Child Indicators Research (2024) 17:1715–1740
https://doi.org/10.1007/s12187-024-10137-2

Multidimensional Child Poverty and Spatial Interdependencies in Punjab, Pakistan

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Accepted: 3 May 2024 / Published online: 6 June 2024
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Abstract

Child poverty emerges as a critical concern globally which accentuates the urgency of targeted interventions, emphasizing the pivotal role of addressing this problem for achieving Sustainable Development Goal 1 - No Poverty. This study delves into the multidimensional aspects of child poverty and its spatial interdependencies in Punjab, Pakistan. The data were gathered from the Bureau of Statistics Punjab and UNICEF's Multiple Indicator Cluster Survey 2017-18. A range of household-level indicators including household income, parental education, child age, household size, and district-level factors such as early child development, multidimensional poverty, healthcare facilities, and drinking water availability, are examined by logistic and multilevel logistic regression models to explore the multilevel dynamics of child poverty. The findings indicate that higher household income, improved parental education, and household sizes are significantly linked with a reduction in child poverty. Spatial analysis using Univariate Local Moran's I scatter plot, cluster map, and significance map uncovers notable spatial interdependencies of child poverty within districts. The results emphasize the need for targeted policy-driven healthcare, education, and economic interventions to address diverse aspects of child poverty, applicable to similar developing economies with common socioeconomic and geographical characteristics.

Keywords Multidimensional child poverty · Multilevel logistic regression · Spatial interdependencies · Multiple indicator cluster survey · Punjab

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1 Introduction

The progress and growth of every society are contingent upon the well-being and upbringing of its children. The education, health, and overall development of a nation's children can serve as indicators of its values and prospects for the future (Hallaq & Khalifah, 2022). Child poverty is the failure of a society to meet its primary goal, resulting in children feeling sad due to lacking essential factors that shape their character (Leriou, 2022). In the region of Punjab, which is widely recognized for its rich cultural diversity and economic activity, ensuring the well-being of its children emerges as an urgent imperative. The complex and diverse nature of child poverty needs a thorough analysis and the development of a comprehensive approach (Azomahou et al., 2022; Beltramo et al., 2023; Biggeri & Cuesta, 2021).

Child poverty refers to the condition wherein children live in households with income levels that fall below the designated poverty threshold (McAuley & Rose, 2019). Determining the poverty line often involves figuring out the least amount of money that someone needs to meet their basic wants, like food, shelter, clothing, and other essential items. A lot of government agencies and other relevant organizations use this metric. Poverty among children can diminish social cohesion, which can make economic disasters worse (Leriou, 2019).

The presence of child poverty has been found to have a substantial negative impact on children's overall development and well-being (Beltramo et al., 2023). Children residing in impoverished conditions may have barriers to obtaining the essential resources required for their holistic development and prospects. These resources include things that people need to live, like healthy food, medical care, educational opportunities, and other basic needs. Consequently, individuals may encounter numerous challenges and drawbacks throughout their lifetime, thereby perpetuating a cycle of poverty over successive generations (Biggeri & Cuesta, 2021).

Poverty manifests in several ways in Punjab, a province characterized by its unique amalgamation of urban hubs and rural landscapes (Iqbal et al., 2020). In this context, it is common for children to encounter challenges in obtaining sufficient healthcare services, and essential resources. The development and potential of individuals are impeded by multidimensional deprivation, resulting from interconnected circumstances (Sher et al., 2012). To effectively combat child poverty, it is imperative to incorporate government policies, social programs, and local initiatives that specifically target the reduction of economic disparities and provide assistance to low-income families. This comprehensive approach is essential for addressing the complex issue of child poverty (Cuesta & Meyer, 2018).

Parents with more schooling are better able to meet their children's needs and cultivate an environment that fosters their development. Nevertheless, it is important to note that some regions in Punjab continue to have limited educational opportunities, hence perpetuating a cycle of poverty. Parents who don't have a good education have less earning potential, which makes it harder for them to pay for their children's schooling and overall development (Begum et al., 2012).

The absence of suitable healthcare poses a threat to both the immediate welfare and long-term prospects of a child. Healthcare access in Punjab is subject to differences due to the various landscape of the province, with rural areas often seeing

the most impact (Vaaltein & Schiller, 2017). Children who experience inadequate healthcare are at a heightened risk of contracting preventable diseases, impeding their physical and cognitive development. The intricate interaction between child poverty and the availability of healthcare calls for a more in-depth examination of how these two factors may mutually reinforce each other (Empey et al., 2021).

A larger household typically results in a greater dispersion of limited resources. The household sizes in Punjab exhibit considerable variation across its extensive socioeconomic spectrum, hence influencing the extent of poverty experienced by children in the region. The utilization of resources must be optimized by larger households to mitigate potential challenges in accessing essential services such as healthcare and education (Andresen & Meiland, 2019). To devise effective strategies for addressing the intricate issue of child poverty, it is imperative to get a comprehensive understanding of the impact of family size on this phenomenon (Qi & Wu, 2015).

Nevertheless, it can be argued that household income plays a pivotal role in the underlying causes of child poverty. The financial resources accessible to a family significantly influence a child's growth and potential for achievement (Singh & Sarkar, 2015). Punjab exhibits a significant discrepancy in income, characterized by discernible variations between urban and rural regions. Children who are born into economically disadvantaged households face a range of challenges, as necessities transition into luxuries and schooling becomes a primary objective (Ingutia et al., 2020).

The province of Punjab, situated at a significant historical juncture, is renowned for its noteworthy contributions to the domains of manufacturing, agriculture, and cultural heritage. Notwithstanding the remarkable achievements and affluence observed in the region, it is crucial to acknowledge that certain demographic segments have not experienced commensurate advancements in terms of enhanced welfare. Specifically, the offspring of the region continue to face a multitude of obstacles that impede their growth and hinder their ability to reach their full potential. Child poverty is still a problem in Punjab, making it difficult for young people to have a better future (MICS Punjab, 2018). The comprehension and resolution of these challenges yield advantages for the children and families directly affected, while also exerting an influence on the long-term development of Punjab (Mitik & Decaluwé, 2009; Qi & Wu, 2015).

The objective of this study is to identify the fundamental causes of child poverty that obstruct children's well-being by analyzing its different dimensions and indicators. This study examines the fundamental mechanisms contributing to child poverty by analyzing the factors of parental education, accessibility to healthcare, family size, and income. Existing research has analyzed the multidimensional aspect of child poverty (Ge & Wang, 2019) but falls short of comprehensively addressing the interconnected dynamics, multilevel analysis, and spatial variations of child poverty (Sher et al., 2012), creating a gap. In contrast to previous research, this study offers a comprehensive examination of child poverty, addressing eight distinct dimensions. Categorizing child poverty into three tiers based on the number of dimensions in which children are deprived, provides a nuanced understanding previously lacking. The present study fills this gap by using the latest available data, multilevel logistic regression analysis, and investigating spatial patterns of child poverty to inform targeted interventions for the well-being of children in Punjab. The study's findings offer insights applicable beyond Punjab, providing a roadmap for other regions to

combat child poverty and enhance children's well-being globally. Armed with this knowledge, governmental bodies, advocacy groups, and local communities can collaborate to formulate targeted efforts aimed at alleviating individuals from the grips of poverty.

2 Literature Review

The literature reviewed in this study provides a comprehensive analysis of child poverty, considering various perspectives and scenarios, and highlighting the complex nature of this issue. Examining child poverty from a multidimensional perspective can improve the depth and scope of comprehension, offering a broader awareness of the intricacies and subtleties of this crucial social problem. Previous studies have indicated that child poverty exhibits disparities across nations and regions due to the interplay of cultural dynamics, policy frameworks specific to each place, and socioeconomic factors. It also suggests that a comprehensive understanding of child poverty necessitates thorough data analysis.

The efficacy of anti-poverty measures, particularly those aimed at reducing child poverty, has come under scrutiny in China, highlighting the necessity for a multidimensional approach to tackle this issue effectively (Qi & Wu, 2015). The examination of lived experiences of poverty among children in Germany highlights the importance of children's opportunities and encounters within their socio-spatial and infrastructural contexts. The research findings demonstrate that child poverty is influenced by a combination of contextual, familial, and individual factors, emphasizing the multidimensional nature of the issue (Andresen & Meiland, 2019). Incorporating comprehensive poverty solutions is crucial to addressing multidimensional deprivation experienced by children. Earlier findings suggest childhood deprivation extends beyond low-income households (Singh & Sarkar, 2015).

Significant variations in child poverty rates exist across different regions, underscoring the necessity for targeted interventions. This emphasizes the profound impact of district-specific child poverty on children, particularly concerning issues like overcrowding and enrollment (Sher et al., 2012). By shedding light on the particular challenges faced by children, while also emphasizing the importance of targeted anti-poverty initiatives, the focus is placed on ultimately enhancing children's welfare (Beltramo et al., 2023). Significant disparities persist among children residing in immigrant households within the United States (Acevedo-Garcia et al., 2021). Earlier studies explore the physiological mechanisms linking child poverty to long-term health outcomes. The authors highlight the societal and economic advantages of prioritizing investments in children to alleviate disparities and improve overall well-being (Schmidt et al., 2021). When examining and comparing the circumstances faced by children in China and Bangladesh, it's crucial to consider various factors such as economic development, income disparity, and demographic changes. These factors play a significant role in understanding the causes of child poverty and its variations across different contexts (Begum et al., 2012).

There is a need to enhance understanding by emphasizing conceptual clarity and incorporating children's perspectives in the examination of poverty (McAuley &

Rose, 2019). Academic achievement is suggested to play a moderating role in the relationship between poverty and children's overall well-being (Zhang et al., 2021). There is a pressing need for a comprehensive framework to enhance understanding of the complex interconnections associated with child poverty (Biggeri & Cuesta, 2021). A comparative analysis of child poverty and child support legislation in Colombia and the United States reveals nuanced perspectives on poverty complexities. The importance of comprehensive approaches, encompassing governmental interventions and fair labor market practices, is underscored for meaningful child poverty alleviation (Cuesta & Meyer, 2018). Policy recommendations on child poverty stress the need for rigorous empirical investigations into poverty's impact on children's welfare (Duncan, 2021). The issue of child poverty in Zimbabwe prompts crucial policy considerations. Emphasizing thorough data collection, the importance lies in crafting anti-child poverty policies that specifically target socioeconomic determinants (Musiwa, 2019).

Earlier studies linked child poverty to distinct indicators. Examining the Family Security Act's potential impacts on child poverty, researchers have analyzed proposed tax and transfer system changes aimed at reducing child poverty (Ortigueira & Siassi, 2022). Recognizing the intricate factors behind child poverty and the impact of language and exclusion on understanding, this perspective challenges prevailing views. By delving into the narratives of street children, it advocates for smarter approaches (Aufseeser, 2020). The significance of incorporating children's perspectives into poverty-related research is paramount, highlighting the need for ethical research methodologies (Bessell et al., 2020). Research highlights the pivotal role of women's empowerment in tackling child poverty in Sub-Saharan Africa. Specifically, enhancing women's position within the agricultural sector emerges as a crucial strategy to alleviate poverty among children and foster their educational advancement (Ingutia et al., 2020). Some studies have also linked reductions in child poverty to improvements in gender equity (Ekbrand & Halleröd, 2018). Ambitions contribute to perpetuating inequality among indigenous children. Research findings show that those from disadvantaged backgrounds often aspire to lower-status occupations (Pasquier-Doumer & Brandon, 2015).

A comparison between children entering care and child poverty reveals a linkage, indicating that child poverty may lead to children being placed in care. This underscores the necessity of implementing anti-poverty measures to break this cycle and enhance the welfare of children (Bennett et al., 2022). The examination of challenges faced by caregivers in South Africa reveals significant hurdles as they endeavor to address child poverty. Researchers highlight prevalent issues such as high unemployment rates and inadequate healthcare services, which impede caregivers' efforts. Furthermore, the authors note that the current financial assistance provided to these individuals falls short of meeting the fundamental needs of the children under their care (Vaaltein & Schiller, 2017).

Addressing this child poverty and fostering sustainable development requires governmental interventions, collaboration with non-governmental groups, and legislative measures (Ogwumike & Ozughalu, 2018). To ensure the comprehensive well-being of children, it is advocated for governmental adjustments, recognition of tribal sovereignty, and the revitalization of traditional knowledge and systems (Empey et

al., 2021). The significance of neighborhoods and housing in relation to child poverty underscores the need for comprehensive and interdisciplinary approaches, alongside necessary policy modifications, to ensure the well-being of all children and families (Green et al., 2021). An exploration was made into the extent and root causes of child poverty in metropolitan areas of China, highlighting both theoretical implications and practical consequences. The study suggested policy modifications aimed at mitigating structural risk factors associated with child poverty (Qi & Wu, 2016). The linkage between child poverty, social ties, and academic achievement in rural areas of China was examined, shedding light on the complex connections between poverty, social interactions, and academic performance among children (Ge & Wang, 2019).

This literature study highlights the complex nature of child poverty and emphasizes the need for targeted interventions that prioritize the well-being of children. In exploring child poverty, controversies emerge over methods, definitions, and interpretations. The results indicate a pressing necessity for comprehensive policy reforms, as they shed light on the issue of child poverty and its interconnectedness with health, education, and overall well-being. A research gap exists in the comprehensive examination of child poverty due to a lack of studies incorporating multilevel analysis, which integrates both district and household-level characteristics. These studies often overlook spatial interdependencies and fail to fully grasp the interconnectedness of child poverty with other socioeconomic factors, as well as its spatial spread. By using comprehensive data, this study seeks to close this gap by offering thorough insights into the unique challenges of child poverty and directing focused solutions for the children's well-being.

3 Theoretical Framework

This study's theoretical approach is based on well-established theories and concepts from the domains of socioeconomic well-being, poverty studies, and child development. Fundamentally, the research is guided by the knowledge that a variety of socioeconomic determinants are closely associated with children's well-being. The factors that are being examined are grounded in established theories and are consistent with this viewpoint. The Multidimensional Child Poverty Index (MDCPI) is based on eight different dimensions. This multidimensional method goes beyond conventional income-based metrics to enable a more comprehensive assessment of child poverty. Through the integration of these varied aspects, MDCPI offers a thorough comprehension of the difficulties Punjabi children encounter and enables focused interventions to improve their welfare.

Child poverty arises from a complex interplay of factors. Research suggests that parental financial inclusion plays a role, with families having greater financial access experiencing lower levels of child poverty, particularly benefiting boys and rural children. This influence is evident in significant improvements across living conditions, health, and education, possibly mediated by household income and the accumulation of long-term assets (Koomson et al., 2023). The exacerbation of child poverty amid the COVID-19 response and austerity measures underscores the urgency for comprehensive policy interventions. Addressing the growing inequality, particularly

impacting families with young children, becomes imperative in mitigating these adverse effects (Hayre & Pollock, 2022). The profound link between unemployment and the surge in child poverty underscores the intricate impact of unstable economies on child welfare, highlighting the pressing need for economic stability and targeted interventions to safeguard the well-being of children (Bennett et al., 2020).

The theory behind Household Income (HHI) holds that children's possibilities are mostly shaped by their financial resources. Based on the Family Stress Model, which emphasizes how financial stress affects family dynamics, the study acknowledges that families with greater household incomes have more resources to devote to their children's education, health, and general development (Hartley et al., 2022; Wang et al., 2021; Yu et al., 2023). Human Capital Theory, which maintains that education increases a person's productivity and socioeconomic well-being, serves as the foundation for Parental Education (PEDU). The framework recognizes that greater parental education levels provide a more stimulating home environment, which helps children develop cognitively and socioemotionally (Zhang et al., 2021).

Child Age (CA) is viewed via the framework of Bronfenbrenner's Ecological Systems Theory, acknowledging that a child's experiences and developmental requirements change as they progress through life. This viewpoint emphasizes how crucial it is to modify interventions to meet the unique needs of children of various ages (Pradhan et al., 2022). In examining Household Size (HHS), this study unveils expanding household size is linked to a decrease in multidimensional poverty among children. A larger household size can contribute to the mitigation of child poverty through the consolidation of resources, the sharing of expenses, and the cultivation of mutual support. The presence of a variety of abilities and income sources within households has a vital role in enhancing economic stability (Babalola & Mohd, 2022; Cheung & Chou, 2018).

The Early Child Development Index (ECDI), which emphasizes every child's right to realize their full potential, is in line with the principles of the Convention on the Rights of the Child. This variable highlights the significance of early childhood well-being as a basic ingredient for future development by integrating elements of Maslow's Hierarchy of Needs (Schmidt et al., 2021). Alkire and Foster's capabilities approach to multidimensional poverty measurement serves as the foundation for the Multidimensional Poverty Index (MPI). In contrast to other factors, a greater MPI value denotes a higher level of poverty, highlighting the necessity of addressing poverty on various levels beyond money (Iqbal et al., 2020; Musiwa, 2020).

The Social Determinants of Health framework serves as the foundation for Healthcare Facilities (HF) and Drinking Water Availability (DWA). It acknowledges that a child's health and general well-being are directly impacted by their access to healthcare and basic amenities (Lee et al., 2022; Popoola, 2022). The study attempts to elucidate the complex interactions among these variables and their combined impact on multidimensional child poverty in Punjab through the application of Multilevel Logistic Regression Analysis. To alleviate child poverty and promote the well-being of children in Punjab, evidence-based initiatives are informed by a theoretical framework that provides a strong foundation by combining multiple viewpoints.

4 Data Sources and Methodology

4.1 Data Sources

The data utilized in this study is gathered from the Bureau of Statistics Punjab (BOSP) in partnership with UNICEF, primarily to conduct the Multiple Indicator Cluster Surveys (MICS) across the Punjab region. The partnership between the BOSP and UNICEF guarantees the systematic arrangement and reliability of the statistical data, establishing it as a credible and meaningful resource for this study. To ensure the provision of informed advice and the development of a thorough understanding of children's well-being in Punjab, it is crucial to employ the biggest and latest dataset available (MICS, 2017-18). The MICS, under the supervision of the BOSP, adequately meets this stipulation. The incorporation of level 2 (district level) regressors was undertaken in this study by the utilization of data from the socio-economic profile by district Punjab (SPDP) provided by BOSP. It is important to highlight that the present study utilized a dataset consisting of children under the age of five for the examination of child poverty in Punjab.

Table 1 presents a Multidimensional Child Poverty Index (MDCPI), which encompasses eight distinct dimensions designed to completely assess the welfare of children. Each dimension is linked to a distinct variable that functions as a meter for evaluating various aspects of children's living environment. The MDCPI in this study is developed using the Alkire-Foster method, with equal weighting assigned to each dimension. The Nutrition dimension assesses dietary diversity through 19 specific food items. Children consuming fewer than 10 items are classified as deprived, highlighting concerns about potential nutritional deficiencies. The Leisure dimension assesses children's access to books or picture books, reflecting their access to educational and recreational resources. Lack of access defines deprivation, emphasizing the importance of intellectual engagement.

The Asset Ownership dimension evaluates children's access to commercially manufactured toys. The lack of such toys indicates deprivation, underlining the absence of essential recreational resources. The Health dimension evaluates the child's state of well-being by examining whether the child has experienced an episode of illness accompanied by fever within the past two weeks. A recent fever indicates deprivation, stressing the need for access to healthcare. The Social Service dimension focuses on

Table 1 Multidimensional child poverty index dimensions

Dimension	Variable	Description
1	Nutrition	Dietary intake of 19 items
2	Leisure	Number of children's books or picture books for child
3	Asset Ownership	Toys from a shop or manufactured toys
4	Health	Child ill with fever in last 2 weeks
5	Social Service	Birth registered
6	Child Safety	Beat child up as hard as one could
7	Housing Conditions	Number of rooms used for sleeping
8	Water and Sanitation	Type of toilet facility

Source: Author's creation

birth registration, highlighting the importance of formally acknowledging a child's existence. Lack of registration indicates deprivation, essential for accessing rights.

In the Child Safety dimension, deprivation is identified through the occurrence of severe physical abuse, such as being subjected to beatings. If a child experiences such abuse, it signifies deprivation, highlighting the urgent need for a secure and protective environment. In the Housing Conditions dimension, the number of rooms in the household is assessed to gauge the available living area for children. Deprivation is identified in households with only one room, emphasizing the critical need for adequate living space. In the Water and Sanitation dimension, the accessibility of toilet facility to the child is evaluated, indicating their access to hygienic sanitation facilities. Lack of a toilet facility signifies deprivation in this dimension, essential for maintaining hygiene and health.

The multidimensional approach employed in this study surpasses traditional indicators of child poverty by including a wide range of factors. Through the adoption of a holistic perspective, the index provides a more nuanced and comprehensive assessment of the well-being and living conditions of children. This approach recognizes the multiple characteristics of child poverty. Figure 1 depicts the methodology employed in this work for constructing the multidimensional child poverty index, highlighting the inclusion of eight separate dimensions.

Figure 2 aims to provide a detailed depiction of multidimensional child poverty across 36 districts in Punjab, illustrating poverty levels across more than three, four, and five dimensions. Panel (a) illustrates MDCPI_3, which signifies that children residing in these districts encounter poverty across more than three dimensions of child poverty. Panel (b) illustrates the MDCPI_4, which indicates a heightened level of child poverty, wherein children experience poverty across more than four dimensions. Panel (c) is indicative of the most extreme circumstances, as it displays MDCPI_5, which signifies that children residing in these districts experience deprivation across more than five dimensions. It is imperative to acknowledge that this research covers eight dimensions to assess multidimensional child poverty. In aggregate, the three panels present a comprehensive comprehension of the diverse levels of child poverty within the districts under examination, providing valuable perspectives on the intensity of multidimensional poverty among children in the area. Child poverty is a matter of great concern throughout the 36 districts of Punjab, with particular emphasis on D.G. Khan, Muzaffargarh, and Rajanpur.

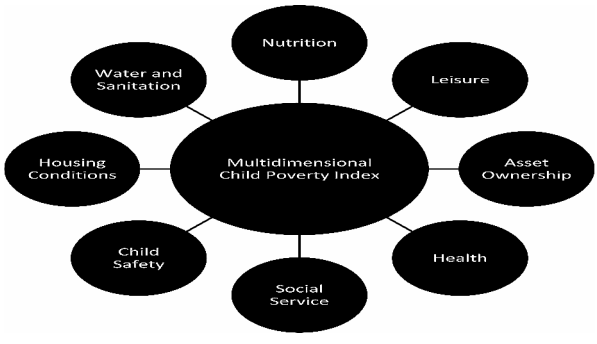

Fig. 1 Multidimensional child poverty index. Source: Author's Creation

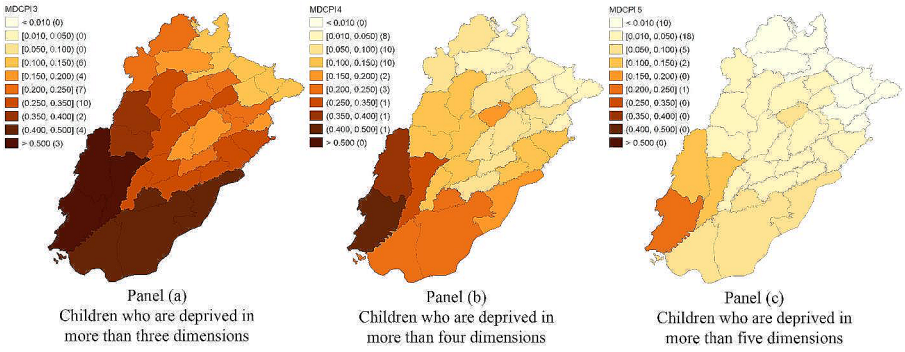

Fig. 2 Multidimensional child poverty in Punjab. Source: Author's Creation

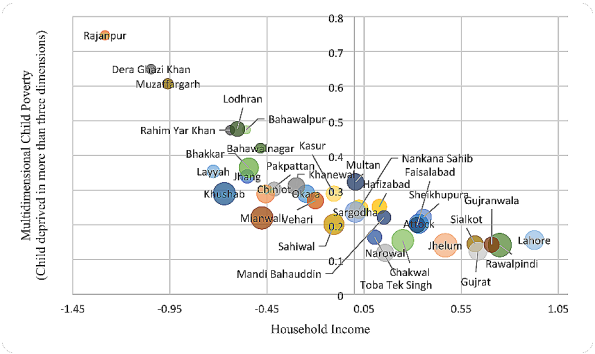

Fig. 3 MDCPI, household income, and parental education in Punjab. Source: Author's Creation

The aim of Fig. 3 is to visually depict the interrelationship among multidimensional child poverty, household income, and parental education across 36 districts in Punjab. The vertical axis of the graph reflects the average level of multidimensional child poverty (MDCPI_3), where higher positions on the axis indicate higher levels of child poverty. The horizontal axis of the graph represents average household income, where districts on the right side are characterized by higher incomes and those on the left side are characterized by lower incomes. The magnitude of each bubble is indicative of the degree of parental education, whereby larger bubbles represent higher levels and smaller ones imply lower levels. It is worth mentioning that Lahore stands out as having the greatest average household income, bringing it into the affluent segment of the income distribution. Conversely, Rajanpur demonstrates the lowest average household income, placing it at the opposite end of the economic spectrum. Moreover, it has been observed that Bahawalpur is characterized by the lowest mean level of parental education, whilst Jhelum exhibits the highest level. When considering the average levels of multidimensional child poverty, Narowal exhibits the lowest rates, while Rajanpur demonstrates the highest rates. This visualization offers a thorough depiction of the discrepancies in household income, parental education, and multidimensional child poverty. It allows for a quick and intuitive evaluation of the distinct circumstances present in 36 districts of Punjab.

Table 2 Description of variables

Variable	Description	Measurement	Source	Level of Variables
$MDCPI_{ij}$	Multidimensional Child Poverty Index	MDCPI Index (CP = 1 if child is multidimensionally deprived, 0 otherwise)	MICS	Household
HHI_{ij}	Household Income	Household wealth score, a composite standardized measure, indicating the economic status of households. A negative value reflects lower economic status relative to the sample mean and vice versa.	MICS	Household
$PEDU_{ij}$	Parental Education	Education of household head, spans from 0 to 4 (none/preschool = 0, primary = 1, middle = 2, secondary = 3, and higher education = 4)	MICS	Household
CA_{ij}	Child Age	Age of child from 0 to 4 years	MICS	Household
HHS_{ij}	Household Size	Number of Household members	MICS	Household
$ECDI_j$	Early Child Development Index	Children's well-being for early development status	SPDP	District
MPI_j	Multidimensional Poverty Index	MPI Poor People (%)	SPDP	District
HF_j	Healthcare Facilities	Lady health worker visited the house during the past month (%)	SPDP	District
DWA_j	Drinking Water Availability	Availability of sufficient drinking water (%)	SPDP	District

Source: Author's creation

Table 3 Descriptive statistics

Variables	Obs	Mean	Std. Dev.	Min	Max	Skew.	Kurt.
MDCPI_3	39,849	0.289	0.454	0	1	0.928	1.862
MDCPI_4	39,849	0.121	0.326	0	1	2.327	6.413
MDCPI_5	39,849	0.036	0.186	0	1	4.981	25.807
HHI	39,849	-0.057	0.993	-3.111	2.497	-0.197	2.464
PEDU	39,849	1.411	1.408	0	4	0.489	1.826
CA	39,849	1.989	1.412	0	4	-0.004	1.700
HHS	39,849	8.396	4.247	2	45	2.079	10.662
ECDI	39,849	65.959	10.943	44.100	91.700	0.012	2.551
MPI	39,849	27.104	14.700	6.200	65.800	0.554	2.665
HF	39,849	56.615	19.134	11.900	90.100	-0.318	2.471
DWA	39,849	91.661	4.195	80.200	98.300	-0.301	2.567

Source: Author's estimation

Table 2 presents a comprehensive list of crucial variables that are integral to the study. These variables encompass the Multidimensional Child Poverty Index, Household Income, Parental Education, Child Age, Household Size, Early Child Development Index, Multidimensional Poverty Index, Healthcare Facilities, and Drinking Water Availability. Every variable is deliberately selected to completely analyze child poverty in the region of Punjab.

Table 3 representing descriptive statistics, offers a concise overview of important characteristics within the dataset, presenting a summary of measures of central ten-

dency and dispersion. The utilization of this tool is of utmost importance in facilitating a rapid comprehension of the inherent attributes of the data, hence assisting in the process of decision-making and subsequent analysis. The MDCPI_3 is an index used to determine the poverty status of a child who is experiencing deprivation in more than three dimensions. Moreover, MDCPI_4 defines a child as poor when experiencing deprivation in more than four dimensions, encompassing a broader range of vulnerability. Moreover, the MDCPI_5 identifies a child as impoverished when they encounter deprivation in more than five dimensions, thereby providing a comprehensive and intricate evaluation of multidimensional poverty. When the multidimensional poverty index is equal to 1, it indicates that a child is considered poor; conversely, a value of 0 signifies that the child is not in poverty.

4.2 Methodology

This study employs the Alkire-Foster method, a robust framework known for its thorough approach to assessing child poverty. This approach offers a comprehensive understanding of poverty dynamics by examining various dimensions (Mishra et al., 2022; Tavares & Betti, 2021). Having detailed information allows policymakers to create precise interventions customized to particular requirements, thus improving the effectiveness of poverty reduction initiatives (McAuley & Rose, 2019). The present study innovatively employed this method to assess multidimensional child poverty by delineating three distinct intensity levels within the multidimensional child poverty index. The utilization of this methodological framework facilitates a detailed examination of child poverty, hence enhancing a more intricate and situation-specific comprehension of the difficulties encountered by children concerning diverse aspects of their overall welfare.

The present study conducts a thorough investigation of the various factors that impact multidimensional child poverty, utilizing a dual analytical methodology. The study commences by employing a Logistic Regression Model (LRM) to ascertain the influence of different predictors on MDCPI. Following this, the study proceeds to employ a Multilevel Logistic Regression Model (MLRM) to uncover the intricate factors that contribute to child poverty, taking into account the hierarchical nature of the data. By incorporating both individual and contextual factors, these models provide a comprehensive framework for comprehending the complex interaction between household-level traits and district-level characteristics in influencing the multidimensional poverty experienced by children in Punjab. The utilization of this dual technique enhances the analysis by including the diverse aspects of child poverty, hence yielding significant insights into the distinct dynamics at both household and district levels within the specified geographical setting. In the logistic regression analysis, this study prioritized the utilization of estimated coefficients instead of log odds to improve the comprehensibility of the findings and provide a better understanding of the nature of underlying linkages for a broader audience. The determination of the cutoff points of indices utilized in this study is carried out by a rigorous examination and analysis of the data.

4.2.1 The Logistic Regression Model

This study initially applied a logistic regression model technique to evaluate the impact of different regressors on the MDCPI. The analysis tool of choice for examining the effect of the chosen independent variables on multidimensional child poverty is logistic regression. By systematically examining the linkages between the selected variables and how they affect child poverty as a whole, this method offers an important new understanding of the factors that contribute to MDCPI.

$$\begin{aligned} MDCPI_{ij} =& \alpha_1 + \alpha_2 HHI_{ij} + \alpha_3 PEDU_{ij} + \alpha_4 CA_{ij} \\ &+ \alpha_5 HHS_{ij} + \alpha_6 ECDI_j + \alpha_7 MPI_j + \alpha_8 HF_j \\ &+ \alpha_9 DWA_j + \epsilon_{1ij} \end{aligned} \tag{1}$$

where Eq. (1) is the logistic regression model estimated in the current investigation. The slope coefficients of regressors are denoted by α's, i represents the household and j represents the district, while the error term ε_{1ij} represents unobserved components or random variability that affects the MDCPI and is not accounted for by the independent variables. The study seeks to offer important insights into the combined impact of these variables on child poverty through a methodical analysis. This research intends to provide a comprehensive understanding of the elements that influence the MDCPI.

4.2.2 The Multilevel Logistic Regression Model

Following the initial application of LRM, this study further enhanced its analytical methodology by using an MLRM to examine the variation in MDCPI across 36 districts of Punjab. The use of an MLRM is justified by its ability to consider the hierarchical nature of the data, acknowledging that children are situated within districts. This methodology facilitates a more comprehensive comprehension of the disparity in MDCPI among various districts, encompassing both the impacts at the household level and the elements at the district level that might contribute to child poverty. Through an examination of the multilevel structure, this study aims to reveal both the comprehensive extent of child poverty and the contextual intricacies at the district level, thereby illuminating the varied socioeconomic environments present within the region of Punjab. The utilization of multilevel modeling in this specific context offers notable benefits, as it facilitates a more precise and resilient analysis. By considering the hierarchical structure of the data, this approach provides valuable insights into the influence of district-level factors on the multidimensional poverty of children. In contrast, a simplistic Logistic Regression model would be limited in its ability to discern such impacts. The MLRM used in this study is presented below.

$$MDCPI_{ij} = \beta_{0j} + \beta_{1j} HHI_{ij} + \beta_{2j} PEDU_{ij} + \beta_{3j} CA_{ij} + \beta_{4j} HHS_{ij} + \epsilon_{2ij} \tag{2}$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01} ECDI_j + \gamma_{02} MPI_j + \gamma_{03} HF_j + \gamma_{04} DWA_j + \mu_{0j} \tag{3}$$

$$\beta_{1j} = \gamma_{10} \tag{4}$$

$$\beta_{2j} = \gamma_{11} \tag{5}$$

$$\beta_{3j} = \gamma_{12} \tag{6}$$

$$\beta_{4j} = \gamma_{13} \tag{7}$$

$$\begin{aligned} MDCPI_{ij} =& \gamma_{00} + \gamma_{01} ECDI_j + \gamma_{02} MPI_j + \gamma_{03} HF_j \\ &+ \gamma_{04} DWA_j + \gamma_{10} HHI_{ij} + \gamma_{11} PEDU_{ij} \\ &+ \gamma_{12} CA_{ij} + \gamma_{13} HHS_{ij} + \mu_{0j} + \epsilon_{2ij} \end{aligned} \tag{8}$$

where Eq. (8) comprises a multilevel model structure (mixed model) aimed at examining the determinants of the MDCPI within the context of different districts in Punjab. The level-1 Eq. (2) depicts the household-level linkage between the MDCPI for a child in household *i* within district *j* and various predictors, including HHI_{ij}, $PEDU_{ij}$, CA_{ij}, and HHS_{ij}. The level-2 Eq. (3) showcases district-level variation, with β_{0j} representing the mean multidimensional child poverty in district *j*. The district-level intercept β_{0j} is further modeled in the level-2 equation as a function of district-specific variables ($ECDI_j$, MPI_j, HF_j, DWA_j). The coefficients β_{1j}, β_{2j}, β_{3j} and β_{4j} at level-1 are linked to district-level predictors at level-2 ($\gamma_{10,}$ $\gamma_{11,}$ γ_{12} and γ_{13}), forming a comprehensive mixed model. Here ε_{2ij} is the level-1 residual associated with household *i* in district *j*, γ_{00} is the grand mean (i.e. mean of all district *j* means / intercepts), and μ_{0j} is the level-2 residual for district *j*. Finally, Eq. (8) comprehensively represents the collective influence of both household and district-level influences on the MDCPI. The utilization of a multilevel model offers a comprehensive framework for analyzing the intricate linkages between child poverty and the factors that contribute to it.

4.2.3 Moran's I

Moran's I, a fundamental spatial autocorrelation statistic, is employed in the present study to assess spatial interdependencies of child poverty in 36 districts of Punjab. At the outset, a spatial distance (kilometer) weights matrix (36×36) is constructed to check the spatial interdependencies among observations. Then normalization of the dataset is a crucial procedure that guarantees uniformity in both the range and distribution of the data. Subsequently, the computation of spatially lagged values is executed, which entails determining the mean value of adjacent observations for any given district. The calculation for Moran's I involves the utilization of normalized values, spatial weights, and the mean of the variable across all districts. The resultant statistic has the potential to be positive, indicating the presence of spatial interdependencies, or negative, implying the occurrence of dispersion.

$$I = \frac{n}{W} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n} (x_i - \bar{x})^2} \tag{9}$$

where Eq. (9) represents the formula for Moran's I, here n is the number of observations, W is the sum of spatial weights, w_{ij} represents the spatial weight between districts i and j, x_i and x_j are the values of child poverty at district i and j respectively, $\overline{x}$ denotes the mean of child poverty across all districts.

5 Results and Interpretation

To ensure the robustness of the findings, this study examines how results fare across three distinct intensity levels of the MDCPI, namely MDCPI_3 (child poverty in more than 3 dimensions), MDCPI_4 (child poverty in more than 4 dimensions), and MDCPI_5 (child poverty in more than 5 dimensions). The findings from the logistic regression analysis presented in Table 4 demonstrate discernible patterns for each independent variable with respect to varying levels of child poverty. To begin, it is seen that the HHI_{ij} displays negative coefficients for low, moderate, and high child poverty. This suggests that an increase in the HHI_{ij} is statistically associated with a significant drop in child poverty (Hartley et al., 2022). Likewise, the variables *PED-*

Table 4 Results of the logistic regression analysis

MDCPI	Low Child Poverty MDCPI_3	Moderate Child Poverty MDCPI_4	High Child Poverty MDCPI_5
	Coef.	Coef.	Coef.
HHI_{ij}	-1.3068***	-1.4856***	-1.6677***
	(0.0208)	(0.0281)	(0.0475)
$PEDU_{ij}$	-0.0590***	-0.0953***	-0.0818***
	(0.0114)	(0.0168)	(0.0303)
CA_{ij}	-0.7685***	-0.7477***	-0.8567***
	(0.0115)	(0.0155)	(0.0279)
HHS_{ij}	-0.1118***	-0.1425***	-0.1862***
	(0.0040)	(0.0063)	(0.0119)
$ECDI_j$	-0.0031*	-0.0020	0.0055
	(0.0018)	(0.0024)	(0.0041)
MPI_j	0.0204***	0.0201***	0.0257***
	(0.0012)	(0.0015)	(0.0027)
HF_j	-0.0102***	-0.0080***	-0.0065***
	(0.0010)	(0.0014)	(0.0024)
DWA_j	-0.0167***	-0.0146***	-0.0103
	(0.0033)	(0.0044)	(0.0075)
Constant	2.8148***	0.8635**	-1.9216**
	(0.3159)	(0.4308)	(0.7469)
Number of obs	39,849	39,849	39,849
LR chi^2	15870.00***	10521.01***	4753.38***
Pseudo R^2	0.3309	0.3582	0.3847
Log likelihood	-16042.022	-9426.9461	-3801.9984
AIC	32102.04	18871.89	7621.997
BIC	32179.38	18949.23	7699.332

Source: Author's Estimations, *** prob. <0.01, ** prob. <0.05, * prob. <0.1 (Standard Error values are in parentheses)

U_{ij}, CA_{ij}, and HHS_{ij} have negative coefficients, indicating that elevated values of these factors are associated with a reduced likelihood of encountering elevated levels of child poverty. The factors of parental education, child age, and household size have a notable impact on the reduction of child poverty in Punjab through the facilitation of enhanced income and effective resource allocation. The dynamics between parental education, the age of the child, and the size of the family play a pivotal role in alleviating child poverty in the region of Punjab (Babalola & Mohd, 2022; Pradhan et al., 2022; Zhang et al., 2021).

Conversely, $ECDI_j$ demonstrates a nuanced pattern. While an increase in $ECDI_j$ is associated with a statistically significant decrease in child poverty (Schmidt et al., 2021), the coefficient becomes positive for high child poverty, however, its coefficient is insignificant. MPI_j shows positive coefficients for child poverty, indicating that an increase in MPI_j is associated with higher child poverty. This finding is in line with earlier investigations (Musiwa, 2020). HF_j has a negative coefficient, meaning it is reducing child poverty in Punjab. The provision of healthcare services in easily reachable facilities plays a crucial role in disrupting the cycle of child poverty through the timely implementation of interventions, preventative care measures, and the dissemination of health education. This finding is in line with earlier investigations (Lee et al., 2022).

DWA_j exhibits a noteworthy pattern, wherein its augmentation is linked to a reduction in the number of children being in poverty. The provision of drinking water has been shown to mitigate child poverty by its positive impact on health outcomes, the prevention of waterborne diseases, and the facilitation of regular school attendance among children, hence disrupting the perpetuation of poverty (Popoola, 2022).

Table 5 presents the results of a multilevel logistic regression analysis investigating the linkages of child poverty. The coefficients corresponding to each variable offer valuable insights into their influence on encountering low, moderate, and high child poverty. The results indicate that HHI_{ij} consistently displays negative coefficients for all child poverty categories, indicating that an increase in household income is linked to a decrease in levels of child poverty. A higher level of family income affords families greater resources, facilitating their ability to obtain necessary products and services, upgrade their living conditions, and provide improved educational and well-being possibilities for their children. An increase in household income is associated with an enhanced ability of families to fulfill the fundamental requirements of their children, consequently diminishing the probability and intensity of child poverty (Hartley et al., 2022). Likewise, the coefficient of $PEDU_{ij}$ reveals a comparable pattern, suggesting a persistent negative linkage between elevated levels of parental education and the chances of child poverty. There exists a positive linkage between higher levels of parental education and enhanced cognitive abilities, expertise, and income prospects, hence facilitating parents in attaining more favorable job prospects. Consequently, this leads to a heightened level of financial stability within the household, thereby diminishing the probability of child poverty (Zhang et al., 2021).

CA_{ij} exhibits negative coefficients, indicating that as the age of the child increases, there is a corresponding decrease in child poverty across all levels. During the developmental phase from early childhood to school age, the opportunity to receive education, less reliance on parental support, and the possibility of higher household income

Table 5 Results of the multilevel logistic regression analysis

MDCPI	Low Child Poverty MDCPI_3	Moderate Child Poverty MDCPI_4	High Child Poverty MDCPI_5
	Coef.	Coef.	Coef.
HHI_{ij}	-1.3908***	-1.5674***	-1.7214***
	(0.0218)	(0.0296)	(0.0495)
$PEDU_{ij}$	-0.0382***	-0.0673***	-0.0570*
	(0.0116)	(0.0171)	(0.0308)
CA_{ij}	-0.7842***	-0.7622***	-0.8645***
	(0.0117)	(0.0158)	(0.0281)
HHS_{ij}	-0.1112***	-0.1428***	-0.1842***
	(0.0042)	(0.0065)	(0.0121)
$ECDI_j$	-0.0033	-0.0037	0.0022
	(0.0073)	(0.0075)	(0.0090)
MPI_j	0.0173***	0.0146***	0.0228***
	(0.0046)	(0.0047)	(0.0056)
HF_j	-0.0109***	-0.0085**	-0.0077
	(0.0041)	(0.0042)	(0.0052)
DWA_j	-0.0160	-0.0120	-0.0035
	(0.0135)	(0.0138)	(0.0162)
Constant	2.8312**	0.8493	-2.2807
	(1.3059)	(1.3405)	(1.5984)
District var(Constant)	0.1102	0.10782	0.1170
	(0.0282)	(0.0294)	(0.0432)
Number of obs	39,849	39,849	39,849
Number of groups	36	36	36
Obs per group: Min	632	632	632
Average	1,106.9	1,106.9	1,106.9
Maximum	2,118	2,118	2,118
Wald chi^2	7358.26***	4713.97***	2157.11***
Log likelihood	-15847.027	-9332.266	-3784.1176
LR test vs. logistic model $chibar^2$	389.99***	189.36***	35.76***
AIC	31714.05	18684.53	7588.235
BIC	31799.98	18770.46	7674.164
District level ICC	0.0324	0.0317	0.0343
	(0.0080)	(0.0084)	(0.0123)

Source: Author's Estimations, *** prob. <0.01, ** prob. <0.05, * prob. <0.1 (Standard Error values are in parentheses)

resulting from parental employment collectively contribute to a reduction in child poverty (Pradhan et al., 2022). The findings indicate that an increase in HHS_{ij} is linked to a reduction in child poverty. The presence of a larger household size has the potential to mitigate child poverty through the consolidation of resources, collective sharing of expenses, and cultivation of mutual support among family members. These dynamics contribute to the establishment of a more robust financial milieu for children. The presence of a variety of talents and income sources within households has been found to play a significant role in promoting economic stability (Babalola & Mohd, 2022).

The significance of pleasant early experiences is shown by the theorized link between a higher $ECDI_j$ score and a diminished likelihood of child poverty. The aforementioned experiences play a significant role in the developmental process of children, establishing a fundamental basis for their long-term welfare and economic adaptability (Schmidt et al., 2021). Nonetheless, the lack of statistical significance in the coefficient of $ECDI_j$ indicates the necessity for further investigation or the inclusion of contextual intricacies.

The coefficient of MPI_j in child poverty models demonstrates a positive linkage, indicating that an increase in multidimensional poverty is associated with a higher likelihood of child poverty. MPI_j is closely linked with $MDCPI_{ij}$ as it serves as an indicator of deficiencies in education and health. A higher MPI score indicates an elevated level of difficulties faced by children, hence necessitating focused interventions to address the many dimensions of poverty (Musiwa, 2020).

The negative coefficients for HF_j indicate that there is a negative linkage between enhanced health facilities and a decrease in child poverty. It highlights the significant importance of improved healthcare availability in mitigating economic susceptibility among children, thus influencing not only their current welfare but also molding their future opportunities for both health and financial success (Lee et al., 2022). The linkage between access to drinking water and reduced child poverty is established through the facilitation of health promotion, mitigation of waterborne diseases, and improvement of general well-being (Popoola, 2022). However, the present study does not find statistically significant coefficients of DWA_j for child poverty.

District-level variations are explored through variance components for the intercept, indicating a significant impact of district-level differences on child poverty. The district-level intraclass correlation coefficients (ICC) reveal that district-level differences contribute to a proportion of the total variance in child poverty. The LR test results, particularly the highly significant chi-square values (chibar^2), imply a substantial difference in model fit. Specifically, these findings suggest that the traditional logistic regression model may be less effective in explaining the data compared to the multilevel logistic regression approach. Therefore, the results recommend adopting the multilevel logistic regression as a more suitable and superior method for analyzing the given dataset.

The results show Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values for the three models. Lower values indicate better model fit with lower complexity. The third model has the lowest AIC (7588.235) and BIC (7674.164), suggesting it is the preferred model in terms of balancing goodness of fit. The log-likelihood values (-15847.027, -9332.266, -3784.1176) represent the goodness of fit for three models, with higher values indicating better fit; thus, the third model (high child poverty) seems to provide the best fit for the given data. Model fits are also supported by the Wald chi-square tests. Figure 4 succinctly illustrates the comprehensive findings and the interrelation between variables in a single, visually informative diagram. It demonstrates that household income, parental education, child age, household size, ECDI, health facilities, and drinking water availability are associated with a reduction in child poverty, while MPI is linked to an increase in child poverty.

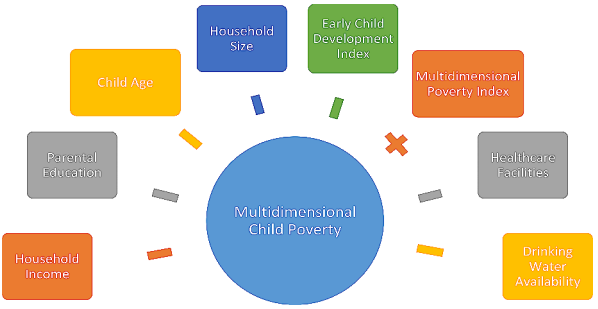

Fig. 4 Summary of empirical findings. Source: Author's Creation

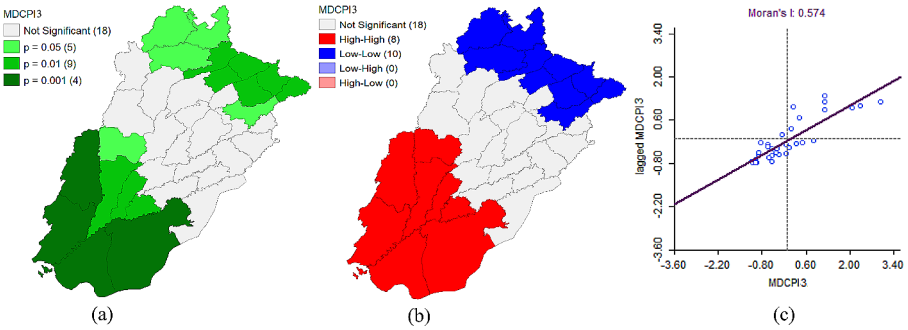

Fig. 5 MDCPI_3's Local Moran's I Significance Map, Cluster Map, and Scatter Plot. Source: Author's Creation

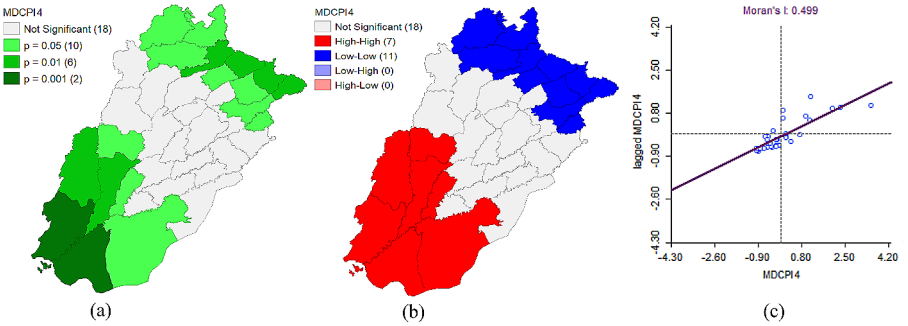

Fig. 6 MDCPI_4's Local Moran's I Significance Map, Cluster Map, and Scatter Plot. Source: Author's Creation

Figures 5, 6, and 7 depict the Univariate Local Moran's I significance map in panel (a). The significance map provides a visual representation of the geographical distribution of local Moran's I values across Punjab. This statistic looks at the spatial autocorrelation between individual observations. More specifically, it looks at the correlation between MDCPI_3, MDCPI_4, and MDCPI_5 in each district and the places close by. According to the statistical significance of the local Moran's I values, the maps show different areas using a color-coding system. Darker shades mean

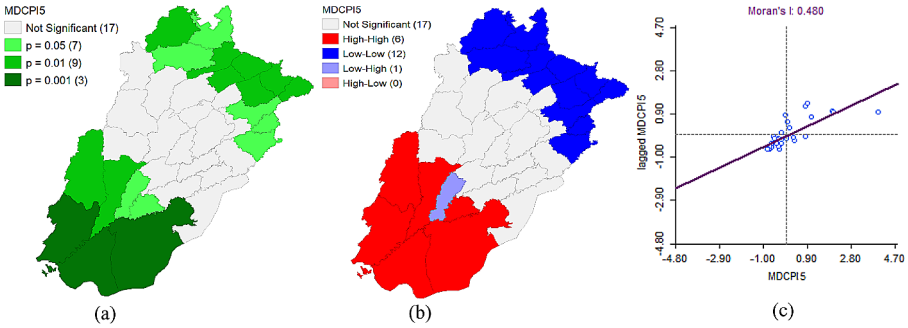

Fig. 7 MDCPI_5's Local Moran's I Significance Map, Cluster Map, and Scatter Plot. Source: Author's Creation

higher statistical significance (e.g., p-value = 0.001). This method makes it easier to find "hot spots," which are clusters that have values that are either very high or very low and are surrounded by values that are similar. It also makes it possible to find "cold spots," which are clusters with high values surrounded by low values or the other way around. Using this method gives information about the dataset's spatial patterns and correlations. The significance map highlights pronounced statistically significant clustering in districts such as Bahawalpur, D.G Khan, Rahim Yar Khan, and Rajanpur.

The cluster map presented in Panel (b) of Figs. 5, 6, and 7 is a graphical representation that illustrates the geographical clusters present in Punjab. Each place on the map is assigned a specific color based on the results of the respective local Moran's I analysis. The map utilizes distinct colors to represent areas of high values surrounded by other high values (referred to as hot spots indicated by red color) and areas of low values surrounded by other low values (referred to as cold spots indicated by blue color). The intensity of the colors or symbols is indicative of the strength of clustering. Through a careful examination of the map, it is possible to identify specific districts exhibiting significant spatial concentrations, hence providing valuable insights into the localized distribution patterns characterized by either elevated or diminished values. This comprehension surpasses worldwide tendencies, offering a sophisticated perspective on diversities. The cluster map reveals pronounced high-high clustering in districts like Bahawalpur, D.G Khan, Layyah, Lodhran, Multan, Muzaffargarh, Rahim Yar Khan, and Rajanpur. Conversely, it also illustrates distinct low-low clustering in districts including Attock, Chakwal, Gujranwala, Gujrat, Jhelum, Kasur, Lahore, Mandi Bahauddin, Narowal, Rawalpindi, Sheikhupura, and Sialkot.

The Univariate Local Moran's I scatter plot represented in panel (c) of Figs. 5, 6, and 7 is employed as a visual aid to depict the relationship between the values of MDCPI_3, MDCPI4, and MDCPI5, respectively, in a specific district and the average value of child poverty in the neighboring districts. Every data point depicted on the plot corresponds to a unique spatial entity, akin to a specific location on a map. The spatial coordinates of each point are defined by two primary factors: the MDCPI's value at the specific district and the mean value of MDCPI in the surrounding locations. Through the use of plotted points, the Moran scatter plot offers significant

insights into the spatial patterns and interactions pertaining to multidimensional child poverty. This aids in the development of a full comprehension of its distribution and clustering. Analyzing spatial interdependencies is crucial for comprehending poverty across different regions (Xiao et al., 2023).

The Moran's I value varies between −1 and 1, representing the degree of spatial correlation: -1 signifies perfect negative correlation, 1 signifies perfect positive correlation, and 0 indicates no spatial correlation. The estimated Moran's I values of 0.574, 0.499, and 0.480, respectively, for child poverty indices observed across the 36 districts of Punjab, Pakistan, indicate the presence of statistically significant positive spatial autocorrelation. This observation implies the presence of a spatial clustering effect, indicating that surrounding districts exhibit similar values for child poverty. This suggests that child poverty is disseminated among adjacent districts, with those exhibiting higher levels of child poverty often situated near others experiencing similar challenges.

6 Conclusion and Policy Recommendations

This study signifies a pivotal advancement in tackling the pressing matter of multidimensional child poverty in Punjab, acknowledging its far-reaching consequences for societal advancement and welfare worldwide. Despite the economic strength of Punjab, specific demographic groups, particularly children, continue to face ongoing difficulties associated with poverty, limited access to healthcare, and inadequate educational opportunities. Using a comprehensive analytical approach, this study employs logistic and multilevel logistic regression models to examine the factors that contribute to child poverty. This study is novel due to its comprehensive examination of several dimensions of child poverty, innovative methodology, and incorporation of spatial analysis, providing valuable insights into addressing multidimensional child poverty.

The results highlight the interrelatedness of several factors that contribute to child poverty in the region. Various factors continuously appear as key drivers of child poverty at different levels, including household income, parental education, child age, and household size. It is worth noting that there is a clear linkage between increased household income and parental education and a decreased probability of child poverty. This highlights the significance of economic and educational empowerment for families in alleviating the adverse effects of poverty on children.

Child age and household size are significant factors in decreasing child poverty. As children mature, they acquire access to educational and job prospects, and larger families can combine resources to improve financial stability and better withstand poverty. The ECDI, HF, and DWA are crucial in alleviating child poverty. ECDI programs enhance child development, while healthcare access decreases financial burdens and enhances well-being. Access to clean water reduces the risk of diseases, improving children's overall health. MPI is exacerbating child poverty, exposing the intricate levels of deprivation that children experience.

The logistic regression model unveils discernible patterns for each variable, revealing their contributions to varying levels of child poverty. The incorporation of

the MLRM enhances the examination, providing nuanced perspectives on the hierarchical structure of child poverty in Punjab. The findings of the study provide support for the utilization of the MLRM as a more effective approach for assessing the information. This approach effectively encompasses the intricacies of child poverty by including both household and district-level factors, hence offering a more precise comprehension of the intricate dynamics within the region of Punjab.

The finding of spatial interdependencies within districts by Univariate Local Moran's I and their influence on child poverty highlights the necessity for interventions that are specifically tailored to the context to effectively tackle the complex issues experienced by children in diverse districts. The understanding of geographical patterns of child poverty has a dual purpose: it not only enhances the knowledge base for targeted policy interventions but also highlights the significance of localized methods designed to tackle the distinct obstacles encountered by communities. This study contributes to the academic field by offering a novel methodology and addressing a significant gap in the current body of literature. The study acknowledges certain constraints despite its efforts to address child poverty in Punjab, Pakistan. The reliance on MICS data and the regional specificity of findings are acknowledged shortcomings. Additionally, the study's delimitations encompass a concentration on recent data, potential oversight of external factors, and a narrow socioeconomic perspective. However, this study's findings have global relevance, enabling countries facing similar situations to analyze results and apply the study's insights to examine child poverty.

The study establishes the foundation for targeted strategies aimed at promoting equal opportunities and improving the prospects of children in Punjab's various districts. The study recognizes the diverse contextual elements that impact child poverty. Primarily, this study advocates for the implementation of focused educational initiatives, with a particular emphasis on places that have low educational resources. The objective is to disrupt the recurring linkage between parental education and child poverty. Furthermore, it is imperative to formulate policies aimed at mitigating the income discrepancies that exist between regions, promoting a more equitable distribution of economic possibilities among households. It is recommended to implement skill development programs and vocational training initiatives to enhance the employability of parents, hence leading to an improvement in household income levels.

In addition, it is imperative to implement strategies aimed at improving access to healthcare services. It is recommended that the implementation of awareness initiatives focused on preventative healthcare be considered as a means to mitigate the prevalence of diseases among children. This study highlights the significance of enhancing water and sanitation infrastructure, particularly in regions characterized by restricted availability of clean drinking water. The implementation of interventions that are specific to each district is of utmost importance, as it allows for the development of customized programs that effectively tackle the distinct difficulties faced by each district.

Community engagement is advocated as a crucial approach, aiming to stimulate active participation in decision-making procedures about the mitigation of child poverty, with the ultimate goal of cultivating a sense of ownership and empower-

ment among individuals. It is recommended that capacity-building programs be implemented for local authorities to strengthen their efficacy in implementing and monitoring poverty reduction measures. The prioritization of long-term planning and sustainable development is important, wherein the integration of initiatives aimed at reducing child poverty is incorporated into comprehensive, inclusive, and sustainable growth strategies. The set of policy recommendations presented here is a comprehensive framework aimed at tackling child poverty in Punjab, recognizing the interconnected nature of the challenges and proposing targeted, evidence-based strategies for improvement.

Author Contributions Syed Jaffar Abbas: Conceptualization, Writing-Original draft preparation, Data curation, Methodology, Formal analysis, Investigation. Asim Iqbal: Methodology, Formal analysis, Reviewing and Editing, Validation, Supervision.

Funding This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data Availability We have used MICS data with permission from BOSP. The data may collected by requesting BOSP (https://bos.punjab.gov.pk/downloads), and we do not have the rights to share it without their permission.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent for Publication The authors give permission for this paper to be published.

Competing Interest The authors affirm that there are no financial or personal conflicts that would have seemed to have an impact on the research presented in this study.

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