



Research Article

Opportunity Differential in Early Childhood Development in Punjab, Pakistan: Role of Stunting

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Abstract

Persistent inequalities in Early Childhood Development (ECD) services pose a major challenge to equitable human development. These disparities can limit a child's future potential and reinforce the cycle of poverty and inequality. The aim of this study is to examine the extent and sources of opportunity differentials in ECD in Punjab, Pakistan by analyzing how various socioeconomic and demographic factors affect children's early access to essential ECD services. This study explores opportunity differentials in ECD among children aged 3 to 5 years in Punjab, Pakistan, using data from the Multiple Indicator Cluster Survey (MICS) 2017. Drawing upon the Human Opportunity Index (HOI) within the Equality of Opportunity framework, the research quantifies inequalities in access to key developmental opportunities such as literacy, cognitive skills, motor development and social behaviour. In second stage of analysis, Shapley decomposition analysis is utilized, to assess the circumstance based factors contribution in inequality of opportunity. The analysis reveals significant contribution of each circumstance factor to inequality. Stunting is found as the largest contributor of inequality in behaving well with others with 57.5% and 20.4% in reading skills. Early childhood education contributing 20.5% in word recognition, 40% in alphabet recognition, and 28.3% in being able to perform small tasks, followed by household wealth contributing 35.5 % to follow directions, 26.7% to get distracted, 16.1% contribute to health in large proportion while child gender accounts for the smallest share. The study concludes that targeted policy interventions are urgently needed to reduce ECD disparities.

Keywords: Early childhood development, Inequality of opportunity, Pakistan.

Introduction

Early childhood development (ECD) is a crucial period that shapes cognitive, physical and socio-emotional outcomes in later life (Chaparro et al., 2020). ECD shapes a child's future well-being, educational attainment and economic productivity. This stage occurs from birth to age eight when the brain undergoes rapid development and forms key neural connections. Positive early experiences such as access to quality education, adequate nutrition, and stimulating environments are vital for laying the groundwork for future success in school, relationships, and overall well-being. These early years are foundation for building the skills and abilities that determine future health, learning, and economic productivity. Scientific evidence shows that nurturing care, defined by good health, adequate nutrition, security and safety, responsive care giving, and opportunities for early learning is essential for optimal development. Children without supportive environments and stimulation in early life are at a higher risk of developmental delays, reduced academic

achievement and lifelong disadvantage (UNICEF, WHO, & World Bank, 2018).

According to the World Bank's early childhood development report (2024), over 250 million children under the age of five in low-and middle-income countries are at risk of not reaching their developmental potential due to factors like poverty, poor nutrition, and lack of stimulation. These developmental delays manifest in cognitive, emotional, and physical impairments that not only affect individual well-being but also hinder national productivity and economic growth. Asia, despite its rapid economic growth, is home to a large share of the world's underdeveloped children. This is particularly alarming, as early deficits in child development, if left unaddressed, become increasingly difficult and costly to reverse. In many Asian countries, children face persistent challenges like poor maternal nutrition, inadequate health care and low investment in early childhood education, which directly contribute to poor ECD outcomes. The United Nations Children's Fund (UNICEF) estimates that one in four children globally lives in severe child food poverty, meaning they receive no more than two food groups per day, increasing their risk of stunting, wasting, and cognitive delays (UNICEF, 2024). Furthermore, access to pre-primary education remains limited, particularly in low-income countries, where only 20–30% of children aged 3–6 years are enrolled in early education (World Bank, 2021). This early deprivation contributes to a lifelong cycle of inequality. The burden of stunting, wasting, and under-nutrition is heavily concentrated in Asia. The children from low-income households or underprivileged areas are more likely to experience poor nutrition, lower cognitive stimulation, and inadequate early education, reinforcing inter-generational cycles of disadvantage (Bornstein et al., 2015).

In Pakistan, ECD indicators reflect a serious public health and social challenge. According to the most recent international surveys, approximately 40.2% of children under the age of five are stunted, 17.7% are wasted, and 28.9% are underweight (UNICEF, WHO, & World Bank, 2021). These figures highlight widespread chronic under-nutrition, particularly in rural and low-income households. According to UNICEF Pakistan, Pakistan is home to nearly 8 million children under five who are at risk of not reaching their full developmental potential due to poverty, inadequate early stimulation, and poor access to essential health and nutrition services. Within Pakistan, the province of Punjab, despite having a relatively better infrastructure, also faces alarming disparities. According to the Punjab Multiple Indicator Cluster Survey (MICS) 2017–18, 37% of children under five in the province are stunted, with higher rates among children from the lowest wealth quantiles and rural areas. Early learning indicators in Punjab are equally concerning; only 26% of children aged 3–5 is enrolled in early childhood education, and less than 55% receive adequate adult support for learning at home (MICS, 2017–18).

ECD lays the foundation for a child's growth and learning but still millions of children around the world are deprived of the opportunities they need to reach their full potential. The Punjab Multiple Indicator Cluster Survey (MICS) 2017-18 highlights that access to quality early childhood education is significantly lower in rural areas than in urban centers, reinforcing disparities in learning outcomes, only 36.8% of children aged 3–5 years attend early childhood education programs, and developmental outcomes vary sharply across household wealth levels, parental education, and urban–rural residence. This gap in early learning opportunities limits the ability of children from disadvantaged backgrounds to reach their full potential (Chaparro et al., 2020).

The early years of a child's life are critical for cognitive, emotional, and physical development, and ensuring equitable access to nurturing care and education during this period is essential for long-term well-being. In order to prepare them for primary schooling, Sustainable Development Goal 4.2 expressly seeks to guarantee that all girls and boys have access to high-quality ECD, care, and pre-primary education. These disparities indicate that a child's opportunity to develop is strongly influenced by the circumstances of birth rather than personal effort or merit.

The significance of this study lies in its focus on quantifying these opportunity differentials using the Human Opportunity Index and Shapley decomposition. By identifying the most influential background characteristics that drive inequality in early development outcomes, the study contributes to evidence-based planning for reducing inequities and advancing progress toward SDG 4.2. It also adds to the academic understanding of how structural disadvantages limit children's potential in their most formative years. This study intends to provide valuable insights for policymakers to design inclusive, equitable, and targeted interventions that

promote universal access to ECD services in Punjab. The following objectives will be considered in this study:

1. To construct Human Opportunity Index, coverage index, dissimilarity index, for ECD in Punjab, Pakistan.
2. To decompose Inequality of Opportunities regarding ECD in Punjab, Pakistan.

The study contributes to the growing body of research on inequality of opportunity in early childhood and offers a data-driven basis for designing targeted and equity oriented policies. Addressing these disparities is essential not only for improving individual well-being but also for achieving broader development goals.

Literature Review

ECD encompasses child's social, cognitive and physical development during early childhood period. This period is widely recognized as a critical window for brain development and the foundation for lifelong health, learning, and well-being. The experiences and opportunities children receive in their early years significantly influence their ability to reach their full potential and contribute meaningfully to society (Akram et al., 2024). Household head education has consistently emerged as a critical determinant of ECD. An analysis using Pakistan's MICS6 (2017–2020) across the four provinces modeled the Early Childhood Development Index (ECDI) found both mother's and father's education positively associated with being developmentally "on-track", with maternal effects larger in magnitude, but paternal (often household head) education remaining independently significant after adjustment for wealth, province, disability, and child discipline practices (Akram et al., 2024).

In South Asia, Aslam and Kingdon (2012) found a positive association between maternal schooling and children's test scores at early ages, particularly in literacy and numeracy. Hentschel et al. (2022), demonstrated that maternal education was significantly associated with higher child development scores and increased school readiness. Furthermore, UNICEF (2019) highlighted maternal education as a core strategy in achieving Sustainable Development Goal (SDG) 4.2 ensuring all children have access to quality ECD. Finally, Naudeau et al. (2011) confirmed through cross-country evidence that maternal education improves not only direct learning outcomes but also broader developmental aspects like social interaction and emotional regulation. These findings strongly justify the inclusion of maternal education as a key circumstance variable in the present study, as it plays a substantial role in shaping equity and opportunity in early development among children in Punjab.

ECD is influenced by a range of biological, socioeconomic, and environmental factors. Among biological indicators, child nutrition plays a critical role. Studies show that stunting, wasting, and underweight status are directly associated with poor cognitive and motor development. Similarly, Black et al. (2013) report that under-nutrition in early years leads to long-term deficits in schooling and productivity. A meta-analysis across 15 low- and middle-income countries found that severe stunting significantly correlates with poor overall development, physical growth, and literacy/numeracy; independent of maternal education, wealth, or the presence of learning materials at home (Miller et al., 2015)

Furthermore, residential area (urban vs. rural) contributes to opportunity gaps; children in rural areas typically experience reduced access to quality early childhood services (UNESCO, 2015). Demographic variables like child's age and gender of household head also play a role. Engle et al. (2011) note that ECD interventions must be age-specific, as brain development is most sensitive during the first five years. Gender of household head may indirectly affect child outcomes through decision-making power and resource allocation. In sum, existing literature affirms that both nutritional and socio-demographic variables significantly shape ECD outcomes.

While financial resources influence access to education and health care, nutrition plays an equally significant role in shaping cognitive and physical development. In Punjab, MICS 2014 and 2017-18 reveal that approximately 38% of Pakistani children are stunted, with Punjab reporting 27% moderate and 10% severe stunting rates. The primary causes of stunting include malnutrition, food insecurity, poor maternal health, and inadequate health care access (Iqbal, 2007). Research further suggests that stunted children exhibit lower

cognitive scores, poorer school readiness, and delayed psychomotor skills compared to their non-stunted peers (Bornstein et al., 2015). These long-term effects highlight how nutritional deficiencies extend beyond physical health to impact intellectual development and future academic performance (Chaparro et al., 2020). In Punjab, ECD continues to be severely affected by nutritional deficits and regional disparities. A multilevel analysis of Punjab's MICS-2014 data shows that 37% of children under five are stunted, with significant clustering in rural and low-income districts (Mahmood et al., 2020). Research also reveals that household socioeconomic deprivation, such as limited parental education, poor sanitation, and low-income levels, is strongly linked to under nutrition in under-five children in marginalized districts of the province (Shahid et al., 2022).

In contexts like Punjab, where socioeconomic disparities, regional inequalities, and cultural factors often determine a child's opportunities, understanding the factors that create opportunity differentials in ECD is vital. Addressing these disparities can not only improve individual outcomes but also advance broader goals of social equity, economic growth, and sustainable development (Naudeau et al., 2011). Punjab, while relatively developed compared to other provinces, still shows variation in health and educational outcomes across districts and social groups (Bureau of Statistics Punjab, 2019). Understanding opportunity differentials within the province can help design targeted interventions in early childhood education and health-care delivery, contributing to SDG goals related to health, education, and inequality (World Bank, 2021).

Methodology

Data

The study has utilized the data from Punjab MICS 2017-18. The description of variables is presented in Table 1.

Table 1. Description of dependent and explanatory variables.

| Variable | Definition | Measurement/coding | Reference |
|------------------------------|---|---|--|
| Dependent | | | |
| Early Child development | It is a multidimensional process that is completed at the age of 2 to 5 years. It is a process that aligned cognitive and motor skills. It is considered on track when children can perform different tasks as identify at least ten letters of alphabets, read four simple reading skills, and, recognize symbols. | Identify at least ten letters of alphabets, read four simple reading skills, recognize symbol, pickup objects, sick to play, able to do some task, well with others, kick objects and get distracted Yes=1 No=0 | Akram et al. (2024), Nabizada et al. (2024) |
| Independent Variables | | | |
| Underweight | Underweight is defined as low weight-for-age. A child who is underweight may be stunted, wasted or both. Underweight in children is assessed using growth charts and is typically define as a weight-for-age below -2 standard deviations from the WHO child Growth Standard median. | 1 = below and equal -2 0 = above -2 | Weiss et al. (2017), Abubakar et al. (2009) |

| | | | |
|--------------------------|---|---|------------------------|
| Wasting | According to the World Health Organization (WHO), wasting in nutrition refers to low weight-for-height, indicating recent and severe weight loss, often due to inadequate food intake and/or illness. Wasting is defined as a weight-for-height measurement that falls below -2 standard deviations of the WHO Child Growth Standards median. | Wasting is defined as a weight-for-height measurement that falls below -2 standard deviations of the WHO Child Growth Standards median. 1= below and equal -2 0= above -2 | McCoy et al. (2021) |
| Stunting | The child's stunting status is a binary variable. The child's height-for-age z-score indicates that they are stunted (HAZ score), the long-term cumulative nutritional conditions, if score below -2, i.e., two standard deviations below the international reference median. | Yes=1 No=0 | Muhammad et al. (2022) |
| Household Head Education | Highest level of education attained by the head of household, as recorded in the MICS Household Questionnaire. | No education Primary education Secondary education Higher education | Sarwar et al. (2024) |
| Area of residence | Type of locality where the household resides, classified as Urban or Rural | Categorized as: Urban Rural | Akram et al. (2024) |
| Household Wealth | It is the accumulation of assets over time by any family, including any type of home, farmland, vehicle, and animal. A household is deemed wealthy if they possess particular items, which are categorized based on the quantity of holdings (Karagiannaki, 2017). | Measured in terms of possession of assets. Poorest quintile=1 Second quintile=2 Middle quintile=3 Fourth quintile =4 Richest quintile=5 | Asif et al. (2022) |
| Gender | Gender refers to the social and cultural constructs of masculinity and femininity, including the roles, behaviors, responsibilities assigned to women, men ,girls and boys in a society.(UNICEF) | Categorized as: Boy Girl | UNICEF |

Source: Authors' own compilation based on studies.

This study employs quantitative methods to measure opportunity differentials in ECD across Punjab, Pakistan using secondary data from the Multiple Indicator Cluster Survey (MICS) 2017 conducted by the Bureau of Statistics Punjab with technical support from UNICEF. The Punjab Multiple Indicator Cluster Survey (MICS) 2017 was conducted across all 36 districts of Punjab, covering both urban and rural areas to provide representative data for the province. The total sample included about 53,840 households, selected to give

reliable estimates for key indicators related to children and women. The survey used standardized UNICEF MICS questionnaires, adapted to the local context of Pakistan, covering topics like child health, nutrition, education, water and sanitation, maternal health, and ECD. Data were collected through household interviews with women of reproductive age and caregivers of children under five, ensuring a comprehensive assessment of child and maternal well-being across Punjab. It offers detailed information on variables relevant to inequality of opportunity, such as child nutritional status (stunting, wasting, and underweight), parental education, household wealth, and access to basic services. Key independent variables included child gender, household wealth, area of residence, maternal education, household gender, underweight, wasting and stunting.

Model

The basic concept of this study builds on the insights of Romer's endogenous growth theory, which emphasizes that long-term economic growth is driven not merely by physical capital or labor, but by the accumulation of human capital, innovation, and knowledge (Romer, 1990). Romer highlights the role of education, skills, and early cognitive stimulation as fundamental inputs into the production of knowledge implying that ECD is not only a social concern but an economic investment. In his framework, when individuals are equipped with equal opportunities for skill development and learning from the beginning of life, they become productive contributors to society. However, Romer does not deeply differentiate whether disparities in skill development arise from personal choices or from external barriers. To address this distinction, the current study extends Romer's human capital perspective by incorporating the Equality of Opportunity framework as introduced by Roemer (1998).

According to Romer (1998), inequality in outcomes can be divided into two categories; effort-based inequality and circumstance-based inequality. Effort-based inequality arises due to individual choices, motivation, or behavior. These are considered "fair" differences because they reflect a person's own actions. Circumstance-based inequality, on the other hand, results from factors that individuals cannot control such as place of birth, parental education, income level, gender, ethnicity, or access to services. These differences are considered "unfair" because they reflect structural disadvantages that prevent some individuals from accessing the same opportunities as others.

This study focuses specifically on circumstance-based inequality, as it plays a critical role in early childhood. At this young stage, children have not yet exercised personal effort or responsibility. Their development depends almost entirely on the environment and resources available to them through their caregivers and community. In regions like Punjab, children from low-income families or rural areas are often deprived of basic services such as quality early education, nutrition, or home learning support. These limitations are not the result of personal effort but are rooted in circumstantial disadvantage, making it essential to study how opportunity is unequally distributed across different background conditions.

In the World Bank report "Measuring Inequality of Opportunity in Latin America and the Caribbean," Barros et al. (2009) developed and applied the Human Opportunity Index (HOI), which is based on Roemer's theory (1998). The methodology of HOI will be employed for this study which estimates the average accessibility of fundamental services, adjusted for the inequitable distribution of these services within the population. This is accomplished by assessing the coverage rate of a specific service and subsequently modifying it based on an equal distribution of available services among various circumstance groups. The formulation of the HOI entails combining circumstance-specific coverage rates into a scalar metric that rises with overall coverage and diminishes with disparities in coverage among groups with varying circumstances.

The HOI for a specific basic service or opportunity is the coverage rate (\bar{P}), modified to account for variations in access:

$$HOI = \bar{P}(1 - D) \quad (1)$$

Here D is a dissimilarity indicator that measures the average access rate to a basic service for the population to the disparity in access rates for groups based on circumstances (Barros et al., 2009). The coverage rate, " \bar{P} ",

is the first part of HOI and can be computed using information from household surveys. To guarantee equal access, "D" can be viewed as the portion of the total quantity of opportunities that must be redistributed among circumstance groups. If access is unaffected by the circumstance, then $(1 - D)$ will equal 1, and HOI will be equivalent to the typical coverage rate (\bar{P}).

According to Barros et al. (2009), suppose that a random sample of children is available, along with a vector of variables (e.g., sex and education of household head, location, wealth status of a family, and many others are identified in literature) indicating the child's information on whether the child has access to a basic opportunity ($I_i = 1$ if that child has access to the opportunity and $I_i = 0$ otherwise)). The total circumstances / criteria is m .

$$X_i = (X_{i1}, \dots, X_{mi}).$$

The first stage in estimating D is to estimate the separable logistic model that follows equation 2. As with the current study, given this information, the predicted likelihood of a child's access to an opportunity (depending on circumstance variables) may be and has been derived by using following:

$$\text{Ln}\left(\frac{P(I = 1|x_1, \dots, x_m)}{1-P(I = 1|x_1, \dots, x_m)}\right) = \sum_{k=1}^m h_k(x_k) \tag{2}$$

Where x_k represents a vector of variables that reflect the k-dimension of characteristics (as already mentioned circumstance factors). The entire specification has been explained in the part on dataset and estimation, however it is crucial to note that the specification is selected so that all functions ultimately have linear parameters in every scenarios. Estimates of the parameters, $\{\beta_k\}$ obtained from the above logistic regression are denoted by $\{\hat{\beta}_k\}$. Each child in the population has the following anticipated likelihood of having access to an opportunity based on these following coefficient estimates:

$$\hat{P} = \frac{\text{Exp}(\hat{\beta}_0 + \sum_{k=1}^m x_{ki}\hat{\beta}_k)}{1 + \text{Exp}(\hat{\beta}_0 + \sum_{k=1}^m x_{ki}\hat{\beta}_k)} \tag{3}$$

Next, as a final step, the following are computed

$$\bar{P} = \sum_{i=1}^n W_i \hat{P}_i \tag{4}$$

and

$$\hat{D} = \frac{1}{2\bar{P}} \sum_{i=1}^n W_i |\hat{P}_i - \bar{P}| \tag{5}$$

Where n is the total population and $W_i = \frac{1}{n}$ or are some sampling weights. Equation 1 can be used to calculate HOI after estimating the average access rate (\bar{P}) and dissimilarity index (\hat{D}). It is important to note that both the \hat{D} and human opportunity index (HOI) vary between 0 and 1.

On second stage of analysis, we used the decomposition method of Shorrocks (2013), to understand the contribution of each circumstance variable (e.g., gender, wealth, education) to the observed inequality, Shapley decomposition involves adding or deleting each contributing element in a specified elimination sequence in order to determine the marginal effect on the index of inequality index. Equation 5 defines the \hat{D} , which calculates opportunity inequality in accordance with Barros et al. (2009). The set of conditions (circumstances) under consideration determines the value of (\hat{D}). They also possess the fundamental quality that, by adding more conditions, constantly raises the value of (\hat{D}). For instance, $\text{HOI}(C_1, C_2) \leq \text{HOI}(C_1)$ and

$D^*(C_1, C_2) \geq D^*(C_1)$ by following the two sets of conditions, C_1 and C_2 , and C_1 and C_2 do not overlap. The outcome of including scenario A is provided by:

$$D_{A=\sum_{S \subseteq N \setminus \{A\}} \frac{|S|!(n-|S|-1)!}{n!} [D(S \cup \{A\}) - D(S)] \tag{6}$$

The total number of circumstances is N , which is the set of all circumstances. S is a subset of N that excludes the specific situation A . The dissimilarity index (\widehat{D}) calculated using the set of situations is $D(S)$. The (\widehat{D}), S . $D(S \cup \{A\})$, is computed using the set of circumstances S and the circumstance A . The way that scenario A contributes to the (\widehat{D}) can be defined as:

$$\phi_A = \frac{D_A}{D(N)} \tag{7}$$

Where $\sum_{i \in N} \phi_i = 1$

Put otherwise, the Shapley decomposition achieves a critical property: the sum of all circumstance's contributions to the index of dissimilarity equals 100%.

Results and Discussion

Descriptive Stats

Descriptive statistics summarize the key characteristics of the data set and provide an overview of the sample distribution. In this section descriptive statistics focused on dependent variables and independent variables to understand the importance of ECD. Table 2 presents the dependent variables used in this study.

Table 2. Descriptive statistics.

| Variable | Frequency | | Percentage | |
|--|-----------|--------|------------|-------|
| | Yes | No | Yes | No |
| Child identifies at least ten letters of the alphabets | 4,330 | 11,518 | 27.07 | 72.01 |
| Child read at least four simple ,popular reading skills | 4153 | 11761 | 25.96 | 73.52 |
| Child recognize the symbol off all numeracy | 4,510 | 11,395 | 28.19 | 71.24 |
| Child can pick up objects | 14,345 | 1,604 | 89.68 | 10.03 |
| Child sometimes too sick to play | 5,298 | 10,679 | 33.12 | 66.76 |
| Child follow simple directions and how to do something correctly | 14,142 | 1,839 | 88.41 | 11.50 |
| Child able to do something independently | 13,349 | 2,614 | 83.45 | 16.34 |
| Child get along well with other children | 15,046 | 920 | 94.60 | 5.75 |
| Child kick, bite or hit other children or adults | 10,167 | 5,797 | 63.56 | 36.24 |
| Child get distracted easily | 11,038 | 4,896 | 69 | 30.61 |
| Child play with homemade toy | 4,508 | 11,472 | 28.18 | 71.72 |
| Child play with toy from shop or manufactured toys | 12,224 | 3,764 | 76.42 | 23.53 |
| Child play with household objects such as bowls or pots or objects from outside such as sticks, rocks, animal shells or leaves | 10,998 | 4,986 | 68.75 | 31.17 |

Source: Authors' own compilation by using the data from MICS 2017-18.

Results

We have measured the Coverage rate (C-Rate), Dissimilarity Index (D-Index) and Human opportunity index (HOI) for ECD of Punjab by using the MICS Punjab 2017-18. The results of C-Rate, D-Index and HOI of ECD for cognitive skills, functional development and access to toys are presented in Table 3, 4 and 5 respectively.

Table 3. Results of C-rate, D-index and HOI for cognitive indicators.

| Variable | C-Rate | D-Index | HOI |
|----------------|--------|---------|------|
| Reading skills | 30.9 | 9.54 | 27.9 |
| Numeracy | 38.1 | 6.45 | 31.8 |
| Alphabets | 35.8 | 15.1 | 30.4 |

Source: Authors' own estimations.

Here we can see in these tables that C-Rate varies from 33.1% (Sick to play) to 95.3% (toys access) among different indicators of ECD. The opportunity's equitable distribution among the different scenario groups is indicated by the D-Index. It may be deduced from the D-Index value that in order to restore equal chance for all children, a specific portion of opportunities must be redistributed among children from different circumstance groups. It can be seen in all tables that D-Index varies from 0.59 to 9.54 with respect to different objects. It is observed that DI have rising trend with respect to reading skills.

Table 4. Results of C-rate, D-index and HOI for functional development indicators.

| Variable | C-Rate | D-Index | HOI |
|-----------------|--------|---------|------|
| Pickup | 91.1 | 0.59 | 90.6 |
| Sick to play | 33.1 | 3.37 | 32.0 |
| Directions | 89.2 | 0.75 | 88.6 |
| Able to do | 84.6 | 1.42 | 83.4 |
| Well with other | 94.3 | 0.60 | 93.7 |
| Kick | 61.2 | 3.91 | 58.8 |
| Distracted | 68.9 | 1.61 | 67.8 |

Source: Authors' own estimations.

The HOI is an aggregate indicator that evaluates the distribution of access to the service (equality of opportunity) as well as the coverage of fundamental services. It provides information on the decline rate of access to specific opportunities and illustrates how much coverage of an opportunity is discounted by differential of opportunity. To put it simply, HOI stands for coverage adjusted for equity. The HOI is a number between 0 and 100, where 100 denotes a society where a particular service is widely available (universal coverage).

Table 5. Results of C-Rate, D-Index and HOI for access to toys.

| Variable | C-Rate | D-Index | HOI |
|-------------|--------|---------|------|
| Toys access | 95.3 | 1.0 | 94.4 |

Source: Authors' own estimations.

It has been discovered that cognitive indicators have low HOI value from 27.9 to 30.4 implying less universal access to cognitive indicators and the lowest value of HOI exist for Reading skills (27.4%), Alphabets (30.4%) and Numeracy (31.8%). We can see from Table 4 that functional development indicators have moderate universal access and from Table 5 that Access to toys have high universal access due to inclusion of all types (even homemade toys) of toys.

ECD's inequality of opportunity (IOP) is broken down using the Shapley decomposition technique, which yields the percentage contributions of different situations to the D-Index. Table 6 revealed that a number of factors significantly contributed IOP across Punjab..

Table 6. Contribution of circumstance factors in IOP in access to ECD in Punjab.

| Variables | Reading skills | Numeracy | Alphabets | Pickup | Sick to play | Direction | Able to do | Well with other | Kick | Distracted | Toys access |
|-------------|----------------|----------|-----------|--------|--------------|-----------|------------|-----------------|------|------------|-------------|
| Underweight | 6.96 | 6.23 | 7.37 | 2.85 | 24.0 | 1.67 | 4.34 | 18.1 | 0.97 | 2.22 | 2.50 |
| Wasting | 0.84 | 0.39 | 0.46 | 0.50 | 0.48 | 2.83 | 0.66 | 3.45 | 2.46 | 2.88 | 1.54 |
| Stunting | 20.4 | 11.8 | 13.8 | 24.04 | 16.66 | 1.94 | 17.2 | 57.5 | 1.78 | 2.06 | 2.18 |
| HHE | 43.1 | 35.1 | 30.1 | 23.4 | 21.5 | 1.08 | 13.5 | 0.73 | 25.8 | 12.7 | 67.4 |
| HH sex | 1.48 | 2.61 | 1.69 | 8.02 | 4.96 | 3.02 | 2.32 | 4.16 | 57.1 | 0.32 | 0.60 |
| Area | 0.98 | 0.71 | 0.56 | 25.5 | 3.68 | 50.0 | 17.5 | 3.35 | 4.08 | 46.7 | 19.1 |
| ECE | 20.5 | 40.0 | 40.0 | 0.95 | 0.42 | 2.88 | 28.2 | 0.75 | 1.77 | 5.02 | 4.88 |
| Wealth | 5.15 | 3.00 | 5.57 | 3.35 | 16.1 | 35.5 | 4.97 | 3.82 | 4.88 | 26.7 | 1.51 |
| Gender | 0.32 | 0.07 | 0.18 | 11.2 | 11.9 | 0.95 | 11.1 | 7.98 | 1.09 | 1.32 | 0.10 |

Source: Authors' own estimations.

The Shapley decomposition of opportunity inequality in ECD outcomes reveals that household head education and stunting consistently emerge as the most influential determinants across multiple domains. For cognitive skills such as reading and numeracy, household head education contributes the largest share of inequality (43.1% and 35.1%, respectively), followed closely by access to early childhood education (40.0% for numeracy and alphabets), underscoring the pivotal role of both parental education and institutional learning opportunities in shaping early competencies. Stunting, a proxy for chronic under-nutrition, also shows a significant contribution, particularly for children's social outcomes, accounting for 57.5% of disparities in "getting along well with others." Similarly, area of residence explains nearly half of the inequality in following directions (50.0%) and inattention or distractibility (46.7%), indicating strong geographic disparities in developmental opportunities. On the other hand, household wealth emerges as a key driver for outcomes such as attentiveness (26.7%) and health-related measures like being too sick to play (16.1%), highlighting material resource differences across families. Interestingly, the gender of the household head or child contributes relatively little overall, except in behavioral outcomes such as aggression (kicking, biting, or hitting), where the household head's sex accounts for more than half (57.1%) of the inequality of opportunity of Kick.

The Human Opportunity Index (HOI) for reading skills was only 27.9%, while numeracy and alphabet recognition scored 31.8% and 30.4%, respectively. This indicates that cognitive opportunities are limited and unequally distributed across Punjab. Similar patterns have been observed by Kamal et al. (2022), who reported that children from wealthier households and educated parents in Punjab showed significantly higher literacy and numeracy skills, and by Black et al. (2017), who highlighted persistent global inequalities in early cognitive development.

Functional indicators such as picking up objects (HOI = 90.6%), following directions (HOI = 88.6%), and getting along well with others (HOI = 93.7%) showed high and relatively equal access. However, inequalities were found in being too sick to play (HOI = 32.0%) and aggression (kicking/hitting, HOI = 58.8%). These results are consistent with findings by Engle et al. (2011), who showed that health and care giving environments strongly shape developmental outcomes, and by Muhammad et al. (2022), who demonstrated that stunted children are more likely to show delays in social and psychomotor skills.

Access to toys recorded the highest HOI of 94.4%, mainly due to the inclusion of homemade toys. This is in line with Bornstein et al. (2015), who noted that household resources and parental engagement play an

important role in ensuring access to play and stimulation materials in low- and middle-income countries.

The decomposition analysis showed that household head education was the strongest contributor to inequality in cognitive outcomes such as reading (43.1%) and numeracy (35.1%). Similar evidence is provided by Akram et al. (2024), who found that both maternal and paternal education significantly improve ECD outcomes in Pakistan. Stunting was another major factor, contributing 57.5% to inequality in social outcomes such as “well with others,” consistent with Miller et al. (2015), who found stunting strongly associated with poorer social and cognitive development. Furthermore, wealth and area of residence emerged as significant drivers of inequality, echoing the findings of Mujaddad et al. (2023), who identified household wealth and rural–urban disparities as key determinants of child development in Punjab.

Collectively, these findings emphasize that factors like education, nutrition, area of residence, and household resources play a far greater role in shaping developmental opportunity gaps than individual biological differences such as gender or wasting.

Conclusion and Policy Recommendations

This study analyzed the opportunity differential in ECD across Punjab using the Human Opportunity Index and Shapley Decomposition, based on MICS 2017–18 data. The findings reveal significant inequalities in access to foundational cognitive and behavioral developmental opportunities among children aged 3–5 years. Particularly, early learning indicators such as word, number, and alphabet recognition displayed both low coverage and high inequality, suggesting that many children are denied essential opportunities at a crucial stage of their development. The decomposition analysis identified wealth, nutritional status (underweight, stunting and underweight), gender, and area of residence as the most influential circumstances driving these disparities. Children from low-income, rural, and less-educated households experience a considerable disadvantage in accessing quality ECD services.

Based on Shapley decomposition results, we can now suggest targeted government policy recommendations to reduce opportunity differentials in ECD in Punjab, Pakistan. The findings highlight several priority areas for policy intervention to reduce inequality in early childhood education. First, since early childhood education is the largest contributor to opportunity differentials, governments should expand access to affordable, high-quality early childhood education programs. Second, household wealth and parental education are also significant drivers of inequality. Policies should therefore aim to support families economically and educationally. Third, child health and nutrition, as captured through the contribution of stunting, must be addressed. It demands the scaling up nutrition interventions by government to reduce inequalities. Finally, given the contribution of the urban–rural divide, rural areas require targeted investment in early childhood infrastructure, qualified teachers, and access to health and educational services. Collectively, these recommendations emphasize that reducing early childhood opportunity gaps requires a multi-sectoral strategy; integrating education, health, and social protection policies to break the cycle of inter-generational inequality. Government should expand and strengthen programs to provide targeted nutrition support for children under 5.

Future Research

While this study provides valuable insights into opportunity differentials in ECD in Punjab, it is important to acknowledge certain limitations. First, the study is based on cross-sectional data from MICS 2017, which restricts the ability to establish causality or track changes over time. Second, the dataset lacks detailed qualitative variables such as parental involvement, teacher quality, or home learning environment, which are crucial for a comprehensive understanding of ECD. Third, several indicators rely on self-reported data from caregivers, which may introduce response bias. Moreover, the findings are specific to Punjab and may not be generalize to other provinces or contexts.

References

- Abubakar, A., Holding, P., van de Vijver, F. J. R., Newton, C., & van Baar, A. (2009). Children at risk for developmental delay can be recognized by stunting, being underweight, ill health, little maternal schooling or high gravidity. *Journal of Child Psychology and Psychiatry*, 51(6), 652–659.
- Akram, S., Zahid, F., & Pervaiz, Z. (2024a). Socioeconomic determinants of early childhood development: Evidence from Pakistan. *BMC Public Health*, 24(1), 1845.
- Asif, M. F., Pervaiz, Z., Afridi, J. R., Safdar, R., Abid, G., & Lassi, Z. S. (2022). Socio-economic determinants of child mortality in Pakistan and the moderating role of household wealth index. *BMC Pediatrics*, 22, Article 3.
- Aslam, M., & Kingdon, G. G. (2012). Parental education and child health—Understanding the pathways of impact in Pakistan. *World Development*, 40(10), 2014–2032.
- Barros, R. P., Ferreira, F. H. G., Molinas Vega, J. R., & Saavedra Chanduvi, J. (2009). Measuring inequality of opportunities in Latin America and the Caribbean. World Bank. <https://documents.worldbank.org/curated/en/219971468045038973/pdf/468270PUBoMeas101OFFICIALUSEONLY1.pdf>
- Black, M. M., Walker, S. P., Fernald, L. C., Andersen, C. T., DiGirolamo, A. M., Lu, C., ... Grantham-McGregor, S. (2017). Early childhood development coming of age: Science through the life course. *The Lancet*, 389(10064), 77–90.
- Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., De Onis, M., ... & Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet*, 382(9890), 427–451.
- Bornstein, M. H., Putnick, D. L., Bradley, R. H., Lansford, J. E., & Deater-Deckard, K. (2015). Pathways among caregiver education, household resources, and infant growth in 39 low- and middle-income countries. *Infancy*, 20(4), 353–376.
- Chaparro, J., Sojourner, A., & Wiswall, M. (2020). Early childhood care and cognitive development (IZA Discussion Paper No. 13047). Institute of Labor Economics (IZA). <https://www.iza.org/publications/dp/13047/early-childhood-care-and-cognitive-development>
- Engle, P. L., Fernald, L. C., Alderman, H., Behrman, J., O’Gara, C., Yousafzai, A., Iltus, S. (2011). Strategies for reducing inequalities and improving developmental outcomes for young children in low-income and middle-income countries. *The Lancet*, 378(9799), 1339–1353.
- Hentschel, E., Tomlinson, H., Hasan, A., Yousafzai, A., Ansari, A., Tahir-Chowdhry, M., & Zamand, M. (2022). Risks to child development and school readiness among children under six in Pakistan: Findings from a nationally representative phone survey (Policy Research Working Paper No. 10221). World Bank. <https://documents1.worldbank.org/curated/en/099704011032225221/pdf/IDUoad66722fofdb20458f0944505a7ddd7b229e.pdf>
- Iqbal, B. (2007). Early childhood development in Pakistan: The relative contributions of neighbourhood, socioeconomic inequalities and home environment to growth and psychomotor development (Doctoral dissertation, London School of Hygiene & Tropical Medicine). London School of Hygiene & Tropical Medicine Research Online. <https://researchonline.lshtm.ac.uk/id/eprint/4646550/>
- Kamal, A., Amjad, N., Yaqoob, U., Saud, N., Ijaz, M., Khan, I., & Anduaem, M. (2022). Role of socioeconomic and parental involvement factors on children foundational learning skills based on MICS 2017–2018 data Punjab, Pakistan. *Scientific Reports*, 12(1), 10313.
- Karagiannaki, E. (2017). The effect of parental wealth on children’s outcomes in early adulthood. *Journal of Economic Inequality*, 15(3), 217–243.
- Mahmood, T., Abbas, F., Kumar, R., & Somrongthong, R. (2020). Why under five children are stunted in Pakistan? A multilevel analysis of Punjab Multiple Indicator Cluster Survey (MICS-2014). *BMC Public Health*, 20(1), 952.

- McCoy, D. C., Usui, M., Galasso, E., et al. (2021). Wasting and stunting in infants and young children as risk factors for subsequent stunting or mortality: Longitudinal analysis of data from Malawi, South Africa, and Pakistan. *The Journal of Nutrition*, 151(7), 2022-2028.
- Miller, A. C., Murray, M. B., Thomson, D. R., & Arbour, M. C. (2015). How consistent are associations between stunting and child development? Evidence from a meta-analysis of associations between stunting and multidimensional child development in fifteen low- and middle-income countries. *Public Health Nutrition*, 19(8), 1339-1347.
- Muhammad, R. D., Irwanto, Roedi, I., Irmawati, M., & Setyoboedi, B. (2022). Impact of stunting on development of children between 1-3 years of age. *Ethiopian Journal of Health Sciences*, 32(3), 569-578.
- Mujaddad, H. G., Ashraf, W., & Danish, M. H. (2023). Role of households' wealth and maternal education in early child development: A case study of Punjab, Pakistan. *Journal of Development Policy, Research & Practice*, 7, 141-164.
- Nabizada, S., Noori, M. M., & Rasul, M. (2024). Early childhood development in Afghanistan: Analysis of MICS 2022-23 data. *BMC Pediatrics*, 24(1), 232.
- Naudeau, S., Kataoka, N., Valerio, A., Neuman, M. J., & Elder, L. K. (2011). Investing in young children: An early childhood development guide for policy dialogue and project preparation (Directions in Development: Human Development). World Bank. <https://hdl.handle.net/10986/2525>
- Roemer, J. E. (1998). *Equality of Opportunity*. Harvard University Press.
- Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5, Pt. 2), S71-S102.
- Sarwar, A., Jadoon, A. K., Chaudhry, M. A., Latif, A., & Javaid, M. F. (2024). How important is parental education for child nutrition: Analyzing the relative significance of mothers' and fathers' education. *Journal of Social and Economic Policy & Planning*, 6(2023-0483).
- Shahid, M., Cao, Y., Ahmed, F., Raza, S., Guo, J., Malik, N. I., Rauf, U., Qureshi, M. G., Saheed, R., & Maryam, R. (2022). Does mothers' awareness of health and nutrition matter? A case study of child malnutrition in marginalized rural community of Punjab, Pakistan. *Frontiers in Public Health*, 10, 792164.
- Shorrocks, A. F. (2013). Decomposition procedures for distributional analysis: a unified framework based on the Shapley value. *Journal of Economic Inequality*, 11(1), 99-126.
- UNESCO. (2015). *Education for All 2000-2015: Achievements and challenges*. Paris: UNESCO. <https://share.google/G2XY8WxZ8EvvNk4ph>
- UNICEF (2019). *The state of the world's children 2019: Children, food and nutrition*. UNICEF. <https://www.unicef.org/sites/default/files/2019-12/SOWC-2019.pdf>
- UNICEF, WHO, & World Bank. (2018). *Nurturing care for early childhood development: A framework for helping children survive and thrive to transform health and human potential*. Geneva: WHO, UNICEF, World Health Organization, & World Bank. (2018). *Nurturing care for early childhood development: A framework for helping children survive and thrive to transform health and human potential*. World Health Organization. <https://apps.who.int/iris/bitstream/handle/10665/272603/9789241514064-eng.pdf>
- UNICEF, WHO, & World Bank. (2021). *Levels and trends in child malnutrition: UNICEF/WHO/World Bank Group joint child malnutrition estimates: Key findings of the 2021 edition*. World Health Organization. <https://iris.who.int/handle/10665/341135>
- UNICEF. (2024, June 5). 1 in 4 children globally live in severe child food poverty due to inequity, conflict, and climate crises. United Nations Children's Fund.
- World Bank. (2021). *World Development Report 2021: Data for better lives*. World Bank. <https://documents1.worldbank.org/curated/en/248201616598597113/pdf/World-Development-Report-2021-Data-for-Better-Lives.pdf>