Among rural migrant workers, men account for a larger proportion of the informal workforce because fewer employment opportunities are available to women (Cuevas, 2009; Kantor, 2009). In addition, gender inequality among disabled people is more likely to occur in low-income countries, especially during the downturn in the informal economy (Ebuenyi et al., 2022). Liu and Li (2007) pointed out that the majority of the male rural workforce had low levels of education and tended to be employed in architecture, transport, and other manual labour industries. As a result, disabled men find it harder to enter or re-enter the workforce, resulting in their poverty and deprivation.

Marital status showed the largest gender difference and a huge urban-rural disparity. Disabled men in rural areas are subject to greater social stigma as a result of their illiteracy and lower socioeconomic status (Awasthi et al., 2017). This may, in part, be explained by the mate preference of rural residents, which is deeply influenced by the traditional beliefs that husbands should take greater responsibility for earning money and supporting their family (Bianchi et al., 2000; Yu & Xie, 2015). The fewer employment opportunities and lower incomes available to disabled men make them less desirable as husbands. Secondly, having a new house and being able to afford marriage expenses, including housing costs, bride-price, and marriage banquet expenses, is a key indicator of male economic status in China (Yu & Xie, 2015). However, this is beyond the reach of many rural men, particularly disabled men. Although these marriage customs are unique to China, it is widely recognized that economic status, represented by occupation, played a more important role in men's marital status than women's (Koball, 2004; Larson, 1988). It is worth noting that disabled men in urban fringes are at higher risk of being excluded from marriage due to both traditional mate preference and the higher costs of marriage, especially as urban commercial housing is more expensive than rural self-built housing.

5.2. *Age: relative deprivation among working-age disabled people in the urban centre and urban fringes*

Our results showed that working age disabled people face the most economic disadvantages and highest levels of social stigma. We explain this by comparing other age groups. According to Tianjin Disability Database in 2020, 75% elderly disabled people became disabled after the age of 60. This statistic from individuals with certificated disabilities is consistent with the Chinese statistics that the life expectancy of persons with mild disability is 62.5 years and 42 years old for those with severe disability (Zheng & Chen, 2011). It reveals that people who become disabled during their working life or school age are much less likely to survive into older age. The much shorter average life expectancy of disabled people, and the life expectancy gap between disabled and non-disabled people, were also evidenced in many other countries (Thomas & Barnes, 2011; Bahk et al., 2019). For the majority of elderly disabled people who have not been disabled during their working years, their education, training, employment, and other opportunities to accumulate capital have not been affected by their disability, and they have been able to build families that care for them in older age (Mont & Nguyen, 2018). Disabled people of school age are supported by their parents and do not yet need to confront employment and mate-choice problems. Whilst it is acknowledged that their family may suffer from material and mental stress (Dyson, 1997) but this was not measured in this study.

From the perspective of spatial heterogeneity, the urban centre and urban fringe areas were associated with high levels of deprivation. Mónica et al. (2020) demonstrated a “Disability and Development Gap” phenomenon whereby disabled people are left behind by public policies in developed regions and countries. This may be because disabled people are more likely to suffer relative deprivation. Relative deprivation refers to an individual's feeling of economic inequality compared with his/her reference group (Walker & Smith, 2001). Since both labour market competition and marriage costs are higher in developed areas, disabled people are relatively more vulnerable. Furthermore, the costs associated with a basic quality of life are higher in affluent areas. Therefore, disabled people of working age are less likely to be able to support a family and more likely to rely on welfare benefits and assistance programs.

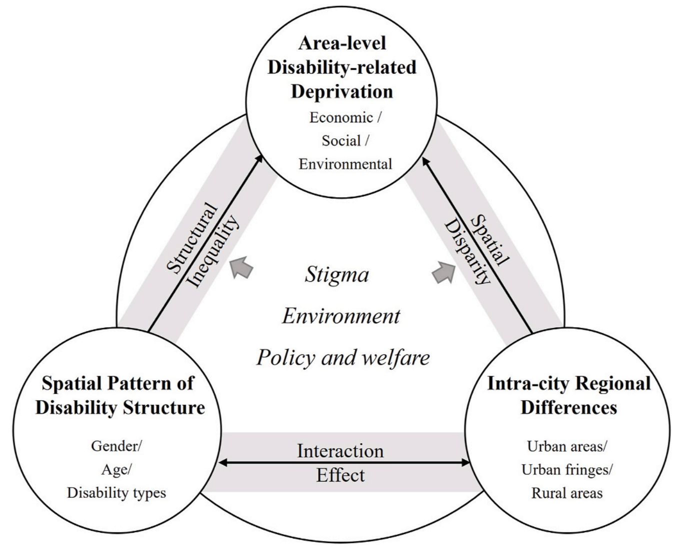

Fig. 6. The proposed framework for understanding the structural inequality and regional disparity of disability-related deprivation.

5.3. *Disability type: impact of environment and disability type on deprivation in rural areas*

The spatial analysis of deprivation showed a remarkable urban-rural gap for all disability types, with rural disabled people facing higher levels of deprivation. One of the key explanatory factors is the environmental differences between rural and urban areas. For example, residential environments in urban areas provide more convenient services and comfortable living conditions for disabled people. The dichotomous urban-rural system in China has contributed to long-standing disadvantages in rural areas (Sicular et al, 2008; Yuan et al., 2018). The effects of economic structuring (Giles, Park, & Cai, 2006)() and housing reform (Chen et al., 2011) implemented in the late 1990s have lasted well into the new century. The household registration (*hukou*) system has also resulted in the non-transferability of social welfare benefits and public services for rural migrants (Bosker et al., 2018).

Another key explanatory factor is the difference in the causes of disabilities in urban and rural areas. The prevalence of different types of disability and the age of disabled people are strong related to other spatially variable factors, such as rates of epidemic disease and socio-economic conditions. For example, limb disabilities in urban fringe and rural areas are mainly caused by occupational injuries, traffic accidents and infectious diseases (Poliomyelitis) and frequently affect young adults (Salminen, 2004) and children (Kumar et al., 1991). Acquiring a disability at a young age is likely to incur education, employment and marriage discrimination. However, in urban areas cerebrovascular disease is the primary cause of limb disability and frequently occurs in the elderly (Prince et al., 2015), who are beyond school, working and marriageable age. Furthermore, they may have children who could provide material and emotional support. The incidence of factors causing intellectual disabilities also differ between urban and rural areas. There is a higher disability rate in children in rural areas, and the most common causes are congenital rather than acquired (Christianson et al., 2010; Wellesley et al., 2010). However inadequate attention to care needs, lower levels of health promotion, and more difficulties accessing quality health care services in rural areas place limits on early rehabilitation of intellectual disabilities (Mirza et al., 2010). A similar situation occurs with speech, visual and mental disabilities (Phillips et al., 2009; Zheng et al., 2008).

Based on the findings from this empirical study in Tianjin, a conceptual framework for understanding the structural inequality and spatial disparity of disability-related deprivation is shown in Fig. 6. Group- and region-specific disabled populations are faced with differences in disability stigmas, physical and social environments, and assistance policies and welfare benefits. These economic, social and environmental differences contribute to the spatial variability of disability-related deprivation at the area level.

6. Conclusions and policy implications

Using disability census data this study has developed an Index of Disability-Related Multiple Deprivation (IDMD) that identifies the spatial disparity and structural determinants of disability-related deprivation in Tianjin in 2020. The major findings from the spatial analysis results of PCA, LISA and MGWR can be summarized as follows. First, the conceptual basis of IDMD is broader than other deprivation indices because it includes economic status, social exclusion, and environmental accessibility in the deprivation domains. The LISA analysis of IDMD revealed that left-behind disabled people in rural China have not been paid the same attention by planning and government stakeholders as left-behind migrants' children (Fang & Shi, 2018) or the elderly (Liu et al., 2014) during the rapid process of urbanisation. Also, the significant disparity in disability-related deprivation between urban and rural areas adds a new dimension to debates on the relative merits of urbanisation-driven development (Yuan et al., 2018).

The results revealed the presence of structural inequalities in disability-related deprivation, driven by gender, age, and disability type. (1) A higher proportion of women in the disabled population was associated with a lower IDMD in the urban fringe. It was suggested that disabled men face greater gender inequality in terms of marriage (Kohrman, 1999) and employment opportunities (Kantor, 2009). (2) Working age disabled people, being more economically vulnerable, had a greater probability of suffering relative deprivation than other age groups in urban areas due to fiercer competition for jobs and higher living costs (Saracoğlu & Roe, 2019). (3) People with intellectual and limb disabilities were the most disadvantaged among all disability types, and those in rural areas experienced greater deprivation due to the disparity of factors leading to disability and the availability of accessible environments (Zhang & Fu, 2020). These results can be explained by the stigma associated with disabilities in particular social and cultural contexts (Mitra et al., 2013), physical environment differences resulting from particular social-economic development histories (Grisé & Boisjoly, 2019), and specific disability policies and welfare provisions (Stapleton et al., 2006).

The multiscale effect of the structural determinants of disability-related deprivation was measured at three scales: global, regional, and local. Four structural determinants (%Aged18-40, %Visual, %Limb, and %Intellectual) exhibited local influences on IDMD, implying the need for a corresponding intervention policy at the sub-district/district scale. Three structural determinants (%Aged41-59, %Mental, and %Speech) demonstrated regional influences on IDMD in urban, urban fringe, and rural areas. This suggests region-specific policies are needed to tackle urban and rural related deprivation. Only one structural determinant (%Female) had a global impact on IDMD, suggesting that a gender-specific intervention throughout the whole municipality is required to tackle gender related aspects of deprivation in the disabled population. Generally, these findings highlight the importance of heterogeneous policies and interventions at multiple scales to effectively reduce equality, rather than a homogeneous 'one rule for all' ('yidaoqie' in Chinese) approach (Cheng, 2022).

These findings contribute to the development of the poverty geography of disability which seeks to understand the geographical patterns, distribution characteristics, and areal types of poverty faced by disabled people, taking particular account of deprivation associated with impairment and disability in the context of an ableist society (Haveman & Robert, 2000, pp. 995–1051; Zhou & Liu, 2019). Firstly, this study offers an additional validated conceptual framework for assessing the spatial relationship between poverty and patterns of disability prevalence, disabled population growth, disability types, cause factor of disability, and disability level.

Secondly, the results showed, perhaps surprisingly, that disabled women were less deprived than men. This reflects the predominance of male-oriented informal employment opportunities (Huang et al., 2016), and the exclusion of disabled men from marriage as a result of traditional family roles (Artazcoz et al, 2004) and specific Chinese traditional marriage customs (Liu, 2017). Previous research has addressed the motivations (Huang & Zhang, 2017), functions (Loayza & Rigolini, 2011), income (Xue et al, 2014) and health impact (Ruiz, Vives, Martínez-Solanas, Julià, & Benach, 2017)) of informal employment. This study found that informal employment causes disability in working age males who are living in urban fringes and rural areas. In terms of marriage exclusion, the results of this study are consistent with previous research in showing that disabled men find it especially difficult to find a spouse (Kohrman, 1999), particularly in urban fringes. These findings suggest that feminist geography should consider the influence of disability on gender inequalities. The concept of intersectionality, which encourages consideration of how gender and disability may combine to create specific forms of deprivation, is likely to have relevance in future research (Valentine, 2007).

Thirdly, in relation to the "Disability and Development Gap" (e.g. Banks et al., 2017; Pinilla-Roncancio & Mónica, 2017), the results of this study provide evidence of the relationship between disability and city-scale socio-economic development. Working age groups were significantly influenced by the pattern and level of socio-economic development, which highlights the relative deprivation experienced by disabled people in specific areas and at different life stages.

The empirical evidence from this study has several implications for planning and urbanisation policies, with particular relevance to the disabled population. Firstly, high quality employment opportunities should be made available to working age disabled men and tax reduction policies for employers of disabled people should be better publicised and promoted. Secondly, social innovation policies that encourage a disabled-friendly social climate should be applied to tackle marriage exclusion. Thirdly, additional disability-adapted public services and facilities should be equalising developed in the new-type urbanisation stage of China (Gu et al., 2022). Furthermore, reforming the household registration system and improving the welfare available to rural registered households, such as medical insurance and pensions, would help improve the quality of life of rural disabled people.

The study has reported some significant results, but it was not without limitations. A major limitation is that, despite our attempt to capture a full picture of disability-related deprivation, the use of registration information of disabled people in Tianjin Disability Database limited the number of domains and indicators that could be included. It is therefore recommended that local organisations and policy makers include more questions, such as disabled people's subjective perceptions of society and family, into local disability surveys in future. Furthermore, this case study applies to the political, socio-economic and environmental context of Chinese mega-cities at a specific stage of rapid urbanisation. Findings are likely to vary in different contexts. As such, national or international comparative studies would help inform urban theories of disability-related planning and governance. China's urban development has expanded rapidly since economic reform started in 1978. Understanding temporal variations in spatial disparity and structural inequality will be essential for understanding the impacts of urbanisation on disability. Future studies would benefit from using temporal data sets. Finally, disabled people are, to a large extent, supported by their families in terms of education, rehabilitation and care. Future measures of disability-related deprivation should incorporate familial support.

Author statement

Manuscript title: Spatial disparity and structural inequality in disability patterns across Tianjin municipality: a multiple deprivation perspective.

I have made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND.

I have drafted the work or revised it critically for important intellectual content; AND I have approved the final version to be published; AND.

I agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

All persons who have made substantial contributions to the work reported in the manuscript, including those who provided editing and writing assistance but who are not authors, are named in the Acknowledgments section of the manuscript and have given their written permission to be named. If the manuscript does not include Acknowledgments, it is because the authors have not received substantial contributions from nonauthors.

Attachment: Yes No (circle).

Acknowledgements

This study is supported by Ministry of Housing and Urban-Rural Development of The People's Republic of China (Grant No.202205000262) and National Natural Science Foundation of China (Grant No. 51778403).

Appendix

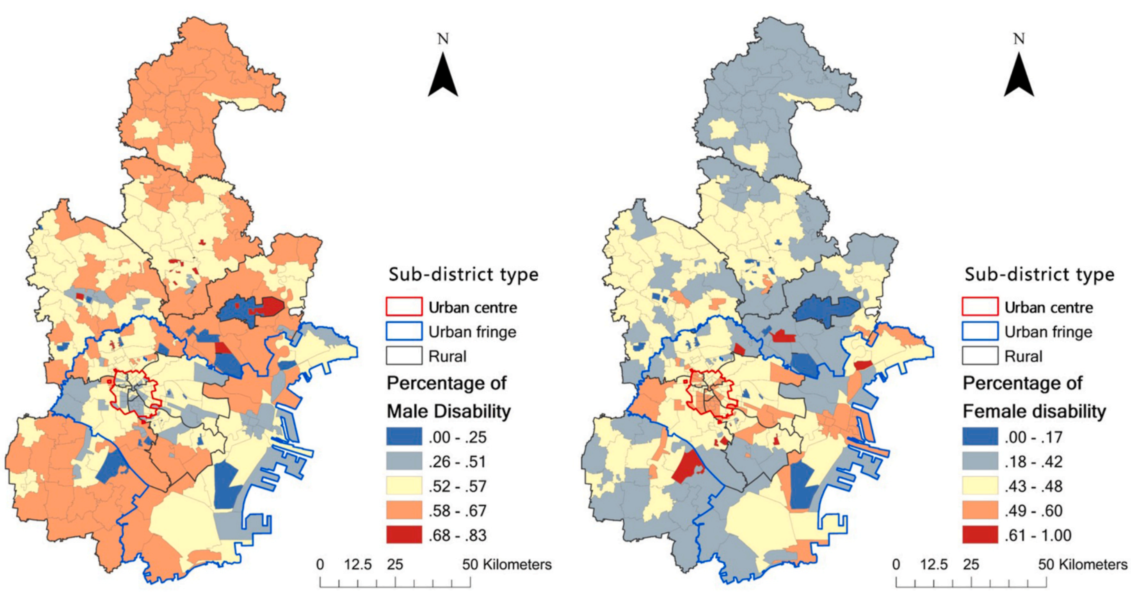

Fig.A1. Spatial distribution of the percentage of disabled people in different gender groups

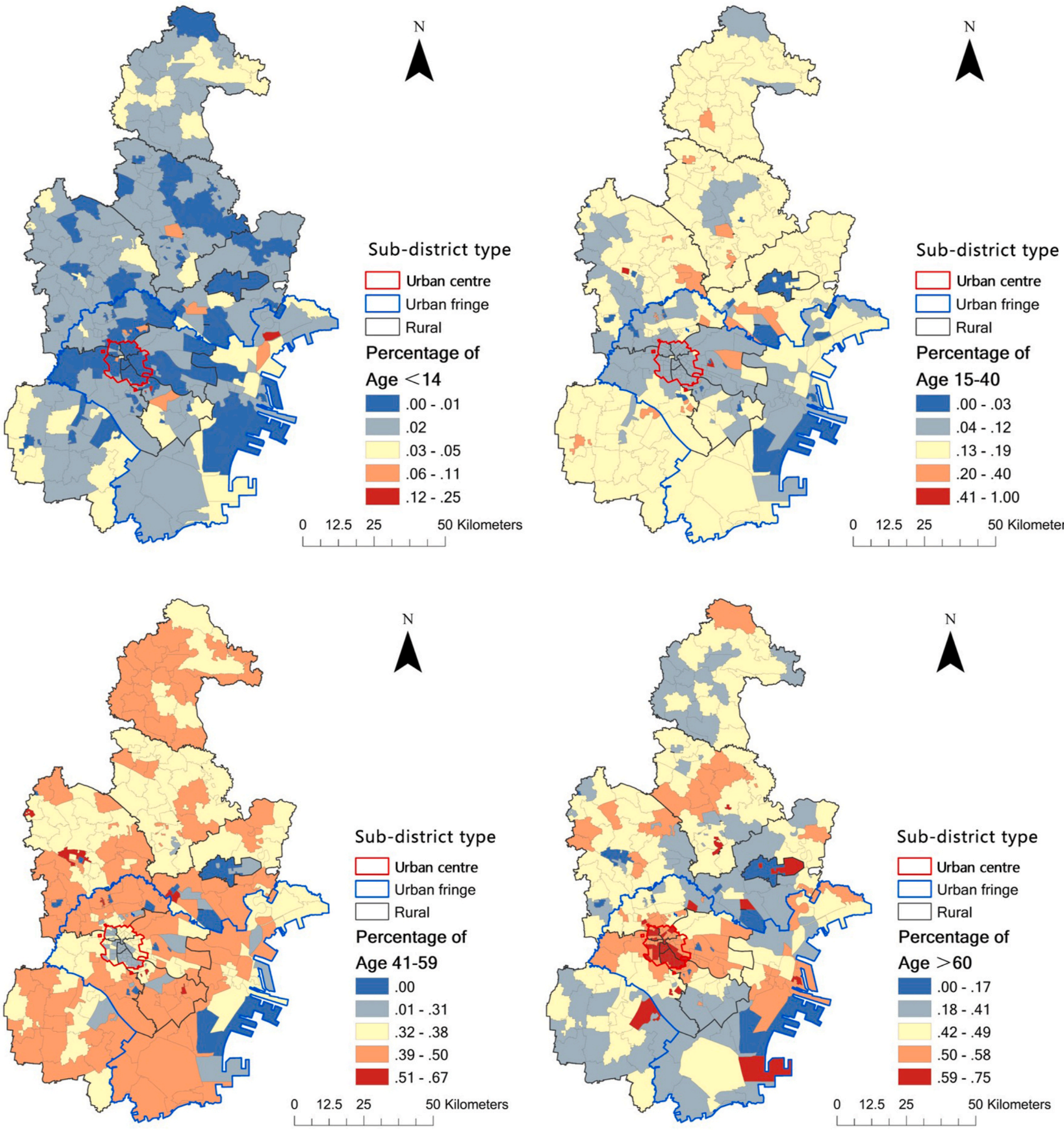

Fig. A2. Spatial distribution of the percentage of disabled people in different age groups

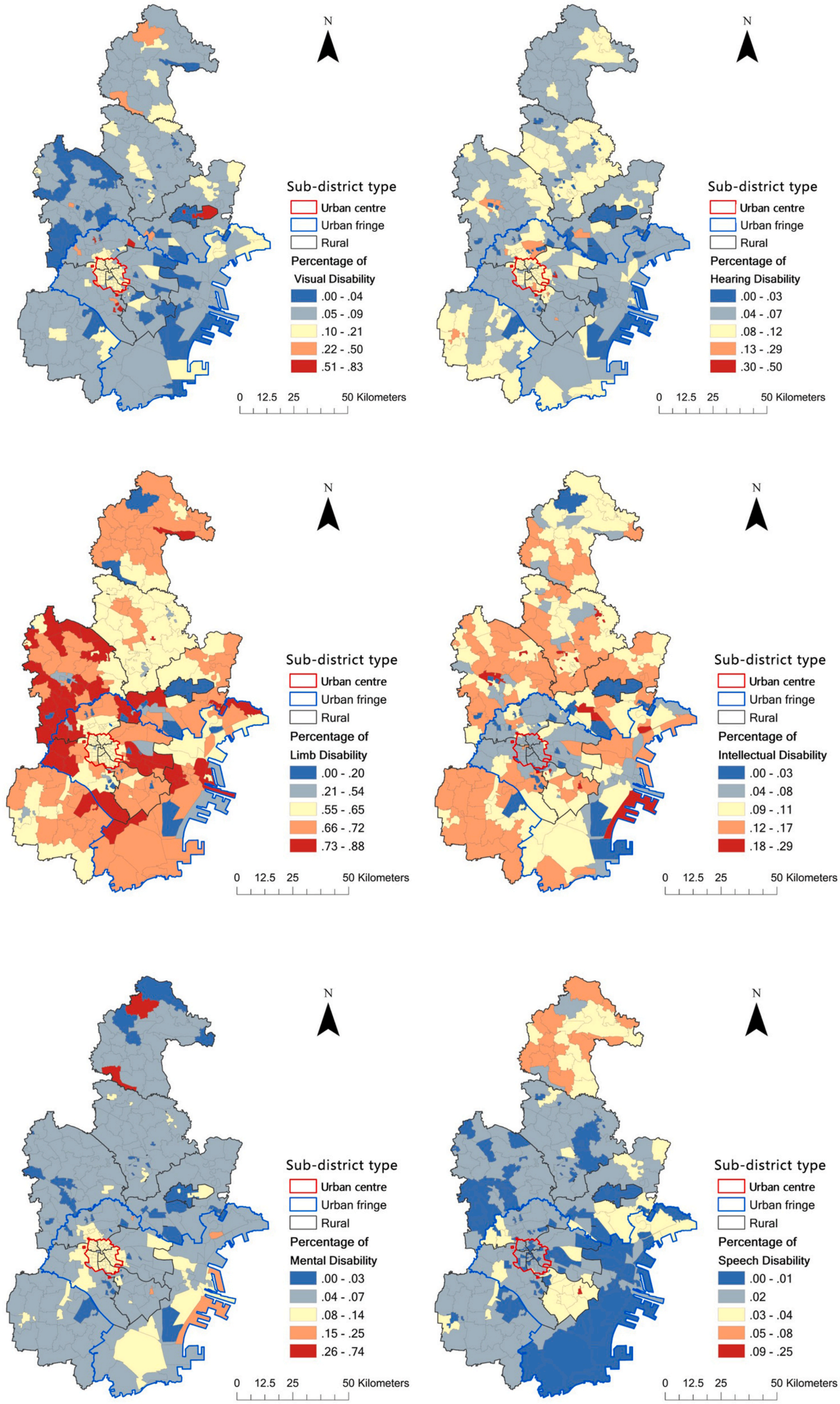

Fig. A3. Spatial distribution of the percentage of disabled people of different disability types

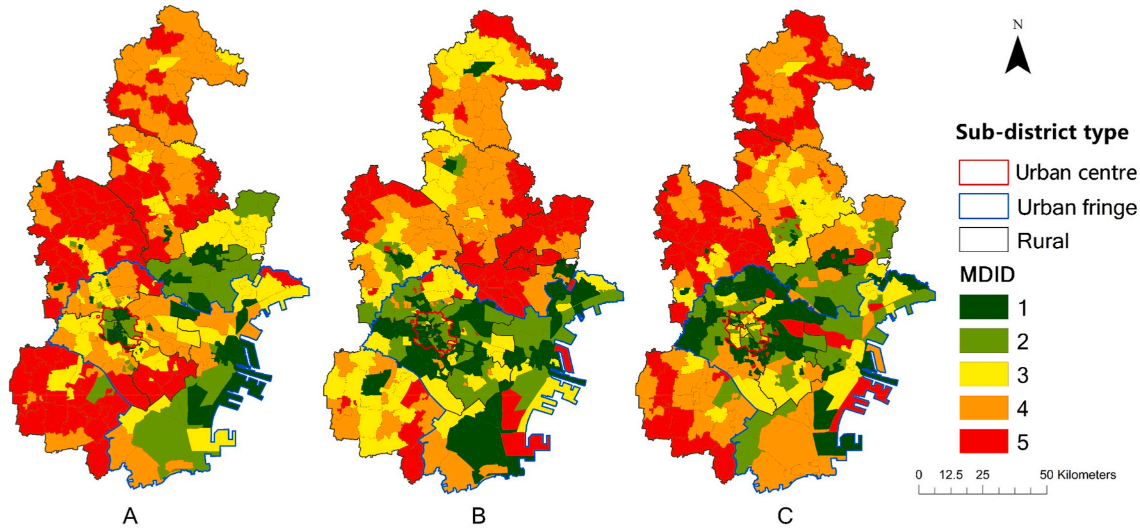

Fig. A4. Spatial pattern of the components of MDID (A-The employment and education factor; B-The accessibility factor; C-The martial status factor)

References

Alkire, S., & Kanagaratnam, U. (2021). Revisions of the global multidimensional poverty index: Indicator options and their empirical assessment. *Oxford Development Studies, 49*(2), 169–183.

Awasthi, A., Pandey, C. M., Dubey, M., & Rastogi, S. (2017). Trends, prospects and deprivation index of disability in India: Evidences from census 2001 and 2011. *Disability and Health Journal, 10*(2), 247–256.

Bahk, J., Kang, H., et al. (2019). The life expectancy gap between registered disabled and non-disabled people in Korea from 2004 to 2017. *International Journal of Environmental Research and Public Health, 16*(14).

Banks, L. M., Hameed, S., Usman, S. K., & Kuper, H. (2020). No one left behind? Comparing poverty and deprivation between people with and without disabilities in the Maldives. *Sustainability, 12*(5), 2066.

Banks, L. M., Kuper, H., & Polack, S. (2017). Poverty and disability in low- and middle-income countries: A systematic review. *PLoS One, 12*(12), Article e0189996.

Bella, A., & Dartanto, T. (2018). Persons with disabilities (PWD) and poverty in Indonesia. *Malaysian Journal of Economic Studies, 55*(2), 167–188.

Belzunegui-Eraso, A., Pastor-Gosálbez, I., Puig-Andreu, X., & Valls-Fonayet, F. (2018). Risk of exclusion in people with disabilities in Spain: Determinants of health and poverty. *International Journal of Environmental Research and Public Health, 15*(10), 2129.

Bianchi, S. M., Milkie, M. A., Sayer, L. C., & Robinson, J. P. (2000). Is anyone doing the housework? Trends in the gender division of household labor. *Social Forces*, (1), 191–228.

Bosker, M., Deichmann, U., & Roberts, M. (2018). Hukou and highways the impact of China's spatial development policies on urbanization and regional inequality. *Regional Science and Urban Economics, 71*, 91–109.

Carles, M., Orielle, S., Christophe, V., José, M. M., Montserrat, V., Vilma, S., Antía, C., Il-Ho, K., & Joan, B. (2010). UNEMPLOYMENT, informal work, precarious employment, child labor, slavery, and health inequalities: Pathways and mechanisms. *International Journal of Health Services, 40*(2), 281.

CDPF (China Disabled Persons' Federation). (2019). *China statistical yearbook on the work for persons with disabilities*. China Statistics Press.

Chandirli, S. A., Bogova, O. T., Potapov, V. N., & Puzin, S. N. (2019). Features of the formation of disability due to coronary heart disease in people of retirement age in the Russian federation in the period 2006–2017. *Advances in Gerontology, 9*(3), 355–360.

Chatterjee, L., & Mitra, M. (1998). Evolution of federal and state policies for persons with disability in the United States: Efficiency and welfare impacts. *The Annals of Regional Science, 32*(3), 347–365.

Cheng, J. (2022). Editorial introduction Special section on sustainable healthy city. *Int. Rev. Spatial Plan Sustain. Dev., 10*(3), 1–3.

Cheng, J., Jan, T., Peng, M., Du, N., & Ho, P. (2006). Urban land administration and planning in China: Opportunities and constraints of spatial data models. *Land Use Policy, 23*(4), 604–616.

Chen, & Guo. (2011). Privatization, marketization, and deprivation: Interpreting the homeownership paradox in postreform urban China. *Environment & Planning A, 43*(5), 1135–1153.

Chen, J., Guo, F., & Wu, Y. (2011). One decade of urban housing reform in China: Urban housing price dynamics and the role of migration and urbanization, 1995–2005. *Habitat International, 35*(1), 1–8.

Christianson, A. L., Zwane, M. E., Manga, P., Rosen, E., & Kromberg, J. G. R. (2010). Children with intellectual disability in rural South Africa: Prevalence and associated disability. *Journal of Intellectual Disability Research, 46*(Pt 2), 179–186.

Clausen, J., & Barrantes, N. (2020). Implementing a group-specific multidimensional poverty measure: The case of persons with disabilities in Peru. *Journal Of Human Development And Capabilities, 21*(4), 355–388.

Cuevas, S. (2009). Informal employment in Indonesia. *Adb economics working paper, 156*.

Cumming, S., & Vervier, P. (2002). Statistical models of landscape pattern metrics, with applications to regional scale dynamic forest simulations. *Landscape Ecology, 17*(5), 433–444.

Dyson, L. L. (1997). Fathers and mothers of school-age children with developmental disabilities: Parental stress, family functioning, and social support. *American Journal on Mental Retardation, 102*(3), 267–279.

Ebuenyi, I. D., Gitonga, I., Tele, A., & Syurina, E. V. (2022). Unemployment in women with psychosocial disabilities during the COVID-19 pandemic: Lessons from tana river county, Kenya. *Journal of International Development, 1*, 10.

Ebuenyi, I. D., Guxens, M., Ombati, E., Bunders-Aelen, J. F. G., & Regeer, B. J. (2019). Employability of persons with mental disability: Understanding lived experiences in Kenya. *Frontiers in Psychiatry, 10*, 539.

Elgin, C., & Oyvat, C. (2013). Lurking in the cities: Urbanization and the informal economy. *Structural Change and Economic Dynamics, 27*, 36–47.

Fang, Y., & Shi, Z. (2018). Children of migrant parents: Migrating together or left behind. *Habitat International, 76*, 62–68.

Flores-Flores, O., Bell, R., Reynolds, R., & Bernabé-Ortiz, A. (2018). Older adults with disability in extreme poverty in Peru: How is their access to health care? *PLoS one, 13*(12), Article e0208441.

Fotheringham, A. S., Brunsdon, C. F., & Charlton, M. E. (2002). *Geographically weighted regression: The analysis of spatially varying relationships*.

Fotheringham, A. S., Yang, W., & Kang, W. (2017). *Multiscale geographically weighted regression (MGWR)*. Taylor and Francis, Great Britain.

Giles, J., Park, A., & Cai, F. (2006). How has economic restructuring affected China's urban workers? *The China Quarterly, 185*, 61–95.

Goli, A., Kermany, F. S., & Askarian, M. (2014). *Spatial prevalence of intellectual disability and related socio-demographic factors in Iran, using GWR: Case study*, 2006.

Grisé, E., Boisjoly, G., et al. (2019). Elevating access: Comparing accessibility to jobs by public transport for individuals with and without a physical disability. *Transportation Research Part A Policy & Practice: S096585641730705X*.

Groce, N., Kett, M., Lang, R., & Trani, J. F. (2011). Disability and poverty: The need for a more nuanced understanding of implications for development policy and practice. *Third World Quarterly, 32*(8), 1493–1513.

Gu, H., Jie, Y., & Lao, X. (2022). Health service disparity, push-pull effect, and elderly migration in ageing China. *Habitat international*, 125N.PAG-N.PAG.

Guo, C., Luo, Y., Tang, X., Ding, R., Song, X., & Zheng, X. (2019). *Poverty and youth disability in China: Results from a large, nationwide, population-based survey*.

Hacini, C. E., Bada, Y., & Pihet, C. (2022). The mobility of people with disability: Between urban accessibility and urban attractiveness. A case study from algiers, Algeria. *Int. Rev. Spatial Plan Sustain. Dev., 10*(2), 38–57.

Haveman, & Robert. (2000). *Handbook of health economics] volume 1 || chapter 18 the economics of disability and disability policy*.

Hollar, D. W. (2017). *Disability and health outcomes in geospatial analyses of Southeastern U. S. county health data*. Amsterdam, United States: inElsevier Science B.V.

Hong, Z. (2013). The earnings differential between formal and informal employees in urban China. *Contemporary Economics, 7*(3), 115–124.

Hong-Luu, P., Masashi, K., Takehito, T., Kaoruko, S., & Masafumi, W. (2012). Out-of-pocket costs of disabilities and their association with household socioeconomic status among school-aged children in Vietnam. *Journal of Rural Medicine, 8*(2), 212–221.
Horse, A., Yang, T. C., & Huyser, K. R. (2021). Structural inequalities established the architecture for COVID-19 pandemic among native Americans in Arizona: A geographically weighted regression perspective. *Journal of Racial and Ethnic Health Disparities*, (10).
Huang, G., Xue, D., & Zhang, H. (2016). The development of urban informal employment and its effect on urbanization in China. *Geographical Research, 35*, 442–454, 03.
Huang, G., Zhang, H. O., et al. (2017). Beyond unemployment: Informal employment and heterogeneous motivations for participating in street vending in present-day China. *Urban Studies, 55*(12), 2743–2761.
Kantor, P. (2009). Women's exclusion and unfavorable inclusion in informal employment in lucknow, India: Barriers to voice and livelihood security. *World Development, 37*(1), 194–207.
Katarina, R., & Nik, A. J. (2018). Achieving a construction barrier–free environment: Decision support to policy selection. *Journal of Management in Engineering, 34*(4), Article 04018020.
Kearns, A., Gibb, K., & Mackay, D. (2000). Area deprivation in scotland: A new assessment. *Urban Studies, 37*(9), 1535–1559.
Koball, H. L. (2004). Crossing the threshold: Men's incomes, attitudes toward the provider role, and marriage timing. *Sex Roles, 51*(7), 387–395.
Kohrman, M. (1999). Grooming que zi: Marriage exclusion and identity formation among disabled men in contemporary China. *American Ethnologist, 26*(4), 890–909.
Kumar, R., Singh, A., & Kumar, V. (1991). Survey of village informants–an alternate method to estimate paralytic poliomyelitis prevalence in rural area. *Indian Journal of Pediatrics, 58*(2), 239–243.
Lakhani, A., Parekh, S., Gudes, O., Grimbeek, P., & Kendall, E. (2019). Disability support services in Queensland, Australia: Identifying service gaps through spatial analysis. *Applied Geography, 110*, Article 110102045.
Larson, A. (1988), 1. *Marriage in late nineteenth-century melbourne* (Vol. 5, pp. 15–45).
Liao, Y., Wang, J., Du, W., Gao, B., Liu, X., Chen, G., Song, X., & Zheng, X. (2016). *Using spatial analysis to understand the spatial heterogeneity of disability employment in China: Spatial heterogeneity of disability employment in China", Transactions in Gis*.
Li, L., Cheng, J., Bannister, J., & Mai, X. (2022). Geographically and temporally weighted co-location quotient: An analysis of spatiotemporal crime patterns in greater manchester. *International Journal of Geographical Information Science, 36*(5), 918–942.
Liu, Y., Dijst, M., & Geertman, S. (2014). Residential segregation and well-being inequality between local and migrant elderly in Shanghai. *Habitat International*, 42175–42185.
Liu, Y., & Li, Y. (2007). Gender difference in informal employment of rural migrants in urban areas: A case study of nanjing. *Chinese Rural Economy*, (12), 20–27.
Liu, J., et al. (2017). Practice and relection of participatory community planning under the background of transformation: A case study of Y community, Qinghe District in Beijing. *Shanghai Urban Planning, 02*, 23–28.
Liu, J., Meng, B., Yang, M., Peng, X., Zhan, D., & Zhi, G. (2022). Quantifying spatial disparities and influencing factors of home, work, and activity space separation in Beijing. *Habitat International, 126*, 102621.
Loeb, M., Eide, A. H., Jelsma, J., Toni, M. K., & Maart, S. (2008). Poverty and disability in eastern and western cape provinces, South Africa. *Disability & Society, 23*(4), 311–321.
Masasa, T.L. (2002). Cultural beliefs towards disability: their influence on rehabilitation. Stellenbosch: Stellenbosch: Doctoral dissertation.
Mclennan, D., Barnes, H., Noble, M., Davies, J., & Dibben, C. (2011). *The English indices of deprivation*, 2010.
McLennan, D., Noble, S., Noble, M., Plunkett, E., Wright, G., & Gutacker, N. (2019). *The English indices of deprivation 2019: Technical report*.
Min, L., Schootman, M., Doubeni, C. A., Park, Y., Major, J. M., Stone, R., Laiyemo, A. O., Hollenbeck, A. R., Graubard, B. I., & Schatzkin, A. (2011). Geographic variation in colorectal cancer survival and the role of small-area socioeconomic deprivation: A multilevel survival analysis of the NIH-AARP diet and health study cohort. *American Journal of Epidemiology, 174*(7), 828–838.
Mirza, I., Tareen, A., Davidson, L. L., & Rahman, A. (2010). Community management of intellectual disabilities in Pakistan: A mixed methods study. *Journal of Intellectual Disability Research, 53*(6), 559–570.
Mitra, S., Palmer, M., Kim, H., Mont, D., & Groce, N. (2017). Extra costs of living with A disability: A review and agenda for research. *Disab. Health J., 10*(4), 475–484.
Mitra, S., Posarac, A., & Vick, B. (2013). Disability and poverty in developing countries: A multidimensional study. *World Development, 41*(none), 1–18.
Mónica, P., Islay, M., Hannah, K., Carlos, D., Jonathan, N., G, V. S. M., & Sarah, P. (2020). *Multidimensional poverty and disability: A case control study in India, Cameroon, and Guatemala*.
Mont, D., & Nguyen, C. (2018). Spatial variation in the poverty gap between people with and without disabilities: Evidence from Vietnam. *Social Indicators Research: An International and Interdisciplinary Journal for Quality-of-Life Measurement, 137*(2), 745.
Morris, Z. A., & Zaidi, A. (2020). Estimating the extra costs of disability in European countries: Implications for poverty measurement AND disability-related decommodification. *Journal of European Social Policy, 30*(3), 339–354.
Nguyen, C. V., & Mont, D. (2011). Disability and poverty in Vietnam. *The World Bank Economic Review, 25*(2), 323–359.
Noble, M., Mclennan, D., Wilkinson, K., Whitworth, A., & Barnes, H. (2008). *The English indices of deprivation*, 2007.
Noble, M., Wright, G., Smith, G., & Dibben, C. (2006). *Measuring multiple deprivation at the small-area level*. Great Britain: PION LTD.
Parey, B. (2020). Using Sen's capability approach to assess wellbeing among working-age persons with disabilities in Trinidad. *Social Indicators Research, 151*(3), 1129–1148.
Parey, B. (2021). Well-being among older persons with disabilities in Trinidad. *Health and Social Care in the Community, 30*(4), e1101–e1111.
Park, E. Y., & Nam, S. J. (2018). Influential factors of poverty dynamics among Korean households that include the aged with disability. *Applied Research in Quality of Life, 13*.
Pham, H. L., Kizuki, M., Takano, T., Seino, K., & Watanabe, M. (2013). Out-of-pocket costs of disabilities and their association with household socioeconomic status among school-aged children in Vietnam. *Journal of Rural Medicine, 8*(2), 212–221.
Phillips, M. R., Zhang, J., Shi, Q., Song, Z., & Wang, Z. (2009). Prevalence, treatment, and associated disability of mental disorders in four provinces in China during 2001-05: An epidemiological survey. *Lancet, 373*(9680), 2041–2053.
Pinilla-Roncancio, M., & Alkire, S. (2020). How poor are people with disabilities? Evidence based on the global multidimensional poverty index. *Journal of Disability Policy Studies, 31*(4), 206–216.
Pinilla-Roncancio, & Mónica. (2017). The reality of disability: Multidimensional poverty of people with disability and their families in Latin America. *Disability and Health Journal, 11*(3), 398–404.
Prince, M. J., Wu, F., Guo, Y., Gutierrez, R., & L. (2015). *The burden of disease in older people and implications for health policy and practice*. Lancet London.
Puschmann, P., Grönberg, P., Schumacher, R., & Matthijs, K. (2014). Access to marriage and reproduction among migrants in Antwerp and Stockholm. A longitudinal approach to processes of social inclusion and exclusion, 1846–1926. *The History of the Family, 19*(1), 29–52.
Ruiz, M. E., Vives, A., Martínez-Solanas, È., Julià, M., & Benach, J. (2017). How does informal employment impact population health? Lessons from the Chilean employment conditions survey. *Safety Science, 100*, 57–65.
Salminen, S. (2004). Have young workers more injuries than older ones? An international literature review. *J Safety Res, 35*(5), 513–521.
Saracoğlu, D.Ş., & Roe, T. L. (2019). Regional cost-of-living differentials, rural–urban migration, and the contribution to economic growth. *Papers in Regional Science, 98*(2), 973–994.
Sen, A. (1999). *Development as freedom*. Oxford University Press.
She, P., & Livermore, G. A. (2007). Material hardship, poverty, and disability among working-age adults. *Social Science Quarterly, 88*(4), 970–989.
Shi, Q., & Dorling, D. (2020). Growing socio-spatial inequality in neo-liberal times? Comparing beijing and london. *Applied Geography, 115*.
Sicular, T., Ximing, Y., Gustafsson, B., & Li, S. (2008). The urban-rural income gap and income inequality in China. In *Understanding inequality and poverty in China* (pp. 30–71). London: Palgrave Macmillan.
Smith, T., Noble, M., Noble, S., Wright, G., & Plunkett, E. (2015). *The English indices of deprivation 2015: Research report*.
Solan, H. A., & Mozlin, R. (1997). Biosocial consequences of poverty: Associated visual problems. *Optometry and Vision Science, 74*(4), 185–189.
Stapleton, D. C., O'Day, B. L., Livermore, G. A., & Imparato, A. J. (2006). Dismantling the poverty trap: Disability policy for the twenty-first century. *The Milbank Quarterly, 84*(4), 701–732.
Taghizadeh, Z., Ebadi, A., & Farmahini Farahani, M. (2020). Marriage challenges of women with intellectual disability in Iran: A qualitative study. *Sexuality and Disability, 38*(1), 31–39.
Thomas, R., & Barnes, M. (2011). Life expectancy for people with disabilities. *NeuroRehabilitation, 28*(2), 201–209.
TJDPF (Tianjin Disabled Persons' Federation). (2021). Tianjin Statistical Bulletin on the Development of Disabled People (2020). http://www.tjdpf.org.cn/system/2021/04/23/030039126.shtml.
Townsend, P. (1987). Deprivation. *Journal of Social Policy, 16*(2), 125.
Trani, J., Bakhshi, P., Brown, D., Lopez, D., & Gall, F. (2018). Disability as deprivation of capabilities: Estimation using a large-scale survey in Morocco and Tunisia and an instrumental variable approach. *SOCIAL SCIENCE & MEDICINE*, 21148–21160.
Trani, J. F., Bakhshi, P., Myer Tlapek, S., Lopez, D., & Gall, F. (2015). Disability and poverty in Morocco and Tunisia: A multidimensional approach. *Journal of Human Development and Capabilities*, 1–31.
Trani, J. F., & Cannings, T. I. (2013). Child poverty in an emergency and conflict context: A multidimensional profile and an identification of the poorest children in western darfur. *World Development, 48*, 48–70.
UN (United Nations). (2018). *Disability and Development Report.Realizing the Sustainable Development Goals by, for and with Persons with Disabilities*. New York: UN.
Valentine, G. (2007). *Theorizing and Researching Intersectionality: A Challenge for Feminist Geography* (p. 10). United States: BLACKWELL: PUBLISHERS.
Walker, I., & Smith, H. J. (2001). *Relative deprivation; specification, development, and integration, United Kingdom, europe*. Cambridge University Press.
Wellesley, D., Hockey, A., & Stanley, F. (2010). The aetiology of intellectual disability in western Australia: A community-based study. *Developmental Medicine and Child Neurology, 33*(11).
Xue, J., Gao, W., & Guo, L. (2014). Informal employment and its effect on the income distribution in urban China. *China Economic Review, 31*, 84–93.
Yoshida, D., Ninomiya, T., Doi, Y., Hata, J., Fukuhara, M., Ikeda, F., Mukai, N., & Kiyohara, Y. (2012). Prevalence and causes of functional disability in an elderly general population of Japanese: The hisayama study. *Journal of Epidemiology, 22*(3), 222–229.
Yuan, Y., & Wu, F. (2014). The development of the index of multiple deprivations from small-area population census in the city of Guangzhou, PRC. *Habitat International, 41*, 142–149.

Yuan, Y., Xu, M., Cao, X., & Liu, S. (2018). Exploring urban-rural disparity of the multiple deprivation index in Guangzhou City from 2000 to 2010. *Cities, 79*(sep), 1–11.

Yu, J., & Xie, Y. (2015). Changes in the determinants of marriage entry in post-reform urban China. *Demography, 52*(6), 1869–1892.

Zhang, L. (2007). *Study on the trend prediction of disabled population in China*. Beijing: Peking University.

Zheng, X. Y., & Chen, S. J. (2011). Life expectancy of people with physical disabilities in China. *Zhonghua Liuxingbingxue Zazhi, 32*(7), 693–696.

Zhang, L., Fu, S., et al. (2020). Prediction of the number of and care costs for disabled elderly from 2020 to 2050: A comparison between urban and rural areas in China. *Sustainability (Switzerland), 12*(7).

Zheng, X., Zhang, L., Chen, G., Pei, L., & Song, X. (2008). [Prevalence of visual, hearing, speech, physical, intellectual and mental disabilities in China, 2006]. *Chinese Journal of Epidemiology, 29*(7), 634–638.

Zhou, Y., & Liu, Y. (2019). The geography of poverty: Review and research prospects. *Journal of Rural Studies, 93*, 408–416.

UN (United Nations), 2015. Transforming our world: the 2030 Agenda for Sustainable Development. (Available at: https://sustainabledevelopment.un.org/post2015/transformingourworld).

Artazcoz, L. and J. Benach, et al. (2004). Unemployment and mental health: understanding the interactions among gender, family roles, and social class. American Journal of Public Health **94** (1): 82-88.

Loayza, N.V. and J. Rigolini (2011). Informal Employment: Safety Net or Growth Engine? World Development **39** (9): 1503-1515.