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A Comparative Assessment of Parametric and Semi-parametric Regression Models for Functional Difficulties among Children Aged 5–17 Years in Bangladesh

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Abstract

Background

Functional difficulties among children are becoming a major public health challenge in Bangladesh. It is affecting children's development, education, and daily life. Understanding the determinants of these difficulties is required to develop effective strategies to reduce this burden.

Objective

The present study aimed to identify the key socio-demographic determinants of child functional difficulties among children aged 5–17 years in Bangladesh and further compare the performance of the semi-parametric transition model with the parametric count regression models.

Methods

Analyzing data from the 2019 MICS (37,579 children aged 5–17), this study examined child functional difficulties derived from 13 domains. Key variables were identified using one-way ANOVA. After fitting multiple classical count regression models (Poisson, Negative Binomial, discrete Lindley, and discrete Weibull), the discrete Weibull model was selected based on AIC and dispersion criteria. Its performance was then evaluated against the semi-parametric transition model. Finally, transition models were used to analyze the data and determine critical risk factors of child functional difficulties.

Results

Functional difficulties were less common among children aged 5–9 years. Maternal functional difficulty was significantly associated with functional difficulties in children (incidence rate ratio [IRR]: 2.31, 95% confidence interval [CI]: 2.09–2.57). In addition, administrative division, household wealth index, children's educational status, and the sex of the household head were identified as significant determinants of functional difficulties among children.

Conclusion

The semi-parametric transition model provides robust estimates compared to the best-performing parametric model without requiring distributional assumptions, making it a reliable alternative to parametric models. The findings of this study can help policymakers to develop evidence-based policies to reduce the burden of child functional difficulties in Bangladesh.

Background of the Study

Functional difficulties among children present a significant challenge to their development and daily activities, affecting millions of children worldwide [1]. Such functional difficulties include hearing impairments, vision loss,

epilepsy, autism spectrum disorder, cerebral palsy, deficiency in attention, lack of intellectual ability, and learning disorder [2–4]. These difficulties can arise from various physical, cognitive, sensory, or emotional impairments [5, 6]. They impede a child's ability to perform age-appropriate tasks and impact their education, social interactions, and overall quality of life [7, 8]. Children with functional difficulties or disabilities are at a higher risk of psychological issues compared to their peers [9, 10], and mentally healthy children experience a good quality of life in their school and communities [11].

Understanding the factors associated with a child's functional difficulties is crucial for effective intervention strategies and support systems [12, 13]. The International Classification of Functioning, Disability and Health (ICF) provides a comprehensive framework for assessing child functioning and disability [12, 13]. Research has shown that children with disabilities are more likely to engage in hazardous child labor, experience difficulties in accessing education and health services, and face exclusion from society [14]. Functional difficulties among children are particularly concerning due to their association with psychological morbidity [10, 15].

Child functional difficulties are one of the major public health concerns across the world, particularly in low- and middle-income countries. Previous studies had reported that 15% of people have functional difficulties, and 150 million children live with a disability worldwide [16]. In the United States, learning disability is the most prevalent difficulty among children and adolescents (35%) [17]. In addition, children also have speech or language impairment (21%), intellectual disability (7%), and emotional disability (5%) [17].

In sub-Saharan Africa, more than half (66%) of the children are at risk of failing to achieve their potential development, whereas only 57% of children in low- and middle-income countries achieve their child development target [18]. Although several studies have been conducted on child development in Bangladesh, a limited study has been done on child functional difficulties. Evidence from the previous research based on the Multiple Indicator Cluster Survey (MICS) indicates that child functional difficulties have been a global health issue. In Bangladesh, research based on MICS data revealed that 3% of children aged 2–4 years are experiencing severe functional difficulties, while 8% among the children aged 5–17 years [19].

In Bangladesh, multiple studies have investigated the prevalence and determinants of child functional difficulties using data from the MICS 2019. A study utilized Poisson and Negative Binomial regression models to explore factors contributing to functional difficulties among children aged between 5 and 17 years [20]. Their research highlighted key determinants impacting these children's functional abilities. Another study employed Chi-square tests and a multivariable logistic regression model to identify urban-rural differences in factors associated with childhood functional difficulties [21]. Their study revealed that one in thirty-five children had functional difficulties, with a higher prevalence in urban areas compared to rural areas [15]. Similarly, another study applied Chi-square tests and survey-weighted logistic regression models to assess socio-demographic factors contributing to functional difficulties among children aged 2–4 and 5–17 years [22]. Their findings indicated that mother's functional difficulties significantly affect their child's functioning [16]. Furthermore, risk factors for early childhood disability in Bangladesh were explored by another study, using ordinal logistic regression models utilizing MICS 2019 data [23]. The study found that about 2.8% of children under five years of age experience difficulties in daily functioning, with maternal functional difficulties being a significant risk factor [17]. A mixed-effect logistic regression model to identify functional difficulties among young children in Bangladesh were also investigated by another study [24]. They discovered that children whose mothers had

functional difficulties were 2.75 times more likely to experience functional difficulties compared to children whose mothers had no such difficulties [18].

Based on the above background, this study aims to identify the key determinants associated with child functional difficulties among the children aged 5–17 years in Bangladesh. Furthermore, it also evaluates the performance of the semiparametric transition model, and compares it with the parametric count regression models, an analysis that, to the researchers' knowledge, has not been conducted in any previous study. Dealing with count data often poses challenges in modeling complex structures like dispersion, inflation, and truncation. Incorrect distribution assumptions can distort findings. By employing a semi-parametric transition model; a data-driven approach — this study effectively captures the underlying data structure, eliminating the need to pre-specify a count distribution or rely on multiple traditional count models. The findings of the present study would help policymakers to identify the vulnerable groups are at risk of experiencing difficulties, and develop policy and program to reduce the burden of child functional difficulties in Bangladesh.

Methods

Data Source

This study utilized data from nationally representative cross-sectional household survey program, Bangladesh Multiple Indicator Cluster Survey (MICS) 2019 [19]. The MICS 2019 employed a two-stage stratified cluster sampling design to ensure national representativeness. In the first stage, the urban and rural areas within each of 64 administrative districts were defined as the primary sampling strata. A specified number of census enumeration areas (EAs) were then selected within each stratum using a probability proportional to size (PPS) sampling technique. These enumeration areas served as the primary sampling units (PSUs). In the second stage, a complete household listing was conducted within each selected enumeration area to establish a sampling frame. From each selected PSU, 20 households were systematically sampled, resulting in a total of 64400 households included in the survey. For the present study, information was extracted from the children aged 5–17 years dataset. Mothers or primary caregivers were interviewed to collect information on children's health, education, and functional difficulties. After applying the relevant inclusion criteria and excluding observations with missing information on selected variables, a total of 37579 children aged 5–17 years were included in the final dataset (Fig. 1) [19].

Response variable

The total number of functional difficulties among children aged 5–17 years was considered as the response variable in this study. The child's functional difficulties were measured based on the 13 distinct domains, such as seeing, hearing, walking, self-care, communication, learning, remembering, concentrating, accepting change, controlling behavior, making friends, anxiety, and depression. If these domains had responses either "A lot of difficulties", or "Cannot at all", or "Daily", or "Weekly" were recoded as 1 for "Yes", otherwise these variables were recoded as 0 for "No". To create our response variable, we summed up all of these variables. As a result, the final response variable ranged from 0 to 13, as it counts the total number of functional difficulties a child could face out of these 13 difficulties.

Explanatory variables

Explanatory variables in this study were included based on the previously published literature. Not all explanatory variables and their categories were readily available in the MICS 2019 dataset. Therefore, necessary categorizations were performed to derive the required covariates for this study. A brief description of explanatory variables with their categories is provided in Table 1.

Table 1
Description of the explanatory variables included in this study.

Variables	Categories
Administrative division	The original dataset had eight administrative divisions in Bangladesh, including Dhaka, Barishal, Chittagong, Khulna, Mymensingh, Rajshahi, Rangpur, and Sylhet [20, 22–24].
Place of residence	The place of residence of the children had two categories: urban and rural [20, 22–24].
Wealth index	The household wealth index had three categories: poor, middle, and rich [20, 22].
Religion	The original dataset had four different religions, such as Muslim, Hinduism, Buddhism, and Christianity. However, it was categorized into Muslim and non-Muslim categories, where Hinduism, Buddhism, and Christianity were merged into the non-Muslim category [20, 25].
Children's age	Children's age was a numeric variable in the original dataset and is categorized into three categories: 5–9 years, 10–14 years, and 15–17 years [20].
Children's sex	Male and female.
Children's education level	Children's educational level had four categories: pre-primary, primary, secondary, and post-secondary [20].
Mother's age	Mother's age was a numeric variable in the original dataset, and this study categorized it into three categories: 15–24 years, 25–34 years, and $\geq$ 35 years [20, 23].
Mother's educational level	Mother's educational level was categorized into the following four categories: pre-primary or none, primary, secondary, and post-secondary [21–24].
Mother's disability	Mother's disability had two categories in the original dataset: yes and no [20–22, 24].
Household head's sex	Male and female.
Household members	The total number of household members was categorized into two categories: < 5 members, and $\geq$ 5 members [25].

Statistical Analyses

Statistical analyses were performed in several stages in this study. At first, descriptive statistics were presented to summarize the distribution of the total number of child functional difficulties and socio-demographic characteristics of the study participants. Moreover, one-way ANOVA was performed to assess the relationship between the response variable and explanatory variables. To identify the key socio-demographic determinants

of child functional difficulties, this study applied both parametric count regression models (Poisson, Negative Binomial (NB), discrete Lindley (DL), and discrete Weibull (DW)) and a semi-parametric model (Transition model). Model performance was evaluated and compared using the Akaike Information Criterion (AIC) and dispersion. A p-value obtained less than 0.05 was considered statistically significant in this study.

All statistical analyses of this study were performed using R (version 4.5.1), which is a free and open-source statistical software. Data cleaning, management, and visualization were performed by using the 'tidyverse' package. Count regression models, such as Poisson and Negative Binomial regression models, were fitted using the "MASS" package. The Discrete Weibull model was implemented through the 'DWreg' package. Finally, a semi-parametric transition model was fitted by using the "mgcv" and "discSurv" packages.

Semi-parametric Regression Model

Analyzing count data presents notable challenges, particularly in accurately accounting for data structures (such as dispersion, zero-inflation, and truncation) and correctly specifying the underlying parent distribution—missteps that can lead to misleading conclusions. To address these, the present study utilizes a semi-parametric transition model.

The transition model is a flexible semi-parametric approach for modeling count data, which focuses on transition probabilities between counts, where the probability of moving to the next state (count) depends only on the current state (count). This property is known as the Markov chain property, which makes it adaptable to various count data characteristics such as overdispersion, and excessive zeros without requiring specific distributional assumptions. The model is defined by the conditional probabilities as follows [26]:

$$P\left[Y_i > r \mid Y_i => r,\ \varvec{x}_i\right] = F[\theta_r + \varvec{x}_i^T\varvec{\beta}]\ ;\ Y = 0,\ 1,\ 2,\ \ldots\ ;\ r = 0,\ 1,\ 2,$$

where the theoretical count and observed count is denoted by Y and r, respectively. $F(\bullet)$ be the specified distribution function, which links the response probability with linear predictor ($\theta_r + \varvec{x}_i^T\varvec{\beta}$). The vector of covariates expressed by $\varvec{x}_{\varvec{i}}$, and intercept coefficients θ_r. The vector of regression coefficients corresponding $\varvec{x}_{\varvec{i}}$ denoted by $\varvec{\beta} = (\beta_1,\ \ldots\ ,\ \beta_p)^T$. The model uses penalized maximum likelihood method for estimating parameters instead of classical maximum likelihood method due to the large number of parameters relative to the number of counts [26].

Ethical Consideration

This study utilized the dataset from Bangladesh MICS 2019. The ethical approval does not require for this study as the MICS 2019 is secondary data. However, the survey protocol was approved by the technical committee of the Government of Bangladesh, which was led by the Bangladesh Bureau of Statistics. Participants included in this survey were assured that all information would remain confidential and anonymous. In addition, participants also retained the right to withdraw from the interview at any time without mentioning any reason.

Results

The distribution of child functional difficulties was presented in Fig. 2. The majority (87.04%) of the children experienced no difficulties in their daily functioning, whereas children with more than two functional difficulties were 2.02%. The average number of functional difficulties was 0.25 among children aged 5–17 years in Bangladesh, while the variance was 0.85, indicating the presence of overdispersion.

The socio-demographic characteristics of the study participants were presented in the Table S1 (see Supplementary Table 1). The majority of the children in this study were aged 5–9 years (39.3%), while only 3.1 had mothers with disabilities. The largest proportion of children had completed primary education (46.8%), whereas the largest proportion of their mothers had attained secondary education (39.9%).

Children's average number of functional difficulties with 95% CIs and p-values across several socio-demographic factors were presented in Table S2 (see Supplementary Table 2). Children's age, division, wealth index, mother's disability, residence, children's education, and religion were found statistically significant at 5% level in the bivariate analysis. However, all the variables were included in the regression model to see the overall adjusted effect of each socio-demographic determinant.

In the final analysis, four count regression models (Poisson, NB, DL, and DW) were initially fitted, and model suitability was assessed using AIC and dispersion criteria (Table 2). The DW model was chosen as the optimal traditional count model, exhibiting the lowest AIC and a dispersion index near 1. Subsequently, a semi-parametric transition model was fitted as a data-driven alternative. Overall, both the DW and transition models handled overdispersion more effectively than the remaining models.

Table 2
Comparison of the performance of several models for child functional difficulties.

Fitted Regression Models	**Model Selection Criteria**	
	AIC	**Dispersion**
Poisson	1.32	2.45
Negative Binomial	1.06	1.14
Discrete Lindley	1.19	2.15
Discrete Weibull	**1.05**	**1.01**
Transition	**0.84**	**0.97**
AIC = AIC / n		

Transition model was finally utilized to identify the key socio-demographic factors responsible for child functional difficulties in Bangladesh. The estimated regression coefficients, their corresponding p-values, and incidence rate ratios (IRRs) along with their 95% confidence intervals (CIs) are presented in Table 3. Except place of residence, wealth index, children's sex, mother's education, mother's age, and number of household members, the rest of the included covariates were found statistically significant at the 5% level in both the DW and transition models.

Table 3
Comparison of the Discrete Weibull and Transition model for parameter estimates.

Variables	Discrete Weibull				Transition Model			
	Estimate	p-value	IRR	95% CI for IRR	Estimate	p-value	IRR	95% CI for IRR
Administrative division								
Dhaka			1				1	
Barishal	0.83	< 0.001	2.28	(2.11, 2.48)	0.93	< 0.001	2.52	(2.30, 2.77)
Chittagong	0.21	< 0.001	1.23	(1.15, 1.32)	0.24	< 0.001	1.27	(1.16, 1.39)
Khulna	0.12	< 0.001	1.13	(1.05, 1.21)	0.11	0.019	1.12	(1.02, 1.23)
Mymensingh	1.04	< 0.001	2.83	(2.58, 3.11)	1.0	< 0.001	2.73	(2.47, 3.02)
Rajshahi	0.40	< 0.001	1.49	(1.38, 1.61)	0.44	< 0.001	1.55	(1.41, 1.70)
Rangpur	-0.22	< 0.001	0.80	(0.74, 0.87)	-0.27	< 0.001	0.76	(0.68, 0.85)
Sylhet	-0.58	< 0.001	0.56	(0.50, 0.63)	-0.80	< 0.001	0.45	(0.38, 0.53)
Place of residence								
Urban			1				1	
Rural	0.05	0.059	1.06	(0.99, 1.12)	0.07	0.055	1.07	(1.00, 1.15)
Wealth index								
Middle			1				1	
Poor	0.02	0.511	1.02	(0.96, 1.08)	0.02	0.502	1.02	(0.96, 1.10)
Rich	-0.004	0.905	0.996	(0.94, 1.06)	0.01	0.783	1.01	(0.94, 1.09)
Religion								
Muslim			1				1	
Non-Muslim	-0.22	< 0.001	0.80	(0.75, 0.86)	-0.25	< 0.001	0.78	(0.71, 0.86)
Children's age								
5–9 years			1				1	

Variables	Discrete Weibull				Transition Model			
	Estimate	p-value	IRR	95% CI for IRR	Estimate	p-value	IRR	95% CI for IRR
10–14 years	0.20	< 0.001	1.23	(1.15, 1.30)	0.31	< 0.001	1.36	(1.27, 1.46)
15–17 years	0.31	< 0.001	1.37	(1.26, 1.48)	0.43	< 0.001	1.54	(1.40, 1.69)
Children's sex								
Male			1				1	
Female	-0.02	0.463	0.98	(0.94, 1.03)	-0.02	0.555	0.98	(0.94, 1.04)
Children's education								
Pre-primary			1				1	
Primary	-0.57	< 0.001	0.57	(0.53, 0.60)	-0.72	< 0.001	0.49	(0.45, 0.52)
Secondary	-0.90	< 0.001	0.41	(0.38, 0.44)	-1.2	< 0.001	0.31	(0.28, 0.34)
Secondary +	-0.99	< 0.001	0.37	(0.31, 0.43)	-1.3	< 0.001	0.27	(0.22, 0.33)
Mother's age								
15–24 years			1				1	
25–34 years	-0.003	0.925	0.997	(0.93, 1.07)	0.01	0.874	1.01	(0.93, 1.09)
$\geq$ 35 years	-0.04	0.242	0.96	(0.90, 1.03)	-0.03	0.416	0.97	(0.89, 1.05)
Mother's education								
Pre-primary or None			1				1	
Primary	0.01	0.710	1.01	(0.95, 1.07)	0.02	0.654	1.02	(0.95, 1.09)
Secondary	0.02	0.416	1.03	(0.97, 1.09)	0.02	0.510	1.02	(0.95, 1.10)
Higher secondary +	-0.03	0.545	0.97	(0.88, 1.07)	-0.05	0.401	0.95	(0.85, 1.07)
Mother's disability								
No			1				1	
Yes	0.88	< 0.001	2.41	(2.16, 2.68)	0.84	< 0.001	2.31	(2.09, 2.57)

Variables	Discrete Weibull				Transition Model			
	Estimate	p-value	IRR	95% CI for IRR	Estimate	p-value	IRR	95% CI for IRR
Household head's sex								
Male			1				1	
Female	0.09	0.008	1.10	(1.03, 1.18)	0.13	0.003	1.14	(1.05, 1.24)
Household members								
< 5 members			1				1	
$\geq$ 5 members	0.03	0.299	1.03	(0.98, 1.08)	0.03	0.338	1.03	(0.97, 1.09)
The categories with an IRR value of 1 serve as the reference categories.								
Insignificant p-values are highlighted in red.								

Children residing in Barishal (IRR: 2.52) and Mymensingh (IRR: 2.73) divisions had more than 2.5 times the expected number of functional difficulties compared to the children residing in Dhaka division. In addition, children residing in Chittagong, Khulna, and Rajshahi divisions had 27%, 12%, and 55% higher average number of functional difficulties as compared to the children residing in Dhaka division, respectively. However, a lower average number of functional difficulties was found among the children from Rangpur (IRR: 0.76) and Sylhet (IRR: 0.45) divisions. Children from non-Muslim families had 22% reduced average number of functional difficulties compared to children who came from Muslim families.

Children aged 10–14 years had 36% (IRR: 1.36) higher expected number of functional difficulties compared to children aged 5–9 years, while 54% (IRR: 1.54) had increased expected number of functional difficulties was found among children aged 15–17 years. Children's education level at primary, secondary, and post-secondary level had 51% (IRR: 0.49), 69% (IRR: 0.31), and 73% (IRR: 0.27) lower average number of functional difficulties than their counterparts, respectively.

Children had 2.31 times the expected number of functional difficulties among the children whose mother had disability compared to the children whose mother did not have any disability. Children had 14% (IRR: 1.14, p-value = 0.003) higher expected number of functional difficulties if their family had female as a household head compared to their counterparts.

Discussion

The present study aims to identify the key determinants associated with child functional difficulties among the children aged 5–17 years in Bangladesh. Furthermore, it also evaluates the performance of the semiparametric transition model, and compares it with the parametric count regression models (Poisson, NB, DL, and DW) used in this study. Among the parametric approaches considered in this study, the DW model outperformed compared to other parametric models. Since parametric models have well-defined distributional properties and rely on strong distributional assumptions, those may not always hold in practice. In such situations, the

semiparametric model has advantages over the parametric models, which does not require such assumptions. To compare the performance of the semiparametric transition model with the best-performed parametric DW model, we utilized the MICS 2019 dataset for analyzing the functional difficulties among children aged 5–17 years old in Bangladesh. Overall, this study showed that the semiparametric transition model performed similarly to the best-fitted parametric DW model in identifying the factors of child functional difficulties in Bangladesh. The findings highlighted that the administrative division, place of residence, religion, child's age and education, mother's disability, and household head's sex are important factors in child functional difficulties in Bangladesh.

A significant geographical variation in child functional difficulties was observed across eight administrative divisions of Bangladesh. Compared to Dhaka division, children residing in Barishal, Mymensingh, Chittagong, Khulna, and Rajshahi divisions exhibited a higher likelihood of experiencing functional difficulties, whereas those from Rangpur and Sylhet division showed a lower chance. These regional variations were consistent with the findings from three previous studies conducted in Bangladesh [20, 22, 24]. Religion was significantly associated with functional difficulties among children. Compared to Muslim children, non-Muslim children had a lower likelihood of experiencing functional difficulties, having consistency with a previous study [20].

Functional difficulties are more common among children in the early stages of their academic life, and the chance of experiencing the difficulties reduces with their higher academic levels, which aligns with a previous study [20].

Mother's disability emerged as a crucial and important determinant of child functional difficulties. It was evident from this study that children of disabled mothers had a higher chance of experiencing functional difficulties, which is also coincides with a study in Ghana [27]. One possible explanation is the influence of shared biological or genetic factors between mothers and their children. Evidence from the most recent study in Bangladesh reported that parents' disability, particularly among mothers, was associated with an increased chance of child functional difficulties [20–24]. Previous studies have also documented mental health problems and physical challenges among families of children with disabilities [28–30].

A novel finding of this study is that the sex of the household head was significantly associated with child functional difficulties. Children from female-headed households were more likely to experience functional difficulties than those from male-headed households, possibly due to greater socioeconomic disadvantages, caregiving burdens, and limited access to healthcare and other resources.

Strengths and Limitations

This study has some notable strengths. Firstly, this study utilized a nationally representative MICS 2019 data, which generalizes the findings across the country. Secondly, this study also considered a total of 13 distinct functional difficulties among children, which provided a holistic view of functional difficulties among children. Thirdly, the robust findings of this study methodologically focused on the advantage of using semiparametric transition model over parametric count regression models. However, the study also has several limitations that should be acknowledged. Since this study used cross-sectional MICS 2019 data, which limits the ability of establishing the causal inference between explanatory variables and functional difficulties among children. Secondly, the data were collected from the parents or caregivers, which might introduce bias to underreport functional difficulties.

Conclusion

Children's health and well-being are fundamental to their growth, development, and ability to reach their full potential. However, many children worldwide experience functional difficulties that hinder their physical, cognitive, and social development, as well as their participation in daily activities. Thus, the present study aims to identify the key determinants associated with child functional difficulties among the children aged 5–17 years in Bangladesh. Data from the 2019 Bangladesh MICS were used for the analysis. To identify the associated factors, we compared the performance of several traditional count regression models with a data-driven semiparametric transition model. Therefore, the semiparametric transition model produced close estimates with the outperformed parametric DW model without requiring strong assumptions. This study found child's age, administrative divisions, mother's disability, place of residence, children's education level, child's religion, and household head's sex were significantly associated with functional difficulties among children. Notably, children of mothers with disabilities had high likelihood of experiencing functional difficulties. The findings highlight the high-risk groups, which require targeted interventions to mitigate the burden. Future research is recommended to utilize longitudinal data to establish causal relationships, and develop strategies to reduce the burden of functional difficulties among children in Bangladesh.

Declarations

Conflict of Interest:

There is no conflict of interest.

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Author Contribution

AHS conceptualized and supervised the study along with JAK. SA dealt with the data curation process and conducted the analysis. SR drafted the original manuscript along with SA. All authors reviewed and approved the final manuscript.

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Data Availability

The datasets used in the current study are publicly available from the Bangladesh Multiple Indicator Cluster Survey (MICS) repository, maintained by UNICEF. The data can be accessed upon request through the MICS website at https://mics.unicef.org/surveys.

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Figures

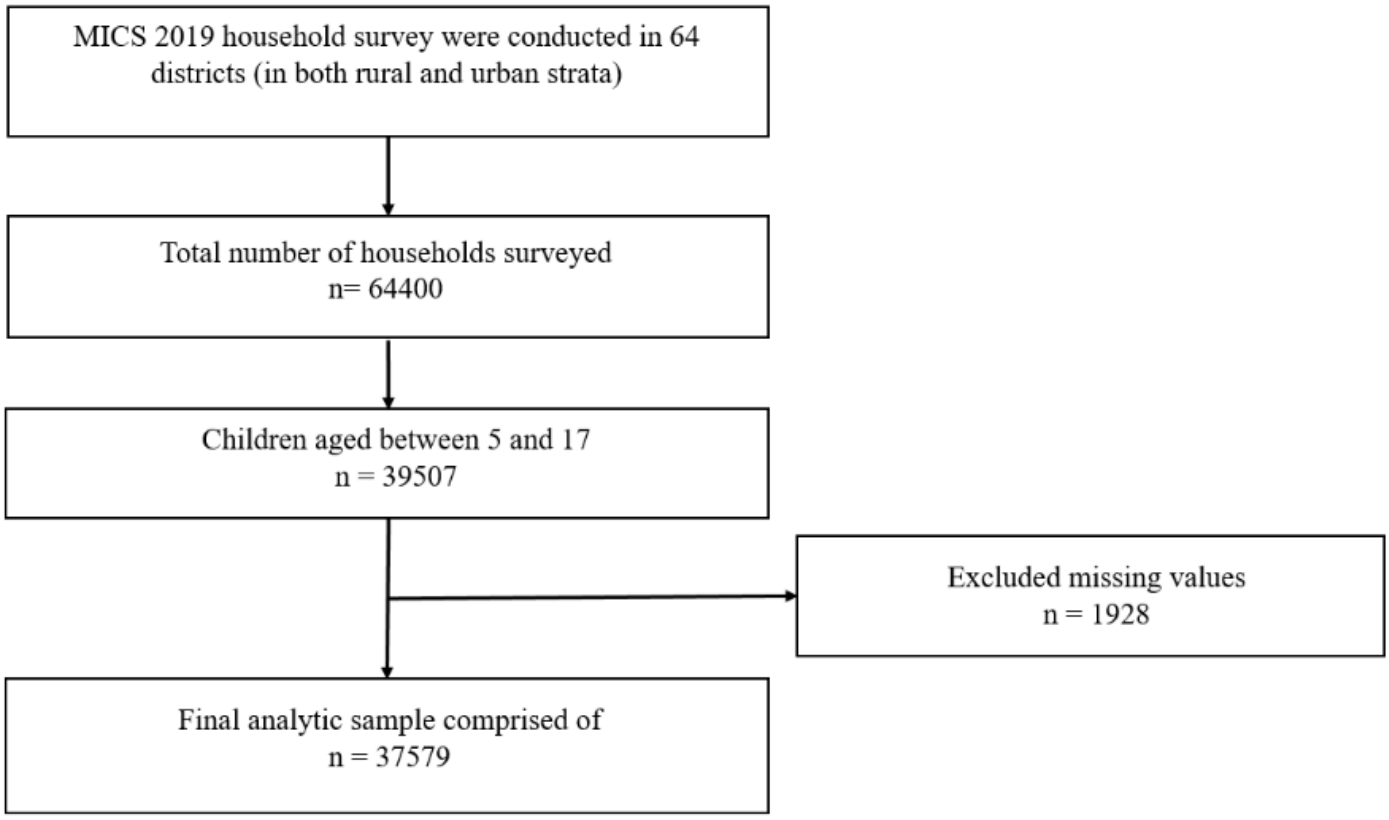


Figure 1

Flowchart of MICS 2019 sampling design and inclusion criteria for this study

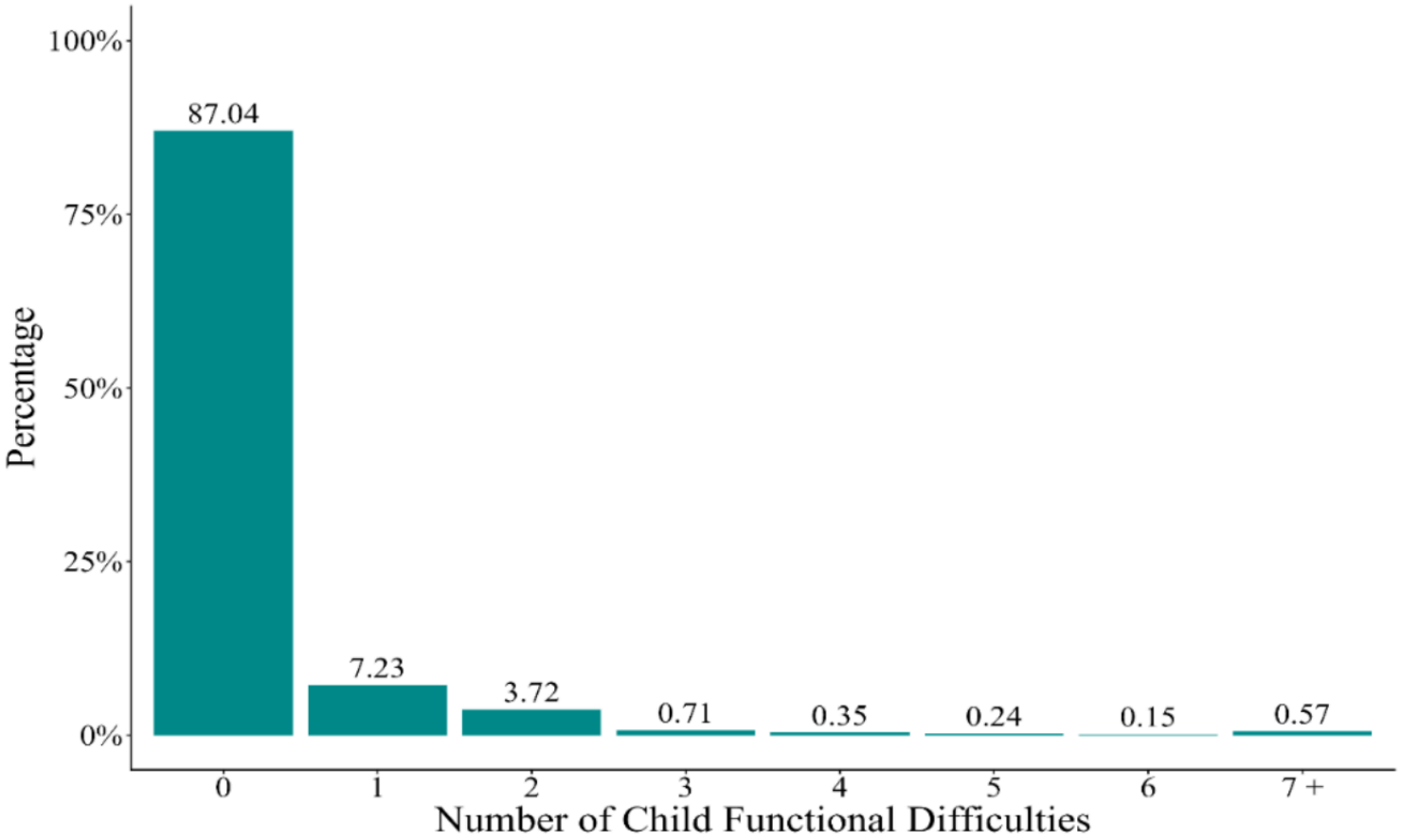


Figure 2

Distribution of the total functional difficulties among children aged 5-17 years

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